N00129.AR.001357
NSB NEW LONDON
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FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 4 (OU 4) VOLUME 2 OF 4 SECTIONS 3, 4, 5 AND REFERENCES NSB NEW LONDON CT

12/01/2010

TETRA TECH NUS

Feasibility Study
for
Operable Unit 4, Lower Subase

Volume II of IV - Sections 3, 4, 5, and References

Naval Submarine Base
New London

Groton, Connecticut

Naval Facilities Engineering Command Mid-Atlantic

Contract Numbers N62467-04-D-0055 and

N62470-08-D-1001

Contract Task Orders 424, WE24, and WE57

December 2010

100706/P

FEASIBILITY STUDY FOR OPERABLE UNIT 4, LOWER SUBASE

VOLUME II - SECTIONS 3, 4, 5, AND REFERENCES

NAVAL SUBMARINE BASE - NEW LONDON GROTON, CONNECTICUT

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Naval Facilities Engineering Command Mid-Atlantic
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CONTRACT NOs. N62467-04-D-0055 AND N62470-08-D-1001
CONTRACT TASK ORDERS 424, WE24, AND WE57

DECEMBER 2010

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3.0 SCREENING OF REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS

This section identifies, screens, and evaluates the potential remediation technologies and process options that may be applicable to assemble remedial alternatives for soil in Zones 1 to 7, groundwater in Zones 1, 4 and 7, the Thames River sediment in Zone 4 and Outer Pier 1, and LNAPL in Zone 1 within the Lower Subase at NSB-NLON. The primary objective of this phase of the FS was to develop an appropriate range of remedial technologies and process options to be used for developing remedial alternatives.

The basis for remediation technology identification and screening began in Section 2.0 with a series of discussions that included the following:

- Identification of ARARs
- Development of RAOs
- Identification of GRAs
- Identification of volumes or areas of media of concern

Remediation technology screening is performed in this section with the completion of the following analytical steps:

- Identification and screening of remediation technologies and process options
- Evaluation and selection of representative process options

In this section, a variety of remediation technologies and process options are identified for each of the GRAs listed in Section 2.3.1 and then screened. The selection of remediation technologies and process options for initial screening is based on the Guidance for Conducting Remedial Investigations/Feasibility Studies under CERCLA (EPA, 1988). The screening is first conducted at a preliminary level to focus on relevant remediation technologies and process options, then the screening is conducted at a more detailed level based on certain evaluation criteria. Finally, process options are selected to represent the remediation technologies that have passed the detailed evaluation and screening.

The evaluation criteria for detailed screening of remediation technologies and process options that have been retained after the preliminary screening are effectiveness, implementability, and cost. The following are descriptions of these evaluation criteria:

- Effectiveness
  - Protection of human health and the environment; reduction in toxicity, mobility, or volume; and permanence of the solution.
  - Ability of the technology to address the estimated areas or volumes of contaminated media.
  - Ability of the technology to attain the PRGs required to meet the RAOs.
  - Technical reliability (innovative versus well proven) with respect to contaminants and site conditions.

- Implementability
  - Overall technical feasibility at the site.
  - Availability of vendors, mobile units, storage and disposal services, etc.
  - Administrative feasibility.
  - Special long-term considerations (e.g., maintenance and operation requirements).

- Cost (Qualitative)
  - Capital cost.
  - Operation and maintenance (O&M) costs.

3.1 PRELIMINARY SCREENING OF SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS FOR ZONES 1 THROUGH 7

This section identifies and screens remediation technologies and process options for soil at a preliminary stage based on implementation with respect to site conditions and COCs. Table 3-1 summarizes the preliminary screening of technologies and process options applicable to soil at Zones 1 through 7. It presents the GRAs, identifies the technologies and process options, and provides a brief description of each process option followed by screening comments.

The following are the soil remediation technologies and process options retained for detailed screening based on the results of preliminary screening.

General Response Action	Remediation Technology	Process Option
No Action	None	Not Applicable
Limited Action	LUCs	Institutional Controls Engineered Controls
	Monitoring	Sampling and Analysis
	Natural Attenuation	Biodegradation, Dilution, Dispersion
Containment	Capping	Multimedia Cover
Removal	Bulk Excavation	Excavation

General Response Action	Remediation Technology	Process Option
In-Situ Treatment	Biological	Enhanced Bioremediation
	Physical/Chemical	Chemical Stabilization/Solidification
Ex-Situ Treatment	Pretreatment	Dewatering
	Biological	Bioslurry Reactor/Biopile
	Physical/Chemical	Soil Washing/Solvent Extraction
		Chemical Stabilization/Solidification
	Thermal	Low-Temperature Thermal Desorption (LTTD)
		Incineration
Disposal	Landfill	Off-Site Landfilling

3.2 DETAILED SCREENING OF SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS FOR ZONES 1 THROUGH 7

3.2.1 No Action

No Action would not include any new environmental action and stop the application of any existing administrative or engineering environmental controls. As required under CERCLA regulations, the No Action alternative is carried through the FS to provide a baseline for comparison of alternatives and their effectiveness in mitigating risks posed by site contaminants. Because no remedial actions would be conducted under this alternative, the only cost associated with the No Action alternative is that of the CERCLA-mandated five-year reviews. There would also not be any reduction in risk through exposure control or treatment. No Action would not be effective in evaluating contaminant mobility and potential migration off site because no monitoring would be performed.

Effectiveness

No Action would not be effective in meeting the soil RAOs. No Action would also not be effective in evaluating either removal of soil COCs through natural attenuation or the potential migration of these COCs either off site or to another medium because no monitoring would be performed.

Implementability

There would be no implementability concerns because no action would be implemented.

Cost

Minimal costs (five-year reviews) would be associated with No Action.

Conclusion

No Action is retained because of NCP requirements, although it would not be effective.

3.2.2 Limited Action

The technologies considered under this GRA include LUCs, monitoring, and natural attenuation.

3.2.2.1 LUCs

LUCs are designed to protect public health and the environment from residual contamination at environmental sites. LUCs consist of administrative or legal mechanisms (e.g., zoning restrictions, permits, etc.) designated as institutional controls and/or physical controls (e.g., pavement, fencing, security guards, etc.) designated as engineering controls. Site-specific LUCs are typically formulated through a LUC Remedial Design (RD) prepared in accordance with the Navy's LUC Principles (DOD, 2003) following approval of the ROD. LUCs typically also include performance of regular site inspections to verify their continued implementation.

Effectiveness

LUCs consisting of site use and site access restrictions would effectively minimize unacceptable risks from direct exposure of human receptors to contaminated soil. Provided that administrative controls are in place for its continued maintenance, the existing pavement that covers much of the Lower Subase would also be an effective engineering control to minimize direct exposure to contaminated soil and overland erosion of that soil, which could affect marine ecological receptors. However, LUCs would not of themselves completely prevent the potential migration of soil contamination that could eventually affect marine ecological receptors because some areas are not covered by pavement or buildings. LUCs would also not be effective in protecting ecological receptors from potential exposure to contaminated soil, but because the Lower Subase constitutes a relatively unlikely ecological habitat, unacceptable risks to ecological receptors would be minimal.

Implementability

LUCs would be easy to implement on a military facility where access is already restricted. A LUC RD could be readily prepared. LUCs for the Lower Subase could easily be integrated in and implemented as part of NSB-NLON's existing Standard Operating Procedures Administration (SOPA) Instruction 5090.25 (Navy, current version) which implements Installation LUCs. In the event of property transfer and with confirmation that contaminated media remains at the sites, an environmental land use restriction (ELUR) pursuant to state law would be recorded to limit the use of media.

Cost

The capital and O&M costs for LUCs would be low.

Conclusion

LUCs are retained for the development of soil remedial alternatives.

3.2.2.2 Monitoring

Monitoring would consist of sampling and analyzing groundwater in areas of soil contamination to evaluate the potential for migration of soil COCs either off site or to another medium, particularly groundwater and surface water.

Effectiveness

Monitoring alone would not reduce the toxicity, mobility, or volume of contaminants in soil. However, monitoring would allow for a determination to be made of the potential off-site migration of contaminants or of potential reductions in COC concentrations through natural attenuation.

Implementability

Monitoring would be easy to implement. Such monitoring has already been performed on several occasions at the Lower Subase. The resources and materials required for monitoring are readily available.

Cost

The capital and O&M costs of monitoring would be low.

Conclusion

Monitoring is retained for the development of soil remedial alternatives.

3.2.2.3 Natural Attenuation

Natural attenuation would consist of allowing naturally occurring processes such as biodegradation, dispersion, dilution, and adsorption to reduce concentrations of soil COCs over time. To evaluate natural

attenuation, soil samples would be regularly collected and analyzed to establish trends in concentrations of COCs.

Effectiveness

Insufficient soil analytical data are currently available to establish clear trends in concentrations of COCs at the Lower Subase. Typically, organic compounds such as the PAHs and TPH, which are soil COCs at the Lower Subase, are amenable to long-term natural attenuation primarily through aerobic biodegradation. However, as previously mentioned, there is no clear evidence that such natural attenuation is currently taking place, and the same organic COCs, particularly the PAHs, can also prove very persistent. In addition, inorganics such as lead, which is one of the main soil COCs at the Lower Subase, are not significantly susceptible to such natural attenuation.

Implementability

Natural attenuation would be very easy to implement because it requires limited actions of monitoring and evaluation. As noted earlier, the resources and materials required for monitoring are readily available.

Cost

The capital and O&M costs for natural attenuation would be low.

Conclusion

Natural attenuation is eliminated from further consideration as a primary remediation technology because of effectiveness concerns. However, it still might be appropriate for remedial polishing.

3.2.3 Containment

The technology considered under the containment GRA is capping. Capping consists of installing either a semi-permeable cover system to prevent direct contact with contaminated soil or an impervious cover system to prevent direct contact with contaminated soil and to minimize infiltration through it. At the Lower Subase, where direct contact with contaminated soil and potential migration of soil COCs to groundwater and surface water are of concern, installation of an impervious cover system would be the capping option of choice.

Effectiveness

Capping would not of itself remove the soil COCs or reduce their toxicities. Nonetheless, capping is a well-established and proven technology that would be effective in preventing direct exposure to the contaminated soil. A cap would also be effective in minimizing the potential for migration of soil COCs from either leaching to groundwater or off-site erosion. Long-term maintenance of the cap and long-term monitoring would ensure the continued effectiveness of the cap. Because the effectiveness of a cap depends on the maintenance of its integrity, this technology is typically incompatible with residential development which would make such maintenance difficult.

Implementability

Installation of a cap over one or more areas of contaminated soil at the Lower Subase would be technically feasible, and many such areas are already covered either with pavement or the foundations of existing or former buildings, particularly the foundation of former Building 31 in Zone 3. Materials and services required to implement this technology are readily available. However, installation of a new cap or modification of an existing one would require very careful planning and execution to minimize interference with ongoing activities at the Lower Subase. Because of the flat site topography and need to maintain normal access to existing buildings, cap installation in the immediate vicinity of these buildings could require excavation and off-site disposal of a significant amount of contaminated soil. Construction of a cap would also restrict the future use of the site, but this would not be a problem as long as Lower Subase remains part of a military facility as currently foreseen. Risk of worker exposure to contaminated soil during cap construction would be adequately mitigated by the wearing of appropriate personal protective equipment (PPE) and by compliance with Occupational Safety and Health Act (OSHA) regulations and site-specific health and safety procedures. Adverse impact on the surrounding community and the environment as a result of the installation of a cap could also be adequately mitigated by implementation of engineering controls such as dust suppression and air quality monitoring.

Cost

The capital and O&M costs for capping would be moderate.

Conclusion

Capping is retained for the development of soil remedial alternatives for industrial use of the site.

3.2.4 Removal

The technology considered under the removal GRA is excavation. Excavation can be performed by a variety of equipment such as tractor shovels (front-end loaders), backhoes, grade-alls, etc. The type of equipment selected must take into consideration several factors such as the type of material to be removed, load-bearing capacity of the ground surrounding the removal area, depth and areal extent of removal, required rate of removal, and elevation of the water table. Excavation is the technology of choice for the removal of well-consolidated material such as soil to depths of up to 30 feet and from well-defined areas of ground with significant load-bearing capacity (i.e., greater than 1,500 pounds per square foot).

Excavation of poorly cohesive soil, such as the sand and gravel present at the Lower Subase, and/or soil significantly below the water table, which would also be the case at the Lower Subase, requires shoring of excavation walls. A typical method of shoring would be to drive sheet piling along the periphery of the area to be excavated. Excavation significantly below the water table, which would occur in several zones, particularly if residential exposure criteria are to be met, could also require pumping to prevent excessive accumulation of groundwater in the excavated areas. Groundwater would be pumped either from the excavated area itself or from wells located on the periphery of this area to locally depress the water table elevation.

The logistics of excavation must take into account the available space for operating the equipment, loading/unloading to transport the removed material, location of the site, etc. After excavation is completed, the location would be filled and graded with clean fill material or treated soil.

Effectiveness

Excavation is a well-proven and effective method of removing contaminated material from a site. Fill material and contaminated sandy/silty soils such as those present at the Lower Subase would be amenable to excavation. Properly designed excavation could remove virtually all of the soil with concentrations greater than PRGs, and remaining soil would not pose an unacceptable risk to human health or the environment.

Verification sampling is typically required to confirm the effectiveness of soil removal. Soil samples would be collected from the sidewalls and, as applicable, from the bottom of the excavation. These samples would be analyzed for COCs to ensure that the remaining soil is not contaminated at unacceptable levels. However, the need for shoring of the excavated areas with sheet piling and/or the presence of water in these areas, both of which could be the case for several of the Lower Subase zones, would hinder verification sampling, especially at depths below 3 to 4 feet bgs.

Implementability

Excavation equipment and services are readily available from multiple vendors or contractors. This technology is well proven and established in the construction/remediation industry. During excavation, site-specific health and safety procedures and OSHA regulations would have to be complied with to ensure that exposure of workers to COCs is minimized.

Very careful planning and execution would be required to prevent interference from excavation with the ongoing activities of the Lower Subase. In addition, excavation would be significantly hindered, and might even be prevented, by the presence of many underground structures such as utility lines and existing and former building foundations. Nonetheless, if obstacles prevent the use of typical excavation equipment such as a backhoe or grade-all in certain areas, and if moving of these obstacles is not practical, excavation could still be performed with a small backhoe or a vactor, or even with hand shovels if the areas to be excavated are relatively small in size. Accordingly, for the purpose of this FS, it is assumed that ongoing base operations and underground obstacles would not actually prevent the excavation of contaminated soil.

At the Lower Subase, excavation of all soil contaminated in excess of PRGs (particularly for the hypothetical future residential land use scenario) would be very difficult to implement because it would require removal of poorly cohesive soil to depths up to 15 feet bgs, which is significantly below the water table. This would lead to two significant implementability concerns. First, as noted above, extensive shoring would be required. Sheet piling would have to be installed on the periphery of the excavated areas to a depth at least three times that of the excavation depth. Second, depending on location, any excavation deeper than approximately 5 to 9 feet bgs would take place under water, which would seriously impair visual control and thus effectiveness of the excavation. Typically and as noted above, this second implementability concern would be addressed by pumping to prevent significant accumulation of groundwater in the excavation. However, such pumping is not practically implementable at the Lower Subase because excavation would take place in a highly permeable stratum (i.e., sand and gravel) along the bank of a tidal river. Under these conditions, depressing the water table, if it could be accomplished at all, would require the pumping (and treatment and discharge) of very large volumes of water, at a rate of at least several hundreds, and probably several thousands, of gallons per minute (gpm). Also, any significant lowering the water table would require a corresponding reinforcement and deepening of the sheet piling to counteract the pressure of the external groundwater on that piling.

Cost

Excavation costs are typically low. At the Lower Subase, excavation of soil below 5 to 9 feet bgs would be relatively expensive because of the reasons discussed above.

Conclusion

Excavation is retained for the development of remedial alternatives in spite of some concerns about effectiveness and significant concerns about implementability for excavation of soil below 5 to 9 feet.

3.2.5 In-Situ Treatment

The technologies and process options considered under the in-situ treatment GRA include enhanced bioremediation and chemical stabilization/solidification.

3.2.5.1 Enhanced Bioremediation

In-situ bioremediation involves the use of naturally occurring microorganisms, primarily bacteria and fungi, to breakdown hazardous organic compounds into nontoxic or less toxic forms. Enhanced in-situ bioremediation would consist of accelerating this process by stimulating biological activity through the blending of chemical additives (nutrients) and/or custom microorganism cultures into contaminated soil.

One of the most likely process options for implementation of this technology at the Lower Subase would consist of using an oxygen-release compound (ORC) such as hydrogen or magnesium peroxide to enhance the aerobic degradation of PAHs and TPH, which constitute the organic soil COCs. For treatment depths of up to 3 feet, this ORC would be mixed into the areas of soil contamination using typical excavation equipment such as a backhoe. For deeper applications, specialized excavating and blending equipment such as a large-diameter auger (LDA) would be used to combine augering of the soil with high-pressure injection of reagents, resulting in formation of a column of treated soil with a diameter ranging from 3 to 10 feet. Treatment would consist of an initial application followed, as required, by maintenance dosages. Soil samples would be regularly collected and analyzed to evaluate the progress of remediation.

Effectiveness

The effectiveness of ORC application is well documented for the in-situ aerobic biodegradation of a very wide range of non-chlorinated organic compounds including PAHs and TPH. However, it is likely that much of the TPH in Lower Subase contaminated soil consists of what is typically referred to as “weathered” product, which is petroleum that has already lost its lighter and more biodegradable or

volatile components through naturally occurring processes. Therefore, this TPH may no longer be very biodegradable. In addition, if this technology is applied in the saturated zone, as might occur at the Lower Subase, the aerobic biodegradation of PAHs and TPH promoted by ORC injection might be significantly impacted by the high salinity of the aquifer. Treatability testing would be required to evaluate the site-specific biodegradability of TPH and to assess the impact of aquifer salinity.

ORC application would not be effective for the treatment of most of the metallic soil COCs including antimony, lead, and mercury. ORC application might be effective for the treatment of arsenic, but through chemical rather than biological action as a result of the oxidation of arsenic from its relatively mobile trivalent state to its much less mobile pentavalent state.

Implementability

Enhanced in-situ bioremediation of contaminated soil is a well-proven and well-established technology which is typically relatively easy to implement, and qualified contractors are readily available to perform this work. However, very careful planning and execution would be required to prevent interference with ongoing activities at the Lower Subase. Implementation of this technology below the water table would probably not be feasible or effective. In addition, implementation would be significantly hindered, and might even be prevented, by the presence of many underground structures such as utility lines and existing and former building foundations. Nonetheless, if obstacles prevent the use of typical in-situ blending equipment such as an LDA in certain areas and if moving of these obstacles is not practical, the ORC could still be manually worked into the soil to be treated using hand tools such as shovels, provided that the areas to be so treated are relatively small in size. Accordingly, for the purpose of this FS, it is assumed that ongoing base activities and underground obstacles would not actually prevent the application of ORC. The blending action and addition of ORC associated with this technology result in an increase of the volume of treated soil which typically ranges from 5 to 25 percent. For the purpose of this FS, this increase in soil volume was estimated at approximately 10 percent. Because the bioremediation process would take a significant period of time to complete (at least one year), the incremental volume of soil must be kept on site and dispersed through appropriate re-grading as may be necessary to accommodate existing buildings and other structures. As mentioned earlier, treatability testing would be required to evaluate the site-specific biodegradability of TPH and to assess the impact of aquifer salinity.

Cost

The capital and O&M costs for enhanced in-situ bioremediation would be low.

Conclusion

Although there are some concerns about its site-specific effectiveness, enhanced in-situ bioremediation is retained to address organic COCs in the development of soil remedial alternatives.

3.2.5.2 Chemical Stabilization/Solidification

Chemical stabilization consists of mixing contaminated soil with chemical reagents that modify COCs to render them less soluble and hence less mobile. Chemical solidification consists of mixing contaminated soil with chemical reagents that bind the COCs within the matrix of the material being treated. The most common stabilization reagents are phosphates, carbonates, hydroxides, and sulfates. The most common solidification reagents are pozzolanic-based materials such as Portland cement, cement kiln dust (CKD), and fly ash. Other reagents such as thermoplastic binders (i.e., asphalt); sorbents such as granular activated carbon (GAC), clays, zeolites, and anhydrous sodium silicate; and MAECTITE® (a proprietary treatment process using phosphate-based additives) have also been successfully used for chemical stabilization/solidification.

As with enhanced bioremediation, the above-mentioned chemical reagents are normally mixed with the contaminated soil to be treated using typical excavation equipment such as a backhoe if the depth of application does not exceed 2 to 3 feet and with an LDA for deeper applications.

Effectiveness

Chemical stabilization/solidification is a well-established and proven technology, but its effectiveness is highly dependent on the type of material being treated and the type of COCs being immobilized. A thorough physical and chemical characterization of the material to be treated and COCs to be immobilized is needed, and treatability testing is typically required to determine the most suitable stabilization/solidification reagents and mixing ratios. The effectiveness of in-situ chemical stabilization/solidification is also dependant on the thoroughness of the in-situ soil/reagent blending process, which is typically not quite as complete as its ex-situ counterpart.

At the Lower Subase, pozzolanic fixation/solidification would very likely be effective for treatment of soil contaminated with metallic COCs and low concentrations of PAHs and TPH. A slight variant of this technology, with excavation and on-site treatment of contaminated soil and backfill of treated soil, has already been successfully used to remediate lead-contaminated soil beneath former Building 31 (Zone 3) down to the water table (HNUS, 1995a). Soil contaminated with high concentrations of PAHs and/or TPH would most likely require the use of a specialized reagent. Because in-situ chemical stabilization/solidification does not eliminate the toxicity of COCs immobilized in the treated soil and

leaves this treated soil in place, this technology would not be effective in meeting either the I/C or Residential DECs. In-situ chemical stabilization/solidification would effectively minimize the potential for migration of COCs from soil to other environmental media such as groundwater. Therefore, this technology would be very effective in meeting the PMCs. Long-term stability and leachability of the treated soil would remain as potential concerns because COCs would remain within the treated soil. These concerns would be particularly valid for application of this technology to saturated soil, where the high salinity of the Lower Subase aquifer could significantly impact the long-term stability of the stabilized soil.

Implementability

In-situ chemical stabilization/solidification is a well-proven and well-established technology which is typically fairly easy to implement, and qualified contractors are readily available to perform this work. However, very careful planning and execution would be required to prevent interference with ongoing activities at the Lower Subase. Implementation of this technology below the water table would probably not be feasible or effective. In addition, implementation would be significantly hindered, and could even be prevented, by the presence of many underground structures such as utility lines and existing and former building foundations. Nonetheless, if obstacles prevent the use of typical in-situ blending equipment such as an LDA in certain areas, and if moving of these obstacles is not practical, the stabilization reagent and water could still be manually worked into the soil to be treated using hand tools such as shovels, provided that the areas to be so treated are relatively small in size. Accordingly, for the purpose of this FS, it is assumed that ongoing base activities and underground obstacles would not actually prevent the implementation of in-situ chemical stabilization/solidification. As for in-situ enhanced bioremediation, the blending action and addition of fixating agent associated with this technology result in an increase of the volume of treated soil which was estimated at approximately 10 percent. However, because the chemical stabilization/solidification is much quicker to complete than the bioremediation one, the incremental treated soil could either be kept on site and re-graded as necessary, or it could be disposed at an off-site municipal type solid waste landfill if this option would be easier to implement. Treatability tests would be required to determine the appropriate mix ratios prior to implementation.

Cost

The O&M costs of off-site stabilization/solidification would be moderate. Because application of this technology would be contracted as a service, there would be no capital costs.

Conclusion

In-situ chemical stabilization/solidification is retained for the development of soil remedial alternatives. However, because of effectiveness and implementability concerns, application of this technology is limited to unsaturated soil contaminated with concentrations of COCs greater than pollutant mobility PRGs.

3.2.6 Ex-Situ Treatment

The technologies and process options considered under this GRA include those that might be required as on-site pretreatment, such as dewatering, or as part of disposal at an off-site treatment, storage, and disposal facility (TSDF), including bioslurry reactors/biopiles, soil washing/chemical extraction, chemical stabilization/solidification, LTTD, and incineration.

3.2.6.1 Dewatering

Dewatering is a process for reducing the free water content of a solid material. Dewatering can be achieved by either passive (gravity-aided) drainage of water from stockpiled material or by mechanical expression of that material.

Stockpiling of wet material on a drainage pad can cause most of the free water to drain as a result of gravity and of mechanical expression of the lower strata of stockpiled soil by the weight of the upper strata. The free water drains through a pad designed to filter out solid particles. If required, this pre-filtered water can then be treated by such technologies as GAC adsorption to meet the appropriate criteria for discharge to local surface water.

Mechanical expression of free water from the material to be dewatered can be achieved using pressure or centrifugal forces developed by specialized equipment such as belt filter presses, plate-and-frame filter presses, vacuum filters, or centrifuges. As required, the released water can also be treated on site as with the stockpiling option.

Effectiveness

Mechanical expression is generally more effective than stockpiling because the rate and extent of dewatering are usually higher when forces greater than gravity alone are applied to separate liquids from solids. However, stockpiling provides a simple and effective means of releasing most of the free water from relatively granular material such as the soil at the Lower Subase.

Implementability

Both stockpiling and mechanical expression are readily implementable. Resources, equipment, and materials to implement either of these options are readily available. Stockpiling would be simpler to implement but would require far more space than mechanical expression. Under the current industrial site use scenario, the space needed to implement stockpiling would not be available at the Lower Subase. However, dewatering would only be required for pre-treatment of soil excavated to meet the environmental requirements of a hypothetical future residential site use, and the space needed for stockpiling could be readily available during the transition period to such site use. Mechanical expression would require more equipment and maintenance than stockpiling. Depending on the types and concentrations of contaminants present in the material being treated, an on-site dewatering system might have to meet the substantive requirements of a hazardous or non-hazardous waste TSDF. Also, the substantive requirements of an NPDES permit might have to be met for the surface discharge of treated drainage water.

Cost

The cost of stockpiling would typically be low. The cost of mechanical expression would be moderate.

Conclusion

Dewatering is retained for the development of soil remedial alternatives. Because of its simplicity and the availability of the necessary space during the transition period to hypothetical future residential development, stockpiling would be the option of choice.

3.2.6.2 Bioslurry Reactor/Biopile

A bioslurry reactor is an enclosed vessel in which contaminated material is biologically treated in an enclosed vessel. After removal of foreign materials such as stones and rubble, the contaminated material is mixed with water and a culture of appropriate microorganisms to form a slurry containing 10 to 30 percent solids. This slurry is placed in a tank with process controls so that temperature, mixing, and nutrient additions can be manipulated to achieve maximum biological treatment efficiency. Following treatment, the slurry is dried and tested to verify that COCs have been adequately removed, and the treated material is replaced in its original location or used as fill material elsewhere.

A biopile is a technology in which contaminated material is mixed with biologically amended soil and formed into an enclosed compost pile. Oxygen, if needed for aerobic treatment, is provided either by inducing an air current through the pile with blowers or vacuum pumps or by the mixing in of an ORC. Moisture, heat, nutrients, oxygen, and pH are controlled to enhance biodegradation. Duration of

operation may vary from a few weeks to several months, at which time the treated material is either returned to its original location or used as fill material elsewhere.

Effectiveness

Bioslurry reactors and biopiles have been proven effective for the treatment of soil contaminated with a wide range of organic compounds including PAHs and TPH, which are the organic soil COCs at the Lower Subase. However, as noted earlier for the evaluation of in-situ enhanced bioremediation (Section 3.2.5.1), much of the TPH in Lower Subase contaminated soil might consist of so-called "weathered" product that is no longer very biodegradable, and treatability testing would be required to verify the site-specific biodegradability of this TPH. In addition, bioslurry reactors or biopiles would not be effective for the removal of metallic soil COCs.

Implementability

Bioslurry reactor or biopile technologies would be implementable. Specialized contractors or selected TSDFs could perform this treatment. However, both of these technologies would require a relatively complex sequence of operations, including staging, treatment, and disposal of treated soil. In addition, treated soil from a bioslurry reactor would require dewatering and drying prior to disposal or reuse. The necessary equipment and resources are only available from a relatively limited number of contractors or off-base permitted TSDFs. Because of the relatively congested nature and high level of activity at the Lower Subase, this technology could not be practically implemented on site under the current industrial scenario. However, the space required for implementation could be available during the transition period to hypothetical future residential development. Treatability testing would be required to verify effectiveness and determine operating parameters.

Cost

The capital and O&M costs for bioslurry reactors/biopiles would be moderate to high.

Conclusion

Bioslurry reactors/biopiles are eliminated from further consideration because of effectiveness and implementability concerns.

3.2.6.3 Soil Washing/Solvent Extraction

Soil washing uses physical processes such as high-pressure water, screening, attrition scrubbing, froth flotation, electromagnetic separation, mechanical separation, hydrogravimetric separation (including

hydrocyclones, mineral jigs, and spiral classifiers), and multigravity separation. Such physical separation processes achieve waste minimization through a volume reduction process by separating out a size fraction of soil containing little or no contamination (such as coarse-grained soil and large-sized material) from more highly contaminated finer-grained material such as clays and silts.

Solvent extraction uses water or other solvents to extract or desorb COCs from soil and to dissolve them into the liquid phase. Solvent extraction often requires preliminary treatment using physical separation to reduce the volume of material to be treated.

Effectiveness

The effectiveness of soil washing is highly waste specific, and this technology can be successfully adapted to the removal of a wide range of inorganic and organic contaminants. A thorough physical and chemical characterization of the waste and treatability testing are essential to determine the most suitable and efficient means of separating COCs from clean soil. When different classes of COCs are present, such as would be the case for Lower Subase soil that contains PAHs, TPH, and metals, a series of extraction operations using different solvents, pH adjustment, etc. would be required. Such a combination of physical separation and various chemical extraction techniques would probably be required to successfully remove the Lower Subase soil COCs, with nontoxic organic solvents used for the removal of PAHs and TPH and acids to remove metals. The extraction process would yield clean soil that would require water rinsing to remove the residual extractant. By-products of the process would consist of spent solvent streams containing wastes requiring further treatment/disposal and recovery/recycle of the extractants.

Implementability

Soil washing/chemical extraction would be implementable. Specialized contractors or selected TSDFs could perform this treatment. However, a soil washing/chemical extraction system would be complex, consisting of physical separation operations and chemical extraction processes. Physical separation would consist of several operations depending on the type of debris, sizes, densities of materials, etc. A sieve analysis of the soil would be required for design of the treatment system. Chemical extraction would require treatability studies to determine the specific type and composition of solvent. Typically, waste streams produced from chemical extraction are more contaminated and greater in volume than waste streams from other processes. To treat the extracted liquid, an extensive wastewater treatment facility would be required to separate reagents from treated soil and then to treat the residuals. The wastewater facility would be required to have organic treatment and neutralization processes in addition to dewatering processes. Unless efficient recovery/recycle of the extractant is achievable, there would be significant implementability concerns for further treatment/disposal of the waste streams. Because of the

relatively congested nature and high level of activity at the Lower Subase, this technology could not be practically implemented on site under the current industrial scenario. However, the space required for implementation could be available during the transition period to hypothetical future residential development.

Cost

The capital and O&M costs for soil washing/chemical extraction would be moderate to high. Additional costs for disposal of residues could also be moderate to high.

Conclusion

Ex-situ soil washing/chemical extraction is eliminated from further consideration because it would be significantly more complex and costly to implement than other equally effective ex-situ treatment technologies such as chemical stabilization/solidification and LTTD.

3.2.6.4 Chemical Stabilization/Solidification

Chemical stabilization consists of mixing contaminated soil with chemical reagents that modify COCs to render them less soluble and hence less mobile. Chemical solidification consists of mixing contaminated soil with chemical reagents that bind the COCs within the matrix of the material being treated. The most common stabilization reagents are phosphates, carbonates, hydroxides, and sulfates. The most common solidification reagents are pozzolanic-based materials such as Portland cement, CKD, and fly ash. Other reagents such as thermoplastic binders (i.e., asphalt); sorbents such as GAC, clays, zeolites, and anhydrous sodium silicate; and MAECTITE® have also been successfully used for chemical stabilization/solidification.

For ex-situ chemical stabilization/solidification, mixing of the material to be treated with the chemical reagents is normally accomplished in the presence of a controlled amount of water and with specialized mechanical blending equipment such as a pug mill. After the material is mixed with the chemical reagents, it is typically allowed to cure for the stabilization or solidification process to take full effect. In the case of chemical solidification, the treated material may either be allowed to cure as a monolithic block, or it can be made into a granular material with the consistency of a soil-cement.

Chemical stabilization/solidification may require pretreatment for removal of oversized materials that would not be adequately blended with the chemical reagents and that would interfere with the treatment process.

Effectiveness

Chemical stabilization/solidification is a well-established and proven technology, but its effectiveness is highly dependent on the type of material being treated and type of COCs being immobilized. A thorough physical and chemical characterization of the material to be treated and COCs to be immobilized is needed, and treatability testing is typically required to determine the most suitable stabilization/solidification reagents, mixing ratios, and any special pretreatment or material-handling methods that may be required.

At the Lower Subase, pozzolanic fixation/solidification would very likely be effective for the treatment of soil contaminated with metallic COCs and low concentrations of PAHs and TPH. Soil contaminated with high concentrations of PAHs and/or TPH would most likely require the use of a specialized reagent. Because chemical stabilization/solidification would not eliminate the toxicity of COCs immobilized in the treated soil, this material would still require proper disposal to minimize unacceptable human health risks that could result from direct exposure. Chemical stabilization/solidification would effectively minimize the potential for migration of COCs from soil to other environmental media such as groundwater. Long-term stability and leachability of the treated soil would remain as potential concerns because COCs would remain within the treated soil. Most chemical stabilization/solidification processes, including in particular the use of pozzolanic reagents, result in an increase in the volume of the treated material typically ranging from 5 to 15 percent.

Implementability

Ex-situ chemical stabilization/solidification would be relatively easy to implement. The necessary equipment and resources are available at most permitted TSDFs to perform this work. Because of the relatively congested nature and high level of activity at the Lower Subase, this technology could not be practically implemented on site under the current industrial scenario. However, the space required for implementation could be available during the transition period to hypothetical future residential development. Treatability tests would be required to determine the appropriate mix ratios prior to implementation.

Cost

The O&M costs of off-site stabilization/solidification would be moderate. Because application of this technology would be contracted as a service, there would be no capital costs.

Conclusion

Ex-situ chemical stabilization/solidification is retained for the development of soil remedial alternatives.

3.2.6.5 LTTD

LTTD uses direct or indirect heating to desorb or volatilize organic COCs. Operating temperatures are contaminant and matrix specific, with a range of approximately 200 to 1,200°F (95 to 650°C). In the higher range of operating temperatures, LTTD might also be capable of limited removal of a few metals such as arsenic and mercury through volatilization/sublimation. Typically, wastes are processed through an externally fired pug mill or rotary drum system equipped with heat transfer surfaces that are heated by circulating hot oil. An induced airflow conveys desorbed organic chemicals through a secondary treatment system such as a vapor-phase GAC adsorption unit, catalytic oxidation unit, condenser unit, or afterburner (although use of an afterburner for secondary treatment has typically resulted in the LTTD unit being considered an incinerator by regulatory agencies). The off-gas is then discharged through a stack.

Effectiveness

LTTD is a well-established and proven technology. LTTD effectiveness is typically quite sensitive to particle size, and it generally performs better with relatively coarse soil to which contaminants do not adhere too tightly, which would be the case at the Lower Subase where the soil consists mostly of sand and gravel. LTTD would likely also be quite effective for the removal of PAHs and TPH from contaminated soil at the Lower Subase. Because these organic COCs have relatively low volatilities, operating temperatures would be expected to be towards the higher end of the range (probably 800 to 900º F). As noted earlier, it is possible that at these temperatures, some removal of a few of the metallic COCs such as arsenic and mercury might also occur. However, such removal would have to be verified through testing. To be fully effective, LTTD would require additional treatment of volatilized contaminants, which would be accomplished through treatment of off-gases by such processes as condensation, vapor-phase GAC adsorption, or catalytic oxidation.

Implementability

LTTD would be relatively easy to implement. Specialized contractors or selected TSDFs could perform this treatment. Treatability testing might be required to determine operating parameters and evaluate the potential removal of metallic COCs. Off-gases from the thermal desorption unit would have to be treated. Because of the relatively congested nature and high level of activity at the Lower Subase, this technology could not be practically implemented on site under the current industrial scenario. However, the space required for implementation could be available during the transition period to hypothetical future residential development. Adverse impact on the surrounding community and the environment as a result of off-site transportation of contaminated soil would be adequately mitigated by adherence to spill

prevention procedures and compliance with United States Department of Transportation (DOT) regulations.

Cost

The O&M costs of off-site LTTD would be moderate. Because application of this technology would be contracted as a service, there would be no capital costs.

Conclusion

Off-site LTTD is retained for the development of soil remedial alternatives.

3.2.6.6 Incineration

Incineration is a thermal oxidation process that converts organic solids, liquids, and gases to inorganic substances at high temperatures in the presence of oxygen. The technology uses controlled flame combustion in an enclosed reactor to decompose organics. Carbon and hydrogen waste components are converted to carbon dioxide (CO_2) and water, respectively. Other combustion products are also present in smaller quantities. These may include carbon monoxide, nitrogen oxides, chlorine, fluorine, and trace metals. If a wet scrubber air pollution control system is used, a liquid waste stream could also be generated. Screening of the contaminated material would be required to remove non-combustible waste/debris from the soil. The non-combustible waste/debris must be treated or disposed by other means depending on the level of contamination.

Rotary kilns are one of the most widely used incinerators for wastes in the form of solids, sludges, liquids, and gases. An integrated system for incineration by rotary kiln includes a solid feed system, rotary kiln and secondary combustion chamber, air pollution control units for particulate and acid gas removal; and exhaust stack. Such a system employs a refractory-lined rotary kiln operating at high temperatures (1,470 to 2,910°F or 800 to 1,600°C) to combust wastes in the presence of oxygen. A typical throughput for a transportable rotary kiln is 75 to 200 tons per day. For wastes that have high heat content, the throughput may be limited by the capacity of the unit to control the heat generation rate. Fixed-base units, such as cement kilns that may be permitted to accept contaminated soil, are also available.

Effectiveness

Incineration is a well-established and proven technology that would be very effective for destroying the organic soil COCs such as PAHs and TPH. Incineration would typically achieve in excess of 99.99 percent destruction of these types of COCs, with the resulting formation of inert CO_2 and water. In addition, similar to LTTD operating in the higher range of temperatures and probably more dependably

so, incineration could achieve a certain degree of removal of a few of the metallic COCs such as arsenic and mercury. Because the organic COCs at the Lower Subase contain no significant chlorine or nitrogen, off-gas treatment requirements would probably be minimal and limited to control of solid particulates.

Implementability

Incineration could be implemented; however, on a practical level, this technology could only be implemented off site, and only a few qualified TSDFs are available to provide this service. As noted earlier, off-gas treatment requirements would probably be minimal. However, pre-approval of the material to be incinerated by the TSDF would be required, and a trial burn might be necessary. Adverse impact on the surrounding community and the environment as a result of off-site transportation of contaminated soil would be adequately mitigated by adherence to spill prevention procedures and by compliance with DOT regulations.

Cost

The O&M cost of off-site incineration would be very high. Because application of this technology would be contracted as a service, there would be no capital costs.

Conclusion

Off-site incineration is not retained for development soil remedial alternatives because its relatively greater effectiveness compared to LTTD does not warrant its more complex implementability and higher cost. In addition, this degree of treatment is not required to successfully treat the vast majority of the Lower Subase contaminated soil, which contains moderate concentrations of organic COCs. However, off-site incineration is retained for the treatment/disposal of LNAPL that might be recovered as part of soil remediation.

3.2.7 Disposal

The technology considered under the disposal GRA is off-site landfilling, which consists of transporting excavated soil for burial at a permitted facility. Prior to landfilling, excavated soil with higher concentrations of COCs might require treatment by one or more of the above-described ex-situ treatment technologies at an off-site TSDF. In addition, soil that contains metals with TCLP extract concentrations greater than their RCRA toxicity characteristics would be identified as hazardous and would have to be disposed at a hazardous waste TSDF where they would undergo treatment to satisfy Land Disposal Restrictions (LDRs) prior to secure landfilling.

Effectiveness

Landfilling does not permanently or irreversibly reduce the concentrations or toxicities of soil COCs. However, although the CERCLA preference for treatment relegates landfilling to a less preferable option, this technology can be an effective disposal option for contaminated soil. Landfills are only permitted to operate if they meet certain requirements of design and operation governing foundation, liner, leak detection, leachate collection and treatment, daily cover, post-closure inspections and monitoring, etc., which ensure the effectiveness of these facilities. The requirements of a hazardous waste TSDF are typically significantly more stringent than those of a municipal solid waste landfill.

Implementability

Off site landfilling would be easy to implement. Permitted municipal solid waste and hazardous waste TSDFs are available for this purpose. Disposal at either type of facility may require certain pretreatment, mainly the removal of free liquids by dewatering. This dewatering pretreatment is typically performed on site to facilitate the transporting process, and it would be required for any soil excavated below the water table. A waste profile would have to be prepared, including contaminant concentrations and their leachabilities. Adverse impact on the surrounding community and the environment as a result of the off-site transportation of contaminated soil would be adequately mitigated by adherence to spill prevention procedures and compliance with DOT regulations.

Cost

The O&M cost of off-site disposal would be low to moderate for a municipal solid waste landfill, moderate for a non-hazardous waste TSDF, and high for a hazardous waste TSDF. Because application of this technology would be contracted as a service, there would be no capital costs.

Conclusion

Landfilling is retained for the development of soil remedial alternatives. Depending on the characteristics of the soil to be disposed, this might occur at a municipal solid waste landfill, non-hazardous waste TSDF, or hazardous waste TSDF.

3.3 SELECTION OF SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS FOR ZONES 1 THROUGH 7

The following GRAs, remediation technologies, and process options were retained to develop soil remedial alternatives:

- No Action.
- Limited Action: LUCs (Engineering and Institutional Controls) and Monitoring.
- Containment: Capping.
- Removal: Bulk Excavation.
- In-Situ Treatment: Enhanced Bioremediation and Chemical Stabilization/Solidification.
- Ex-Situ Treatment: On-Site Dewatering (stockpiling) and (if required as part of off-site disposal) Off-Site Chemical Stabilization/Solidification and LTTD.
- Disposal: Off-Site Landfilling (municipal solid waste landfill, non-hazardous waste TSDF, or hazardous waste TSDF) and Off-Site Incineration (for LNAPL only).

3.4 PRELIMINARY SCREENING OF GROUNDWATER REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS FOR ZONES 1, 4, AND 7

This section identifies and screens remediation technologies and process options for groundwater at a preliminary stage based on implementation with respect to site conditions and COCs. Table 3-2 summarizes the preliminary screening of remediation technologies and process options applicable to groundwater. This table presents the GRAs, identifies the remediation technologies and process options, and provides a brief description of each process option followed by screening comments.

The following are the groundwater remediation technologies and process options remaining for detailed screening based on the results of preliminary screening:

General Response Action	Remediation Technology	Process Options
No Action	None	Not Applicable
Limited Action	LUCs	Institutional Controls
	Monitoring	Sampling and Analysis
	Natural Attenuation	Naturally Occurring Biodegradation, Dispersion, and Dilution
Removal	Groundwater Extraction	Extraction Wells
In-Situ Treatment	Biological	Enhanced Bioremediation
	Physical/Chemical	Chemical Oxidation and Precipitation
		Permeable Reactive Barriers (PRBs)

General Response Action	Remediation Technology	Process Options
Ex-Situ Treatment	Biological	Aerobic Biodegradation
	Physical/Chemical	Filtration
		Adsorption
		Chemical Oxidation
		Chemical Precipitation
		pH Adjustment/Neutralization
Disposal	Surface Discharge	Indirect Discharge to On-Site/Off-Site Treatment System
		Direct Discharge to Thames River

3.5 DETAILED SCREENING OF GROUNDWATER REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS FOR ZONES 1, 4, AND 7

3.5.1 No Action

No Action would not include any new environmental action and stop the application of any existing administrative or engineering environmental controls. As required under CERCLA regulations, the No Action alternative is carried through the FS to provide a baseline for comparison of alternatives and their effectiveness in mitigating risks posed by site contaminants. Because no remedial actions would be conducted under this alternative, the only cost associated with the No Action alternative is that of the CERCLA-mandated five-year reviews. There would also not be any reduction in risk through exposure control or treatment. No Action would not be effective in evaluating contaminant mobility and potential migration off site because no monitoring would be performed.

Effectiveness

No Action would not be effective in meeting the groundwater RAOs. No Action would not allow the evaluation of either the possible reduction of concentrations of arsenic, copper, or TPH through natural attenuation or potential migration of these COCs, particularly to the Thames River.

Implementability

There would be no implementability concerns because no actions would be implemented.

Cost

Minimal costs (five-year reviews) would be associated with No Action.

Conclusion

No Action is retained for comparison to other options.

3.5.2 Limited Action

The technologies and process options considered under this GRA include LUCs, monitoring, and natural attenuation.

3.5.2.1 LUCs

LUCs are designed to protect public health and the environment from residual contamination at environmental sites. LUCs consist of administrative or legal mechanisms (e.g., zoning restrictions, permits, etc.) designated as institutional controls and/or physical controls (e.g., fencing, security guards, etc.) designated as engineering controls. Site-specific LUCs are typically formulated through a LUC RD that is prepared in accordance with the Navy's LUCs Principles (DoD, 2003) following approval of the ROD.

For Zones 1, 4, and 7 groundwater, LUCs would consist of institutional controls that would limit access to groundwater. Institutional controls would include restrictions to restrict contact of site with groundwater as a result of excavation and prohibit the use of surficial aquifer groundwater for human consumption. As part of the LUCs, regular site inspections would be performed to verify continued implementation.

Effectiveness

LUCs would not remove COCs from groundwater or restore aquifer quality; however, LUCs would effectively minimize potential human health risks associated with exposure to contaminated groundwater. The groundwater beneath the Lower Subase is presumed unfit for human consumption without prior treatment and is therefore classified as GB by CTDEP. However, additional closely enforced site-specific groundwater use restrictions would be effective to address the incremental risk from contamination.

Implementability

LUCs would be easy to implement on a military facility where restrictions on access to and use of groundwater could easily be enforced. A LUC RD could be readily prepared. LUCs for the Lower Subase could easily be integrated in and implemented as part of NSB-NLON's existing SOPA Instructions 5090.25 (Navy, 2009). In the event of property transfer and with confirmation that contaminated media remains at the sites, an environmental land use restriction (ELUR) pursuant to state law would be recorded to limit the use of media.

Cost

The cost of LUCs would be low.

Conclusion

LUCs are retained for the development of groundwater remedial alternatives.

3.5.2.2 Monitoring

Monitoring would consist of using sampling and analysis of groundwater in areas of groundwater contamination to evaluate trends in concentrations of COCs and their potential off-site migration. Monitoring could also be used to evaluate possible natural attenuation of COCs and/or the progress of active groundwater remediation.

Effectiveness

Monitoring would not remove COCs from groundwater or restore aquifer quality; however, monitoring would make it possible to evaluate the potential migration of COCs either off site or to other media, particularly surface water in the nearby Thames River. Monitoring would also allow evaluation of the reduction in concentrations of COCs either through natural attenuation or as a result of active remediation. As a result, monitoring is an effective and indispensable remedial technology.

Implementability

A groundwater monitoring program would be easy to implement at the Lower Subase. Such monitoring has already been performed on a number of occasions at similar sites within NSB-NLON. The resources and materials required for monitoring are readily available.

Cost

The capital and O&M costs of monitoring would be low.

Conclusion

Monitoring is retained for the development of groundwater remedial alternatives.

3.5.2.3 Natural Attenuation

Natural attenuation would consist of allowing naturally occurring processes such as biodegradation, dispersion, dilution, and adsorption to reduce groundwater concentrations of COCs over time. To evaluate natural attenuation, groundwater samples would be regularly collected and analyzed to establish trends in concentrations of COCs.

Effectiveness

Based on the groundwater and natural attenuation data presented in the Lower Subase RI (Tetra Tech, 1999), additional modeling performed for this FS (see Appendix D), experience at other sites with similar groundwater contamination, and the small size of the points of groundwater contamination, natural attenuation processes, particularly biodegradation, should typically result in significant reductions in concentrations of TPH within a reasonable time frame (i.e., less than 30 years). However, natural attenuation would not be particularly effective to deal with areas of TPH contamination where LNAPL is present, particularly if this LNAPL is made up of highly weathered petroleum product, such as is the case at in Zone 1. Based on modeling results (see Appendix D), natural attenuation would also not be particularly effective for the removal of the metals COCs in the groundwater of Zone 1 (arsenic and copper), Zone 4 (arsenic and lead), and Zone 7 (arsenic). However, it should be noted that the remediation time frames presented in this modeling are extremely conservative because: (a) only maximum historical concentrations of unfiltered metals were used for this modeling and, in most cases, the corresponding filtered concentrations and/or subsequently detected concentrations were below PRGs and (b) the type of modeling used was relatively simple and has a tendency to overemphasize metal retardation.

Implementability

Natural attenuation would be very easy to implement because it requires limited actions of monitoring and evaluation. As noted earlier, the resources and materials required for monitoring are readily available.

Cost

The capital and O&M costs for natural attenuation would be low.

Conclusion

Although it may not be particularly effective for TPH in Zone 1 and for metals COCs in all impacted zones, natural attenuation is retained for the development of groundwater remedial alternatives because it has the potential to be a useful complement to more active remedial measures.

3.5.3 Removal

The only technology and process option considered under the removal GRA is groundwater extraction with wells.

3.5.3.1 Extraction Wells

To implement groundwater extraction, wells are drilled and screened below the water table to access the groundwater. Pumping is used to extract the water as it collects in the wells and bring it to the surface. The process of extraction creates a hydraulic gradient that induces further flow of groundwater into the well. Extraction wells placed in the path of migration of a groundwater contaminant can also be used to intercept and contain this contaminant. Extraction wells can be used to remove contaminated groundwater and flush the saturated zone. The flushing action occurs when fresh water from upgradient (uncontaminated) areas replaces the extracted contaminated groundwater and causes more contaminants to desorb from saturated zone soil. Thus, theoretically, saturated zone soil progressively loses contaminants until concentrations in groundwater are at acceptable levels. The selection of the appropriate well system depends on the depth of contamination and the hydrologic and geologic characteristics of the aquifer.

Extraction pumps are typically submersible, electrically operated, centrifugal pumps or pneumatically operated ejector pumps. For shallow groundwater extraction (depths up to 10 feet), surface pumps may be used. Centrifugal pumps are not practical for use at low extraction rates less than 1 gpm, and in such cases, pneumatic ejector pumps are preferred.

Effectiveness

Extraction wells can be effective for intercepting and containing the migration of groundwater contaminants such as those that might be present at the Lower Subase. The locations and screening depths of the wells are important criteria that must be taken into consideration in achieving adequate contaminant capture. Extraction wells are a well-established and well-proven technology for the removal of contaminated groundwater and the containment of groundwater contaminants. Although the initial effectiveness of this technology for contaminant capture is high, it has often been shown to decrease over time. This decrease is generally due to one or more of several factors including the presence of preferential flow pathways due to aquifer heterogeneity, contaminant adsorption onto aquifer materials, diffusion of contaminants into the pore spaces of low-permeability materials, and creation of stagnation zones due to pumping operations. It should be noted, however, that no such decrease over time is observed in the effectiveness of this technology for containment of contaminated groundwater. Based on

modeling performed for this FS (see Appendix D), an extraction well system would not be particularly effective for the capture of TPH but would reduce concentrations of metals COCs much more rapidly than natural attenuation. However, as discussed above, the metals remediation time frames provided by this modeling are still very conservative. This technology is reliable, and minimal effects on human health and the environment would be expected during implementation.

Implementability

Groundwater extraction is a well-proven and well-established technology. Extraction wells are relatively easy to install, and pumps are widely available for a variety of flow rates and aquifer conditions. Many qualified contractors are available to provide this service. However, the Lower Subase is a very congested and active area where numerous existing above- and below-ground structures restrict extraction well placement. Implementation of this technology would require long-term O&M. Well screens require regular inspection and well flushing to remove fine-grained material that may clog the wells and pumps require regular preventive maintenance. Pneumatic pumps have an additional requirement of a source of compressed air and regular inspection of the pump mechanism and air supply lines. Local and state permits may be required for installation of extraction wells. Extracted groundwater would require treatment prior to disposal/discharge.

Cost

The capital and O&M costs of extraction wells are low.

Conclusion

Extraction wells are retained for the development of groundwater remedial alternatives.

3.5.4 In-Situ Treatment

The technologies and process options considered under the in-situ treatment GRA include enhanced bioremediation, chemical precipitation and oxidation, and PRBs. For the Lower Subase groundwater, the first of these technologies would be applicable for the treatment of TPH and the other two for the treatment of the metals COCs.

3.5.4.1 Enhanced Bioremediation

In-situ bioremediation involves the use of naturally occurring microorganisms, primarily bacteria and fungi, to breakdown hazardous organic compounds into nontoxic or less toxic forms. Enhanced in-situ

bioremediation would consist in accelerating this process by stimulating biological activity through the injection of chemical additives and/or custom microorganism cultures into the contaminated groundwater.

Although the concentrations of TPH detected in groundwater in Zones 1 and 4 are relatively modest (16 mg/L maximum), much higher concentrations of TPH (10,000 to 20,000 mg/kg) are likely to be present in the soil of the capillary zone of the TPH points of groundwater contamination. Because these high TPH soil concentrations are a likely ongoing source of the soluble TPH detected in groundwater, effective bioremediation of the TPH points of groundwater contamination would require not only treatment of the TPH present in groundwater but also treatment of TPH in the associated capillary zone soil. Aerobic bioremediation of such high concentrations of TPH would require the ongoing delivery of very large quantities of oxygen to the subsurface. One of the most likely process options to achieve such an ongoing delivery is the recirculation of a stream of super-oxygenated and bacteria-amended groundwater through the capillary zone of the TPH points of groundwater contamination such as is provided by the Dissolved Oxygen In situ Treatment (DO-IT™) process marketed by ETEC, LLC. Groundwater samples would be regularly collected and analyzed to evaluate the progress of remediation.

Effectiveness

In-situ aerobic biodegradation is a well-proven remedial technology for the treatment of a very wide range of non-chlorinated organic compounds including TPH. The DO-IT™ process is a relatively innovative technology that would be effective for delivery of the large quantities of oxygen that would be required for timely aerobic biodegradation of the soil-bound TPH present in the Zone 1 and Zone 4 TPH points of groundwater contamination. However, as noted earlier in the evaluation of soil remedial technologies (Section 3.2.5.1), much of the TPH present as a contaminant at the Lower Subase might consist of so-called “weathered” product that is no longer very biodegradable, but this is less likely to be the case in groundwater than in soil. In addition, also as noted in the evaluation of soil remedial technologies, the aerobic biodegradation of TPH that is promoted by oxygen and bacteria injection might be significantly impacted by the high salinity of the Lower Subase aquifer. Therefore, treatability testing would be required to evaluate the site-specific biodegradability of TPH and to assess the impact of aquifer salinity.

Implementability

Enhanced in-situ bioremediation of contaminated groundwater could be implemented at Zones 1 and 4. Installation of the groundwater recirculation systems required for the DO-IT™ process would be relatively unobtrusive with respect to existing structures and underground utilities, although these structures and utilities might restrict the optimal placement of some of the groundwater extraction and reinjection wells. A wide range of in-situ enhanced bioremediation technologies are commercially available, but the

DO-IT™ process is proprietary and only available from ETEC, LLC. As noted above, treatability testing would be required to verify site-specific effectiveness and confirm operating parameters.

Cost

The capital and O&M costs for enhanced in-situ bioremediation would be moderate.

Conclusion

Although there are some concerns about its site-specific effectiveness, enhanced in-situ bioremediation is retained for the development of groundwater remedial alternatives because it has the potential to offer a relatively quick and easily implementable approach for TPH removal from groundwater.

3.5.4.2 Chemical Precipitation and Oxidation

In-situ chemical precipitation consists of injecting chemical agents into the contaminated groundwater to chemically transform the COCs and render them either less soluble or insoluble and thus less mobile. Chemical precipitation agents include iron salts, phosphates, and zero-valent iron (ZVI). Chemical precipitation of certain inorganic chemicals such as arsenic is also enhanced by the injection of chemical oxidation agents. Chemical oxidation agents include powerful oxidants such as iron-catalyzed hydrogen peroxide (known as Fenton's Reagent), sodium persulfate, or potassium permanganate. Milder oxidants such as ORC, typically magnesium peroxide, or catalytically complexed sodium percarbonate (marketed as RegenOx™) have also been successfully used.

In-situ chemical precipitation and oxidation reagents are generally fed into contaminated groundwater using either multiple DPT injection well points or one or more focused groundwater recirculation systems. Focused recirculation typically provides better control over the subsurface distribution of reagents, but it also requires a more complex system, especially for large areas of groundwater contamination. DPT injection is simpler to implement and can be used over large or small areas, but the technical difficulty and cost of installing DPT injection points becomes prohibitive when depths exceed approximately 75 feet bgs. For treatment of the Lower Subase groundwater, the relatively small size of the points of groundwater contamination and the shallowness of the water table favors the use of DPT injection.

Effectiveness

In-situ chemical precipitation with or without the addition of oxidation agents is an established and fairly well-proven technology for the immobilization of a range of metals in groundwater. A combination of a mild oxidant such as ORC with a co-precipitant such as ferric chloride or sulfate would likely be effective for the immobilization arsenic, and the use of a phosphate reagent such as ammonium phosphate would

likely be effective for the immobilization of lead. However, effectiveness of this technology for the immobilization of copper in the Zone 1 groundwater is not as well proven. There is also some uncertainty about the impact of the relatively high salinity of the Lower Subase groundwater on the chemical oxidation and precipitation processes. In any case, treatability testing, preferably at both bench and pilot scales, would be required to confirm the effectiveness of this technology and the design of a treatment system. There would also be a slight possibility that the metals that have been removed from groundwater and immobilized in the surrounding soil could be redissolved and remobilized over the long term as a result of naturally occurring changes in groundwater chemistry.

Implementability

In-situ chemical precipitation with or without chemical oxidation could be implemented at the Lower Subase. Several qualified contractors are available to provide this service. Installation of a significant number of DPT injection points should not unduly interfere with current site activities. However, site activities might significantly restrict the DPT installation schedule, and existing structures and underground utilities would likely interfere with placement of a significant portion of proposed injection points. As previously mentioned, bench- and pilot-scale treatability testing would be required to verify the site-specific effectiveness of this technology and to develop design parameters. A permit might be required for the subsurface injection of chemicals.

Cost

Capital and O&M costs of in-situ chemical precipitation and oxidation would be moderate.

Conclusion

In-situ chemical precipitation and oxidation is retained for the development of groundwater remedial alternatives. A combination of ORC and ferric salts is retained for the treatment of arsenic, and the use of phosphates is retained for the treatment of lead.

3.5.5.3 PRBs

A PRB is an emplacement of reactive materials in the subsurface designed to intercept contaminated groundwater, provide a flow path through the reactive media, and transform the contaminant(s) into environmentally acceptable forms to attain remediation concentration goals downgradient of the barrier.

PRBs are generally built in two basic configurations: funnel-and-gate and continuous. The funnel-and-gate PRB uses impermeable walls (sheet pilings, slurry walls, etc.) as a ”funnel” to direct contaminated groundwater into a “gate” containing the reactive medium, whereas the continuous PRB completely

intercepts the contaminated groundwater flow path with the reactive medium. Because PRBs are not designed to contain groundwater movement but to intercept groundwater COCs, the permeability of the reactive medium must be at least equal or greater than the permeability of the surrounding aquifer to avoid diversion of the groundwater flow path. This is particularly necessary with the funnel-and-gate design where the cross-section of the permeable zones is restricted. Because the emplacement of reactive material generally requires excavation, both types of PRBs has been typically limited to relatively shallow depths of around 50 feet bgs. However, the use of alternate technologies such as slurry injection and hydrofracturing may help to overcome some of these emplacement limitations.

The most common PRB reactive medium is ZVI, which has been proven effective for the removal of several chlorinated solvents (DCE, TCE, and PCE) and metals (arsenic and hexavalent chromium). Other reactive media include activated alumina, which has been proven effective for the removal of arsenic, and GAC, zeolite, and cottonseed, which have been used for the biological treatment of perchlorates. In addition, proprietary media, such as the United States Department of Energy (DOE) MOP-UP® have been reported as very efficient for the removal of a wide range of metals including arsenic, copper, and lead (DOE, 1998).

Effectiveness:

Under proper hydrological, geological, and geochemical conditions, PRBs can effectively treat contaminated groundwater. Major issues associated with design of an effective PRB include the selection of the reactive medium, residence time in the reaction zone, and reaction zone sites for appropriate life span, as well as addressing issues such as the effect of the reaction zone medium on groundwater quality and the ultimate fate or disposition of a treatment wall. For treatment of the metals groundwater COCs at the Lower Subase, an absorbing medium such as activated alumina or GAC would probably be effective as would reactive media such as ZVI, iron salts, or DOE MOP-UP® reagents. However, site-specific hydrological characteristics would not be favorable to effective interception because of tidal impact on groundwater movements. In addition, as with chemical oxidation and precipitation, there would be some uncertainty about the impact of the relatively high salinity of the Lower Subase groundwater on the adsorptive and/or reactive capabilities of the PRB media. Treatability testing, preferably at both the bench and pilot scales, would be required to confirm the effectiveness of this technology and the design of a treatment system.

PRBs are an innovative technology and their long-term effectiveness has not been thoroughly determined. There are limited field data concerning longevity of wall reactivity or loss of permeability due to fouling caused by other constituents in groundwater.

Implementability:

PRBs could be implemented at most locations of the Lower Subase. To date, most full-sized PRBs have used ZVI to treat chlorinated solvents. However, the use of PRBs to treat metals, particularly arsenic, has also been demonstrated, and qualified contractors would be available to provide this service. The shallow depth of the water table at the Lower Subase would be favorable to the installation of PRBs, but, as for the excavation of contaminated soil, installation of PRBs could be significantly hindered or even prevented by the presence of many underground structures such as utility lines and existing and former building foundations. To minimize the previously mentioned serious concerns about the shoring and dewatering that would normally be required to excavate below the water table, PRBs could be installed with the same soil blending LDA equipment as proposed for in-situ chemical solidification/stabilization (see Section 3.5.2.2). As previously mentioned, treatability testing, preferably at both the bench and pilot scales, would be required to confirm the effectiveness of this technology and the design of a treatment system.

Cost:

Capital costs of PRBs are typically low to moderate. However, because of the serious implementability restrictions expected at the Lower Subase, capital cost would likely be moderate to high. O&M costs would be low.

Conclusion

PRBs are eliminated from further consideration because of significant effectiveness and implementability concerns and because in-situ chemical precipitation would provide a more effective technology for the removal of metals COCs.

3.5.5 Ex-Situ Treatment

The technologies and process options considered under the ex-situ treatment GRA include aerobic biological treatment, filtration, liquid-phase adsorption, chemical oxidation, chemical precipitation, and neutralization/pH adjustment. For the remediation of Lower Subase groundwater, biological treatment would be applicable to the removal of TPH, chemical precipitation would be applicable to the removal of metals, and the other technologies would be applicable to either purpose.

3.5.5.1 Aerobic Biological Treatment

Ex-situ aerobic biological treatment consists of contacting contaminated groundwater with a concentrated culture of microorganisms such as bacteria and fungi under controlled operating conditions, including mixing, the presence of oxygen, pH, temperature, and addition of nutrients.

Ex-situ aerobic biological treatment of groundwater may require pretreatment of groundwater, including neutralization/pH adjustment and/or removal of excess suspended solids by gravity separation or filtration. For the treatment of TPH-contaminated groundwater at Zones 1 and 4, it is anticipated that pretreatment with filtration might be required. Ex-situ aerobic biological treatment may also generate fugitive emissions that have to be controlled and solid or liquid residues, such as waste biological sludge, that require further treatment and disposal.

Effectiveness

Ex-situ aerobic biological treatment is a well-proven technology for the removal of a wide range of non-chlorinated organic compounds including TPH. As for in-situ enhanced bioremediation, treatability testing would be required to verify the site-specific biodegradability of TPH and to evaluate the impact of the high salinity of the Lower Subase aquifer on the biodegradation process. In addition, there is a concern that the moderate concentrations of TPH in the Lower Subase groundwater may be somewhat insufficient to sustain effective biological growth and that an additional substrate (typically methanol) would be required for this purpose.

Implementability

Ex-situ aerobic biological treatment would be easy to implement. Numerous qualified vendors and contractors offer equipment and services for this technology. Long-term O&M of such a treatment system would require the frequent supervision of qualified operators. In addition, this technology would generate some treatment residues (waste biological sludge) that would have to be properly disposed. As previously mentioned, supplemental substrate addition would likely be required to maintain an efficient biomass, and treatability testing would be required to verify site-specific effectiveness and to confirm operating parameters.

Cost

The capital and O&M costs for ex-situ aerobic biological treatment would be moderate.

Conclusion

Ex-situ aerobic biological treatment is eliminated from further consideration because of effectiveness and implementability concerns and because liquid-phase adsorption with GAC is expected to be better suited to the removal of the moderate concentrations of soluble organic contaminants in Lower Subase groundwater.

3.5.5.2 Filtration

Filtration uses a porous medium to remove solid particles from a liquid or gas. This technology is generally used as a groundwater pretreatment to remove suspended material before other treatment processes and/or for the final cleaning or polishing of treated effluent.

Liquid filtration may be accomplished by numerous methods including screens, fibrous fabrics (paper or cloth), or beds of granular material such as sand. Flow through a filter can be encouraged by pressure on the inlet side or by drawing a vacuum on the filter outlet.

Most types of liquid filters, except those utilizing disposable filter elements (such as cartridge filters), require periodic cleaning to remove suspended solids accumulated in the filter medium and to restore filtration efficiency. This cleaning is typically performed with a countercurrent of water, or backwash, which carries away the solids retained on the filter medium.

A particular type of filtration used for the treatment of metals-contaminated water is oxidative filtration. Oxidative filtration uses a specialized filter medium such as a natural zeolite, greensand, or a variety of proprietary media, mostly of the ferro oxide type, which have the capability of oxidizing, precipitating, and filtering common dissolved metals such iron and manganese and also heavy metals contaminants such as arsenic, copper, and lead. As required, a strong oxidizing reagent, typically potassium permanganate, might also have to be added ahead of the filtration unit to enhance its efficiency. Arsenic typically precipitates inside the filtration unit as a ferro-oxide that coats the filter medium and acts as a catalyst for further oxidation and precipitation of arsenic and other metals. As oxides deposit and other suspended solids accumulate inside the filter bed, regular backwashing of this bed is required (typically every 2 or 3 days) to restore normal performance of the filtration unit. In addition, as the reactive properties of the specialized medium eventually wear off, the entire filter bed requires periodic replacement (typically every 5 years).

Effectiveness

Filtration is a very well-proven technology for the removal of insoluble metals and TPH from groundwater. In addition, filtration would also be very effective in reducing excessive concentrations of other solid particles suspended in groundwater that might otherwise undermine the efficiency of downstream treatment technologies such as liquid-phase GAC adsorption.

Oxidative filtration is a well-established and proven technology that could be very effective for the removal of dissolved arsenic from groundwater. Although not quite as well proven as for arsenic removal, oxidative filtration has also shown to be effective for the removal of other dissolved heavy metals such as copper and lead, particularly when present at relatively low concentrations as is the case for copper in the Lower Subase groundwater. However, effectiveness would have to be verified through treatability testing.

Implementability

Filtration and oxidative filtration would be readily implementable. Treatment systems are commercially available from a wide variety of manufacturers and can be readily ordered to almost any specification. This process is very simple and it can be fully automated and require minimum operating supervision and does not require the on-site storage of chemicals. Clogged filter medium needs to be periodically cleaned, which results in a liquid waste or replaced which results in a solid waste.

Cost

The capital and O&M costs for normal and oxidative filtration would be low.

Conclusion

Filtration and oxidative filtration are retained for the development of groundwater remedial alternatives. Filtration is retained as a pre- or post-treatment technology to remove naturally occurring or treatment-generated suspended solids. Oxidative filtration is retained for the removal of arsenic and copper.

3.5.5.3 Liquid-Phase Adsorption

Adsorption is a frequently applied technology for the removal of contaminants from air or water. Liquid-phase adsorption consists of percolating the fluid to be treated on a bed of a granular medium with a very high surface area that features numerous active sites capable of capturing on contact organic and inorganic chemicals dissolved in groundwater. The fundamental principle behind liquid-phase adsorption involves the physical attraction of dissolved molecules to exchange sites on the internal pore surface areas of a specially treated (activated) granular medium. As the contaminated groundwater passes

through one or more vessels containing this activated granular medium, contaminants are captured on the active sites and eventually occupy all of these sites, at which point the exhausted medium must then either be regenerated or disposed.

Liquid-phase adsorption is principally targeted towards the removal of organic compounds with GAC but is also fairly well proven for the removal of certain dissolved metals, particularly arsenic, with other activated media such as alumina.

Typical liquid-phase adsorption treatment systems include atmospheric or pressurized columns operating in series and/or parallel configuration. When treating fluids contaminated with significant concentrations of suspended solids or if the life cycle of the adsorption medium is expected to be fairly long, liquid-phase adsorption columns are typically designed with backwashing capability to minimize solids fouling that would increase medium replacement frequency. Factors such as pH and temperature of the influent, empty bed contact time (EBCT), surface area–to-volume ratio of the adsorption medium, and solubility of the contaminant to be removed will affect the adsorption process.

Effectiveness

Liquid-phase adsorption with GAC is a well-proven reliable technology that would be effective for removing many organic compounds such as the TPH contained in Zones 1 and 4 groundwater. Adsorption of the relatively high-molecular-weight compounds that are likely to be the typical components of TPH should be reasonably efficient in terms of the ratio of TPH removed to GAC used, particularly if the molecular structure of these compounds is of the branched or substituted type rather than of the linear type. Liquid-phase adsorption with GAC could also be effective for removal of the low concentrations of metals COCs present in Lower Subase groundwater. However, adsorptivity of this class of contaminants on GAC is most often unpredictable, and there also is a noted tendency for the GAC to release previously adsorbed metals even prior to reaching saturation. Treatability testing would be required to predict GAC adsorption efficiency.

Liquid-phase adsorption with activated alumina is a well-established and proven technology for the removal of dissolved arsenic. However, adsorptivity is highly dependant on the state of oxidation under which that arsenic is present, and the trivalent state (arsenic^{+3}) that is most common is not nearly as effectively adsorbed as the pentavalent state (arsenic^{+5}). As for the adsorption of the other Lower Subase groundwater metals COCs such as lead and copper, effectiveness of liquid-phase adsorption with activated alumina or any other activated medium is not well documented. Treatability testing would be required to verify effectiveness.

Implementability

Liquid-phase adsorption would be readily implementable. This technology is widely used, and numerous qualified equipment vendors and contractors offer this type of equipment and services. This process is very simple and can be fully automated and require minimum operating supervision. This process also does not require the on-site storage of chemicals, and the only treatment residual is the exhausted adsorption medium, which can easily be reprocessed or disposed. As previously mentioned, treatability testing would be required to verify adsorption effectiveness and to determine the anticipated frequency of medium replacement.

Cost

The capital cost for liquid-phase adsorption would be low, and O&M costs would be moderate based on expected medium consumption.

Conclusion

Liquid-phase adsorption with GAC is retained for the development of groundwater remedial alternatives principally for the removal of TPH and also for the removal of metals COCs, particularly copper, in mixed TPH/metals points of groundwater contamination. Liquid-phase adsorption with activated alumina is eliminated from further consideration because of significant effectiveness concerns, even for the treatment of arsenic, and because oxidative filtration would provide a more effective option.

3.5.5.4 Chemical Oxidation

Ex-situ chemical oxidation would be somewhat similar to the previously described in-situ chemical oxidation, with the difference that the oxidation process would take place above ground in more controlled conditions. Either a strong oxidizing reagent such as chlorine, potassium permanganate, ozone, or hydrogen peroxide or a milder one such as ORC would be used to either destroy such organic compounds as TPH or to convert inorganic chemicals, particularly arsenic, to less soluble and/or less mobile higher oxidation states. This is typically accomplished by thoroughly mixing groundwater to be treated with the appropriate reagent in a stirred vessel designed to provide sufficient contact time (up to 1 hour). pH conditions may have to be adjusted for optimum oxidation. When using ozone or hydrogen peroxide, the chemical oxidation process can be enhanced by irradiation with ultraviolet (UV) light, but use of this option is typically limited to the oxidative destruction of organic compounds such as chlorinated solvents.

Effectiveness

Chemical oxidation is a well-established and proven technology that could destroy TPH. Although chemical oxidation would not of itself remove arsenic, it would effectively convert it from its trivalent to its pentavalent state. As such, chemical oxidation might be required as a pre-treatment to improve the efficiency of an arsenic removal technology such as activated alumina adsorption. The effectiveness of chemical oxidation for the treatment of lead and copper is unproven. Treatability testing would be required to verify effectiveness and/or determine design parameters.

Implementability

Chemical oxidation would be relatively easy to implement. This technology is widely used, and numerous qualified equipment vendors and contractors offer this type of equipment and services. This process is not particularly complex and can be almost completely automated, but it would require fairly close monitoring as well as the storage and handling of hazardous chemicals. This process might also result in the formation of suspended material that would have to be removed from the groundwater by another technology such as filtration. As previously mentioned, treatability testing would be required to verify the effectiveness of this technology and to develop site-specific design criteria.

Cost

The capital and O&M costs of chemical oxidation would be low to moderate.

Conclusion

Chemical oxidation is eliminated from further consideration because it would not be as effective as liquid-phase adsorption with GAC for the removal of TPH, oxidative filtration for the removal of arsenic and copper, or phosphate precipitation for the removal of lead.

3.5.5.5 Chemical Precipitation

Chemical precipitation consists of bringing out of solution one or more metals COCs present in a water-soluble form through a chemical reaction that results in the formation of less soluble or insoluble forms of these metals. The desolubilized or precipitated metals can then be removed by physical means such as gravity settling, flotation, or filtration. Chemical precipitation is typically accomplished by thoroughly mixing the groundwater to be treated with the appropriate reagent in a stirred vessel designed to provide sufficient contact time (10 to 30 minutes).

Typically, chemical precipitation is accomplished with the addition either of an alkaline reagent such as lime or caustic soda to form an insoluble oxide or hydroxide or addition of hydrogen or sodium sulfide to form an insoluble sulfide. However, the practical solubility of these oxides, hydroxides, or sulfides is such that, if very low concentrations of residual metals have to be achieved, such as is the case for Lower Subase groundwater, other methods of precipitation are required. One such method is co-precipitation, which is the ex-situ equivalent of the previously discussed in-situ chemical oxidation and precipitation (see Section 3.5.4.2) and which consists of adsorbing the metals COCs to be removed on the active surfaces of a suspended gel typically generated by the precipitation of a non-toxic metal such as ferric iron.

Another alternative method of chemical precipitation would be the use of a phosphate-based reagent such as ammonium phosphate, which can react with dissolved heavy metals, particularly lead, to form insoluble metal phosphates.

Effectiveness

Chemical precipitation is a well-established and proven technology for the removal of dissolved metals from groundwater, including arsenic, copper and lead. Because of the low concentrations of these metals in Lower Subase groundwater and because of the very low PRGs that have to be met, traditional alkaline or sulfide precipitation would probably not be effective, and either iron co-precipitation or phosphate precipitation would be required. For the treatment of the Lower Subase groundwater metals COCs, iron co-precipitation should be effective for the removal of arsenic and copper while phosphate precipitation should be well suited to the removal of lead. However, the effectiveness of either of these methods of precipitation is not fully proven, and there are in particular some uncertainties about the impact of the relatively high salinity of the Lower Subase groundwater on these processes. Treatability testing would be required to confirm the effectiveness of this technology and the design of a treatment system.

Implementability

Chemical precipitation would be relatively easy to implement. Many qualified equipment vendors and contractors offer this type of technology. This process is not particularly complex and can be almost completely automated, but it would require fairly close monitoring as well as the storage and handling of hazardous chemicals. In addition, chemical precipitation, particularly with iron co-precipitation, would result in the formation of a significant quantity of suspended material that would have to be removed from the groundwater through another technology such as filtration. As previously mentioned, treatability testing would be required to confirm the effectiveness of this technology and the design of a treatment system.

Cost

The capital and O&M cost of iron co-precipitation would be moderate.

Conclusion

Chemical precipitation is retained for the development of groundwater alternatives. More specifically, phosphate precipitation is retained for the removal of lead, but iron co-precipitation is eliminated from further consideration for the treatment of arsenic and copper because oxidative filtration would be as effective and more practical to use because it would generate much less of an easier to handle treatment residue.

3.5.5.6 Neutralization/pH Adjustment

Neutralization/pH adjustment is a process for achieving appropriate pH levels for removal of contaminants. This is generally accomplished by adding acidic compounds to balance alkaline solutions or vice-versa.

Effectiveness

Neutralization/pH adjustment is a well-established and proven technology that can be effective for the removal of certain contaminants, mostly inorganic chemicals, by bringing them out of solution. At the Lower Subase, neutralization/pH adjustment would not of itself be effective for the removal of any of the groundwater COCs; however, this technology would enhance the effectiveness of other ex-situ treatment technologies such as oxidative filtration, enhanced oxidation, or chemical precipitation, and it might also be required to meet standards for direct or indirect discharge.

Implementability

Neutralization/pH adjustment would be easy to implement. This technology is widely used, and numerous qualified equipment vendors and contractors offer this type of equipment and services.

Cost

Capital and O&M costs for neutralization/pH adjustment would be low.

Conclusion

Neutralization/pH adjustment is eliminated because the pH of the extracted groundwater is anticipated to be within the range of applicability for other considered ex-situ treatment technologies and also acceptable for direct or indirect discharge.

3.5.6 Disposal

The technology and process options considered under the disposal GRA include surface discharge, either indirectly to the Town of Groton publicly owned treatment works (POTW) or directly to the Thames River following on-site treatment.

3.5.6.1 Indirect Surface Discharge

Indirect surface discharge would consist of disposing of the extracted groundwater by discharging it to the Lower Subase sanitary sewer system, which would convey it to the Town of Groton POTW where it would undergo treatment prior to ultimate discharge to the Thames River.

Effectiveness

Indirect discharge of untreated Lower Subase groundwater to the Town of Groton POTW would be an effective means of disposal. The unit processes of a typical sanitary POTW, including primary gravity separation and secondary aerobic biological treatment, are well suited to the removal of the moderate concentrations of insoluble and soluble TPH and low concentrations of arsenic, copper, and lead contained in the groundwater that would be extracted from the Lower Subase aquifer.

Implementability

Indirect surface discharge would be implementable. Conveyance of extracted groundwater to the Lower Subase sanitary sewer system would require installation of some piping and pumping of that groundwater over a relatively short distance. Because the flow of extracted groundwater would be relatively small, this would not be very difficult to accomplish. Also, because the flow of extracted groundwater would be relatively small and the groundwater itself would be easy to treat, it is unlikely that the Town of Groton POTW would be unable (or unwilling) to accept this groundwater. A permit would have to be obtained for discharge to the sanitary sewer.

Cost

The capital and O&M costs for indirect surface discharge would be moderate.

Conclusion

Indirect surface discharge is retained for the development of groundwater remedial alternatives.

3.5.6.2 Direct Surface Discharge

Direct surface discharge would consist of disposing of the extracted groundwater by discharging it directly to the Thames River after it has undergone on-site treatment with one or more of the ex-situ technologies evaluated above.

Effectiveness

Direct surface discharge to the Thames River would be an effective means of disposal of contaminated groundwater extracted from the Lower Subase. However, appropriate on-site treatment would be required prior to discharge to satisfy applicable water quality criteria.

Implementability

Direct surface discharge to the Thames River would be easy to implement. Because the points of groundwater contamination are in close proximity to the river, transfer distances would be relatively short, and it is likely that existing storm sewers might be used for this purpose. As previously mentioned, on-site treatment would be required to bring the concentrations of COCs in the extracted groundwater (arsenic, copper, lead, and TPH) into compliance with the applicable discharge criteria. In addition, the substantive requirements of an NPDES permit would have to be met for the discharge of treated groundwater.

Cost

The capital and O&M costs of direct surface discharge would be low.

Conclusion

Direct surface discharge is retained for the development of groundwater remedial alternatives.

3.6 SELECTION OF GROUNDWATER REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS FOR ZONES 1, 4, AND 7

The following GRAs, remediation technologies, and process options are retained to develop groundwater remedial alternatives for Zones 1, 4, and 7:

- No Action.
- Limited Action: LUCs, Monitoring, and Natural Attenuation.
- Removal: Groundwater Extraction Wells.
- In-Situ Treatment: Enhanced Bioremediation and Chemical Precipitation and Oxidation.
- Ex-Situ Treatment: Filtration, Oxidative Filtration, Liquid-Phase GAC Adsorption, and Chemical Precipitation..
- Disposal: Indirect and Direct Surface Discharge.

3.7 PRELIMINARY SCREENING OF SEDIMENT REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS FOR ZONE 4 AND OUTER PIER 1

This section identifies and screens remediation technologies and process options for sediment at a preliminary stage based on implementation with respect to site conditions and COCs. Table 3-3 summarizes the preliminary screening of technologies and process options applicable to sediment. It presents the GRAs, identifies the technologies and process options, and provides a brief description of each process option followed by screening comments.

The following are the sediment remediation technologies and process options retained for detailed screening based on the results of the preliminary screening.

General Response Action	Remediation Technology	Process Option
No Action	None	Not Applicable
Limited Action	LUCs	Institutional Controls
		Engineered Controls
	Monitoring	Sampling and Analysis
	Natural Recovery	Biodegradation, Dilution, Dispersion
Containment	Capping	Sediment Cover
Removal	Bulk Excavation	Dredging
In-Situ Treatment	Enhanced Natural Recovery	Thin-Layer Placement
Ex-Situ Treatment	Pretreatment	Dewatering
	Biological	Bioslurry Reactor/Biopile
	Physical/Chemical	Sediment Washing/Solvent Extraction
		Chemical Stabilization/Solidification
	Thermal	LTTD
		Incineration
Disposal	Landfill	CAD
		Off-Site Landfilling

3.8 DETAILED SCREENING OF SEDIMENT REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS FOR ZONE 4 AND OUTER PIER 1

3.8.1 No Action

No Action would not include any new environmental action and stop the application of any existing administrative or engineering environmental controls. As required under CERCLA regulations, the No Action alternative is carried through the FS to provide a baseline for comparison of alternatives and their effectiveness in mitigating risks posed by site contaminants. Because no remedial actions would be conducted under this alternative, the only cost associated with the No Action alternative would be that of the CERCLA-mandated five-year reviews. There would also not be any reduction in risk through exposure control or treatment. No Action would not be effective in evaluating contaminant mobility and potential migration off site because no monitoring would be performed.

Effectiveness

No Action would not be effective in meeting the sediment RAOs. No Action would not be effective in evaluating either removal of sediment COCs through natural attenuation or potential migration of these COCs either off site or to another medium because no monitoring would be performed.

Implementability

There would be no implementability concerns because no action would be implemented.

Cost

Minimal costs (five-year reviews) would be associated with No Action.

Conclusion

No Action is retained because of NCP requirements, although it would not be effective.

3.8.2 Limited Action

The technologies considered under the limited action GRA include LUCs, monitoring, and natural attenuation.

3.8.2.1 LUCs

LUCs are designed to protect public health and the environment from residual contamination at environmental sites. LUCs consist of administrative or legal mechanisms (e.g., deed or zoning restrictions, permits, etc.) designated as institutional controls and/or physical controls (e.g., fencing, security guards, etc.) designated as engineering controls. Site-specific LUCs are typically formulated through a LUC RD that is prepared in accordance with the Navy's LUC Principles (DOD, 2003) following approval of the ROD. LUCs typically also include the performance of regular site inspections to verify their continued implementation.

Effectiveness

LUCs consisting of restrictions on disturbance of contaminated sediment would effectively minimize unacceptable risks from the spreading of that contaminated sediment to previously uncontaminated areas. However, LUCs would not be effective for protecting ecological receptors from potential exposure to contaminated sediment.

Implementability

As long as access to the capped area is controlled by the Navy, these LUCs would be implemented in accordance with a post-ROD LUC RD that will be prepared by the Navy as the LUC component of the remedy, in coordination with the State, which owns the subtidal area. If the adjacent shoreline property is transferred so that the Federal government no longer controls access to the capped area, the LUCs would be converted into deed restrictions, which would comply with State recording standards. If the adjacent shoreline property is transferred to another federal agency, the Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required. Monitoring of compliance with LUCs will occur at least yearly.

Cost

The capital and O&M costs for LUCs would be low.

Conclusion

Although their stand-alone effectiveness for the protection of the environment would be somewhat limited, LUCs are retained for the development of sediment remedial alternatives because they could add a useful protective element to other remedial technologies.

3.8.2.2 Monitoring

Monitoring would consist of sampling and analyzing sediment throughout the areas of sediment contamination to evaluate trends in concentrations of COCs and to assess the potential for off-site migration of contaminated sediment.

Effectiveness

Monitoring alone would not reduce the toxicity, mobility, or volume of COCs in the sediment. However, monitoring would allow for a determination of the effectiveness of natural attenuation or active remedial actions and would also detect potential off-site migration of contaminated sediment.

Implementability

Sediment monitoring would be easy to implement. Such monitoring has already been performed on several occasions at the Lower Subase. The resources and material required for monitoring are readily available.

Cost

The capital and O&M costs of monitoring would be low.

Conclusion

Monitoring is retained for the development of sediment remedial alternatives.

3.8.2.3 Natural Recovery

Natural recovery would consist of allowing naturally occurring processes to reduce the risks posed by sediment COCs over time. Natural recovery could involve physical processes (sedimentation, advection, dilution, dispersion, bioturbation, or volatilization), biological processes (biodegradation, biotransformation, or phytoremediation), or chemical processes (natural oxidation/reduction or sorption). To evaluate natural recovery, sediment samples would be regularly collected and analyzed to establish trends in concentrations of COCs.

Effectiveness

Insufficient analytical data are currently available to establish clear trends in the concentrations of sediment COCs at the Lower Subase. With the exception of sedimentation, the above-mentioned physical natural recovery processes are not likely to significantly reduce the risks from Lower Subase

sediment COCs such as PAHs, PCBs, and metals. Sedimentation could reduce risks from these COCs as a result of natural capping; however, sedimentation is not a significant occurrence in this part of the Thames River. Biological natural recovery processes might reduce the concentrations of such organic sediment COCs as PAHs but other organic COCs such as PCBs and inorganic COCs such as metals would not be removed. As for chemical natural recovery processes, sorption is not a very likely risk reduction mechanism because of the relatively coarse sediment present at the Lower Subase, and natural oxidation/reduction would not impact the organic COCs or significantly alter the toxicity of the metallic COCs.

Implementability

Natural recovery would be very easy to implement because it requires limited actions of monitoring and evaluation. As noted earlier, the resources and materials required for monitoring are readily available.

Cost

The capital and O&M costs for natural recovery would be low.

Conclusion

Natural recovery is eliminated from further consideration because of effectiveness concerns.

3.8.3 Containment

The only technology considered under the containment GRA is capping. Capping would consist of installing a cover system over the contaminated sediment to prevent direct exposure of ecological receptors to that sediment and to minimize potential off-site migration of sediment COCs. The cover system would typically consist of a layer, at least 2 feet thick, of clean material with geotechnical characteristics (particle size, density, texture) such that it would be likely to remain above the native contaminated sediment.

Effectiveness

Capping would not remove sediment COCs or reduce their toxicity. Nonetheless, capping is a well-established and proven technology that could be effective in preventing direct exposure of ecological receptors to the contaminated sediment. A cap could also be effective in minimizing the potential for off-site migration of sediment COCs principally as a result of erosion and sedimentation. However, the continued effectiveness of a cap depends on the long-term maintenance of its integrity, and may be affected by ship traffic and have future dredging concerns in order to remain navigable. At the Lower

Subase, the effectiveness of a sediment cap could be significantly enhanced by the previously evaluated LUCs, which would prevent uncontrolled disturbance of contaminated sediment.

Implementability

Installation of a cap over contaminated sediment is typically fairly easy to implement, and the required material and services are readily available. For Outer Pier 1, a natural cap already exists because sediment contamination only occurs at a depth of 4 to 6 feet. However, in Zone 4 this technology would be more difficult to implement because it could significantly interfere with the activities of the facility. Not only would the initial construction of the cap interfere with normal ship movements and harbor activities, but, as mentioned above, these same movements and activities could have long-term structural impacts which would thus require monitoring and maintenance. Because of the need to maintain a specified depth of water for navigation purposes, it is likely that placement of a cap would require pre-dredging of sediment. Placement of a cap would also probably require implementation of navigational restrictions, such as a “no-anchor zone” in the vicinity of the cap to protect it from premature erosion.

Cost

The capital costs for capping would be low to moderate. Because of the need for frequent and long-term monitoring and maintenance, O&M costs would be relatively high.

Conclusion

Although there are some significant concerns about its long-term effectiveness and practical implementability, capping is retained for the development of sediment remedial alternatives because a natural cap already exists in Outer Pier 1 and, with adequate long-term maintenance, this technology could also be effective for Zone 4 and would constitute a viable alternative to the more complex and costly removal and off-site disposal of contaminated sediment.

3.8.4 Removal

The only technology considered under the removal GRA is dredging. Four types of dredging could be considered for sediment removal as described below: mechanical, hydraulic, hybrid, and pneumatic.

Mechanical Dredging

Mechanical dredging uses either normal excavation equipment (e.g., backhoe or grade-all) if it can reach the sediment depth or digging buckets (e.g., clamshell buckets) or dragline buckets suspended by a cable from a crane. This equipment can operate from shore or from a floating platform.

Backhoes are typically used only to remove relatively small volumes of sediment, and their performance is limited by their relative inability to excavate continuous level areas over long distances and by the potential loss of sediment due to the open excavator bucket. However, backhoes can be more effective than dredging systems for removing dense or hard material and are most effective for dredging of shallow sediment along shorelines. Digging buckets, also referred to as clamshell buckets because of their ability to close, are typically dropped by a crane through the water and into the sediment. The bucket is then closed and lifted out by the crane. Dragline buckets are also used with a crane and are similar to digging buckets, with the difference that dragline buckets are open on one side and are lowered into the sediment with a lifting cable, then pulled back towards the crane with a second cable. Draglines buckets have been used particularly for navigational dredging because they are efficient at removing large quantities of sediment. However, dragline buckets are not very well suited for the removal of contaminated sediment because the open side of the bucket does not effectively contain the dredged sediment.

Mechanical dredging typically removes subaqueous sediment at nearly the in-place density and water content; however, some water is added to the collected sediment because every grab cannot be filled completely with sediment. Mechanical dredging typically adds a volume of water 20 to 50 percent of the bucket capacity.

Hydraulic Dredging

Hydraulic dredges are routinely used throughout the United States to move large sediment volumes. A typical hydraulic dredge consists of a suction head that collects the sediment as a slurry and may also be equipped with rotating cutting tools or augers to enhance sediment removal. The suction head is connected to a hydraulic pump that aspirates the sediment slurry and conveys it to the desired location for further processing. Hydraulic dredges typically use a volume of water 5 to 10 times that of the in-place sediment to be removed to slurry the sediment and to transport it. The cutter or auger head hydraulic dredge is most commonly used to remove sediment and can effectively remove a wide variety of sediment types, including dense sand and hard clay. Hydraulic dredges that do not use a cutter or auger head can normally only remove relatively soft sediment with little debris. These hydraulic dredges often include water jets to help loosen and slurry the sediment.

Hybrid Dredging

Hybrid dredges use mechanical devices to remove sediment. Water then is added to the sediment, creating a slurry that is subsequently pumped to the desired location for further processing. The hybrid process option includes various pumps that can move slurries with higher solids content than traditional hydraulic dredges so that much less water may be required to make the slurry.

Pneumatic Dredging

Pneumatic dredges are similar to hydraulic dredges, except that in place of a pump, they use a pressure gradient created with compressed air to lift and move dredged material. Pneumatic dredges are not common and are used primarily for small-scale cleanup of spilled contaminants and marine archaeology.

Effectiveness

Dredging is a well-established and demonstrated technology to remove a wide variety of sediment from aquatic environments. Dredging is effective at addressing any class of contaminant (i.e., organic or inorganic) because it physically and non-selectively removes impacted material. Thus, dredging would be an effective technology to remove contaminated sediment from Zone 4 and Outer Pier 1 at the Lower Subase.

Dredging effectiveness can be limited due to the potential for surface sediment mixing, resuspension, and redeposition and due to limitations in the precision of dredging equipment. The release of contaminants into the water column can be minimized with an environmental bucket that provides a better seal than conventional buckets, and/or the spread of resuspended contaminants beyond the dredge site can be minimized with a silt curtain.

Although mechanical dredging can leave a rougher bottom surface compared to some hydraulic systems, mechanical dredges remove the least amount of water, thus minimizing dewatering and/or treatment needs. Some sloughing can occur, which can create the need for additional dredge passes. Hydraulic dredging typically generates a sediment slurry with a much higher water content than mechanical dredging, which requires additional on-site processing unless a closed water recirculation/reuse system is used to limit the actual amount of water associated with the sediment being conveyed to processing. Less sloughing typically occurs with hydraulic dredging than mechanical dredging. Hybrid dredging that combines components of both mechanical and hydraulic dredging is also an effective method of sediment removal, but its effectiveness can be limited by its inherent inefficiency (i.e., by sequentially instead of simultaneously dredging, slurrying, and transporting). The effectiveness of pneumatic dredging for sediment remediation is largely undocumented because this technology is more commonly applied in other contexts (e.g., archaeology).

Verification sampling is typically required to verify the effectiveness of a sediment removal action. Samples are collected from the dredged areas and analyzed for COCs to ensure that the remaining sediment is not contaminated at unacceptable levels.

Implementability

Dredging is a well-proven technology that can be implemented readily at most sites. Dredging equipment and/or services are readily available from multiple vendors or contractors. During dredging, site-specific health and safety procedures and OSHA regulations would have to be complied with to ensure that the exposure of workers to COCs is minimized.

Very careful planning and execution would be required to prevent interference by dredging with the ongoing activities of the Lower Subase, particularly ship movements and other harbor activities.

Cost

Dredging costs are typically low. However, post-dredging sediment management costs can substantially increase the overall costs of a dredging removal action.

Conclusion

Dredging is retained for the development of sediment remedial alternatives. The relatively small surface areas to be dredged, the shallowness of the layer of sediment to be removed, and the very limited amount of space available at the Lower Subase for support functions favor the selection of mechanical dredging.

3.8.5 In-Situ Treatment

The only technology considered under the in-situ treatment GRA is enhanced natural recovery, which would consist of accelerating the previously discussed natural recovery processes (particularly biodegradation and sedimentation) through engineering means. One of the most common and effective such engineering means is the addition of a thin layer of clean sediment, which is normally referred to as thin-layer placement.

Effectiveness

Compared to unenhanced natural recovery, thin-layer placement could probably accelerate the biodegradation of organic COCs in Thames River sediment, particularly PAHs, by providing an appropriate support medium for biological activity. However, it is not anticipated that thin-layer placement would accelerate the removal of inorganic COCs. In addition, it is likely that this acceleration would mostly manifest itself in the upper layer of contaminated sediment and that the deeper layer would remain essentially unaffected. Thin-layer placement could also enhance natural recovery through sedimentation by increasing the thickness of the layer of clean material isolating the contaminated sediment. However,

as previously discussed, natural sedimentation is not a significant occurrence in this part of the Thames River, and the typical thickness of material involved in thin-layer placement (6 inches or less) would not by itself result in adequate risk reduction.

Implementability

The implementability of enhanced natural recovery through thin-layer placement is typically fairly easy. However, similar to the earlier discussed capping, thin-layer placement would significantly interfere with ongoing ship movements and general harbor activities at the Lower Subase. In addition, accurate placement of a fairly thin layer of sand or similar material over a fairly steep slope (2.5 horizontal to 1 vertical) would be difficult to achieve and maintain over the long term.

Cost

The capital and O&M costs for enhanced natural recovery through thin-layer placement would be moderate.

Conclusion

Enhanced natural recovery is eliminated from further consideration because of effectiveness and implementability concerns.

3.8.6 Ex-Situ Treatment

The technologies and process options considered under the ex-situ treatment GRA include dewatering that would be required as on-site or off-site pretreatment prior to off-site land disposal. Also considered under this GRA are technologies and process options that might be required as part of land disposal at an off-site TSDF, including bioslurry reactors/biopiles, sediment washing/solvent extraction, chemical stabilization/solidification, LTTD, and incineration. In addition, filtration and liquid-phase GAC adsorption is considered for ex-situ treatment of residual fluid from dewatering operations.

3.8.6.1 Dewatering

Dewatering is a process for reducing the free water content of a solid material. Dewatering is most commonly achieved by either passive (gravity-aided) drainage of water from stockpiled material or by mechanical expression of that material. Dewatering can also be achieved through the addition of chemical agents that adsorb free water and/or increase the physical cohesion of the material to be dewatered.

Passive drainage is typically performed by stockpiling wet material on a drainage pad causing most of the free water to drain as a result of gravity and the mechanical expression of the lower strata of stockpiled sediment by the weight of the upper strata. The free water drains through a pad or membrane designed to filter out solid particles. If required, this pre-filtered water can then be further treated by such technologies as GAC adsorption to meet appropriate criteria for discharge to local surface water. Drainage beds can be installed on land or on a barge. For dewatering of Zone 4 and Outer Pier 1 sediment, barge-mounted drainage beds would have the double advantage that they could be positioned next to the dredging equipment, thus minimizing the need to handle wet dredged sediment, and that they would not require any land space, which is at a premium at the Lower Subase. Previous experience with similar applications has also shown that filtered drainage water does not require treatment.

Mechanical expression of free water from the material to be dewatered can be achieved through the use of pressure or centrifugal forces developed by specialized equipment such as belt filter presses, plate-and-frame filter presses, vacuum filters, or centrifuges. As required, the released water can also be treated on site as with the stockpiling option.

Chemical additives such as fly ash, Portland cement, or lime can adsorb free water, reduce the proportional moisture content, and increase the physical cohesion of the treated material. This type of dewatering is referred to as physical stabilization and is somewhat similar to chemical stabilization/solidification, with the difference that its primary aim is to improve the handling characteristics of the treated material rather than to immobilize certain contaminants within the matrix of the treated material. Dewatering additives can be applied in a variety of ways ranging from as simple as being broadcast over the material to be dewatered and subsequently mixed in with such equipment as a front-end loader to as sophisticated as being blended in a carefully controlled manner with such equipment as a pug mill. The use of dewatering additives can result in a swelling effect that increases the overall volume of the dewatered material by 10 to 30 percent.

<u>Effectiveness</u>

Dewatering, either by passive drainage, mechanical expression, or use of dewatering additives, would not reduce COC concentrations in Inner and Outer Pier 1 sediment. However, this technology is a required step for the overall treatment and disposal of dredged sediment.

Passive drainage, mechanical expression, and use of dewatering additives are field-proven methods to reduce sediment water content and have been used successfully to manage contaminated dredged/excavated sediment. Mechanical expression is generally more effective than passive drainage because the rate and extent of dewatering are usually greater when forces greater than gravity alone are applied to separate liquids from solids. However, passive drainage could provide a simple and effective

means of releasing most of the free water from relatively granular material such as the sediment at the Lower Subase. Physical stabilization is an effective method of adsorbing free water but it does not reduce the overall water content of the dewatered material and can significantly increase its volume.

Implementability

Both passive drainage and mechanical expression are readily implementable. Resources, equipment, and material to implement either of these options are readily available. As previously mentioned, barge-mounted drainage beds would have the double advantage that they would minimize handling of wet sediment and would not require onshore space, which may not be available at the Lower Subase under the current industrial site use scenario. Mechanical expression would require more equipment and maintenance than stockpiling. Depending on the types and concentrations of contaminants present in the material being treated, an on-site dewatering system might have to meet the substantive requirements of a hazardous or non-hazardous waste TSDF. These technologies would be expected to generate a filtered drainage water that could typically be discharged to surface water without further treatment. However, a small fraction of the water released by these dewatering technologies, and particularly passive static drainage, would not readily drain and filter and would require special handling. This fraction of released water, hereafter referred to as dewatering fluid, would be collected separately, tested, and either disposed off site or treated prior to on-site disposal. In this later case, the substantive requirements of an NPDES permit might have to be met for surface discharge of the treated dewatering fluid.

The use of dewatering additives would also be readily implementable. Local power plants could be a ready source of fly ash, and this kind of technology would be typically available as a service from a number of off-site contractors. For Zone 4 and Outer Pier 1 sediment dewatering, this technology would best be combined with passive drainage with the dewatering additive being applied to the drainage bed immediately following the removal of free water. This technology would also normally not result in the release of any water that might have to be treated.

Cost

The cost of passive drainage would typically be low. The cost of mechanical expression would be moderate. The cost of dewatering additives would be low to moderate depending on the type and quantity of agent required.

Conclusion

Dewatering is retained for the development of sediment remedial alternatives. Because of their ease of implementation and because they would require little or no onshore space, barge-mounted drainage beds are considered to be the most reasonable dewatering option for the site-specific conditions at and around Zone 4 and Outer Pier 1. The use of additives would most likely also be required as part of the dewatering process and, as mentioned earlier, could easily be combined with passive drainage. Therefore, both of these options are retained for further evaluation.

3.8.6.2 Bioslurry Reactor/Biopile

A bioslurry reactor is a technology in which contaminated material is biologically treated in an enclosed vessel. After removal of foreign materials such as stones and rubble, the contaminated material is mixed with water and a culture of appropriate microorganisms to form a slurry containing 10 to 30 percent solids. This slurry is placed in a tank with process controls so that temperature, mixing, and nutrient additions can be manipulated to achieve maximum biological treatment efficiency. Following treatment, the slurry is dried and tested to verify that COCs have been adequately removed, and the treated material is replaced in its original location or used as fill material elsewhere.

A biopile is a technology in which contaminated material is mixed with biologically amended sediment and formed into an enclosed compost pile. Oxygen, if needed for aerobic treatment, is provided either by inducing an air current through the pile with blowers or vacuum pumps or by the mixing in of an ORC. Moisture, heat, nutrients, oxygen, and pH are controlled to enhance biodegradation. Duration of operation may vary from a few weeks to several months, at which time the treated material is either returned to its original location or used as fill material elsewhere.

Effectiveness

Bioslurry reactors and biopiles have been proven effective for the treatment of sediment contaminated with a wide range of organic compounds including PAHs, one of the two classes of organic sediment COCs at the Lower Subase. Typically, bioslurry reactors or biopiles can achieve close to 100-percent removal of these types of compounds. However, the effectiveness of these processes is largely unproven for the removal of PCBs, the other class of organic sediment COCs at the Lower Subase, and they would not be effective at all for the removal of inorganic sediment COCs.

Implementability

Bioslurry reactor or biopile technologies would be implementable. Specialized contractors or selected TSDFs could perform this treatment. However, both technologies would require a relatively complex

sequence of operations including staging, treatment, and disposal of treated sediment. In addition, treated sediment from a bioslurry reactor would require dewatering and drying prior to disposal or reuse. The necessary equipment and resources are only available from a relatively limited number of contractors or off-base permitted TSDFs. Because of the relatively congested conditions and high level of activities at the Lower Subase under the current industrial use scenario, that is the only considered scenario for sediment remediation, this technology could not practically be implemented on site. Instead, as mentioned earlier, it would have to be implemented off site as part of disposal activities. Treatability testing would be required to verify effectiveness and to determine operating parameters.

Cost

The capital and O&M costs for bioslurry reactors/biopiles would be moderate to high.

Conclusion

Bioslurry reactors/biopiles are eliminated from further consideration because of effectiveness and implementability concerns.

3.8.6.3 Sediment Washing/Solvent Extraction

Sediment washing uses physical processes such as high-pressure water, screening, attrition scrubbing, froth flotation, electromagnetic separation, mechanical separation, hydrogravimetric separation (including hydrocyclones, mineral jigs, and spiral classifiers), and multigravity separation. Such physical separation processes achieve waste minimization through a volume-reduction process by separating out a size fraction of sediment containing little or no contamination (such as coarse-grained sediment and large-sized material) from more highly contaminated finer-grained material such as clays and silts.

Solvent extraction uses water or other solvents to extract or desorb COCs from sediment and to dissolve them into the liquid phase. Solvent extraction often requires preliminary treatment using physical separation to reduce the volume of material to be treated.

Effectiveness

The effectiveness of sediment washing is highly waste specific, and this technology can be successfully adapted to the removal of a wide range of inorganic and organic contaminants. A thorough physical and chemical characterization of the waste and treatability testing is essential to determine the most suitable and efficient means of separating COCs from clean sediment. When different classes of COCs are present, such as would be the case with the Lower Subase sediment that contains PAHs, PCBs, and metals, a series of extraction operations using different solvents, pH adjustment, etc. would be required.

Such a combination of physical separation and various chemical extraction techniques would probably be required to successfully remove the Lower Subase sediment COCs, with nontoxic organic solvents used for the removal of PAHs and PCBs and acids to remove metals. The extraction process would yield clean sediment that would require water rinsing to remove remaining extractant. Residuals from the process would consist of spent solvent streams containing wastes requiring further treatment/disposal and recovery/recycle of the extractants.

Implementability

Sediment washing/chemical extraction would be implementable. Specialized contractors or selected TSDFs could perform this treatment. However, a sediment washing/chemical extraction system would be complex, consisting of physical separation operations and chemical extraction processes. Physical separation would consist of several operations depending on the type of debris, sizes, densities of materials, etc. A sieve analysis of the sediment would be required for design of the treatment system. Chemical extraction would require treatability studies to determine the specific type and composition of solvent. Typically, waste streams produced from chemical extraction are more contaminated and greater in volume than waste streams from other processes. To treat the extracted liquid, an extensive wastewater treatment facility would be required to separate reagents from treated sediment and then to treat the residuals. The wastewater facility would be required to have organic treatment and neutralization processes in addition to dewatering processes. Unless efficient recovery/recycling of the extractant is achievable, there would be significant implementability concerns for further treatment/disposal of the waste streams. Because of the relatively congested conditions and high level of activities at the Lower Subase under the current industrial use scenario, that is the only considered scenario for the sediment remediation, this technology could not be practically implemented on site. Instead, as mentioned earlier, it would have to be implemented off site as part of disposal activities.

Cost

The capital and O&M costs for sediment washing/chemical extraction would be moderate to high. Additional costs for disposal of residues could also be moderate to high.

Conclusion

Ex-situ sediment washing/chemical extraction is eliminated from further consideration because it would be significantly more complex and costly to implement than other equally effective ex-situ treatment technologies such as chemical stabilization/solidification and LTTD.

3.8.6.4 Chemical Stabilization/Solidification

Chemical stabilization consists of mixing contaminated sediment with chemical reagents that modify the COCs to render them less soluble and hence less mobile. Chemical solidification consists of mixing contaminated sediment with chemical reagents that bind COCs within the matrix of the material being treated. The most common stabilization reagents are phosphates, carbonates, hydroxides, and sulfates. The most common solidification reagents are pozzolanic-based materials such as Portland cement, CKD, and fly ash. Other reagents such as thermoplastic binders (i.e., asphalt); sorbents such as GAC, clays, zeolites, and anhydrous sodium silicate; and MAECTITE® have also been successfully used for chemical stabilization/solidification.

For ex-situ chemical stabilization/solidification, mixing of the material to be treated with the chemical reagents is normally accomplished in the presence of a controlled amount of water and with specialized mechanical blending equipment such as a pug mill. After the material is mixed with the chemical reagents, it is typically allowed to cure for the stabilization or solidification process to take full effect. In the case of chemical solidification, the treated material may either be allowed to cure as a monolithic block, or it can be made into a granular material with the consistency of a sediment-cement.

Chemical stabilization/solidification may require pretreatment. The most common pretreatment involves removal of oversized materials that would not be adequately blended with the chemical reagents and that would interfere with the treatment process. However, this is unlikely to be the case with dredged sediment. Instead, because dredged sediment would probably contain too much moisture for efficient stabilization/solidification even after dewatering, thermal drying would most likely be required as a pretreatment step.

<u>Effectiveness</u>

Chemical stabilization/solidification is a well-established and proven technology, but its effectiveness is highly dependent on the type of material being treated and types of COCs being immobilized. A thorough physical and chemical characterization of the material to be treated and COCs to be immobilized is needed, and treatability testing is typically required to determine the most suitable stabilization/solidification reagents, mixing ratios, and any special pretreatment or material-handling methods that may be required.

At the Lower Subase, pozzolanic fixation/solidification would very likely be effective for the treatment of sediment contaminated with metallic COCs and low concentrations of PAHs and PCBs. Sediment contaminated with high concentrations of PAHs and/or TPH would most likely require the use of a specialized reagent. Because chemical stabilization/solidification would not eliminate the toxicity of COCs

immobilized in the treated sediment, this material would still require proper disposal to minimize unacceptable human health and ecological risk that could result from direct exposure. Chemical stabilization/solidification would effectively minimize the potential for migration of COCs from sediment to other environmental media such as groundwater. Long-term stability and leachability of the treated sediment would remain as potential concerns because COCs would remain within the treated sediment. Most chemical stabilization/solidification processes, including in particular the use of pozzolanic reagents, result in an increase in the volume of the treated material typically ranging from 5 to 15 percent.

Implementability

Ex-situ chemical stabilization/solidification would be relatively easy to implement. The necessary equipment and resources to perform this work are available at most permitted TSDFs. Treatability tests would be required to determine the appropriate mix ratios prior to implementation. As previously mentioned, thermal drying would likely be required as a pretreatment step to lower the moisture content of the sediment to be treated to an acceptable level. Because of the relatively congested conditions and high level of activities at the Lower Subase under the current industrial use scenario, that is the only considered scenario for the sediment remediation, this technology could not be practically implemented on site. Instead, as mentioned earlier, it would have to be implemented off site as part of disposal activities.

Cost

The O&M costs of off-site stabilization/solidification would be moderate. Because application of this technology would be contracted as a service, there would be no capital costs.

Conclusion

Ex-situ chemical stabilization/solidification is eliminated from further consideration because, although it would effectively stabilize metallic COCs and might also stabilize organic COCs, this would already be partially accomplished through the previously retained use of dewatering additives such as fly ash, and additional treatment is not required to successfully deal with the low to moderate concentrations of COCs in Lower Subase sediment.

3.8.6.5 LTTD

LTTD uses direct or indirect heating to desorb or volatilize organic COCs. Operating temperatures are contaminant and matrix specific, with a range of approximately 200 to 1,200°F (95 to 650°C). In the higher range of operating temperatures, LTTD might also be capable of limited removal of a few metals such as arsenic and mercury through volatilization/sublimation. Typically, wastes are processed through

an externally fired pug mill or rotary drum system equipped with heat transfer surfaces that are heated by circulating hot oil. An induced airflow conveys desorbed organic chemicals through a secondary treatment system such as a vapor-phase GAC adsorption unit, catalytic oxidation unit, condenser unit, or afterburner (although use of an afterburner for secondary treatment has typically resulted in the LTTD unit being considered an incinerator by regulatory agencies). The off-gas is then discharged through a stack.

Effectiveness

LTTD is a well-established and proven technology. LTTD effectiveness is typically quite sensitive to particle size, and it generally performs better with relatively coarse soil to which contaminants do not adhere too tightly, which would not be the case with sediment. However, LTTD would likely be effective for the removal of PAHs and PCBs from contaminated sediment at the Lower Subase and, because these organic COCs have relatively low volatilities, operating temperatures would be expected to be toward the higher end of the range (probably 800 to 900º F). As noted earlier, it is possible that at these temperatures some removal of a few of the metallic COCs such as arsenic might also occur. However, such removal would have to be verified through testing. To be fully effective, LTTD would require additional treatment of volatilized contaminants, which would be accomplished through treatment of off-gases by such processes as condensation, vapor-phase GAC adsorption, or catalytic oxidation.

Implementability

LTTD would be relatively easy to implement. Specialized contractors or selected TSDFs could perform this treatment. Treatability testing would be required to verify effectiveness and to determine operating parameters. Off-gases from the thermal desorption unit would have to be treated. Because of the relatively congested conditions and high level of activities at the Lower Subase under the current industrial use scenario, that is the only considered scenario for the sediment remediation, this technology could not be practically implemented on site. Instead, as mentioned earlier, it would have to be implemented off site as part of disposal activities. Adverse impacts on the surrounding community and the environment as a result of off-site transportation of contaminated sediment would be adequately mitigated by adherence to spill prevention procedures and by compliance with DOT regulations.

Cost

The O&M costs of off-site LTTD would be moderate. Because application of this technology would be contracted as a service, there would be no capital costs.

Conclusion

Off-site LTTD is eliminated from further consideration because, although it would very effectively remove organic COCs, it would not sufficiently remove the metallic COCs, and this degree of treatment is not required to successfully deal with the low to moderate concentrations of organic COCs in Lower Subase sediment.

3.8.6.6 Incineration

Incineration is a thermal oxidation process that converts organic solids, liquids, and gases to inorganic substances at high temperatures in the presence of oxygen. The technology uses controlled flame combustion in an enclosed reactor to decompose organics. Carbon and hydrogen waste components are converted to carbon dioxide and water, respectively. Other combustion products are also present in smaller quantities, potentially including carbon monoxide, nitrogen oxides, chlorine, fluorine, and trace metals. If a wet scrubber air pollution control system is used, a liquid waste stream could also be generated. Screening of the contaminated material would be required to remove noncombustible waste/debris from the sediments. The noncombustible waste/debris must be treated or disposed by other means, depending on the level of contamination.

Rotary kilns are one of the most widely used incinerators for wastes in the form of solids, sludges, liquids, and gases. An integrated system for incineration by rotary kiln includes a solid feed system, rotary kiln and secondary combustion chamber, air pollution control units for particulate and acid gas removal, and exhaust stack. Such a system employs a refractory-lined rotary kiln operating at high temperatures (1,470 to 2,910°F or 800 to 1,600°C) to combust wastes in the presence of oxygen. A typical throughput for a transportable rotary kiln is 75 to 200 tons per day. For wastes that have high heat contents, the throughput may be limited by the capacity of the unit to control the heat generation rate. Fixed-based units, such as cement kilns that may be permitted to accept contaminated sediment, are also available.

Effectiveness

Incineration is a well-established and proven technology that would be very effective for destroying sediment organic COCs such as PAHs and PCBs. Incineration would typically achieve in excess of 99.99-percent destruction of these types of COCs with the resulting formation of inert carbon dioxide and water. In addition, similarly to LTTD when operating at the higher temperature range and probably more dependably so, incineration could achieve a certain degree of removal of a few of the metallic COCs such as arsenic. Because the organic COCs contain no significant chlorine or nitrogen, off-gas treatment requirements would probably be minimal and limited to control of solid particulates.

Implementability

Incineration could be implemented. However, on a practical level, this technology could only be implemented off site, and only a few qualified TSDFs are available to provide this service. As noted earlier, off-gas treatment requirements would probably be minimal. However, pre-approval of the material to be incinerated by the TSDF would be required, and a trial burn might be necessary. Adverse impacts on the surrounding community and the environment as a result of off-site transportation of contaminated sediment would be adequately mitigated by adherence to spill prevention procedures and by compliance with DOT regulations.

Cost

The O&M cost of off-site incineration would be high. Because application of this technology would be contracted as a service, there would be no capital costs.

Conclusion

Off-site incineration is eliminated from further consideration because, although it would very effectively destroy organic COCs, it would not sufficiently remove the metallic COCs, and this degree of treatment is not required to successfully deal with the low to moderate concentrations of organic COCs in Lower Subase sediment.

3.8.6.7 Filtration and Liquid-Phase GAC Adsorption

Residual fluids from sediment dewatering operations can be treated on site to achieve an aqueous effluent free of contaminants, thereby allowing the water to be directly discharged on site and minimizing disposal costs associated with aqueous waste. Because sediment COCs are typically strongly bound to the solid matrix and do not readily partition to the aqueous phase, common treatment systems for residual fluids from sediment dewatering operations combine filtration to remove suspended solids and liquid-phase GAC adsorption as a final polishing step to further remove strongly bound organic and inorganic COCs and residual suspended solid particles.

Effectiveness

The use of filtration and liquid-phase GAC adsorption is considered a standard and effective approach for the treatment of aqueous waste from dewatering processes.

Implementability

Filtration and liquid-phase GAC adsorption could easily be implemented for the on-site treatment of sediment dewatering residual fluid. The necessary equipment and resources are readily available. As with other ex-situ treatment technologies, a significant implementability concern would be the lack of available space to setup the required treatment system. However, equipment size would be relatively small and sufficient space should be available. Although an actual NPDES permit would not be required to discharge the treated dewatering fluid to the Thames River, the substantive requirements of such a permit would have to be met.

Cost

The capital and O&M cost of on-site filtration and liquid-phase GAC adsorption would be moderate.

Conclusion

Ex-situ treatment of residual fluid from dewatering operations with filtration and liquid-phase GAC adsorption is retained for development of sediment remedial alternatives. These technologies offer a standard and effective approach for minimizing off-site disposal requirements and costs.

3.8.7 Disposal

The technologies considered under the disposal GRA include CAD and off-site landfilling for sediment and disposal at an off-site wastewater treatment facility for sediment dewatering fluid.

3.8.7.1 CAD

Disposal in a CAD facility typically would involve the dredging of contaminated sediment from areas to be remediated, transport to an underwater disposal site, controlled placement in a pit previously dredged in the existing sediment floor, and capping. Pretreatment (including dewatering) and treatment are typically not performed prior to disposal (NAVFAC, 2002). Dredged sediment can also be placed in a mound and covered with a cap, a technique known as level-bottom capping. The cap prevents physical contact between the contaminated sediment and the benthic community, prevents sediment resuspension and dispersion, and inhibits contaminant flux to the water column. CADs require monitoring to ensure cap integrity and stability of buried sediment.

Contaminated sediment likely would be transported to a CAD site by barge. Sediment would be placed in a CAD cell using a pipeline or other method to minimize sediment resuspension or spreading outside of the CAD cell footprint. If practical, silt curtains can be installed to confine sediment to the work area.

After a period of natural consolidation and settling, a cap would be placed on top of the dredged sediment. This cap would likely consist of a layer of clean sediment 2 to 3 feet thick to prevent penetration by benthic organisms and/or resuspension of emplaced sediment. However, practicability of using a pipeline or silt curtains may be limited by the nature of the dredge material and river currents, respectively.

Following construction, the CAD cell would undergo long-term monitoring to verify that the emplaced sediment is not adversely impacting the surrounding aquatic ecosystem. Monitoring of the physical integrity of the cap also would be conducted. Assessment of cap integrity would be conducted through underwater visual inspections and by depth measurements through surveying or sampling to monitor the thickness of the cap. LUCs would be implemented to restrict activities that would potentially disturb the CAD cap.

Effectiveness

Disposal in a CAD facility would not permanently or irreversibly reduce the concentrations or toxicities of sediment COCs. However, disposal in a CAD facility would effectively remove the contaminated sediment from the site and from potential ecological or human exposure, thereby minimizing potential ecological and human health risks. In addition, the mobility of the sediment COCs would be effectively reduced by the confined area provided by a CAD cell. Similarly to a cap, the continued effectiveness of a CAD cell depends on the long-term maintenance of its integrity, and this would have to be verified through monitoring.

Implementability

CAD disposal is a relatively well-established and proven technology that could be readily implemented. The Navy constructed a CAD facility in the Thames River near the southern end of the Lower Subase and used it for disposal of sediments dredged under their maintenance dredging program. Other cells could be constructed in the CAD facility to allow for disposal of additional dredged sediment. Placement of dredged material within a CAD cell may have implementability challenges if the material has high organic content and small particle sizes and thus a potential risk to remain suspended in the water column during placement, particularly in the open channel of the Thames River where currents may preclude the use of silt curtains as an engineering control. However, CAD disposal would be easier to implement than other disposal options because it would not require dewatering pretreatment and because transportation would be simple. CAD disposal would require long-term monitoring and maintenance of the integrity of the CAD cell and long-term monitoring of the potential impact of the disposed sediment on the surrounding aquatic ecosystem. Administratively, CTDEP has indicated that they would not approve of this disposal technology on the grounds that CERCLA waste can not be disposed in a CAD in State waters. CTDEP

does not want to be legally responsible for the long-term care of the CAD because it is not located within the Navy's property but in State waters (CTDEP, 2008).

Cost

CAD disposal typically requires a substantial initial investment for design and construction of the CAD cell, and typically this can only be justified for disposal of a very large volume of material. However, a CAD facility already exists at the Lower Subase, which would allow for cost-effective disposal of smaller quantities of contaminated sediment. The O&M cost of CAD disposal would be low compared to other disposal methods because there would be no need for dewatering and because transportation costs would normally be minimal.

Conclusion

Although it would be effective, technically feasible, and economically attractive, CAD disposal is eliminated from further consideration because of serious administrative implementability concerns.

3.8.7.2 Off-Site Landfilling

Off-site landfilling consists of transporting dredged sediment for burial at a permitted facility. Prior to landfilling, sediment with high concentrations of COCs might require treatment by one or more of the above-described ex-situ treatment technologies at an off-site TSDF. In addition, sediment that contains metals with TCLP extract concentrations greater than RCRA toxicity characteristic concentrations would be identified as hazardous and would have to be disposed at a hazardous waste TSDF where they would undergo treatment to satisfy LDRs prior to secure landfilling. Based on currently available analytical data, it is unlikely that sediment removed from Zone 4 at the Lower Subase would require treatment at an off-site TSDF and even more unlikely that any of that sediment would be identified as hazardous.

Effectiveness

Landfilling would not permanently or irreversibly reduce the concentrations or toxicities of sediment COCs. However, although the CERCLA preference for treatment relegates landfilling to a less preferable option, this technology could be an effective disposal option for contaminated sediment. Landfills are only permitted to operate if they meet certain requirements of design and operation governing foundation, liner, leak detection, leachate collection and treatment, daily cover, post-closure inspections and monitoring, etc., which ensure the effectiveness of these facilities. The requirements of a hazardous waste TSDF are typically significantly more stringent than those of a municipal solid waste landfill.

Implementability

Off-site landfilling would be easy to implement. Permitted municipal solid waste and hazardous waste TSDFs are available for this purpose. Disposal at either type of facility may require certain pretreatment steps, mainly the removal of free liquids by dewatering, which is typically performed on site to facilitate the transport of dredged sediment for disposal. A waste profile would have to be prepared, including contaminant concentrations and their leachabilities. Adverse impact on the surrounding community and the environment as a result of off-site transportation of contaminated sediment would be adequately mitigated by adherence to spill prevention procedures and by compliance with DOT regulations.

Cost

The O&M cost of off-site disposal would be low to moderate for a municipal solid waste landfill, moderate for a non-hazardous waste TSDF, and high for a hazardous waste TSDF. Because application of this technology would be contracted as a service, there would be no capital costs.

Conclusion

Landfilling is retained for the development of sediment remedial alternatives. Depending on the characteristics of the sediment to be disposed, landfilling might occur at a municipal solid waste landfill, non-hazardous waste TSDF, or hazardous waste TSDF.

3.8.7.3 Disposal at an Off-Site Wastewater Treatment Facility

This technology would consist of transporting residual fluids from the sediment dewatering operations to an off-site permitted facility for treatment and discharge. At such a facility, the dewatering fluid would typically undergo a sequence of chemical/physical (e.g., filtration, liquid-phase GAC adsorption) and/or biological (e.g., activated sludge) treatment processes that would remove COCs prior to discharge either to a surface water body or sewer system. Concentrated liquid waste or liquid waste containing highly toxic COCs may be identified as RCRA hazardous and require special treatment, including incineration, but based on currently available analytical data, it is extremely unlikely that dewatering fluid from Zone 4 or Outer Pier 1 sediment would be identified as hazardous.

Effectiveness

Treatment at an off-site wastewater facility would permanently and irreversibly reduce the concentrations and toxicities of the COCs in sediment dewatering fluid. As previously discussed, a number of ex-situ treatment technologies including filtration, liquid-phase GAC adsorption, and biological treatment would effectively remove the COCs likely to be present in the Zone 4 and Pier 1 dewatering fluid.

Implementability

Disposal at an off-site landfill would be easy to implement. Permitted wastewater treatment facilities are available for this purpose within reasonable distances of NSB-NLON. A waste profile would likely be required, including the range of COC concentrations. Adverse impacts on the surrounding community and the environment as a result of the off-site transportation of contaminated sediment would be adequately mitigated by adherence to spill prevention procedures and by compliance with DOT regulations.

Cost

The O&M cost of disposal at an off-site wastewater treatment facility would be low to moderate. However, for large volumes of low-concentration waste, as could be the case for dewatering fluid, transportation costs might be disproportionally high. Because application of this technology would be contracted as a service, there would be no capital costs.

Conclusion

Disposal at an off-site wastewater facility is retained for the development of sediment remedial alternatives.

3.9 SELECTION OF SEDIMENT REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS FOR ZONE 4 AND OUTER PIER 1

The following GRAs, remediation technologies, and process options are retained to develop sediment remedial alternatives:

- No Action.
- Limited Action: LUCs and Monitoring.
- Containment: Capping (sand or sediment layer).
- Removal: Dredging (mechanical).
- Ex-Situ Treatment: On-Site Dewatering (passive dewatering on barges with dewatering additives) and On-Site Filtration and Liquid-Phase GAC Adsorption of Dewatering Fluid.

- Disposal: Off-Site Landfilling of Dewatered Sediment (municipal solid waste landfill, non-hazardous waste TSDF, or hazardous waste TSDF) and Disposal of Sediment Dewatering Fluid at an Off-Site Wastewater Treatment Facility.

3.10 PRELIMINARY SCREENING OF LNAPL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS FOR ZONE 1

To address State petroleum concerns, this section identifies and screens remediation technologies and process options for LNAPL at a preliminary stage based on implementation with respect to site conditions. Table 3-4 summarizes the preliminary screening of technologies and process options applicable to LNAPL. It presents the GRAs, identifies the technologies and process options, and provides a brief description of each process option followed by screening comments.

The following are the LNAPL remediation technologies and process options retained for detailed screening based on the results of preliminary screening.

General Response Action	Remediation Technology	Process Option
No Action	None	Not Applicable
Limited Action	LUCs	Institutional Controls Engineered Controls
	Monitoring	Sampling and Analysis
	Natural Attenuation	Biodegradation, Dilution, Dispersion
Removal	Skimming	Active or Passive Skimming
	Excavation	Excavation and Mechanical Removal
In-Situ Treatment	Biological	Enhanced Bioremediation
	Biophysical	Multiple Phase Extraction (MPE)/Bioslurping
	Thermal	Electrical Resistance Heating (ERH)
Ex-Situ Treatment	Biological	Bioslurry Reactor/Biopile
	Thermal	LTTD
		Incineration
Disposal	Recycle/Reuse	Off-Site Recycling

3.11 DETAILED SCREENING OF LNAPL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS FOR ZONE 1

3.11.1 No Action

No Action would not include any new environmental action and stop the application of any existing administrative or engineering environmental controls. As required under CERCLA regulations, the No

Action alternative is carried through the FS to provide a baseline for comparison of alternatives and their effectiveness in mitigating risks posed by site contaminants. Because no remedial actions would be conducted under this alternative, the only cost associated with the No Action alternative would be that of the CERCLA-mandated five-year reviews. There would also be no reduction in risk through exposure control or treatment. No Action would not be effective in evaluating contaminant mobility and potential migration off site because no monitoring would be performed.

Effectiveness

No Action would not be effective in meeting the LNAPL Remedial Goals. No Action would not be effective in evaluating either potential removal of LNAPL through natural attenuation or potential off-site migration of LNAPL because no monitoring would be performed.

Implementability

There would be no implementability concerns because no action would be implemented.

Cost

Minimal costs (five-year reviews) would be associated with No Action.

Conclusion

No Action is retained because of NCP requirements, although it would not be effective.

3.11.2 Limited Action

The technologies considered under the limited action GRA include LUCs, monitoring, and natural attenuation.

3.11.2.1 LUCs

LUCs are designed to protect public health and the environment from residual contamination at environmental sites. LUCs consist of administrative or legal mechanisms (e.g., zoning restrictions, permits, etc.) designated as institutional controls and/or physical controls (e.g., pavement, fencing, security guards, etc.) designated as engineering controls. Site-specific LUCs are typically formulated through a LUC RD that is prepared in accordance with the Navy's LUC Principles (DOD, 2003) following approval of the ROD. LUCs typically also include the performance of regular site inspections to verify their continued implementation.

Effectiveness

LUCs consisting of restrictions on groundwater access, groundwater use, and soil excavation would effectively minimize unacceptable risks from direct exposure of human receptors to LNAPL. Provided that administrative controls are in place for its continued maintenance, the existing pavement that covers much of the Lower Subase would also be an effective engineering control to minimize direct exposure to LNAPL. However, LUCs would not of themselves completely prevent the potential migration of COCs that could impact marine ecological receptors

Implementability

LUCs would be easy to implement on a military facility where access is already restricted. A LUC RD could be readily prepared. LUCs for the Lower Subase could easily be integrated within and implemented as part of NSB-NLON's existing SOPA Instruction 5090.25 (Navy, 2009).

Cost

The capital and O&M costs for LUCs would be low.

Conclusion

LUCs are retained for the development of LNAPL remedial alternatives.

3.11.2.2 Monitoring

Monitoring would consist of regularly checking for the presence of LNAPL in monitoring wells within the known area of LNAPL accumulation and on the periphery of that area. If LNAPL is detected, the thickness of the LNAPL layer would be measured and recorded.

Effectiveness

Monitoring alone would not remove LNAPL; however, monitoring would allow evaluation of trends in LNAPL accumulation and verification of potential off-site migration of LNAPL.

Implementability

Monitoring would be easy to implement. Such monitoring has already been performed on several occasions at the Lower Subase. The resources and material required for monitoring are readily available.

Cost

The capital and O&M costs of monitoring would be low.

Conclusion

Monitoring is retained for the development of LNAPL remedial alternatives.

3.11.2.3 Natural Attenuation

Natural attenuation would consist of allowing naturally occurring processes such as biodegradation, dispersion, dilution, and adsorption to reduce accumulation of LNAPL over time. For this purpose, the presence of LNAPL would be regularly checked to establish trends in its accumulation and to evaluate its movement.

Effectiveness

Typically, the TPH that is the main component of LNAPL is amenable to long-term natural attenuation, primarily through aerobic biodegradation and volatilization. However, natural attenuation is typically only effective for the removal of light accumulations of LNAPL, and there is a strong tendency for the process to gradually slow down as the lighter, and more volatile and biodegradable, components of LNAPL are removed, leaving the heavier and more refractory components that are typically referred to as “weathered” product. From available monitoring data, it is likely that such a stage has been reached at the Lower Subase.

Implementability

Natural attenuation would be very easy to implement because it requires limited actions of monitoring and evaluation. As noted earlier, the resources and materials required for monitoring are readily available.

Cost

The capital and O&M costs for natural attenuation would be low.

Conclusion

Natural attenuation is eliminated from further consideration because of effectiveness concerns.

3.11.3 Removal

The technologies considered under the removal GRA include skimming and excavation and mechanical removal.

3.11.3.1 Skimming

Skimming consists of mechanically removing LNAPL, either in a static fashion (passive skimming) or with induction of a hydraulic gradient (active skimming). Passive skimming consists of installing devices that include either a hydrocarbon capture hydrophobic filter with a storage canister or an adsorbing element in wells located in the areas of LNAPL contamination. Periodically, the storage canisters are emptied or the adsorbing elements are removed and replaced. Active skimming consists of installing skimming pumps in wells located in the areas of LNAPL contamination and operating these pumps either continuously or intermittently. Skimming pumps are specially designed to induce a hydraulic gradient at the surface of the water table and to collect a thin liquid layer of adjustable thickness from that surface.

Effectiveness

Skimming would be effective for the removal of LNAPL. However, skimming would not be effective for the remediation of the associated TPH-contaminated soil. Passive skimming is typically most effective in areas of low to moderate LNAPL accumulation that would not require overly frequent emptying of the storage canisters or replacement of the adsorbing elements. Active skimming, either continuous or intermittent, is typically most effective in areas of significant LNAPL accumulation where the skimming action of the pumps would not entrain excessive water. At Zone 1 of the Lower Subase, based on the limited monitoring data available, it appears that LNAPL accumulation is neither too severe nor too widespread, and passive skimming is expected to be the option of choice for this technology, at least until more monitoring data are available.

Implementability

Skimming, either passive or active, would be easy to implement. Numerous types of hydrophobic filters/storage canisters, adsorbing elements, and skimming pumps are available, and they could readily be installed and operated either in existing wells or new wells.

Cost

The cost of passive skimming would be low. The cost of active skimming would be moderate.

Conclusion

Passive skimming is retained for the development of LNAPL remedial alternatives. After additional LNAPL monitoring data become available, active skimming could also be considered if necessary.

3.11.3.2 Excavation and Mechanical Removal

This technology would consist of first excavating overlying soil in the area of LNAPL accumulation to the water table to expose LNAPL and then pumping or vacuuming out the LNAPL. In addition, the surrounding TPH-contaminated soil would also be excavated and removed.

Excavation would be similar to that described earlier for the evaluation of soil remedial technologies (Section 3.2.4) and could be performed with conventional construction equipment such as backhoes, front-end loaders, or grade-alls. The exposed LNAPL layer could either be pumped out of the excavated area with one or more mobile pumps or aspirated out with a vacuum truck. The removed LNAPL and TPH-contaminated soil would be transported to an off-site TSDF for disposal. Pre- and post-excavation sampling would be performed to further delineate the areas to be excavated, to provide waste characterization data for the TSDF, and to verify that all contaminated material has been removed.

Effectiveness

Excavation and mechanical removal would be a very effective technology for the removal of LNAPL. In addition and as previously mentioned, excavation and mechanical removal could also remove the TPH-contaminated soil often associated with the presence of LNAPL and can be responsible for the presence of LNAPL. However, to be fully effective, excavation and mechanical removal requires the accurate delineation of the area of LNPAL accumulation and the identification of the source(s) of that LNAPL.

Implementability

Excavation is a well-proven and established technology in the construction/remediation industry, and excavation equipment and/or services are readily available from multiple vendors or contractors. Excavation and removal of LNAPL alone would not extend significantly below the water table, which occurs in Zone 1 at a depth of approximately 9 feet bgs. Therefore, conventional equipment could be used but shoring would be required. However, complete removal of TPH-contaminated soil associated with the LNAPL would require excavation well below the water table, with attendant complexities as previously discussed in Section 3.2.4.

As noted earlier for the evaluation of soil remedial technologies, very careful planning and execution would be required to prevent interference from excavation with the ongoing activities of the Lower Subase. In addition, excavation could be significantly hindered, or even prevented, by the presence of many underground structures such as utility lines and existing and former building foundations. These would not only interfere with the operation of normal excavation equipment but would severely limit or even prevent the installation of the required shoring. An evaluation of the utilities currently located in the vicinity of well 13MW18 where LNAPL was detected has shown that these utilities would essentially prevent installation of proper shoring. Accordingly, for the purpose of this FS, it is concluded that underground obstacles would prevent excavation of overlying soil for the purpose of exposing and removing LNAPL.

Cost

The cost of excavation and mechanical removal would be relatively high.

Conclusion

Excavation and mechanical removal are eliminated from further consideration because of severe implementability concerns.

3.11.4 In-Situ Treatment

The technologies and process options considered under the in-situ treatment GRA include enhanced bioremediation, MPE/bioslurping, and ERH.

3.11.4.1 Enhanced Bioremediation

In-situ bioremediation involves the use of naturally occurring microorganisms, primarily bacteria and fungi, to breakdown toxic organic compounds into nontoxic or less toxic forms. Enhanced in-situ bioremediation would consist of accelerating this process by stimulating biological activity through the injection of chemical additives and/or custom microorganism cultures into the contaminated soil.

Because the LNAPL and associated high concentrations of soil-bound TPH would create an extremely high oxygen demand, one of the most likely process options for implementation of in-situ enhanced bioremediation would be the same as proposed earlier for in-situ bioremediation of groundwater and would consist of recirculating a stream of super-oxygenated and nutrient- and microorganism-amended groundwater through the suspected area of LNAPL accumulation (ETEC DO-IT™ process). Monitoring would be performed to evaluate the progress of remediation.

Effectiveness

The effectiveness of in-situ aerobic biodegradation is well documented for a very wide range of non-chlorinated organic compounds including TPH, which is the main component of LNAPL. The DO-IT™ process is relatively innovative and would provide an effective means of delivering the extremely large quantities of oxygen that would be required for the timely aerobic biodegradation of LNAPL and very high concentrations of associated soil-bound TPH present at Zone 1. However, as noted earlier for the evaluation of soil (Section 3.2.5.1) and groundwater (Section 3.5.4.1) remedial technologies, much of the TPH present as a contaminant at the Lower Subase is likely so-called "weathered" product that is no longer very biodegradable. In addition, the aerobic biodegradation of TPH promoted by oxygen injection might be significantly impacted by the high salinity of the aquifer beneath the Lower Subase. Because of these considerations, treatability testing would be required to verify the site-specific biodegradability of TPH and to evaluate the impact of groundwater salinity on the biodegradation process.

Implementability

Enhanced in-situ bioremediation of LNAPL could be implemented at Zone 1. Installation of the groundwater recirculation systems required for the DO-IT™ process would be relatively unobtrusive with respect to existing structures and underground utilities, although these structures and utilities might restrict the optimal placement of some of the groundwater extraction and reinjection wells. A very wide range of in-situ enhanced bioremediation technologies are currently available, but the DO-IT™ process is proprietary and is only available from ETEC, LLC. As noted above, treatability testing would be required to verify site-specific effectiveness and to confirm operating parameters.

Cost

The capital and O&M costs for enhanced in-situ bioremediation would be moderate to high.

Conclusion

Although there are some concerns about its effectiveness, enhanced in-situ bioremediation with the DO-IT™ process is retained for the development of LNAPL remedial alternatives.

3.11.4.2 MPE/Bioslurping

MPE, also known as bioslurping, is very similar to in-well treatment as discussed in the evaluation of groundwater remedial technologies (Section 3.5.4.2). This technology combines vacuum-assisted LNAPL recovery with bioventing and soil vapor extraction (SVE) to simultaneously recover LNAPL and remediate the vadose zone. This technology uses specially designed extraction wells that draw a

vacuum across the vadose and saturated zones interface. This vacuum pulls vapors and air through the vadose and capillary (or smear) zones, stripping volatile compounds and promoting aerobic biodegradation. This vacuum also aspirates liquids from the capillary zone and surface of the water table, removing LNAPL. The extracted liquid and vapors are then separated in a drop-out tank, and LNAPL is removed from the aspirated groundwater in a conventional oil/water separator. Vapors are treated if required through GAC adsorption or catalytic oxidation prior to venting to the atmosphere. Groundwater and soil samples are regularly collected and analyzed to monitor the progress of the remedial action. In addition, samples of the extracted liquid and vapors are collected and analyzed to evaluate the performance of the treatment system and verify its compliance with regulatory emission requirements.

Effectiveness

MPE/bioslurping is typically very effective for the removal of LNAPL from the capillary zone and groundwater surface through mechanical aspiration. MPE/bioslurping is also typically effective for the remediation of TPH-contaminated soil in the vadose and capillary zones through volatilization and aerobic biodegradation. However, MPE/bioslurping would not be effective for the remediation of TPH-contaminated soil in the saturated zone because its effects do not extend to that zone. At Zone 1, MPE/bioslurping would probably not be very effective for the remediation of the TPH-contaminated soil in the vadose and capillary zones because, as previously stated, the TPH present in Lower Subase soil and groundwater is neither volatile nor likely to be particularly biodegradable. Therefore, the site-specific effectiveness of MPE/bioslurping at Zone 1 would probably be limited to LNAPL removal through aspiration.

Implementability

Typically, MPE/bioslurping is relatively easy to implement. Numerous competent contractors could install such a system, and the necessary equipment and materials are readily available. However, at Zone 1 of the Lower Subase, placement of the MPE wells might be limited by numerous underground obstacles.

Cost

The cost of MPE/bioslurping would be moderate.

Conclusion

MPE/bioslurping is eliminated from further consideration because its effectiveness would essentially be limited to LNAPL removal, which could be accomplished through skimming in a simpler, more effective, and less expensive manner.

3.11.4.3 In-Situ ERH

In-situ ERH consists of installing a pattern of electrodes in the area of soil and groundwater to be treated and passing an alternating current between these electrodes, which results in heating of soil and groundwater. Typical ground-heating electrodes consist of steel-cased vertical pipes with iron filings and graphite in the annular space. The heating releases contaminants adsorbed in soil and boils the surrounding groundwater, resulting in a combination of volatilization and steam stripping of contaminants that can then be removed either by the ground-heating electrodes themselves used as vapor extraction points or by separate dedicated recovery wells installed in the vadose zone. Similar to MPE/bioslurping systems, extracted liquid and vapors are then separated in a drop-out tank, and LNAPL is removed from the aspirated groundwater in a conventional oil/water separator. Vapors are treated if required through GAC adsorption or catalytic oxidation prior to venting to the atmosphere. Groundwater and soil samples are regularly collected and analyzed to monitor the progress of the remedial action. In addition, samples of extracted liquid and gas are collected and analyzed to evaluate the performance of the treatment system and verify its compliance with regulatory emission requirements.

Effectiveness

In-situ ERH is a fairly well-established and demonstrated technology that is typically effective for the remediation of TPH-contaminated soil and groundwater including when LNAPL is present. In-situ ERH would be effective in the vadose, capillary, and saturated zones. Heating would significantly reduce the viscosity of the weathered LNAPL, which would release it from the soil and make it far easier to remove through mechanical aspiration. The steam stripping action resulting from groundwater boiling would also greatly reinforce this process. In addition, because thermal conductivity is not very sensitive to variations in soil characteristics, the effectiveness of in-situ ERH is typically less affected than that of other in-situ treatment technologies by the presence of heterogeneous subsurface conditions. However, although the successful use of in-situ ERH has been fairly well documented for the removal of TPH and LNAPL, treatability testing, preferably of the pilot-scale type, would still be highly desirable to confirm effectiveness and determine ERH system design criteria.

Implementability

In-situ ERH is typically fairly simple to implement. The services of a limited number of qualified contractors specializing in the application of this technology would be available. However, because in-situ ERH has a temporary but significant physical impact on the areas to be treated, mainly as a result of the creation of potentially hazardous conditions (particularly high heat) in the subsurface of these areas, implementation of this technology could be difficult to reconcile with the continued unhindered use of such a congested and active military facility as Zone 1 of the Lower Subase. In addition, as previously noted, a

pilot-scale treatability test would most likely have to be performed to confirm effectiveness and establish the design criteria of the ERH system.

Cost

The capital and O&M costs for in-situ ERH would be high.

Conclusion

In-situ ERH is eliminated from further consideration because of minor concerns about its effectiveness and major concerns about its implementability at the Lower Subase under the current land use scenario.

3.11.5 Ex-Situ Treatment

The technologies and process options considered under the ex-situ treatment GRA include technologies that might be required as part of disposal of any removed LNAPL at an off-site TSDF including bioslurry reactors/biopiles and incineration. Because of the earlier elimination of excavation as a removal technology, LTTD, which had been retained only for the ex-situ treatment of TPH-impregnated soil, will not be evaluated.

3.11.5.1 Bioslurry Reactor/Biopile

A bioslurry reactor is a technology in which contaminated material is biologically treated in an enclosed vessel. After removal of foreign materials such as stones and rubble, the contaminated material is mixed with water and a culture of appropriate microorganisms to form a slurry containing 10 to 30 percent solids. This slurry is placed in a tank with process controls so that temperature, mixing, and nutrient additions can be manipulated to achieve maximum biological treatment efficiency. Following treatment, the slurry is dried and tested to verify that COCs have been adequately removed, and the treated material is replaced in its original location or used as fill material elsewhere.

A biopile is a technology in which contaminated material is mixed with biologically amended soil and formed into an enclosed compost pile. Oxygen, if needed for aerobic treatment, is provided either by inducing an air current through the pile with blowers or vacuum pumps or by the mixing in of an ORC. Moisture, heat, nutrients, oxygen, and pH are controlled to enhance biodegradation. Duration of operation may vary from a few weeks to several months, at which time the treated material is either returned to its original location or used as fill material elsewhere.

Effectiveness

Bioslurry reactors and biopiles have been proven effective for the treatment of a wide range of organic compounds including TPH, which is the main component of LNAPL. Typically, bioslurry reactors or biopiles can achieve close to 100-percent removal of these types of compounds. However, as noted earlier for the evaluation of in-situ enhanced bioremediation (Section 3.11.4.1), much of the TPH present in LNAPL removed from the Lower Subase is likely to consist of so-called “weathered” product that is no longer very biodegradable. Therefore, treatability testing would be required to verify the site-specific biodegradability of the TPH.

Implementability

Bioslurry reactor or biopile technologies would be implementable. Specialized contractors or selected TSDFs could perform this treatment. However, both of these technologies would require a relatively complex sequence of operations including staging, treatment, and disposal of treatment residues. The necessary equipment and resources are only available from a relatively limited number of contractors or off-base permitted TSDFs. Because of the relatively congested conditions and high level of activities at the Lower Subase, this technology could not be practically implemented on site under the current industrial scenario. As noted earlier, treatability testing would be required to verify effectiveness and determine operating parameters.

Cost

The capital and O&M costs for bioslurry reactors/biopiles would be moderate to high.

Conclusion

Bioslurry reactors/biopiles are eliminated from further consideration because of effectiveness and implementability concerns.

3.11.5.2 Incineration

Incineration is a thermal oxidation process that converts organic solids, liquids, and gases to inorganic substances at high temperatures in the presence of oxygen. The technology uses controlled flame combustion in an enclosed reactor to decompose organics. Carbon and hydrogen waste components are converted to carbon dioxide and water, respectively. Other combustion products are also present in smaller quantities, potentially including carbon monoxide, nitrogen oxides, chlorine, fluorine, and trace metals. If a wet scrubber air pollution control system is used, a liquid waste stream could also be generated. Screening of the contaminated material would be required to remove non-combustible

waste/debris from soil. The non-combustible waste/debris must be treated or disposed by other means, depending on the level of contamination.

Rotary kilns are one of the most widely used incinerators for wastes in the form of solids, sludges, liquids, and gases. An integrated system for incineration by rotary kiln includes a solid feed system, rotary kiln and secondary combustion chamber, air pollution control units for particulate and acid gas removal, and exhaust stack. Such a system employs a refractory-lined rotary kiln operating at high temperatures (1,470 to 2,910°F or 800 to 1,600°C) to combust wastes in the presence of oxygen. A typical throughput for a transportable rotary kiln is 75 to 200 tons per day. For wastes that have high heat content, the throughput may be limited by the capacity of the unit to control the heat generation rate. Fixed-based units, such as cement kilns that may be permitted to accept contaminated soil, are also available.

Effectiveness

Incineration is a well-established and proven technology that would be very effective for destroying most organic-based contaminants including the TPH that is the main component of LNAPL. Incineration would typically achieve in excess of 99.99-percent destruction of TPH with the resulting formation of inert carbon dioxide and water. The earlier noted assumption that much of the TPH present in LNAPL removed from the Lower Subase is likely to be a “weathered” product would have no significant impact on the expected high effectiveness of incineration. In addition, because LNAPL is expected to contain high concentrations of TPH with no significant chlorine or nitrogen, combustion of this material is expected to be self-sustaining, and off-gas treatment requirements would probably be minimal and limited to control of solid particulates.

Implementability

Incineration could be easily implemented at a number of off-site TSDFs. As noted earlier, off-gas treatment requirements would probably be minimal. However, pre-approval of the material to be incinerated by the TSDF would be required, and a trial burn might be necessary. Adverse impacts on the surrounding community and the environment as a result of the off-site transportation of LNAPL would be adequately mitigated by adherence to spill prevention procedures and by compliance with DOT regulations.

Cost

The O&M cost of off-site incineration would be moderate. Because application of this technology would be contracted as a service, there would be no capital costs.

Conclusion

Off-site incineration is retained for the development of LNAPL remedial alternatives.

3.11.6 Disposal

The only technology considered under the disposal GRA for the disposal of LNAPL itself is off-site recycling. Because of the earlier elimination of excavation as a removal technology, landfilling, which had been retained only for the disposal of pre-treated TPH-impregnated soil, will not be evaluated.

3.11.6.1 Off-Site Recycling

Off-site recycling would consist of transporting recovered LNAPL for reprocessing at a permitted facility. Depending on the capabilities of the recycling facility and the quality of LNAPL, the recycling process could be as simple as using the raw LNAPL as fuel if its quality is sufficient or as complex as full reprocessing including dewatering, filtration, de-asphalting, and distillation to produce commercially reusable refined petroleum products.

Effectiveness

Recycling would effectively treat recovered LNAPL and result either in its destruction as fuel or its reuse as a commercial product. A wide range of technologies have been proven effective for this purpose.

Implementability

Off-site recycling of LNAPL would be implementable. A limited number of TSDFs are available for this purpose. A waste profile would have to be prepared to secure LNAPL acceptance by the TSDF. Adverse impacts on the surrounding community and the environment as a result of off-site transportation of LNAPL would be adequately mitigated by adherence to spill prevention procedures and by compliance with DOT regulations.

Cost

The O&M cost of off-site recycling could be moderate to high depending on the quality of the LNAPL. Because recycling would be contracted as a service, there would be no capital costs.

Conclusion

Off-site recycling that would use recovered LNAPL as fuel is retained for the development of LNAPL remedial alternatives. For the purpose of this FS, this will be considered as incineration. Off-site

recycling that would reprocess the recovered LNAPL and reuse it as a commercial product is eliminated from further consideration because it would be much harder and costlier to implement.

3.12 SELECTION OF LNAPL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS FOR ZONE 1

The following GRAs, remediation technologies, and process options are retained to develop LNAPL remedial alternatives:

- No Action.
- Limited Action: LUCs and Monitoring.
- Removal: Passive Skimming.
- In-Situ Treatment: Enhanced Bioremediation (DO-IT™ process).
- Disposal: Off-Site Incineration.

Because incineration of an essentially combustible material such as LNAPL can be considered either an ex-situ treatment or disposal technology, off-site incineration will be considered as the LNAPL disposal option for the purpose of this FS.

TABLE 3-1

PRELIMINARY SCREENING OF ZONES 1 TO 7 SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
No Action	None	Not Applicable	No activities conducted at the sites to address contamination.	Required by law. Retain for baseline comparison to other technologies.
Limited Action	Land Use Controls (LUCs)	Institutional Controls: Deed or Land Use Restrictions	Administrative action using property deeds or other land use prohibitions to restrict future site activities.	Retain. Would minimize risk from exposure to contaminated soil.
		Engineering Controls: Physical Barriers/ Security Guards	Fencing, markers, warning signs, and monitoring to restrict site access.	Retain. Would minimize risk from exposure to contaminated soil. Site access is already controlled.
	Monitoring	Sampling and Analysis	Sampling and analysis of soil and groundwater for chemicals of concern (COCs).	Retain. Would allow evaluation of the progress of remedial actions and tracking of potential migration of soil COCs.
	Natural Attenuation	Naturally Occurring Processes	Decrease in COC concentrations as a result of naturally occurring processes (dilution, dispersion, biodegradation).	Retain. Although metallic COCs (antimony, arsenic, lead, mercury) are not likely to attenuate in the vadose zone, they might do so in the saturated zone. Organic COCs [total petroleum hydrocarbons (TPH) and polynuclear aromatic hydrocarbons (PAHs)] could attenuate in both zones.
Containment	Capping	Soil/Multimedia Cover	Installation of a semi-permeable or impermeable barrier over contaminated soil.	Retain. Would be effective in minimizing direct exposure and potential migration of soil COCs to other media.
Removal	Bulk Excavation	Excavation	Use of construction equipment such as backhoe, front-end loader, grade-all, etc. to remove contaminated soil.	Retain. Would be effective in removing contaminated soil.

TABLE 3-1

PRELIMINARY SCREENING OF ZONES 1 TO 7 SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
In-Situ Treatment	Biological	Enhanced Bioremediation	Biostimulation with injection of oxygen- or hydrogen-release compounds (ORCs or HRCs) and/or bioenhancement with injection of microorganisms and nutrients to enhance naturally occurring biodegradation of COCs.	Retain. Organic COCs can typically be biodegraded under aerobic or anaerobic conditions. However, metallic COCs are non-biodegradable.
		Phytoremediation	Removal of COCs through adsorption and metabolization by root systems of selected plants.	Eliminate. Although this technology would remove organic and metallic COCs, its implementation would be incompatible with the planned continued use of the Lower Subase as an active Naval facility.
	Physical/ Chemical	Soil Flushing	Use of water or other solvents to remove COCs by flushing, collecting, and treating/disposing of the wash fluids.	Eliminate. Although it might remove metallic COCs, this technology would not be very effective for the removal of organic COCs and would be very impractical to implement because of the shallowness of the water table and the fluctuation of its elevation.
		Dynamic Underground Stripping	Injection of steam at the periphery of the contaminated areas to volatilize COCs and removal of these COCs through a centrally located extraction well.	Eliminate. Although it might remove organic COCs, this technology would not remove metallic COCs and would be very impractical to implement because of the shallowness of the water table and the fluctuations of its elevation.

TABLE 3-1

PRELIMINARY SCREENING OF ZONES 1 TO 7 SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
In-situ Treatment (continued)	Physical/ Chemical (continued)	Soil Vapor Extraction	Application of vacuum to the vadose zone to volatilize COCs. Can be enhanced through air sparging to enhance air circulation.	Eliminate. Organic COCs (TPH and PAHs) are not particularly volatile, and metallic COCs would not be removed. Also, this technology would be very impractical to implement because of the shallowness of the water table and the fluctuations of its elevation.
		Chemical Stabilization/ Solidification	Mixing of chemical agents in the vadose zone to chemically stabilize COCs and/or solidify the surrounding soil matrix.	Retain. Would immobilize metallic COCs and could also immobilize organic COCs, particularly PAHs. However, would be very impractical to implement below the water table.
	Thermal	Vitrification/ Radiofrequency Heating	Use of moderate to high temperature to either volatilize COCs or to fuse them into a glass matrix.	Eliminate. Although it could volatilize the organic COCs and immobilize the metallic COCs, this technology would be very impractical because of the shallowness of the water table and the fluctuations of its elevation.
Ex-Situ Treatment	Pretreatment	Dewatering	Removal of free water from wet material through passive gravity-driven stockpiling and/or mechanical expression (filter press, belt filter press, centrifuge).	Retain. On site dewatering would be required for the pretreatment of soil excavated below the water table.
		Crushing/Grinding/ Screening	Size reduction of excavated material as a preliminary process to aid in subsequent treatment and/or disposal.	Eliminate. Although asphalt pavement covers most areas of the Lower Subase, this technology would not be required because this pavement could easily be broken into small fragments with excavation equipment.

TABLE 3-1

PRELIMINARY SCREENING OF ZONES 1 TO 7 SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
Ex-Situ Treatment (continued)	Biological	Bioslurry Reactor/Biopile	Treatment of soil in a bioslurry reactor or biopile under controlled conditions using natural or cultured microorganisms to biodegrade organic COCs.	Retain. Could be effective for the removal of organic COCs. However, this technology would not remove metallic COCs.
		Onsite Landfarming	Spreading and tilling of contaminated soil into layers of clean surface soil to aerate and biodegrade organic COCs.	Eliminate. Although this technology would be effective for the treatment of organic COCs, it would not remove metallic COCs, and no suitable area is available for this purpose.
	Physical/ Chemical	Soil Washing/Solvent Extraction	Use of water or other solvents to remove COCs by flushing, collecting, and treating/disposing of the waste fluids.	Retain. Although this technology would not be very effective to remove organic COCs, it could be effective to treat soil where only metallic COCs are present.
		Chemical Stabilization/ Solidification	Mixing of chemical agents to chemically stabilize the COCs and/or solidify the surrounding soil matrix.	Retain. Would effectively immobilize metallic COCs and could also immobilize organic COCs.
	Thermal	Low-Temperature Thermal Desorption (LTTD)	Use of low to moderate temperatures to evaporate COCs and remove them from soil.	Retain. Although it probably would not adequately treat metallic COCs, this technology would be particularly effective for the treatment of soil where only organic COCs are present.
		Incineration	Use of high temperatures to destroy COCs.	Retain. Would destroy organic COCs and could evaporate/sublimate most of the metallic COCs.

TABLE 3-1

PRELIMINARY SCREENING OF ZONES 1 TO 7 SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
Disposal	Landfill	On site Landfilling	Disposal of excavated soil in an on-base landfill.	Eliminate. No suitable on-base area is available for this purpose.
		Off site Landfilling	Disposal of excavated soil and treatment residues in an off-base permitted treatment, storage, and disposal facility (TSDF).	Retain. Would provide environmentally safe disposal of contaminated soil.

TABLE 3-2

PRELIMINARY SCREENING OF ZONES 1, 4, AND 7 GROUNDWATER REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

General Response Action	Technology	Process Option	Description	Screening Comment
No Action	None	Not Applicable	No activities conducted at sites to address contamination.	Required by law. Retain as a baseline for comparison to other technologies.
Limited Action	Land Use Controls (LUCs)	Institutional Controls	Administrative action to restrict current and future use of groundwater.	Retain. Would not remove chemicals of concern (COCs) but could minimize human exposure to contaminated groundwater.
	Monitoring	Sampling and Analysis	Periodic sampling and analysis of groundwater and other media.	Retain. Would be required to evaluate potential migration of COCs and/or progress of remediation.
	Natural Attenuation	Naturally Occurring Processes	Decrease in COC concentrations as a result of naturally occurring processes (dilution, dispersion, biodegradation).	Retain. COCs might be susceptible to natural attenuation, particularly total petroleum hydrocarbons (TPH) through biodegradation.
Containment	Vertical Barriers	Slurry Wall or Sheet Piling	Low-permeability wall formed in a perimeter trench to restrict horizontal migration of groundwater.	Eliminate. Would not remove COCs. Tidal influence, underground interferences (foundations, piping), and the lack of a relatively shallow impervious layer would make implementation of this technology impractical.
		Hydraulic Barrier	Use of extraction wells and/or collection trenches to restrict horizontal migration of groundwater.	Eliminate. Complex hydrogeologic conditions, particularly tidal influence, would significantly limit the effectiveness of this technology.

TABLE 3-2

PRELIMINARY SCREENING OF ZONES 1, 4, AND 7 GROUNDWATER REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

General Response Action	Technology	Process Option	Description	Screening Comment
Removal	Groundwater Extraction	Extraction Wells or Collection Trenches	Array of conventional pumping wells or permeable trenches used to remove contaminated groundwater.	Retain. Although subject to the same limitations as hydraulic barriers, this technology could be effective to remove contaminated groundwater. Wells would be better suited than trenches for installation and operation at the Lower Subase. Extracted groundwater would have to be treated and/or disposed.
In-Situ Treatment	Biological	Aerobic or Anaerobic Bioremediation	Injection of oxygen- or hydrogen-releasing compounds (ORCs or HRCs) to promote subsurface aerobic or anaerobic conditions. Also injection of specialized bacterial cultures to supplement naturally occurring microorganisms.	Retain. The addition of an ORC and bacterial cultures would effectively remove TPH . ORC alone might also immobilize arsenic. Would not treat the other metals COCs (copper and lead).
		Phytoremediation	Removal of COCs through adsorption and metabolization by root systems of selected plants.	Eliminate. Although this technology would remove COCs, including TPH and metals, and is well adapted to the shallowness of the groundwater, its implementation would be incompatible with the planned continued use of the Lower Subase as an active Naval facility.
	Biophysical	In-Well Treatment (Bioslurping/ Bioventing)	Use of specialized well designs that combine biodegradation with in-well air sparging (AS) and air stripping.	Eliminate. Could be effective for the treatment of the relatively small areas of TPH contamination but would not be effective for any of the metals COCs.

TABLE 3-2

PRELIMINARY SCREENING OF ZONES 1, 4, AND 7 GROUNDWATER REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

General Response Action	Technology	Process Option	Description	Screening Comment
In-Situ Treatment (continued)	Physical/ Chemical	AS / Vapor Extraction (VE)	Volatilization and biodegradation enhancement through injection of air and extraction of vapors.	Eliminate. COCs, including the weathered TPH, are not particularly volatile, and this process could actually enhance their migration.
		Chemical Oxidation and Precipitation	Injection of oxidizing agents (ORC, percarbonate) and/or precipitation or stabilization agents (ammonium phosphate, iron oxyhydroxide) to de-solubilize and immobilize COCs.	Retain. Although this technology would probably not be as effective as bioremediation for the removal of TPH, it might be effective to immobilize metals COCs.
		Permeable Reactive Barriers (PRBs)	Use of trenches filled with reactive medium to intercept contaminated groundwater and remove or immobilize COCs.	Retain. Would probably not be effective for removal of TPH but could be effective for treatment of metals COCs.
Ex-Situ Treatment	Biological	Aerobic/Anaerobic	Use of fixed- or suspended-growth medium biological reactor under oxygen-rich or oxygen-deficient conditions to degrade COCs.	Retain. Aerobic bioremediation would be effective for the removal of TPH, particularly with the use of specialized microorganism cultures. Would not be effective to treat metals COCs.
	Physical/ Chemical	Filtration	Percolation of contaminated groundwater through a fixed porous medium (sand or paper) to capture suspended particles. Can be combined with chemical oxidation with the use of a reactive filter medium.	Retain. Would be effective for the removal of insoluble particles in groundwater. Oxidative filtration could be effective for the removal of metals COCs, particularly arsenic.
		Gravity Separation/ Flotation	Separation of light (flotation) and heavy (settling) suspended material in a quiescent vessel. Flotation can be enhanced with the use of a finely diffused air release.	Eliminate. This technology is typically best suited for the removal of much higher concentrations of insoluble material than are present in groundwater. Filtration is more effective for lower concentrations.

TABLE 3-2

PRELIMINARY SCREENING OF ZONES 1, 4, AND 7 GROUNDWATER REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

General Response Action	Technology	Process Option	Description	Screening Comment
Ex-Situ Treatment (continued)	Physical/ Chemical (continued)	Air Stripping	Contact of water with a countercurrent of air to remove volatile COCs.	Eliminate. COCs, including the weathered TPH, are not particularly volatile and would not be removed by this process.
		Adsorption	Removal of dissolved COCs via adsorption onto a bed of reactive material such as granular activated carbon (GAC) or alumina.	Retain. GAC adsorption would be effective for the removal of low concentrations of TPH. GAC or alumina adsorption could be effective for the removal of low concentrations of metals COCs, particularly arsenic.
		Chemical Oxidation	Contact with strong oxidation reagents such as ozone, hydrogen peroxide, or potassium permanganate.	Retain. Could immobilize arsenic and lead. However would probably not be effective for copper and TPH.
		Chemical Precipitation	Use of chemical reagents to bring COCs out of solution so they can be physically removed.	Retain. Would be effective to remove lead. However would not remove TPH and would probably not be effective to remove the low concentrations of arsenic and copper.
		Ion Exchange	Ions, held by electrostatic forces to charged functional groups on the ion exchange resin surface, are exchanged for ions of similar charge in a water stream.	Eliminate. Would not be effective to remove TPH. High groundwater salinity would prevent effective removal of low concentrations of metals COCs.
		Reverse Osmosis/ Ultrafiltration	Use of high pressure and membranes to remove dissolved organic or inorganic chemicals from water.	Eliminate. Would not be effective for removal of high concentrations of weathered TPH. High groundwater salinity would prevent effective removal of low concentrations of metals COCs.

TABLE 3-2

PRELIMINARY SCREENING OF ZONES 1, 4, AND 7 GROUNDWATER REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

General Response Action	Technology	Process Option	Description	Screening Comment
Ex-Situ Treatment (continued)	Physical/ Chemical (continued)	Electrodialysis/ Electrolytic Recovery	Use of electric current with specialized membrane (electrodialysis) or recovery electrodes (electrolytic recovery) to separate and remove ionic COCs.	Eliminate. Would not remove TPH. High groundwater salinity would prevent effective removal of low concentrations of metals COCs.
		Coagulation/ Flocculation	Use of chemical reagents to neutralize surface charges and promote attraction of colloidal particles to facilitate settling.	Eliminate. Based on available groundwater analytical data this level of treatment would not be necessary to remove suspended solids from extracted groundwater.
		pH Adjustment/ Neutralization	Use of acids or bases to adjust pH conditions for optimum effectiveness of a given technology or to meet regulatory requirements.	Retain. Would not of itself remove COCs, but might be required for maximum efficiency of such technologies as chemical oxidation and precipitation.
Disposal	Surface Discharge	Direct Discharge	Discharge of treated water to a local water body (ditch, culvert, pond).	Retain. Treated groundwater could be discharged to the Thames River using existing storm sewers.
		Indirect on site Discharge	Discharge of extracted groundwater to an existing on site treatment facility.	Eliminate. The OT-10 oil/water separation facility is no longer operating, and the existing on-base sanitary waste treatment system is not available for this purpose.
		Indirect off site Discharge	Discharge of extracted groundwater to an off site publicly owned treatment works (POTW).	Retain. Groundwater could be discharged to the Lower Subase sanitary sewer system and from there to the Groton POTW. Pretreatment might be required.
	Subsurface Discharge	Reinjection	Use of injection wells or infiltration galleries to discharge treated groundwater underground.	Eliminate. No suitable reinjection areas are located reasonably close to the sites.

TABLE 3-3

PRELIMINARY SCREENING OF ZONE 4 SEDIMENT REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
No Action	None	Not Applicable	No activities conducted at the site to address contamination.	Required by law. Retain for baseline comparison to other technologies.
Limited Action	Land Use Controls (LUCs)	Institutional Controls: Deed or Land Use Restrictions	Administrative action using property deeds or other land use prohibitions to restrict future site activities.	Retain. Such restrictions are currently used and could effectively limit risks from exposure to contaminated sediment.
		Engineering Controls: Access Restrictions	Fencing, markers, warning signs, and monitoring to restrict site access.	Retain. Such restrictions are currently used and could effectively limit risks from exposure to contaminated sediment.
	Monitoring	Sampling and Analysis	Sampling and analysis of sediment for chemicals of concern (COCs).	Retain. Would allow evaluation of the progress of remedial actions.
	Natural Recovery	Naturally Occurring Processes	Reduction of risks from COCs as a result of naturally-occurring processes (e.g., bioturbation, dilution, dispersion, sedimentation, biodegradation, adsorption).	Retain. Naturally occurring processes might reduce risks from COCs, particularly sedimentation or biodegradation of polynuclear aromatic hydrocarbons (PAHs) or polychlorinated biphenyls (PCBs).
Containment	Capping	Soil/Multimedia Cover	Installation of a semi-permeable or impermeable barrier over contaminated sediment.	Retain. Could be used to isolate contaminated sediment.
Removal	Bulk Excavation	Excavation	Use of construction equipment such as backhoe, front-end loader, grade-all, etc. to remove contaminated sediment.	Eliminate. Would not be effective to remove sediment from bottom of river.
		Dredging	Use of land- or water-based mechanical or hydraulic dredging equipment for the removal of contaminated sediment.	Retain. Would be effective and implementable as a means of sediment removal
In-Situ Treatment	Enhanced Natural Recovery	Enhanced Naturally Occurring Processes	Enhancement of naturally-occurring processes for the removal of COCs (e.g., addition of thin layer of clean sediment).	Retain. Could be more effective than un-enhanced natural recovery, particularly for the removal of organic COCs.

TABLE 3-3

PRELIMINARY SCREENING OF ZONE 4 SEDIMENT REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
In-Situ Treatment (continued)	Biological	Enhanced Bioremediation	Bioenhancement with injection of specialized microorganisms and/or biostimulation with injection of oxygen- or hydrogen-release compounds (ORCs or HRCs) to enhance naturally occurring biodegradation of COCs.	Eliminate. Although biological treatment could remove PAHs, it is not nearly as well proven for the removal of PCBs, especially for sediment in a hard-to-control in-situ environment. Inorganic COCs are non-biodegradable.
	Physical/ Chemical	Chemical Stabilization/ Solidification	Mixing of chemical agents in the vadose zone to chemically stabilize the COCs and/or solidify the surrounding sediment matrix.	Eliminate. Although this technology could immobilize organic and inorganic COCs, its application to the in-situ treatment of sediment is unproven, and it would be very impractical to implement underwater.
Ex-Situ Treatment	Pretreatment	Dewatering	Removal of free water from wet material through passive gravity-driven stockpiling, mechanical expression (filter press, belt filter press, centrifuge), or addition of drying and/or bulking agents.	Retain. On site or off site dewatering would be required for the pretreatment of dredged sediment.
	Biological	Bioslurry Reactor/Biopile	Treatment of sediment in a bioslurry reactor or biopile under controlled conditions using natural or cultured microorganisms to biodegrade organic COCs.	Retain. Could be effective for the removal of organic COCs. However, this technology would not remove inorganic COCs.
		Onsite Landfarming	Spreading and tilling of contaminated sediment into layers of clean surface sediment to aerate and biodegrade organic COCs.	Eliminate. Although this technology would be effective for the treatment of the organic COCs, it would not remove the inorganic COCs, and no suitable area is available for this purpose.

TABLE 3-3

PRELIMINARY SCREENING OF ZONE 4 SEDIMENT REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
Ex-Situ Treatment (continued)	Physical/ Chemical	Sediment Washing/ Solvent Extraction	Use of water or other solvents to remove COCs by flushing, collecting, and treating/disposing of the waste fluids.	Retain. Although this technology would not be very effective to remove organic COCs, it could be effective to treat sediment where only inorganic COCs are present.
		Chemical Stabilization/ Solidification	Mixing of chemical agents to chemically stabilize the COCs and/or solidify the surrounding sediment matrix.	Retain. Would effectively immobilize inorganic COCs and could also immobilize organic COCs.
	Thermal	Low-Temperature Thermal Desorption (LTTD)	Use of low to moderate temperatures to evaporate COCs and remove them from sediment.	Retain. Although it probably would not adequately treat inorganic COCs, this technology would be particularly effective for the treatment of sediment where only organic COCs are present.
		Incineration	Use of high temperatures to destroy COCs.	Retain. Would destroy organic COCs and could evaporate/sublimate most of the inorganic COCs.
Disposal	Landfill	On site Landfilling	Disposal of removed sediment in an on-base landfill.	Eliminate. No suitable on-base area is available for this purpose.
		Off site Landfilling	Disposal of removed sediment and treatment residues in an off-base permitted treatment, storage, and disposal facility (TSDF).	Retain. Would provide environmentally safe disposal of contaminated sediment.
		Contained Aquatic Disposal (CAD)	Burial of removed sediment in a specially designed underwater containment cell.	Retain. This technology has been successfully used for the effective disposal of dredged sediment at NSB-NLON.

TABLE 3-4

PRELIMINARY SCREENING OF ZONE 1 LNAPL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

General Response Action	Technology	Process Option	Description	Screening Comment
No Action	None	Not Applicable	No activities conducted at site to address contamination.	Required by law. Retain as a baseline for comparison to other technologies.
Limited Action	Land Use Controls (LUCs)	Institutional Controls	Administrative action to restrict current and future use of groundwater.	Retain. Would not remove light non aqueous phase layer (LNAPL) but could minimize human exposure to it.
	Monitoring	Sampling and Analysis	Periodic sampling and analysis of groundwater and other media.	Retain. Would be required to evaluate potential migration of LNAPL and/or progress of remediation.
	Natural Attenuation	Naturally Occurring Processes.	Decrease in chemical of concern (COC) concentrations as a result of naturally occurring processes (dilution, dispersion, biodegradation).	Retain. LNAPL is made up of total petroleum hydrocarbons (TPH) that would be susceptible to natural attenuation, principally through biodegradation.
Containment	Vertical Barriers	Slurry Wall or Sheet Piling	Low-permeability wall formed in a perimeter trench to restrict horizontal migration of groundwater.	Eliminate. Would not remove LNAPL. Tidal influence, underground interferences (foundations, piping), and the lack of a relatively shallow impervious layer would make implementation of this technology impractical.
		Hydraulic Barrier	Use of extraction wells and/or collection trenches to restrict horizontal migration of groundwater.	Eliminate. Complex hydrogeological conditions, particularly tidal influence, would significantly limit the effectiveness of this technology.

TABLE 3-4

PRELIMINARY SCREENING OF ZONE 1 LNAPL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

General Response Action	Technology	Process Option	Description	Screening Comment
Removal	Skimming	Active or Passive Skimming	Mechanical removal of LNAPL accumulating in wells through induction of a hydraulic gradient (skimming pumps) or in a static fashion (hydrophobic capture or adsorption).	Retain. Although this is not a very aggressive removal technology, skimming could effectively control the LNAPL layer and prevent its migration. Skimmed LNAPL would have to be disposed.
	Excavation	Excavation and Mechanical Removal	Removal of unsaturated soil to expose LNAPL layer that can then be mechanically removed (pumping or vacuum).	Retain. Potentially the most effective approach for LNAPL removal, particularly in areas of shallow groundwater such as the Lower Subase.
In-Situ Treatment	Biological	Enhanced Aerobic Bioremediation	Injection of oxygen releasing compounds (ORCs) to promote subsurface aerobic conditions. Also injection of specialized bacterial cultures to supplement naturally occurring microorganisms.	Retain. The addition of an ORC would effectively promote the aerobic degradation of the TPH that makes up LNAPL. Injection of specialized bacteria cultures could also accelerate bioremediation.
		Phytoremediation	Removal of LNAPL through adsorption and metabolization by roots system of selected plants.	Eliminate. The effectiveness of this technology would be limited with LNAPL, and its implementation would be incompatible with the planned continued use of the Lower Subase.
	Biophysical	In-Well Treatment (multi-phase extraction (MPE)/ Bioslurping)	Use of specialized well designs that combine biodegradation with in-well air sparging (AS) and air stripping.	Retain. Could be effective for the treatment of the relatively small areas of LNAPL contamination.

TABLE 3-4

PRELIMINARY SCREENING OF ZONE 1 LNAPL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

General Response Action	Technology	Process Option	Description	Screening Comment
In-situ Treatment (continued)	Physical/ Chemical	AS / Vapor Extraction (VE)	Volatilization and biodegradation enhancement through injection of air and extraction of vapors.	Eliminate. Several components of LNAPL are not particularly volatile. This technology would be particularly difficult to accurately control in the complex subsurface environment of the Lower Subase, and it could actually enhance LNAPL migration.
	Thermal	Electrical Resistance Heating (ERH)	In-situ heating of soil and groundwater with electrodes to evaporate and/or steam-strip LNAPL.	Retain. This technology has proven effective for removal of LNAPL.
Ex-Situ Treatment	Biological	Bioslurry Reactor/Biopile	Treatment of LNAPL and/or LNAPL-impregnated soil in a bioslurry reactor or biopile under controlled conditions using natural or cultured microorganisms to biodegrade TPH.	Retain. The high concentrations of weathered TPH present in LNAPL might be biodegraded under the carefully controlled and optimum conditions provided by a bioslurry reactor or biopile.
		Onsite Landfarming	Spreading and tilling of LNAPL and/or LNAPL-impregnated soil into layers of clean surface soil to aerate and biodegrade organic TPH.	Eliminate. The biological treatment conditions provided by this technology would not be effective enough for the biodegradation of the high concentrations of weathered TPH present in LNAPL and no suitable area is available for this purpose.
	Thermal	Low-Temperature Thermal Desorption (LTTD)	Use of low to moderate temperatures to evaporate LNAPL and remove it from soil.	Retain. Although this technology would not destroy LNAPL, it would be effective for the treatment of LNAPL-impregnated soil.
		Incineration	Use of high temperatures to destroy LNAPL.	Retain. Would effectively destroy LNAPL.

TABLE 3-4

PRELIMINARY SCREENING OF ZONE 1 LNAPL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

General Response Action	Technology	Process Option	Description	Screening Comment
Disposal	Recycle/Reuse	Off site Oil Recycling	Sending of removed LNAPL to an off site oil recycle facility.	Retain. Could provide a useful and environmentally safe disposal option for LNAPL.
	Landfill	On site Landfilling	Disposal of removed LNAPL and/or LNAPL-impregnated soil in an on-base landfill.	Eliminate. LNAPL is not appropriate for landfilling, and no suitable on-base area is available for this purpose.
		Off site Landfilling	Disposal of removed LNAPL and/or LNAPL-impregnated soil in an off-base permitted treatment, storage, and disposal facility (TSDF).	Retain. Although this technology would not be appropriate for disposal of LNAPL, it would be effective for the disposal of pretreated LNAPL-impregnated soil.

4.0 ASSEMBLY AND DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

4.1 INTRODUCTION

This section presents an evaluation of each remedial alternative with respect to the CERCLA COCs identified in Section 2.0 and in accordance with the criteria described in the NCP of 40 CFR Part 300, as revised in 1990. Most of these same criteria will also be used, but separately, for the evaluation of each remedial alternative with respect to TPH. These criteria and their relative importance are described in the following subsections.

4.1.1 Evaluation Criteria

In accordance with the NCP (40 CFR 300.430), the following nine criteria are used for the evaluation of remedial alternatives:

- Overall Protection of Human Health and the Environment
- Compliance with ARARs
- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume through Treatment
- Short-Term Effectiveness
- Implementability
- Cost
- State Acceptance
- Community Acceptance

The last two criteria, State Acceptance and Community Acceptance, cannot be assessed until after the FS is complete and comments have been received from the State and public.

Overall Protection of Human Health and the Environment

Alternatives must be assessed for adequate protection of human health and environment, in both the short and long term, from unacceptable risks posed by CERCLA COCs present at the site by eliminating, reducing, or controlling exposure to levels exceeding PRGs. Overall protection draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. A separate assessment will also be provided for the amount of protectiveness provided by each alternative with respect to TPH contamination.

Compliance with ARARs

Alternatives must be assessed to determine whether they attain ARARs under federal environmental laws and state environmental or facility siting laws. This criterion does not apply to the evaluation of TPH because there are no ARARs for TPH. However, a separate assessment of the degree of compliance of alternatives with appropriate TPH-related State regulations (such as the Connecticut RSRs) will be provided in the analysis of other evaluation criteria, particularly Overall Protection of Human Health and the Environment and Long-Term Effectiveness.

If one or more regulations that are applicable cannot be complied with, a waiver must be invoked. Grounds for invoking a waiver would depend on the following circumstances:

- The alternative is an interim measure and will become part of a total remedial action that will attain the ARAR.
- Compliance will result in greater risk to human health and the environment.
- Compliance is technically impracticable from an engineering perspective.
- The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method or approach.
- A state requirement has not been consistently applied, or the state has not demonstrated the intention to consistently apply the promulgated requirement, in similar circumstances at other remedial actions within the state.
- For Superfund-financed response actions only, an alternative that attains the ARAR will not provide a balance between the need for protection of human health and the environment at the site and the availability of fund monies to respond to other sites that may present threats to human health and the environment.

Long-Term Effectiveness and Permanence

Alternatives must be assessed for the long-term effectiveness and permanence they offer for the remediation of CERCLA COCs, along with the degree of certainty that the alternative will be successful. Factors to be considered as appropriate include the following:

Magnitude of Residual Risk

Risk posed by untreated waste or treatment residuals at the conclusion of remedial activities. The characteristics of residuals should be considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

Adequacy and Reliability of Controls

Controls such as containment systems and institutional controls that are necessary to manage treatment residuals and untreated waste must be shown reliable. In particular, the uncertainties associated with land disposal for providing long-term protection from residuals; assessment of the potential need to replace technical components of the alternative such as a cap, slurry wall, or treatment system; and potential exposure pathways and risks posed should the remedial action need replacement must be evaluated.

A similar but separate assessment will also be provided of the long-term effectiveness and permanence achieved by alternatives for the remediation of TPH.

Reduction of Toxicity, Mobility, or Volume through Treatment

The degree to which the alternative employs recycling or treatment that reduces the toxicity, mobility, or volume of CERCLA COCs will be assessed, including how treatment is used to address the principal threats posed by the site. Factors that shall be considered, as appropriate, include the following:

- The treatment or recycling processes the alternative employs and the materials they will treat.
- The amount of hazardous substances, pollutants, or contaminants that will be destroyed, treated, or recycled.
- The degree of expected reduction in toxicity, mobility, or volume of waste due to treatment or recycling and the specification of which reduction(s) is occurring.
- The degree to which the treatment is irreversible.
- The type and quantity of residuals that will remain following treatment considering the persistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their constituents.
- The degree to which treatment reduces the inherent hazards posed by principal threats at the site.

A similar, but separate assessment will also be provided of the degree to which the alternatives use treatment that reduces the toxicity, mobility, or volume of TPH.

Short-Term Effectiveness

The short-term impacts of the alternative will be assessed considering the following:

- Short-term risks that might be posed to the community during implementation.
- Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures.
- Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation.
- Time until protection is achieved.

Because evaluation of this criterion is not contaminant dependant, a single evaluation will be provided for each alternative which will be valid for CERCLA COCs as well as TPH.

Implementability

The ease or difficulty of implementing the alternatives will be assessed by considering the following types of factors, as appropriate:

- Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, reliability of the technology, ease of undertaking additional remedial actions, and ability to monitor the effectiveness of the remedy.
- Administrative feasibility, including activities needed to coordinate with other offices and agencies, and the ability and time required to obtain any necessary approvals and permits from other agencies (for off-site actions).
- Availability of services and materials, including the availability of adequate off-site treatment, storage capacity, and disposal capacity and services; availability of necessary equipment and specialists, and provisions to ensure any necessary additional resources; availability of services and materials; and availability of prospective technologies.

Because evaluation of this criterion is not contaminant dependant, a single evaluation will be provided for each alternative which will be valid for CERCLA COCs as well as TPH.

Cost

Capital costs include both direct and indirect costs. Annual O&M costs will be provided. A net present worth (NPW) of the capital and O&M costs will also be provided. Typically, the cost estimate accuracy range is plus 50 percent to minus 30 percent.

No separate cost will be provided for the remediation of TPH.

4.1.2 Relative Importance of Criteria

Among the nine criteria, the threshold criteria for the remediation of CERCLA COCs are the following:

- Overall Protection of Human Health and the Environment
- Compliance with ARARs (excluding those that may be waived)

The threshold criteria must be satisfied for an alternative to be eligible for selection.

Among the remaining criteria, the following five criteria are considered to be the primary balancing criteria for the remediation of CERCLA COCs:

- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume Through Treatment
- Short-Term Effectiveness
- Implementability
- Cost

The balancing criteria are used to weigh the relative merits of alternatives.

The remaining two of the nine criteria, State Acceptance and Community Acceptance, are considered to be modifying criteria that must be considered during remedy selection. These last two criteria can be evaluated after the document has been reviewed by the State of Connecticut and the Proposed Plan has been discussed at a public meeting, respectively. Therefore, this document addresses only seven of the nine criteria.

There is no ranking of criteria for the evaluation of TPH.

4.1.3 Selection of Remedy

The selection of a remedy is a two-step process. The first step consists of identification of a preferred alternative and presentation of the alternative in a Proposed Plan to the community for review and comment. The preferred alternative must meet the following criteria for the remediation of CERCLA COCs:

- Protection of human health and the environment.
- Compliance with ARARs unless a waiver is justified.
- Cost effectiveness in protecting human health and environment and in complying with ARARs.
- Utilization of permanent solutions and alternate treatment technologies or resource recovery technologies to the maximum extent practicable.

The preferred alternative must also meet the same criteria for the remediation of TPH, except that no compliance with ARARs is required because there are no ARARs. Instead, the preferred alternative must comply with the appropriate TPH-related State regulations.

The second step consists of the review of comments on the Proposed Plan and determination of whether the preferred alternative continues to be the most appropriate remedial action for the site, in consultation with the State of Connecticut.

4.2 ASSEMBLY AND DETAILED ANALYSIS OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 1

The following soil remedial alternatives have been developed for Zone 1 of the Lower Subase:

Alternative S-1.1:	No Action.
Alternative S-1.2:	LUCs (Engineering and Institutional Controls) and Monitoring.
Alternative S-1.3:	In-Situ Treatment (Enhanced Bioremediation) to Meet I/C DECs and PMCs, LUCs (Engineering and Institutional Controls), and Monitoring.
Alternative S-1.4:	Excavation to Meet I/C DECs and PMCs, Off-Site (LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring.
Alternative S-1.5:	Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (LTTD, Landfilling, and Incineration).

Alternative S-1.1 was developed and analyzed to serve as a baseline for other alternatives, as required by CERCLA and the NCP. Alternative S-1.2 was developed and analyzed to evaluate LUCs with engineering

and institutional controls and monitoring under current site use. Alternatives S-1.3, S-1.4, and S-1.5 were developed and analyzed to evaluate a range of remedial actions to address environmental concerns under current site use. Alternative S-1.6 was developed and analyzed to evaluate contaminated soil cleanup for hypothetical future unrestricted site use. Descriptions and detailed analyses of these alternatives are provided in the following sections.

4.2.1 Alternative S-1.1: No Action

4.2.1.1 Description

No Action would not include any action under CERCLA and any existing administrative or engineering environmental controls would not be an enforceable part of a CERCLA remedy. This alternative is required under CERCLA to establish a basis for comparison with other alternatives. The only activity under this alternative would be the performance of five-year reviews. This alternative cannot be chosen because contamination remains on site.

4.2.1.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-1.1 would not be protective of human health and the environment under CERCLA. Potentially unacceptable risk to current site users would be allowed to occur as a result of direct exposure to contaminated soil because the asphalt pavement that covers most of this soil would not be maintained and the disturbance of areas of contaminated soil would not be regulated. There would also be no protection against the even greater risk that would result from exposure to contaminated soil by a wider range of human and ecological receptors if hypothetical future residential use of the site was allowed. In addition, Alternative S-1.1 could allow unacceptable human health and environmental risks to develop because the potential for migration of PAHs from soil to groundwater would continue to exist and because no monitoring would be performed to assess this potential migration. Alternative S-1.1 would not achieve the soil RAOs.

Compliance with ARARs and TBCs

Alternative S-1.1 would not comply with chemical-specific ARARs and TBCs because no action would be taken to reduce concentrations of PAHs in soil. Because Alternative S-1.1 would not involve any action, location- and action-specific ARARs and TBCs would not be relevant. A summary of Alternative S-1.1's compliance with chemical-specific ARARs and TBCs is provided in Table 4-1.

Long-Term Effectiveness and Permanence

Alternative S-1.1 would not be long-term effective and permanent. Paved surfaces would not be maintained and no controls would restrict contaminated soil disturbance, which could result in unacceptable risks to human receptors under current I/C site use. No controls would prevent hypothetical future residential development, which could result in even greater risks to a wider range of human and ecological receptors. In addition, because no monitoring would be performed, there would be no assessment of the potential migration of PAHs from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative S-1.1 would not reduce the toxicity, mobility, or volume of PAHs in soil through treatment because no treatment would occur.

Short-Term Effectiveness

Because no action would occur, implementation of Alternative S-1.1 would not result in any short-term risks to on-site workers or adversely impact the local community or the environment.

Alternative S-1.1 would not achieve the soil RAOs.

Implementability

Technically, Alternative S-1.1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Cost

The estimated costs for Alternative S-1.1 are as follows:

Capital Cost	$0
NPW of O&M Costs	$55,000 (30 years)
NPW	$55,000 (30 years)

These costs have been rounded to the nearest $1,000 to reflect the preliminary nature of the estimates. A detailed cost estimate for this alternative is provided in Appendix E.

4.2.2 Alternative S-1.2: LUCs (Engineering and Institutional Controls) and Monitoring

4.2.2.1 Description

Alternative S-1.2 would consist of two major components: (1) LUCs with engineering and institutional controls and (2) monitoring.

Component 1: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 1. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of building foundations (particularly that of Building 29, which cover a significant part of Zone 1) and paved areas. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 2: Monitoring

A groundwater monitoring program would be developed and implemented to evaluate the long-term potential migration of PAHs from soil to groundwater.

For the purpose of this FS, it was assumed that four groundwater samples would be regularly collected from strategic locations to be identified and that the collected samples would be analyzed for PAHs. Monitoring frequency would be quarterly for the first 2 years, semi-annual for the next 2 years, and annual thereafter.

Reviews would be performed every 5 years to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary. These site reviews are required because this alternative would allow PAHs to remain in soil at concentrations in excess of their PRGs for I/C direct exposure and pollutant mobility.

4.2.2.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-1.2 would be protective of human health and the environment under CERCLA. Unacceptable risk from direct exposure of current site users to contaminated surface soil would be minimized by the existing building foundations (particularly Building 29) and asphalt pavement that cover most of the soil. LUCs ensuring regular maintenance of these foundations and paved areas and regulating the disturbance of contaminated soil would be protective by minimizing uncontrolled exposure of current site users to contaminated soil. In addition, LUCs restricting Zone 1 to its current I/C use would be protective by preventing the even greater risks that would result from exposure to contaminated soil by a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration of PAHs from soil to groundwater. Alternative S-1.2 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-1.2 would also indirectly achieve Soil RAO No.4.

Compliance with ARARs and TBCs

Alternative S-1.2 would comply with location- and action-specific ARARs and TBCs. Alternative S-1.2 would also comply with federal chemical-specific TBCs (there are no federal chemical-specific ARARs) and with the DECs and PMCs mandated by Connecticut RSRs. A summary of Alternative S-1.2's compliance with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 4-2, 4-3, and 4-4, respectively.

Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-1.2 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil. See Appendix D.1.3 for engineering control calculations.

Long-Term Effectiveness and Permanence

Alternative S-1.2 would be long-term effective and permanent under CERCLA. Although soil concentrations of PAHs would not be actively reduced, risks to human health and the environment would be minimized through LUCs and monitoring. LUCs that would ensure regular maintenance of building foundations and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 1 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Long-term monitoring would effectively detect potential migration of PAHs from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-1.2 would not reduce the toxicity, mobility, or volume of PAHs in soil through treatment because no treatment would occur.

Short-Term Effectiveness

Alternative S-1.2 would have minimal short-term effectiveness concerns. Any exposure of workers to contaminated soil during the maintenance and sampling of groundwater monitoring wells would be minimized by wearing of appropriate PPE and complying with site-specific health and safety procedures. Implementation of LUCs and monitoring would not adversely impact the surrounding community or the environment.

Alternative S-1.2 could be implemented within approximately 3 months and would achieve Soil RAOs Nos. 1 to 3 upon implementation. By preventing hypothetical future residential development, Alternative S-1.2 would also indirectly achieve Soil RAO No. 4 upon implementation. Alternative S-1.2 would meet none of the Zone 1 soil PRGs for I/C direct exposure and pollutant mobility, but these cleanup criteria would not apply because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-1.2 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

The technical implementability of Alternative S-1.2 would be easy. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of groundwater could be readily performed.

The administrative aspects of Alternative S-1.2 would be simple to implement. No construction permit issued by NSB-NLON Department of Public Works (DPW) would be required for this alternative. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy

would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all these activities are readily available.

Cost

The estimated costs for Alternative S-1.2 are as follows:

Capital Cost	$70,000
NPW of O&M Costs	$415,000 (30 years)
NPW	$485,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.2.3 Alternative S-1.3: In-Situ Treatment (Enhanced Bioremediation) to Meet DECs and PMCs for I/C Site Use, LUCs (Engineering and Institutional Controls), and Monitoring

4.2.3.1 Description

Alternative S-1.3 would consist of three major components: (1) in-situ treatment to meet DECs and PMCs for I/C site use, (2) LUCs with engineering and institutional controls, and (3) monitoring.

Component 1: In-Situ Treatment to Meet I/C DECs and PMCs

Areas of soil with mass concentrations of PAHs greater than either its I/C DEC (1 mg/kg) to a depth of 2 feet bgs (paved area), or than its Zone 1 Alternative GB PMC for I/C site use (10 mg/kg) in the remainder of the unsaturated zone would be treated via in-situ enhanced bioremediation. The area that exceeds the I/C DEC is estimated to extend over approximately 33,200 square feet to a depth of 2 feet bgs along the northwestern and western boundaries of Zone 1. Within that area, the area that exceeds the Alternative GB PMC for I/C site use is estimated to extend over approximately 5,600 square feet for an additional depth of 3 feet (total depth of 5 feet bgs) in the vicinity of soil sampling point TB2-1RI, and another area that is estimated to extend over approximately 100 square feet for an additional depth of 6 feet (total depth of 8 feet bgs) in the vicinity of soil sampling point TB4-1RI. Estimated surface areas and volumes of soil with concentrations of COCs greater than I/C PRGs are computed in Appendix C and shown on Figure 4-1. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of contaminated soil.

In-situ bioremediation would consist of using ORC to enhance the growth of indigenous microorganisms and augment the natural aerobic biodegradation of PAHs in soil. For treatment of contaminated soil to a depth of up to 3 feet, it was assumed that a backhoe would be used to blend an ORC such as magnesium peroxide with the soil to be treated. For deeper applications, an LDA typically 6 to 10 feet in diameter would be used to blend the ORC with the soil. Each application of the LDA would generate a column of treated soil approximately 6 to 10 feet in diameter, and this would be repeated with a slight column-to-column overlap until the entire contaminated soil area has been treated. The treated areas would be repaved to match original surface conditions. It is estimated that a single application would be required. An estimated total of 2,800 cubic yards of soil would be treated in this way by blending in magnesium peroxide as a 8-percent (by weight) solution at the rate of approximately 10 pounds of dry magnesium peroxide per pound of PAHs to be removed, for a total estimated use of approximately 5,400 pounds of dry magnesium peroxide (or approximately 7,500 gallons of 8-percent solution). The blending action and addition of ORC would result in an increase of the volume of treated soil of approximately 280 cubic yards. Because the bioremediation process would take at least 1 year to complete, this incremental volume of soil must be kept on site and dispersed through appropriate regrading as may be necessary to accommodate existing buildings and other structures. The site-specific effectiveness of this technology and the exact design of the treatment system would be verified through treatability testing prior to implementation. Computations of treated soil volumes are provided in Appendix C. Conceptual design calculations for in-situ bioremediation are provided in Appendix D.

Prior to treatment, a detailed survey would be made of underground obstacles (e.g., underground pipes or cables) in the area to be treated and, when practical, these obstacles would be moved. If obstacles prevent the use of a blending auger in certain areas and if moving of these obstacles is not practical, the ORC could still be manually worked into the soil to be treated using hand tools such as shovels, provided that the areas to be so treated are relatively small in size. Accordingly, it is assumed for the purpose of this FS that underground obstacles would not actually prevent the implementation of in-situ enhanced bioremediation.

Following treatment, confirmation samples would be collected beneath and around the treated area to verify that all contaminated soil has been treated. Additional confirmation samples would also be collected from the treated area within approximately one year to verify that PAHs have been removed.

Component 2: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 1. One of the principal engineering controls that would be specified in the LUC RD would be the regular

maintenance of building foundations that cover inaccessible and/or environmentally isolated soil which cannot be treated. Similarly, another engineering control would be specified for the regular maintenance of the existing paved areas such that the assumptions used for the alternative PMC calculation are still applicable. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 3: Monitoring

Long-term groundwater monitoring would be conducted to confirm that soil contaminants are not mobilizing and migrating to groundwater at unacceptable concentrations.

4.2.3.2 Detailed Analysis

Overall Protection of Human Health and Environment

Alternative S-1.3 would be protective of human health and the environment under CERCLA. In-situ treatment with enhanced bioremediation would be protective because it would actively remove soil with concentrations of PAHs to which current site users should not be exposed and that could promote migration of this COC from soil to groundwater. LUCs ensuring the regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by minimizing uncontrolled exposure of current site users to contaminated soil. In addition, LUCs restricting Zone 1 to its current I/C use would be protective by preventing the even greater risks that would result from exposure to contaminated soil by a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration of PAHs from soil to groundwater. Alternative S-1.3 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-1.3 would also indirectly achieve Soil RAO No.4.

Compliance with ARARs and TBCs

Alternative S-1.3 would comply with chemical-, location- and action-specific ARARs and TBCs, as summarized in Tables 4-5, 4-6, and 4-7, respectively.

Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-1.3 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT

RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil that could not be treated.

Long-Term Effectiveness and Permanence

Alternative S-1.3 would be long-term effective and permanent under CERCLA. In-situ treatment with enhanced bioremediation would effectively remove PAHs from treated soil and prevent unacceptable human health risk from exposure as well as migration of this COC from soil to groundwater. However, treatability testing would be highly recommended to verify the site-specific biodegradability of these PAHs. LUCs that would ensure regular maintenance of building foundations and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 1 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Long-term monitoring would effectively verify that PAH do not migrate from soil to groundwater.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternative S-1.3 would address CERCLA risks by reducing the toxicity, mobility and volume of PAHs in soil through in-situ enhanced bioremediation. An estimated 2,800 cubic yards of PAH-contaminated soil would be permanently and irreversibly treated by this technology.

Short-Term Effectiveness

Implementation of Alternative S-1.3 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during in-situ treatment activities and also as a result of monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-1.3 would have no adverse impact on the surrounding community or the environment.

Alternative S-1.3 could be implemented within approximately 9 months and would achieve Soil RAOs Nos. 1 to 3 upon implementation. By preventing hypothetical future residential development, Alternative S-1.3 would also indirectly achieve Soil RAO No. 4 upon implementation. Alternative S-1.3 would meet the Zone 1 soil PAHs PRGs for I/C direct exposure and pollutant mobility within an estimated 3 to 5 years. In addition, these cleanup criteria would not apply to leftover areas of inaccessible and/or environmentally isolated contaminated soil that could not be treated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-1.3 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

Alternative S-1.3 would be technically implementable. Contractors qualified to perform in-situ enhanced bioremediation are readily available. Very careful planning and execution would be required to prevent interference with ongoing activities at the Lower Subase. In addition, implementation of in-situ treatment would be significantly hindered, and might even be prevented, by the presence of many underground structures such as utility lines and existing and former building foundations. Nonetheless, as previously mentioned, it is assumed for the purpose of this FS that ongoing base activities and underground obstacles would not actually prevent implementation of this alternative. The increase in soil volume resulting from soil blending and ORC addition would also require regrading of the areas of treated soil to accommodate existing buildings and other structures. Treatability testing would be required to verify site-specific effectiveness and confirm operating parameters prior to implementation. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of soil and groundwater could be readily performed.

The administrative aspects of Alternative S-1.3 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for the in-situ treatment activities. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all these activities are readily available.

Cost

Estimated costs for Alternative S-1.3 are as follows:

Capital Cost	$1,186,000
NPW of O&M Costs	$421,000 (30 years)
NPW	$1,607,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.2.4 Alternative S-1.4: Excavation to Meet DECs and PMCs for I/C Site Use, Off-Site Disposal (LTTD and Landfilling), LUCs, and (Engineering and Institutional Controls) Monitoring

4.2.4.1 Description

Alternative S-1.4 would consist of four major components: (1) excavation to meet DECs and PMCs for I/C site use, (2) off-site disposal of excavated soil, (3) LUCs with engineering and institutional controls, and (4) monitoring.

Component 1: Excavation to Meet DECs and PMCs for I/C Site Use

Areas of soil with mass concentrations of PAHs greater than its I/C DEC (1 mg/kg) to a depth of 2 feet bgs (paved area), or than its Zone 1 Alternative GB PMC for I/C site use (10 mg/kg) in the remainder of the unsaturated zone would be excavated to address CERCLA risks. The area that exceeds the I/C DEC is estimated to extend over approximately 33,200 square feet to a depth of 2 feet bgs along the northwestern and western boundaries of Zone 2. Within that area, the area that exceeds the Alternative GB PMC for I/C site use is estimated to extend over approximately 5,600 square feet for a further 3 feet of depth (total depth of 5 feet bgs) in the vicinity of soil sampling point TB2-1RI, and another area that is estimated to extend over approximately 100 square feet for an additional depth of 6 feet (total depth of 8 feet bgs) in the vicinity of soil sampling point TB4-1RI.. An estimated total of 3,100 cubic yards of contaminated soil and asphalt debris would be removed through excavation. Estimated surface areas and volumes of exceedance are computed in Appendix C and shown on Figure 4-1. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

Following excavation, confirmation samples would be collected from the bottoms and walls of the excavated area to verify that contaminated soil has been removed. After confirmation sampling is complete, the excavated area would be backfilled with clean soil and the site restored to its former condition.

Prior to excavation, a detailed survey would be made of underground obstacles (e.g., underground pipes or cables) in the area to be excavated and, when practical, these obstacles would be moved. If obstacles prevent the use of a normal backhoe or grade-all in certain areas and if moving of these obstacles is not practical, a small backhoe or hand shovels could be used provided that the area to be so excavated are relatively small in size. For the purpose of this FS, it is assumed that underground obstacles would not actually prevent the excavation of contaminated soil.

Because excavation of Zone 1 contaminated soil under this alternative would only extend to an estimated depth of 5 feet bgs, it is assumed that all excavation would take place above the water table and that only minimal shoring and no excavation dewatering would be required.

During excavation, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum. The excavated areas would be backfilled as soon as possible and on-site staging and stockpiling of excavated soil would be kept to a minimum. Any on-site stockpiles of excavated soil would be covered with an impervious synthetic liner at the end of each day's work.

Component 2: Off-Site Disposal

Because under this alternative soil would be excavated above the water table, it is assumed that the excavated soil would contain minimal free water and would not have to be pretreated by on-site dewatering prior to off-site transportation for disposal.

Asphalt pavement debris would be segregated and recycled or, if required, disposed at an off-site construction material landfill. For this alternative, it is estimated that 300 cubic yards of asphalt debris would be removed from Zone 1.

To determine the proper method of disposal of the remaining 2,800 cubic yards of excavated soil, composite samples would be collected at the rate of approximately one sample per 100 cubic yards and these samples would be analyzed for mass PAHs. Based on current soil characterization data, it is anticipated that the result of these analyses would show that the mass concentrations of PAHs of all of the excavated soil would be greater than its I/C DEC (1 mg/kg). Therefore, it is also anticipated that the 2,800 cubic yards of excavated soil would be identified as "high PAH" and would be disposed at an off-site TSDF where it would undergo treatment by LTTD prior to landfilling.

Computations of volumes for the above categories are provided in Appendix C.

During off-site transportation of contaminated soil, appropriate spill prevention and control measures would be taken and DOT regulations would be followed.

Component 3: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 1. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of building foundations that cover inaccessible and/or environmentally isolated soil which cannot be excavated. Similarly, another engineering control would be specified for the regular maintenance of the existing paved areas such that the assumptions used for the alternative PMC calculation are still applicable. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD. .

Component 4: Monitoring

Long-term groundwater monitoring would be conducted to confirm that soil contaminants are not mobilizing and migrating to groundwater at unacceptable concentrations.

4.2.4.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-1.4 would be protective of human health and the environment under CERCLA. Excavation and off-site disposal of soil with mass concentrations of PAHs greater than its I/C DEC or Zone 1 Alternative GB PMC for I/C site use would be protective by preventing unacceptable human health risk from exposure of current site users to contaminated soil and minimizing the potential for migration of PAHs from soil to groundwater. LUCs ensuring the regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by minimizing uncontrolled exposure of current site users to contaminated soil. In addition, LUCs restricting Zone 1 to its current I/C use would be protective by preventing the even greater risks that would result from exposure to contaminated soil by a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting potential migration of PAHs from soil to groundwater. Alternative S-1.4 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-1.4 would also indirectly achieve Soil RAO No.4.

Compliance with ARARs and TBCs

Alternative S-1.4 would comply with chemical-, location- and action-specific ARARs and TBCs, as summarized in Tables 4-8, 4-9, and 4-10, respectively.

Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-1.4 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil that could not be excavated.

Long-Term Effectiveness and Permanence

Alternative S-1.4 would be long-term effective and permanent under CERCLA. Excavation and off-site disposal would effectively and permanently remove soil with concentrations of PAHs to which current site users should not be exposed and such that these COCs could potentially migrate from soil to groundwater. LUCs that ensure the regular maintenance of building foundations and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 1 would effectively and permanently prevent even greater risk from direct exposure to contaminated soil. Long-term monitoring would effectively detect potential migration of PAHs from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-1.4 would not address CERCLA risks by reducing the toxicity, mobility, and volume of PAHs in soil through treatment.

Short-Term Effectiveness

Implementation of Alternative S-1.4 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during soil excavation. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-1.4 could also have a minimal adverse impact on the surrounding community and the environment as a result of the excavation and off-site transportation of contaminated soil. This impact would also be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-1.4 could be implemented within approximately 9 months and would achieve Soil RAOs Nos. 1 to 3 at completion. By preventing hypothetical future residential development, Alternative S-1.4 would

also indirectly achieve Soil RAO No. 4 at completion. Alternative S-1.4 would meet the Zone 1 soil PAHs PRGs for I/C direct exposure and pollutant mobility upon implementation. In addition, these cleanup criteria would not apply to leftover areas of inaccessible and/or environmentally isolated contaminated soil that could not be excavated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-1.4 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

Alternative S-1.4 would be technically implementable. Excavation could be performed with normal construction equipment by a wide range of contractors. However, very careful planning and execution would be required to prevent interference with ongoing activities at the Lower Subase. In addition, excavation would be significantly hindered, and could even be prevented, by the presence of many underground structures such as utility lines and existing and former building foundations. Nonetheless, as previously mentioned, it is assumed for the purpose of this FS that ongoing base activities and underground obstacles would not actually prevent excavation. Because excavation would be limited to approximately 5 feet bgs and would not extend below the water table, the need for shoring would be minimal, and there would be no need for excavation dewatering. Off-site borrow locations for clean soil backfill and off-site TSDFs for LTTD treatment and landfilling of the excavated soil are available. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of soil and groundwater could be readily performed.

The administrative aspects of Alternative S-1.4 would be relatively simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for soil excavation. The off-site transportation and disposal of excavated soil would have to be properly documented, which could be readily accomplished. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the

ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all these activities are readily available.

Cost

The estimated costs for Alternative S-1.4 are as follows:

Capital Cost	$1,412,000
NPW of O&M Costs	$416,000 (30 years)
NPW	$1,828,000 (30 years)

Within these costs, the estimated incremental capital cost for off-site treatment (LTTD) of highly contaminated soil would be $680,000.

A detailed cost estimate for this alternative is provided in Appendix E.

4.2.5 Alternative S-1.5: Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (LTTD, Landfilling, and Incineration)

4.2.5.1 Description

Alternative S-1.5 would consist of three major components: (1) excavation to meet Residential DECs, (2) on-site dewatering, and (3) off-site disposal.

Component 1: Excavation to Meet Residential DECs

Areas of soil up to 15 feet deep with mass concentrations of PAHs or mercury greater than their respective Residential DECs (1 mg/kg and 24 mg/kg) would be excavated to address CERCLA risks. In addition, areas of soil with mass concentrations of TPH greater than its Residential DEC (500 mg/kg) would also be excavated to address State petroleum concerns. This includes two areas covering most of Zone 1 and extending over an estimated 152,000 square feet as shown on Figure 4-2. The larger of the two areas, which covers an estimated 145,600 square feet, would be excavated from the ground surface to a depth of 15 feet bgs, except in the 43,000 square feet formerly occupied by Building 29 and USTs A, B, C, and D and USTs E, F, G, K, and L where excavation would extend from 8 feet bgs to 15 feet bgs. The smaller area located in the vicinity of monitoring well 13 MW20 covers an estimated 6,400 square feet and would be excavated to a depth of 12 feet bgs. Overall, an estimated total of 72,600 cubic yards of contaminated soil, uncontaminated soil, and asphalt debris would be removed through excavation.

Computations of excavation volumes are provided in Appendix C. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

Following excavation, confirmation samples would be collected from the bottoms and walls of excavated areas located above the water table to verify that contaminated soil has been removed. After confirmation sampling is complete, the excavated area would be backfilled with clean soil including a 6-inch layer of topsoil, and vegetated to minimize erosion.

Because this alternative would only be implemented prior to residential development of the site, it is assumed that existing underground obstacles (e.g., underground pipes or cables) would have been removed as part of site preparation for this development.

The area of LNAPL accumulation observed in the vicinity of existing well 13MW18 would also be removed as part of this alternative. Based on the computations provided in Appendix C, this area could cover approximately 9,900 square feet and hold an estimated 29,600 pounds (or 3,900 gallons) of LNAPL within the capillary (or smear) zone extending from 9 to 12 feet bgs. After uncovered by excavation, the LNAPL would be removed by vacuum aspiration.

Because excavation of Zone 1 contaminated soil under this alternative would extend to an estimated depth of 15 feet bgs, some of the excavation would take place below the water table and significant shoring would be required. However, as discussed in Section 3.2.4, dewatering of the excavated areas would not be practical, and excavation would be performed with equipment adapted to underwater work, such as a clamshell.

During excavation, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum. The excavated areas would be backfilled as soon as possible and, on-site staging and stockpiling of excavated soil would be kept to a minimum. Any on-site stockpiles of excavated soil would be covered with an impervious synthetic liner at the end of each day's work.

Component 2: On-Site Dewatering

Within Zone 1, it is assumed that excavation beyond a depth of approximately 7 feet bgs would take place below the water table. Therefore, it is also assumed that the as-excavated volume of soil removed below that depth would equal approximately 1.5 times its in-situ volume and would contain an average of 53 percent of free water by volume. This wet soil would require gravity-induced passive dewatering by on-site stockpiling prior to off-site disposal, as discussed in Section 3.2.6.1.

Gravity-induced stockpile dewatering would be performed at a Dewatering/Wastewater Treatment (DW/WWT) facility located as close to the excavation area as possible. Figure 4-3 provides a process flow diagram (PFD) for a typical DW/WWT facility. This facility would consist of one or more dewatering stockpiles, each with an associated modular drainage water treatment system including bag filtration units and liquid-phase GAC adsorption units. The dewatering stockpile would be built up over a drainage pad consisting of sand and gravel layers overlying an impermeable base. The sand layer would be between two geotextile/geonet layers, and the dewatering pad would be bermed and equipped with an underdrain system and collection sump. The pad would have approximate dimensions of 40 feet by 40 feet to provide a total of approximately 1,600 square feet of stockpiling area to accommodate approximately 300 cubic yards of wet excavated soil, assuming an average stockpile height of 5 feet. The soil would be stockpiled on the dewatering pad and covered with an impervious liner [polyethylene (PE) or polyvinylchloride (PVC)] to prevent potential rainfall infiltration. It is anticipated that each dewatering stockpile sequence of operation would require approximately 3 days, including 1 day to build up the stockpile, 1 day to achieve adequate soil dewatering, i.e., to restore the excavated soil to its original in-situ volume and moisture content, and 1 day to remove the stockpile. A typical cross-section of the drainage pad would consist of the following components in descending order:

- A graded sand layer: 1.0 foot in thickness, between two geotextile/geonet membranes.
- A gravel layer: 1.0 foot in thickness.
- A high-density polyethylene (HDPE) liner on a compacted and sloped soil base.
- A 4-inch-diameter slotted PVC pipe placed within the gravel layer.

The sand and geotextile/geonet layers in the base of the drainage pad would function as a pre-filter to retain most soil particles and allow relatively solids-free drainage water into the gravel underdrain layer. The slotted PVC pipe in the gravel layer would collect drainage water and transfer it to an adjacent collection sump. Drainage water would then be pumped into a bag filtration unit for secondary suspended solids removal followed by liquid-phase GAC adsorption for removal of dissolved organic contaminants. The treated drainage water would then be discharged under residual pressure to the nearest storm sewer inlet and flow from there to the Thames River.

Drainage water from the stockpile would be treated at a rate of up to 15 gpm by the DW/WWT. The sand filtration layer is assumed to have a suspended solids retention capacity of 1.5 pounds (dry basis) per square foot of filtration surface before it would require replacement. On that basis, assuming that each cubic yard of wet excavated soil would generate approximately 70 gallons of drainage water with a suspended solids concentration of 2,000 mg/L, it is anticipated that the sand and geotextile layers would need to be replaced after approximately seven stockpile operating sequences. The spent sand and geotextile layers would be disposed off site.

DW/WWT monitoring would consist of collecting one sample of the treatment system influent and effluent for every day of system operation and analyzing these samples for PAHs, metals, and total suspended solids.

An estimated in-situ soil volume of 44,300 cubic yards would be excavated below the water table, yielding approximately 66,500 cubic yards of wet excavated soil that would be dewatered to its original in-situ volume of 44,300 cubic yards (or 79,200 tons). This would require an estimated 222 dewatering stockpile operating sequences, or approximately 111 operating days with six dewatering stockpiles. The total volume of drainage water treated and discharged would be an estimated 4,477,000 gallons. Conceptual design calculations for on-site dewatering of soil are provided in Appendix D.

Component 3: Off-Site Disposal

Asphalt pavement debris would be segregated and recycled or, if required, disposed at an off-site construction material landfill. For this alternative, it is estimated that 1,000 cubic yards of asphalt debris would be removed from Zone 1.

The LNAPL removed from the vicinity of well 13MW18 would be transported off site for disposal/recycling by incineration. As previously mentioned, it is estimated that up to 29,600 pounds or 3,900 gallons of LNAPL could be recovered and disposed under this alternative. For the purpose of this FS, it is assumed that the LNAPL collected under this alternative would be disposed by incineration at an off-site TSDF.

To determine the proper method of disposal for the remaining 71,600 cubic yards of excavated soil, composite samples would be collected at the rate of approximately one sample per 500 cubic yards. These samples would be analyzed for mass concentrations of PAHs, TPH, and mercury to sort the excavated soil into the following categories:

- Soil with mass concentrations of PAHs, TPH, or mercury less than their respective Residential DECs (1 mg/kg, 500 mg/kg, and 24 mg/kg) would be identified as non-contaminated and would be reused on site as backfill. For this alternative, it is estimated that 11,200 cubic yards of soil excavated from Zone 1 would fall into this category.

- Soil with mass concentrations of TPH or mercury greater than their respective Residential DECs but less than their respective I/C DEC (2,500 mg/kg and 610 mg/kg) would be identified as contaminated but not requiring treatment. This soil and would be disposed at an off-site municipal solid waste landfill. For this alternative, it is estimated that 40,400 cubic yards of soil excavated from Zone 1 would fall into this category.

- Soil with mass concentrations of PAHs or TPH greater than their respective I/C DECs would be identified as "high PAH" or "high TPH" soil. This soil would be disposed at an off-site TSDF where it would undergo treatment by LTTD prior to landfilling. For this alternative, it is estimated that a total 20,000 cubic yards of soil excavated from Zone 1 would fall into this category including 5,500 cubic yards of "high PAH" soil and 14,500 cubic yards of "high TPH" soil.

Computations of volumes for the above categories are provided in Appendix C.

During off-site transportation of contaminated soil, appropriate spill prevention and control measures would be taken, and DOT regulations would be followed.

4.2.5.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-1.5 would be fully protective of human health and the environment under CERCLA under the current I/C exposure scenario and any other foreseeable site use. Excavation and off-site disposal of soil with mass concentrations of PAHs or mercury greater than their respective Residential DECs would be protective because it would not only remove unacceptable risk from exposure of current site users to contaminated soil but it would also eliminate future hypothetical human health risks from direct exposure to contaminated soil under a residential scenario. In addition, removal of soil with mass concentrations of PAHs greater than its respective Zone 1 Alternative GB PMCs for Residential use would also be protective because it would eliminate of any potential for migration of these COCs from soil to groundwater. Alternative S-1.5 would achieve all four soil RAOs.

Alternative S-1.5 would also be protective under the Connecticut RSRs by preventing unacceptable human health risk from exposure to TPH contaminated soil and minimizing the source of potential migration of TPH from soil to groundwater.

Compliance with ARARs and TBCs

Alternative S-1.5 would comply with chemical-, location-, and action-specific ARARs and TBCs, as summarized in Tables 4-11, 4-12, and 4-13, respectively.

Long-Term Effectiveness and Permanence

Alternative S-1.5 would be long-term effective and permanent. Excavation and off-site disposal of soil with concentrations of COCs greater than their respective Residential DECs would effectively and permanently

remove soil to which current site users and hypothetical future site residents should not be exposed. In addition, excavation and off-site disposal of soil with concentrations of PAHs greater than its respective Zone 1 Alternative GB PMCs for Residential use would effectively and permanently eliminate the potential for migration of these COCs from soil to groundwater.

In addition, Alternative S-1.5 would effectively and permanently address State petroleum concerns by removing soil with concentrations of TPH to which current site users should not be exposed and such that TPH could potentially migrate from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-1.5 would not address CERCLA risks by reducing the toxicity, mobility, and volume of PAHs lead, and mercury in soil through treatment, except through the treatment of water generated from the dewatering process prior to discharge to the Thames River.

Alternative S-1.5 would also not reduce the toxicity, mobility, and volume of TPH in soil through treatment.

Short-Term Effectiveness

Implementation of Alternative S-1.5 could result in significant short-term risks to on-site workers as a result of exposure to contamination during soil excavation. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-1.5 could also adversely impact the surrounding community and the environment as a result of the excavation and off-site transportation of contaminated soil. Any adverse impact would be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-1.5 could be implemented within approximately 2 years and would achieve the soil RAOs and meet the Zone 1 soil PRGs for residential direct exposure and pollutant mobility as well as the TPH Residential DEC and PMC upon implementation.

Implementability

Alternative S-1.5 would be technically difficult to implement. Excavation could be performed with normal construction equipment by a wide range of contractors. Because this alternative would only be implemented as part of hypothetical future residential development, excavation would not interfere with ongoing activities at the Lower Subase, and it is assumed that underground structures such as utility lines and existing and former building foundations would have been removed as part of site preparation for

development. However, because excavation would extend to a depth of approximately 15 feet bgs, extensive shoring would be required. In addition, because a significant portion of the excavation would be below the water table, much of the excavated soil would have a high initial water content, and a relatively complex on-site dewatering operation would be required to make this soil amenable to further treatment and/or disposal. Also, post-excavation confirmation sampling would not be possible in the underwater excavated areas and would have to be replaced with pre-excavation sampling to verify the extent of contamination. Off-site borrow locations for clean soil backfill and solid waste landfills or TSDFs for the off-site disposal of the excavated soil would be available.

The administrative aspects of Alternative S-1.5 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for soil excavation. The off-site transportation and disposal of the excavated soil would have to be properly documented, which could be readily accomplished. In addition, the substantive requirements of federal and State water discharge regulations would have to be met to discharge treated water from the on-site soil dewatering operation to the Thames River.

Cost

The estimated costs for Alternative S-1.5 (excluding LNAPL handling and disposal) are as follows:

Capital Cost	$20,112,000
NPW of O&M Costs	$0
NPW	$20,112,000 (1 year)

The estimated costs for Alternative S-1.5 (including LNAPL handling and disposal) are as follows:

Capital Cost	$20,195,000
NPW of O&M Costs	$0
NPW	$20,195,000 (1 year)

Within these costs, the estimated incremental capital cost for off-site treatment (chemical stabilization/ solidification and LTTD) of highly contaminated soil would be $8,357,000.

The above figures do not include the cost of demolition of existing structures and removal of underground obstacles that would be required for the implementation of this alternative. Instead, it is assumed that these costs are would be included as part of the hypothetical future residential development of Zone 1. A detailed cost estimate for this alternative is provided in Appendix E.

4.3 ASSEMBLY AND DETAILED ANALYSIS OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 2

Even though there is uncertainty regarding Zone 2 soil presenting a CERCLA risk, the Navy has opted to develop and evaluate soil alternatives following the CERCLA process. Additional data will be collected during a Soil PDI that will be used to address the uncertainty regarding the risk and the appropriateness of the CERCLA evaluation process for Zone 2 soil. The new data and updated evaluation will be captured in an addendum to this FS.

The following soil remedial alternatives have been developed for Zone 2 of the Lower Subase:

Alternative S-2.1:	No Action.
Alternative S-2.2:	LUCs (Engineering and Institutional Controls) and Monitoring.
Alternative S-2.3:	Capping to Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring.
Alternative S-2.4:	In-Situ Treatment (Stabilization/Solidification) to Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring.
Alternative S-2.5:	Excavation to Meet I/C PMCs, Off-Site Disposal (Stabilization/Solidification and Landfilling), and LUCs (Engineering and Institutional Controls).
Alternative S-2.6:	Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/Solidification, LTTD, and Landfilling).

Alternative S-2.1 was developed and analyzed to serve as a baseline for other alternatives, as required by CERCLA and the NCP. Alternative S-2.2 was developed and analyzed to evaluate LUCs with engineering and institutional controls and monitoring. Alternatives S-2.3, S-2-4, and S-2.5 were developed and analyzed to evaluate a range of remedial actions to address environmental concerns under current site use. Alternative S-2.6 was developed and analyzed to evaluate contaminated soil cleanup for hypothetical futures unrestricted site use. Descriptions and detailed analyses of these alternatives are provided in the following sections.

4.3.1 Alternative S-2.1: No Action

4.3.1.1 Description

No Action would not include any action under CERCLA and any existing administrative or engineering environmental controls would not be an enforceable part of a CERCLA remedy. This alternative is required under CERCLA to establish a basis for comparison with other alternatives. The only activity under

this alternative would be the performance of five-year reviews. This alternative cannot be chosen because contamination remains on site.

4.3.1.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-2.1 would not be protective of human health and the environment under CERCLA. Unacceptable risk to current site users would be allowed to occur as a result of direct exposure to contaminated soil because the asphalt pavement that covers most of this soil would not be maintained, and disturbance of areas of contaminated soil would not be regulated. There would also be no protection against the even greater risk that would result from exposure to contaminated soil by a wider range of human and ecological receptors if hypothetical future residential use of the site was allowed. In addition, Alternative S-2.1 could allow unacceptable human health and environmental risks to develop because the potential for migration of lead from soil to groundwater would continue to exist, and no monitoring would be performed to assess this potential migration. Alternative S-2.1 would not meet the soil RAOs.

Compliance with ARARs and TBCs

Alternative S-2.1 would not comply with chemical-specific ARARs and TBCs because no action would be taken to reduce concentrations of lead in soil. Because Alternative S-2.1 would not involve any action, location- and action-specific ARARs and TBCs would not be relevant. A summary of Alternative S-2.1's compliance with chemical-specific ARARs and TBCs is provided in Table 4-1.

Long-Term Effectiveness and Permanence

Alternative S-2.1 would not be long-term effective and permanent. Paved areas would not be maintained and no controls would restrict contaminated soil disturbance, which could result in unacceptable risks to human receptors under current I/C site use. No controls would prevent hypothetical future residential development, which could result in even greater risks to a wider range of human and ecological receptors. In addition, because no monitoring would be performed, there would be no assessment of the potential migration of lead from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative S-2.1 would not reduce the toxicity, mobility, or volume of lead in soil through treatment because no treatment would occur.

Short-Term Effectiveness

Because no action would occur, implementation of Alternative S-2.1 would not result in any short-term risks to on-site workers or adversely impact the local community or the environment.

Alternative S-2.1 would not achieve the soil RAOs or meet the Zone 2 soil lead PRG for I/C pollutant mobility.

Implementability

Technically, Alternative S-2.1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Cost

The estimated costs for Alternative S-2.1 are as follows:

Capital Cost	$0
NPW of O&M Costs	$55,000 (30 years)
NPW	$55,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.3.2 Alternative S-2.2: LUCs (Engineering and Institutional Controls) and Monitoring

4.3.2.1 Description

Alternative S-2.2 would consist of two major components: (1) LUCs with engineering and institutional controls and (2) monitoring.

Component 1: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 2. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of building foundations and paved areas. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership

of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 2: Monitoring

A groundwater monitoring program would be developed and implemented to evaluate the long-term potential migration of lead from soil to groundwater.

For the purpose of this FS, it was assumed that four groundwater samples would be regularly collected from strategic locations to be identified and that the collected samples would be analyzed for lead. Monitoring frequency would be quarterly for the first 2 years, semi-annual for the next 2 years, and annual thereafter.

Reviews would be performed every 5 years to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary. These site reviews are required because this alternative would allow lead to remain in soil at concentrations in excess of its I/C pollutant mobility PRG.

4.3.2.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-2.2 would be protective of human health and the environment under CERCLA. There are no unacceptable human health risks from direct exposure to lead-contaminated soil in Zone 2 under the current I/C site use. The asphalt pavement that covers most Zone 2 soil are protective by minimizing water infiltration, which is the primary pathway for potential migration of lead from soil to groundwater, and LUCs that ensure regular maintenance of building foundations and paved areas would provide continued protection. LUCs regulating the disturbance of contaminated soil would be protective by minimizing uncontrolled exposure of current site users to contaminated soil. In addition, LUCs restricting Zone 2 to its current I/C use would be protective by preventing the even greater risks that would result from exposure to contaminated soil by a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration of lead from soil to groundwater. Alternative S-2.2 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-2.2 would also indirectly achieve Soil RAO No.4.

Compliance with ARARs and TBCs

Alternative S-2.2 would comply with all location- and action-specific ARARs and TBCs. Alternative S-2.2 would also comply with federal chemical-specific TBCs (there are no federal chemical-specific ARARs),

and with the DECs and PMCs mandated by Connecticut RSRs. A summary of Alternative S-2.2's compliance with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 4-2, 4-3, and 4-4, respectively.

Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-2.2 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, PMCs would not apply to those areas of environmentally isolated contaminated soil. See Appendix D.1.3 for engineering control calculations.

Long-Term Effectiveness and Permanence

Alternative S-2.2 would be long-term effective and permanent under CERCLA. Although soil lead concentrations would not be actively reduced, risks to human health and the environment would be minimized through LUCs and monitoring. LUCs that would ensure regular maintenance of building foundations and paved areas would effectively minimize infiltration and potential migration of lead from soil to groundwater. LUCs that restrict disturbance of contaminated soil and prevent hypothetical future residential development of Zone 2 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Long-term monitoring would effectively detect potential migration of lead from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-2.2 would not reduce the toxicity, mobility, or volume of lead in soil through treatment because no treatment would occur.

Short-Term Effectiveness

Alternative S-2.2 would have minimal short-term effectiveness concerns. Any exposure of workers to contaminated soil or groundwater during the maintenance and sampling of groundwater monitoring wells would be minimized by wearing of appropriate PPE and complying with site-specific health and safety procedures. Implementation of LUCs and monitoring would not adversely impact the surrounding community or the environment.

Alternative S-2.2 could be implemented within approximately 3 months and would achieve Soil RAOs Nos. 1 to 3 upon implementation. By preventing hypothetical future residential development, Alternative S-2.2 would also indirectly achieve Soil RAO No. 4 upon implementation. However, Alternative S-2.2 would not meet the Zone 2 soil lead PRG for I/C pollutant mobility, but these cleanup criteria would not apply because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering

controls) of Alternative S-2.2 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

The technical implementability of Alternative S-2.2 would be easy. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of groundwater could be readily performed.

The administrative aspects of Alternative S-2.2 would be simple to implement. No construction permit issued by NSB-NLON DPW would be required for this alternative. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

The estimated costs for Alternative S-2.2 are as follows:

Capital Cost	$27,000
NPW of O&M Costs	$287,000 (30 years)
NPW	$314,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.3.3 Alternative S-2.3: Capping to Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring

4.3.3.1 Description

Alternative S-2.3 would consist of four major components: (1) capping to prevent leaching, (2) off-site disposal of excavated soil, (3) LUCs with engineering and institutional controls, and (4) monitoring.

Component 1: Capping to Prevent Leaching

Areas of unsaturated soil with SPLP/TCLP lead concentrations greater than the Zone 2 Alternative GB PMC for I/C site use (0.16 mg/L) would be capped with an impervious cover system to prevent potential migration of lead from soil to groundwater.

The area to be capped is located in the vicinity of monitoring well 13MW11 and extends over an estimated total of 6,400 square feet, as shown on Figure 4-4. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

To maintain the current topography of the site, surface preparation of the area where that cap would be installed would require excavation to a depth equal to the thickness of the cap. As part of site preparation, the 6,400 square feet area of contaminated soil would be excavated to a depth of 2 feet bgs generating an estimated total 470 cubic yards of contaminated surface soil and asphalt debris. Subsequently, these 6,400 square feet of exposed subsurface soil would be covered with a 2-foot-thick layer of compacted soil with a permeability of 10^{-6} centimeters per second (cm/sec). Alternately, because soil with such a low permeability may be very difficult and expensive to obtain, the cap could consist of a 2-foot layer of soil with a greater permeability (e.g., 10^{-5} cm/sec) overlying an impervious synthetic liner. The capped area would be repaved to match original surface conditions. Computations of capping and excavation surface areas and volumes are provided in Appendix C.

During construction activities, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum. Appropriate controls such as silt curtains, sediment traps, and hay bales would also be used to minimize erosion and sedimentation. In addition, during the excavation of contaminated soil in close proximity to existing buildings, care would be taken not to undermine the foundations of these buildings.

Component 2: Off-Site Disposal

Because under this alternative soil would be excavated above the water table, it is assumed that the excavated soil would contain minimal free water and would not have to be pretreated by on-site dewatering prior to off-site transportation and disposal.

Asphalt pavement debris would be segregated and recycled or, if required, disposed at an off-site construction material landfill. For this alternative, it is estimated that 60 cubic yards of asphalt debris would be removed from Zone 2.

To determine the proper method of disposal of the remaining 410 cubic yards of excavated soil, composite samples would be collected at the rate of approximately one sample per 50 cubic yards and analyzed for mass lead and SPLP/TCLP lead. Based on current soil characterization data, it is anticipated that the result of these analyses would show that the mass or TCLP concentrations of lead of all of the excavated soil would be greater than the I/C DEC (1,090 mg/kg) or RCRA toxicity characteristic (5 mg/L), respectively, for this COC. Therefore, it is anticipated that the 410 cubic yards of excavated soil would be identified as "high lead" and would be disposed at an off-site TSDF where it would undergo treatment by chemical stabilization/solidification prior to landfilling. Volume computations are provided in Appendix C.

During off-site transportation of contaminated soil, appropriate spill prevention and control measures would be taken, and DOT regulations would be followed.

Component 3: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 2. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of the caps. Similarly, another engineering control would be specified for the regular maintenance of the existing paved areas such that the assumptions used for the alternative PMC calculation are still applicable. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 4: Monitoring

Long-term groundwater monitoring would be conducted to confirm that soil contaminants are not mobilizing and migrating to groundwater at unacceptable concentrations.

4.3.3.2 Detailed Analysis

Overall Protection of Human Health and Environment

Alternative S-2.3 would be protective of human health and the environment under CERCLA. Placement of a cap over the areas of soil with SPLP/TCLP concentrations of lead greater than its Zone 2 Alternative GB PMC for I/C site use would be protective by minimizing the potential migration of lead from soil to groundwater. In addition, placement of a cap would be protective because it would require the removal and off-site disposal of some contaminated soil. LUCs regulating the disturbance of contaminated soil would be protective by minimizing uncontrolled exposure of current site users to contaminated soil. In addition, LUCs restricting Zone 2 to its current I/C use would be protective by preventing the even greater risks that would result from exposure to contaminated soil by a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration of lead from soil to groundwater. Alternative S-2.3 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-2.3 would also indirectly achieve Soil RAO No.4.

Compliance with ARARs and TBCs

Alternative S-2.3 would comply with chemical-, location-, and action-specific ARARs and TBCs, as summarized in Tables 4-14, 4-15, and 4-16, respectively.

Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-2.3 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, PMCs would not apply to those areas of environmentally isolated contaminated soil that could not be capped.

Long-Term Effectiveness and Permanence

Alternative S-2.3 would be long-term effective under CERCLA. Installation of a cap would effectively minimize water infiltration, which is the primary pathway for potential migration of lead from soil to groundwater. LUCs that restrict disturbance of contaminated soil and prevent hypothetical future residential development of Zone 2 would effectively and permanently prevent unacceptable risk from

direct exposure to contaminated soil. Long-term monitoring would effectively verify that lead does not migrate from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-2.3 would not address CERCLA risks by reducing the toxicity, mobility, and volume of lead in soil through treatment.

Short-Term Effectiveness

Implementation of Alternative S-2.3 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during installation of a cap and also as a result of monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-2.3 could also have a minimal adverse impact on the surrounding community and the environment as a result of the excavation and off-site transportation of contaminated soil. This impact would also be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-2.3 could be implemented within approximately 6 months and would achieve soil RAOs Nos. 1 to 3 upon implementation. By preventing hypothetical future residential development, Alternative S-2.3 would also indirectly achieve Soil RAO No. 4 upon implementation. Although Alternative S-2.3 would not meet the Zone 2 soil lead PRG for I/C pollutant mobility these criteria would not apply because the engineering controls of Alternative S-2.3 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs. In addition, these cleanup criteria would not apply to leftover areas of environmentally isolated contaminated soil that could not be capped because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-2.3 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

Alternative S-2.3 would be technically implementable. Contractors qualified to install a cap are readily available, and this work could be performed with normal construction equipment. However, very careful planning and execution would be required to prevent interference of the capping operations with ongoing activities at the Lower Subase. The presence of many underground structures such as utility lines and existing and former building foundations would also interfere with the placement of a cap, although this might be somewhat mitigated because many of these structures are located below the shallow depth (2 feet) of the required pre-excavation. Off-site borrow locations for capping material and TSDFs for off-site treatment and disposal of the excavated soil would be available. Maintenance of building foundations,

capped and paved areas, and needed monitoring wells and sampling and analysis of groundwater could be readily performed.

The administrative aspects of Alternative S-2.3 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for the capping activities. The off-site transportation and disposal of excavated soil would have to be properly documented, which could be readily accomplished. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

Estimated costs for Alternative S-2.3 are as follows:

Capital Cost	$359,000
NPW of O&M Costs	$287,000 (30 years)
NPW	$646,000 (30 years)

Within these costs, the estimated incremental capital cost for off-site treatment (chemical stabilization/ solidification and LTTD) of highly contaminated soil would be $126,000.

A detailed cost estimate for this alternative is provided in Appendix E.

4.3.4 Alternative S-2.4: In-Situ Treatment (Stabilization/Solidification) to Meet PMCs for I/C Site Use, LUCs, (Engineering and Institutional Controls) and Monitoring

4.3.4.1 Description

Alternative S-2.4 would consist of three major components: (1) in-situ treatment to meet PMCs for I/C site use, (2) LUCs with engineering and institutional controls, and (3) monitoring.

Component 1: In-Situ Treatment to Meet PMCs for I/C Site Use

The area of unsaturated soil with SPLP/TCLP lead concentrations greater than the Zone 2 Alternative GB PMC for I/C site use (0.16 mg/L) would be treated using in-situ chemical stabilization/solidification. This area is located in the vicinity of soil sampling point 13MW11 and extends over an estimated 6,400 square feet to 5 feet bgs, as shown on Figure 4-5. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil. For treatment of contaminated soil up to 3 feet deep, it is assumed that a backhoe would be used to blend contaminated soil in that area with controlled amounts of a pozzolanic reagent such as Portland cement and water to chemically stabilize the lead within the soil matrix. For deeper applications, an LDA typically 6 to 10 feet in diameter would be used to blend the Portland cement and water with the soil to be treated. Each application of the LDA would generate a column of treated soil approximately 6 to 10 feet in diameter, and this would be repeated with a slight column-to-column overlap until the entire contaminated soil area has been treated. The treated areas would be repaved to match original surface conditions. An estimated 1,130 cubic yards of "high lead" soil would be treated in this way by blending in Portland cement and water at the rate of approximately 5 percent (by weight) and 2 percent (by weight), respectively, for a total estimated use of approximately 90 tons of Portland cement and 8,900 gallons of water. The blending action and addition of Portland cement would result in an increase in the volume of treated soil estimated at approximately 115 cubic yards. Because the chemical stabilization/solidification would only take a few days to complete, this incremental volume of soil could be disposed off site at a municipal solid waste landfill. Computations of treated soil volumes are provided in Appendix C. Conceptual design calculations for in-situ chemical stabilization/solidifications are provided in Appendix D.

Prior to treatment, treatability testing would be performed to determine the appropriate ratio of Portland cement and water to achieve a properly stabilized soil. Also prior to treatment, a careful survey would be made of underground obstacles (e.g., underground pipes or cables) in the area to be treated and, when practical, these obstacles would be moved. If obstacles prevent the use of a blending auger in certain areas and if moving of these obstacles is not practical, the Portland cement and water would be manually worked into the soil to be treated using hand tools such as shovels, provided that the areas to be so

treated are relatively small in size. Accordingly, it is assumed for the purpose of this FS that underground obstacles would not actually prevent the implementation of in-situ chemical stabilization/solidification.

Following treatment, confirmation samples would be collected beneath and around the treated area to verify that all contaminated soil has been treated. Additional confirmation samples would also be collected from the treated area within approximately one month and tested for SPLP concentrations of lead to verify that treated soil meets the Zone 2 Alternative GB PMC for I/C use for this COC.

Component 2: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 2. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. Similarly, another engineering control would be specified for the regular maintenance of the existing paved areas such that the assumptions used for the alternative PMC calculation are still applicable. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 3: Monitoring

Long-term groundwater monitoring would be conducted to confirm that soil contaminants are not mobilizing and migrating to groundwater at unacceptable concentrations.

4.3.4.2 Detailed Analysis

Overall Protection of Human Health and Environment

Alternative S-2.4 would be protective of human health and the environment under CERCLA. In-situ treatment with chemical stabilization/solidification would be protective because it would immobilize the lead content of the treated soil, which would prevent its potential migration to groundwater and reduce risk associated with direct exposure to contaminated soil. LUCs ensuring regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by minimizing uncontrolled exposure of current site users to contaminated soil. In addition, LUCs restricting Zone 2 to its current I/C use would be protective by preventing the even greater risks that would result from exposure to contaminated soil by a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration

of lead from soil to groundwater. Alternative S-2.4 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-2.3 would also indirectly achieve Soil RAO No.4.

Compliance with ARARs and TBCs

Alternative S-2.4 would comply with chemical-, location-, and action-specific ARARs and TBCs, as summarized in Tables 4-17, 4-18, and 4-19, respectively.

Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-2.4 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, PMCs would not apply to those areas of environmentally isolated contaminated soil that could not be treated.

Long-Term Effectiveness and Permanence

Alternative S-2.4 would be long-term effective and permanent under CERCLA. Although soil lead concentrations would not be actively reduced, risks to human health and the environment would be minimized through in-situ treatment, LUCs and monitoring. In-situ treatment with chemical stabilization/solidification would effectively and permanently immobilize lead within the treated soil, which would prevent its potential migration to groundwater and reduce risk associated with direct exposure to contaminated soil. LUCs that ensure regular maintenance of building foundations and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 2 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Long-term monitoring would effectively verify that lead does not migrate from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-2.4 would address CERCLA risks by reducing the toxicity and mobility of lead in soil through in-situ chemical stabilization/solidification. An estimated 1,130 cubic yards of "high lead" soil would be permanently and irreversibly treated by this technology. However, the degree of lead toxicity reduction achieved through chemical stabilization/solidification is likely to be significantly less than the reduction of mobility, and there would be no reduction in the quantity of lead in the treated soil.

Short-Term Effectiveness

Implementation of Alternative S-2.4 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during in-situ treatment activities and also as a result of monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by

compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-2.4 would have no adverse impact on the surrounding community or the environment.

Alternative S-2.4 could be implemented within approximately 6 months and would achieve Soil RAOs Nos. 1 to 3 upon implementation. By preventing hypothetical future residential development, Alternative S-2.4 would also indirectly achieve Soil RAO No. 4 upon implementation. Alternative S-2.4 would meet the Zone 2 soil lead PRG for I/C pollutant mobility upon implementation. In addition, these cleanup criteria would not apply to leftover areas of environmentally isolated contaminated soil that could not be treated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-2.4 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

Alternative S-2.4 would be technically implementable. Contractors qualified to perform in-situ chemical stabilization/solidification are readily available. Very careful planning and execution would be required to prevent interference with ongoing activities at the Lower Subase. In addition, implementation of the in-situ treatment would be significantly hindered, and might even be prevented, by the presence of many underground structures such as utility lines and existing and former building foundations. Nonetheless, as previously mentioned, it is assumed for the purpose of this FS that ongoing base activities and underground obstacles would not actually prevent implementation of this alternative. Treatability tests would be required to determine the appropriate soil/pozzolanic reagent/water mix ratios prior to implementation. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of groundwater could be readily performed.

The administrative aspects of Alternative S-2.4 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for the in-situ treatment activities. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the

(1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

Estimated costs for Alternative S-2.4 are as follows:

Capital Cost	$544,000
NPW of O&M Costs	$287,000 (30 Years)
NPW	$831,000 (30 Years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.3.5 Alternative S-2.5: Excavation to Meet PMCs for I/C Site Use, Off-Site Disposal (Stabilization/ Solidification and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring

4.3.5.1 Description

Alternative S-2.5 would consist of four major components: (1) excavation to meet PMCs for I/C site use, (2) off-site disposal of excavated soil, (3) LUCs with engineering and institutional controls, and (4) monitoring.

Component 1: Excavation to Meet PMCs for I/C Site Use

The area of unsaturated soil with SPLP/TCLP lead concentrations greater than the Zone 2 Alternative GB PMC for I/C site use (0.16 mg/L) would be excavated. This area is located in the vicinity of soil sampling point 13MW11 and extends over an estimated 6,400 square feet to 5 feet bgs, as shown on Figure 4-5. An estimated total of 1,190 cubic yards of contaminated soil and asphalt debris would be removed through excavation. Computations of excavation volumes are provided in Appendix C. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

Following excavation, confirmation samples would be collected from the bottom and walls of the excavated area to verify that contaminated soil has been removed. After confirmation sampling is complete, the excavated area would be backfilled with clean soil and the site restored to its former condition.

Prior to excavation, a detailed survey would be made of underground obstacles (e.g., underground pipes or cables) in the area to be excavated and, when practical, these obstacles would be moved. If obstacles prevent the use of a normal backhoe or grade-all in certain areas and if moving of these obstacles is not practical, a small backhoe or hand shovels would be used provided that the areas to be so excavated are relatively small in size. For the purpose of this FS, it is assumed that underground obstacles would not actually prevent the excavation of contaminated soil.

Because excavation of Zone 2 contaminated soil under this alternative would only extend to an estimated depth of 5 feet bgs, it is assumed that all excavation would take place above the water table and that only minimal shoring and no excavation dewatering would be required.

During excavation, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum. The excavated areas would be backfilled as soon as possible, and on-site staging and stockpiling of excavated soil would be kept to a minimum. Any on-site stockpiles of excavated soil would be covered with an impervious synthetic liner at the end of each day's work.

Component 2: Off-Site Disposal

Because under this alternative soil would be excavated above the water table, it is assumed that the excavated soil would contain minimal free water and would not have to be pretreated by on-site dewatering prior to off-site transportation and disposal.

Asphalt pavement debris would be segregated and recycled or, if required, disposed at an off-site construction material landfill. For this alternative, it is estimated that 60 cubic yards of asphalt debris would be removed from Zone 2.

To determine the proper method of disposal of the remaining 1,130 cubic yards of excavated soil, composite samples would be collected at the rate of approximately one sample per 100 cubic yards and analyzed for mass and SPLP/TCLP lead. Based on current soil characterization data, it is anticipated that the result of these analyses would show that the mass or TCLP concentrations of lead of all of the excavated soil would be greater than the I/C DEC (1,090 mg/kg) or RCRA toxicity characteristic (5 mg/L), respectively, for this COC. Therefore, it is also anticipated that the 1,130 cubic yards of excavated soil would be identified as "high lead" and would be disposed at an off-site TSDF where it would undergo treatment by chemical stabilization/solidification prior to landfilling. Volume computations are provided in Appendix C.

During off-site transportation of contaminated soil, appropriate spill prevention and control measures would be taken, and DOT regulations would be followed.

Component 3: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 2. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. Similarly, another engineering control would be specified for the regular maintenance of the existing paved areas such that the assumptions used for the alternative PMC calculation are still applicable. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 4: Monitoring

Long-term groundwater monitoring would be conducted to confirm that soil contaminants are not mobilizing and migrating to groundwater at unacceptable concentrations.

4.3.5.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-2.5 would be protective of human health and the environment under CERCLA. Excavation and off-site disposal of soil with SPLP/TCLP concentrations of lead greater than its Zone 2 Alternative GB PMC for I/C site use would be protective by minimizing the source of potential migration of lead from soil to groundwater. LUCs ensuring regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by minimizing uncontrolled exposure of current site users to contaminated soil. In addition, LUCs restricting Zone 2 to its current I/C use would be protective by preventing the even greater risks that would result from exposure to contaminated soil by a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration of lead from soil to groundwater. Alternative S-2.5 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-2.5 would also indirectly achieve Soil RAO No.4.

Compliance with ARARs and TBCs

Alternative S-2.5 would comply with chemical-, location- and action-specific ARARs and TBCs, as summarized in Tables 4-8, 4-9, and 4-10, respectively.

Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-2.5 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, PMCs would not apply to those areas of environmentally isolated contaminated soil that could not be excavated.

Long-Term Effectiveness and Permanence

Alternative S-2.5 would be long-term effective and permanent under CERCLA. Excavation and off-site disposal would effectively and permanently remove soil with concentrations of lead such that this lead could potentially migrate to groundwater. LUCs that ensure regular maintenance of building foundations and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 2 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Long-term monitoring would effectively detect the potential migration of lead from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-2.5 would not address CERCLA risks by reducing the toxicity, mobility, and volume of lead in soil through treatment.

Short-Term Effectiveness

Implementation of Alternative S-2.5 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during soil excavation. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-2.5 could also have some adverse impact on the surrounding community and the environment as a result of the excavation and off-site transportation of contaminated soil. This impact would also be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-2.5 could be implemented within approximately 6 months and would achieve Soil RAOs Nos. 1 to 3 upon implementation. By preventing hypothetical future residential development, Alternative S-2.5 would also indirectly achieve Soil RAO No. 4 upon implementation. Alternative S-2.5 would meet the Zone

2 soil lead PRG for I/C pollutant mobility upon implementation. In addition, these cleanup criteria would not apply to leftover areas of environmentally isolated contaminated soil that could not be excavated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-2.5 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

Alternative S-2.5 would be technically implementable. Excavation could be performed with normal construction equipment by a wide range of contractors. However, very careful planning and execution would be required to prevent interference with ongoing activities at the Lower Subase. In addition, excavation would be significantly hindered, and could even be prevented, by the presence of many underground structures such as utility lines and existing and former building foundations. Nonetheless, as previously mentioned, it is assumed for the purpose of this FS that ongoing base activities and underground obstacles would not actually prevent excavation. Because excavation would be limited to approximately 5 feet bgs and would not extend below the water table, the need for shoring would be minimal, and there would be no need for excavation dewatering. Off-site borrow locations for clean soil backfill and off-site hazardous TSDF for the chemical stabilization/solidification and landfilling of the excavated soil would be available. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of groundwater could be readily performed.

The administrative aspects of Alternative S-2.5 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for soil excavation. The off-site transportation and disposal of the excavated soil would have to be properly documented, which could be readily accomplished. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

The estimated costs for Alternative S-2.5 are as follows:

Capital Cost	$652,000
NPW of O&M Costs	$287,000 (30 years)
NPW	$939,000 (30 years)

Within these costs, the estimated incremental capital cost for off-site treatment (chemical stabilization/ solidification) of highly contaminated soil would be $328,000.

A detailed cost estimate for this alternative is provided in Appendix E.

4.3.6 Alternative S-2.6: Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/Solidification, LTTD, and Landfilling)

4.3.6.1 Description

Alternative S-2.6 would consist of three major components: (1) excavation to meet Residential DECs and PMCs, (2) on-site dewatering, and (3) off-site disposal.

Component 1: Excavation to Meet Residential DECs and PMCs

Areas of unsaturated soil with SPLP/TCLP concentrations of lead greater than its Zone 2 Alternative GB PMC for Residential use (0.15 mg/L) would be excavated to address CERCLA risks. In addition, areas of soil up to 15 feet deep with mass concentrations of TPH greater than its Residential DEC (500 mg/kg) would also be excavated to address State petroleum concerns. These areas are located in the vicinity of soil sampling points 13MW11, 13TB8, and GS-22L and extend over an estimated 32,000 square feet from 5 to 15 feet bgs, as shown on Figure 4-6. An estimated total of 15,400 cubic yards of contaminated soil, uncontaminated soil, and asphalt debris would be removed through excavation. Computations of excavation volumes are provided in Appendix C. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

Following excavation, confirmation samples would be collected from the bottoms and walls of the excavated areas above the water table to verify that contaminated soil has been removed. After

confirmation sampling is complete, the excavated area would be backfilled with clean soil including a 6-inch layer of topsoil, and vegetated to minimize erosion.

Because this alternative would only be implemented prior to residential development of the site, it is assumed that existing underground obstacles (e.g., underground pipes or cables) would have been removed as part of site preparation for this development.

Because excavation of Zone 2 contaminated soil under this alternative would extend to an estimated depth of 15 feet bgs, some excavation would take place below the water table, and significant shoring would be required. However, as discussed in Section 3.2.4, dewatering of the excavated areas would not be practical, and excavation would be performed with equipment adapted to underwater work, such as a clamshell.

During excavation, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum. The excavated areas would be backfilled as soon as possible, and on-site staging and stockpiling of excavated soil would be kept to a minimum. Any on-site stockpiles of excavated soil would be covered with an impervious synthetic liner at the end of each day's work.

Component 2: On-Site Dewatering

Within Zone 2, it is assumed that excavation beyond a depth of approximately 7 feet bgs would take place below the water table. Therefore, it is assumed that the wet soil excavated below that depth would equal approximately 1.5 times its in-situ volume and would contain an average of 53 percent of free water by volume. This wet soil would require gravity-induced passive dewatering by on-site stockpiling prior to off-site disposal, as discussed in Section 3.2.6.1.

Gravity-induced stockpile dewatering would be performed at a DW/WWT facility located as close to the excavation area as possible. A typical DW/WWT facility would consist of a dewatering stockpile and associated drainage water treatment system including bag filtration and liquid-phase GAC adsorption. A more detailed description of this facility is provided in the description of Alternative S-1.5 (see Section 4.2.5.1).

DW/WWT monitoring would consist of collecting one sample of the treatment system influent and effluent for every day of system operation and analyzing these samples for PAHs, metals, and total suspended solids.

An estimated in-situ soil volume of 7,200 cubic yards would be excavated below the water table, yielding approximately 10,800 cubic yards of wet excavated soil that would be dewatered to its original in-situ volume of 7,200 cubic yards (or 12,900 tons). This would require 36 stockpile operating sequences, or approximately 108 operating days with a single dewatering stockpile. The total volume of drainage water to be treated and discharged would be an estimated 726,200 gallons. Conceptual design calculations for the on-site dewatering of soil are provided in Appendix D.

Component 3: Off-Site Disposal

Asphalt pavement debris would be segregated and recycled or, if required, disposed at an off-site construction material landfill. For this alternative, it is estimated that 300 cubic yards of asphalt debris would be removed from Zone 2.

To determine the proper method of disposal of the remaining 15,100 cubic yards of excavated soil, composite samples would be collected at the rate of approximately one sample per 250 cubic yards. These samples would be analyzed for mass concentrations of TPH and SPLP/TCLP concentrations of lead to sort the excavated soil into the following categories:

- Soil with mass concentrations of TPH less than its Residential DEC (500 mg/kg) and/or with SPLP/TCLP concentrations of lead less than its Zone 2 Alternative GB PMC for Residential use (0.15 mg/L) would be identified as non-contaminated and would be reused on site as backfill. For this alternative, it is estimated that 8,200 cubic yards of soil excavated from Zone 2 would fall into this category.

- Soil with mass concentrations of TPH greater than its Residential DEC but less than its I/C DEC (2,500 mg/kg) and/or with TCLP concentrations of lead greater than its Zone 2 Alternative GB PMC for Residential use but less than its RCRA toxicity characteristic (5 mg/L) would be identified as contaminated and not requiring treatment. This soil would be disposed at an off-site municipal solid waste landfill. For this alternative, it is estimated that 5,600 cubic yards of the soil excavated from Zone 2 would fall into this category.

- Soil with mass concentrations of TPH greater than its I/C DEC would be identified as "high TPH" and would be disposed at an off-site TSDF where it would undergo treatment by LTTD prior to landfilling. For this alternative, it is estimated that 200 cubic yards of soil excavated from Zone 2 would fall into this category.

- Soil with TCLP concentrations of lead greater than its RCRA toxicity characteristic would be identified as "high lead". This soil would be disposed at an off-site TSDF where it would undergo treatment by

chemical stabilization/solidification prior to landfilling. For this alternative, it is estimated that 1,100 cubic yards of soil excavated from Zone 2 would fall into this category.

Computations of volumes for the above categories are provided in Appendix C.

4.3.6.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-2.6 would be fully protective of human health and the environment under CERCLA under the current I/C exposure scenario and any other foreseeable site use. Removal of soil with SPLP/TCLP concentrations of lead greater than its respective Zone 2 Alternative GB PMCs for Residential use would also be protective because it would eliminate any potential for migration of lead from soil to groundwater. Alternative S-2.6 would achieve all four soil RAOs.

Alternative S-2.6 would also be protective under the Connecticut RSRs by preventing unacceptable human health risk from exposure to TPH contaminated soil and minimizing the source of potential migration of TPH from soil to groundwater.

Compliance with ARARs and TBCs

Alternative S-2.6 would comply with chemical-, location-, and action-specific ARARs and TBCs, as summarized in Tables 4-11, 4-12, and 4-13, respectively.

Long-Term Effectiveness and Permanence

Alternative S-2.6 would be long-term effective and permanent. Excavation and off-site disposal of soil with mass concentrations of SPLP/TCLP concentrations of lead greater than its respective Zone 2 Alternative GB PMCs for Residential use would effectively and permanently eliminate the potential for migration of lead from soil to groundwater.

In addition, Alternative S-2.6 would effectively and permanently address State petroleum concerns by removing soil with concentrations of TPH to which current site users should not be exposed and such that TPH could potentially migrate from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-2.6 would not address CERCLA risks by reducing the toxicity, mobility, and volume of lead in soil through treatment, except through the treatment of water generated from the dewatering process prior to discharge to the Thames River.

Alternative S-2.6 would also not reduce the toxicity, mobility, and volume of TPH in soil through treatment.

Short-Term Effectiveness

Implementation of Alternative S-2.6 could result in significant short-term risks to on-site workers as a result of exposure to contamination during soil excavation. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-2.6 could also adversely impact the surrounding community and the environment as a result of the excavation and off-site transportation of contaminated soil. This adverse impact would be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-2.6 could be implemented within approximately 9 months and would achieve the soil RAOs and meet the Zone 2 soil PRGs for residential direct exposure use and pollutant mobility as well as the TPH Residential DEC and PMC upon implementation.

Implementability

Alternative S-2.6 would be technically difficult to implement. Excavation could be performed with normal construction equipment by a wide range of contractors. Because this alternative would only be implemented as part of hypothetical future residential development, excavation would not interfere with ongoing activities at the Lower Subase, and it is assumed that underground structures such as utility lines and existing and former building foundations would have been removed as part of site preparation for development. Because excavation would reach to a depth of approximately 8 feet bgs, extensive shoring would be required. In addition, because a significant portion of the excavation would extend below the water table, much of the excavated soil would have a high initial water content, and a relatively complex on-site dewatering operation would be required to make this soil amenable to further treatment and/or disposal. Also, post-excavation confirmation sampling would not be possible in the underwater excavated areas and would have to be replaced with pre-excavation sampling to verify the extent of contamination. Off-site borrow locations for clean soil backfill and solid waste landfills or TSDFs for off-site disposal of the excavated soil would be available.

The administrative aspects of Alternative S-2.6 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for soil excavation. The off-site transportation and disposal of excavated soil would have to be properly documented, which could be readily accomplished. In addition, the substantive requirements of federal and State water discharge regulations would have to be met to discharge treated water from the on-site soil dewatering operation to the Thames River.

Cost

The estimated costs for Alternative S-2.6 are as follows:

Capital Cost	$3,881,000
NPW of O&M Costs	$0
NPW	$3,881,000 (1 year)

Within these costs, the estimated incremental capital cost for off-site treatment (chemical stabilization/ solidification and LTTD) of highly contaminated soil would be $912,000.

The above figures do not include the cost of demolition of existing structures and removal of underground obstacles that would be required for the implementation of this alternative. Instead, these costs are assumed to have been included as part of the hypothetical future residential development of Zone 2. A detailed cost estimate for this alternative is provided in Appendix E.

4.4 ASSEMBLY AND DETAILED ANALYSIS OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 3

Even though there is uncertainty regarding Zone 3 soil presenting a CERCLA risk, the Navy has opted to develop and evaluate soil alternatives following the CERCLA process. Additional data will be collected during a Soil PDI that will be used to address the uncertainty regarding the risk and the appropriateness of the CERCLA evaluation process for Zone 3 soil. The new data and updated evaluation will be captured in an addendum to this FS.

The following soil remedial alternatives have been developed for Zone 3 of the Lower Subase:

Alternative S-3.1:	No Action.
Alternative S-3.2:	LUCs (Engineering and Institutional Controls) and Monitoring.
Alternative S-3.3:	Capping to Allow I/C Site Use and Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring.
Alternative S-3.4:	In-Situ Treatment (Stabilization/Solidification) to Allow I/C Site Use and Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-3.5: Excavation to Meet I/C DECs and PMCs, Off-Site Disposal (Stabilization/Solidification and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-3.6: Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/Solidification, LTTD and Landfilling).

Alternative S-3.1 was developed and analyzed to serve as a baseline for other alternatives, as required by CERCLA and the NCP. Alternative S-3.2 was developed and analyzed to evaluate the LUCs with engineering and institutional controls, and monitoring. Alternative S-3.3 was developed and analyzed to evaluate the adequacy of containment, particularly that provided by existing building foundations acting as caps. Alternatives S-3.4 and S-3.5 were developed and analyzed to evaluate a range of remedial actions to address environmental concerns under current site use. Alternative S-3.6 was developed and analyzed to evaluate contaminated soil cleanup for hypothetical future unrestricted site use. Descriptions and detailed analyses of these alternatives are provided in the following sections.

4.4.1 Alternative S-3.1: No Action

4.4.1.1 Description

No Action would not include any action under CERCLA and any existing administrative or engineering environmental controls would not be an enforceable part of a CERCLA remedy. This alternative is required under CERCLA to establish a basis for comparison with other alternatives. The only activity under this alternative would be the performance of five-year reviews. This alternative cannot be chosen because contamination remains on site.

4.4.1.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-3.1 would not be protective of human health and the environment under CERCLA. Unacceptable risk to current site users would be allowed to occur as a result of direct exposure to contaminated soil because the asphalt pavement that covers most of this soil would not be maintained, and disturbance of areas of contaminated soil would not be regulated. There would also be no protection against the even greater risk that would result from exposure to contaminated soil by a wider range of human and ecological receptors if hypothetical future residential use of the site was allowed. In addition, Alternative S-3.1 could allow unacceptable human health and environmental risks to develop because the potential for migration of lead from soil to groundwater would continue to exist, and no monitoring would be performed to assess this potential migration. Alternative S-3.1 would not achieve the soil RAOs.

Compliance with ARARs and TBCs

Alternative S-3.1 would not comply with chemical-specific ARARs and TBCs because no action would be taken to reduce concentrations of lead in soil. Because Alternative S-3.1 would not involve any action, location- and action-specific ARARs and TBCs would not be relevant. A summary of Alternative S-3.1's compliance with chemical-specific ARARs and TBCs is provided in Table 4-1.

Long-Term Effectiveness and Permanence

Alternative S-3.1 would not be long-term effective and permanent. Paved areas would not be maintained and no controls would restrict contaminated soil disturbance that could result in unacceptable risk to human receptors under current I/C site use. No controls would prevent hypothetical future residential development, which could result in even greater risks to a wider range of human and ecological receptors. In addition, because no monitoring would be performed, there would be no assessment of the potential migration of lead from to groundwater.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative S-3.1 would not reduce the toxicity, mobility, or volume of lead in soil through treatment because no treatment would occur.

Short-Term Effectiveness

Because no action would occur, implementation of Alternative S-3.1 would not result in any short-term risks to on-site workers or adversely impact the local community or the environment.

Alternative S-3.1 would not achieve the soil RAOs or meet the Zone 3 soil lead PRGs for I/C direct exposure and pollutant mobility.

Implementability

Technically, Alternative S-3.1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Cost

The estimated costs for Alternative S-3.1 are as follows:

Capital Cost	$0
NPW of O&M Costs	$55,000 (30 years)
NPW	$55,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.4.2 Alternative S-3.2: LUCs (Engineering and Institutional Controls) and Monitoring

4.4.2.1 Description

Alternative S-3.2 would consist of two major components: (1) LUCs with engineering and institutional controls and (2) monitoring.

Component 1: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 3. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of building foundations and paved areas. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 2: Monitoring

A groundwater monitoring program would be developed and implemented to evaluate potential migration of lead from soil to groundwater.

For the purpose of this FS, it was assumed that four groundwater samples would be regularly collected from strategic locations to be identified and that the collected samples would be analyzed for lead. Monitoring frequency would be quarterly for the first 2 years, semi-annual for the next 2 years, and annual thereafter.

Reviews would be performed every 5 years to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary. These site reviews are required because this alternative would allow lead to remain in soil at concentrations in excess of its I/C direct exposure and pollutant mobility PRGs.

4.4.2.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-3.2 would be protective of human health and the environment under CERCLA. Unacceptable risk from direct exposure of current site users to contaminated surface soil would be minimized by the asphalt pavement that covers most of this soil. LUCs ensuring regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by minimizing uncontrolled exposure of current site users to contaminated soil. In addition, LUCs restricting Zone 3 to its current I/C use would be protective by preventing the even greater risks that would result from exposure to contaminated soil by a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration of lead from soil to groundwater. Alternative S-3.2 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-3.2 would also indirectly achieve Soil RAO No. 4

Compliance with ARARs and TBCs

Alternative S-3.2 would comply with all location- and action-specific ARARs and TBCs. Alternative S-3.2 would also comply with federal chemical-specific TBCs (there are no federal chemical-specific ARARs) and with the DECs and PMCs mandated by Connecticut RSRs. A summary of Alternative S-3.2's compliance with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 4-2, 4-3, and 4-4, respectively.

Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-3.2 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil. See Appendix D.1.3 for engineering control calculations.

Long-Term Effectiveness and Permanence

Alternative S-3.2 would be long-term effective and permanent under CERCLA. Although soil lead concentrations would not be actively reduced, risks to human health and the environment would be minimized through LUCs and monitoring. LUCs that ensure regular maintenance of building foundations

and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 3 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Long-term monitoring would effectively detect potential migration of lead from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-3.2 would not reduce the toxicity, mobility, or volume of lead in soil through treatment because no treatment would occur.

Short-Term Effectiveness

Alternative S-3.2 would have minimal short-term effectiveness concerns. Any exposure of workers to contaminated soil and groundwater during the maintenance and sampling of groundwater monitoring wells would be minimized by wearing of appropriate PPE and complying with site-specific health and safety procedures. Implementation of LUCs and monitoring would not adversely impact the surrounding community or the environment.

Alternative S-3.2 could be implemented within approximately 3 months and would achieve Soil RAOs Nos. 1 to 3 upon implementation. By preventing hypothetical future residential development, Alternative S-3.2 would also indirectly achieve Soil RAO No. 4 upon implementation. However, Alternative S-3.2 would not meet the Zone 3 soil lead PRGs for I/C direct exposure and pollutant mobility and would not meet the TPH soil PMC or I/C DEC, but these cleanup criteria would not apply because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-3.2 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

The technical implementability of Alternative S-3.2 would be easy. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of groundwater could be readily performed.

The administrative aspects of Alternative S-3.2 would be simple to implement. No construction permit issued by NSB-NLON DPW would be required for this alternative. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

The estimated costs for Alternative S-3.2 are as follows:

Capital Cost	$34,000
NPW of O&M Costs	$297,000 (30 years)
NPW	$331,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.4.3 Alternative S-3.3: Capping to Allow I/C Site Use and Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring

4.4.3.1 Description

Alternative S-3.3 would consist of four major components: (1) capping to allow I/C site use and prevent leaching, (2) off-site disposal of excavated soil, (3) LUCs with engineering and institutional controls, and (4) monitoring.

Component 1: Capping to Allow I/C Site Use and Prevent Leaching

Areas of soil with mass concentrations of lead greater than its I/C DEC (1,090 mg/kg) to a depth of 2 feet bgs (paved area), or with SPLP/TCLP concentrations of lead greater than its Zone 3 Alternative GB PMC for I/C site use (0.38 mg/L) at depths greater than 2 feet bgs but above the mean high water table would be capped with an impervious cover system to allow I/C exposure and to prevent potential migration of lead from soil to groundwater to address CERCLA risks. However, as noted below, the top two feet of soil will be excavated in any case in order to install the cap.

For the purpose of this alternative, it is assumed that the foundations of former Building 31 already provide a suitable cap. These foundations consist of a 2-foot-thick concrete slab over which has been added a 4-inch layer of asphalt to allow use of the area as a parking lot. In addition, much of the lead-contaminated soil beneath former Building 31 has been treated by in-situ chemical stabilization/solidification to the water table as part of a previous remedial action (B&RE, 1995). Therefore, no further capping of this area would be required.

The area to be capped is located on Albacore Road, west of former Building 31, and extends over an estimated total of 8,800 square feet, as shown on Figure 4-7. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

To maintain the current topography of the site, surface preparation of the area where the cap would be installed would require excavation to a depth equal to the thickness of the cap. As part of site preparation, the 8,800 square feet area of contaminated soil would be excavated to a depth of 2 feet bgs generating an estimated 650 cubic yards of contaminated surface soil and asphalt debris. Subsequently, these 8,800 square feet of exposed subsurface soil would be covered with a 2-foot-thick layer of compacted soil with a permeability of 10^{-6} cm/sec. Alternately, because soil with such a low permeability may be very difficult and expensive to obtain, the cap could consist of a 2-foot layer of soil with a greater permeability (e.g., 10^{-5} cm/sec) overlying an impervious synthetic liner. The capped area would be repaved to match original surface conditions. Computations of capping and excavation surface areas and volumes are provided in Appendix C.

During construction activities, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum. Appropriate controls such as silt curtains, sediment traps, and hay bales would also be used to minimize erosion and sedimentation. In addition, during the excavation of contaminated soil in close proximity to existing buildings, care would be taken not to undermine the foundations of these buildings.

Component 2: Off-Site Disposal

Because under this alternative soil would be excavated above the water table, it is assumed that the excavated soil would contain minimal free water and would not have to be pretreated by on-site dewatering prior to off-site transportation and disposal.

Asphalt pavement debris would be segregated and recycled or, if required, disposed at an off-site construction material landfill. For this alternative, it is estimated that 80 cubic yards of asphalt debris would be removed from Zone 3.

To determine the proper method of disposal of the remaining 570 cubic yards of excavated soil, composite samples would be collected at the rate of approximately one sample per 50 cubic yards and analyzed for mass lead and SPLP/TCLP lead. Based on current soil characterization data, it is anticipated that the result of these analyses would show that the mass or TCLP concentrations of lead of all of the excavated soil would be greater than the I/C DEC (1,090 mg/kg) or RCRA toxicity characteristic (5 mg/L), respectively, for this COC. Therefore, it is anticipated that the 570 cubic yards of excavated soil would be identified as "high lead" and disposed at an off-site TSDF where it would undergo treatment by chemical stabilization/solidification prior to landfilling. Volume computations are provided in Appendix C.

During off-site transportation of contaminated soil, appropriate spill prevention and control measures would be taken, and DOT regulations would be followed.

Component 3: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 3. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of the caps and building foundations that already cover inaccessible and/or environmentally isolated soil. Similarly, another engineering control would be specified for the regular maintenance of the existing paved areas such that the assumptions used for the alternative PMC calculation are still applicable. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 4: Monitoring

Long-term groundwater monitoring would be conducted to confirm that soil contaminants are not mobilizing and migrating to groundwater at unacceptable concentrations.

4.4.3.2 Detailed Analysis

Overall Protection of Human Health and Environment

Alternative S-3.3 would be protective of human health and the environment under CERCLA. Placement of a cap over the areas of soil with mass concentrations of lead greater than its I/C DEC or SPLP/TCLP concentrations of lead greater than its Zone 3 Alternative GB PMC for I/C site use would prevent unacceptable risk from exposure of current site users with contaminated soil and minimize the potential migration of lead from soil to groundwater. In addition, placement of a cap would be protective because it would require the removal and off-site disposal of some contaminated soil. LUCs ensuring the regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by minimizing uncontrolled exposure of current site users to contaminated soil. In addition, LUCs restricting Zone 3 to current I/C use would be protective by preventing the even greater risks that would result from exposure to contaminated soil by a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration of lead from soil to groundwater. Alternative S-3.3 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-3.3 would also indirectly achieve Soil RAO No.4.

Compliance with ARARs and TBCs

Alternative S-3.3 would comply with chemical-, location-, and action-specific ARARs and TBCs, as summarized in Tables 4-14, 4-15, and 4-16, respectively.

Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-3.3 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil that could not be excavated.

Long-Term Effectiveness and Permanence

Alternative S-3.3 would be long-term effective under CERCLA. Installation of a cap would effectively isolate or remove from the site soil with concentrations of lead to which current site users should not be exposed. The cap would also effectively minimize water infiltration, which is the primary pathway for potential migration of lead from soil to groundwater. LUCs that ensure regular maintenance of building foundations and capped and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 3 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Long-term monitoring would effectively verify that lead does not migrate from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-3.3 would not address CERCLA risks by reducing the toxicity, mobility, and volume of lead in soil through treatment.

Short-Term Effectiveness

Implementation of Alternative S-3.3 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during installation of a cap and also as a result of monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-3.3 could also have some adverse impact on the surrounding community and the environment as a result of the excavation and off-site transportation of contaminated soil. This impact would be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-3.3 could be implemented within approximately 6 months and would achieve Soil RAOs Nos. 1 to 3 upon implementation. By preventing hypothetical future residential development, Alternative S-3.3 would also indirectly achieve Soil RAO No. 4 upon implementation. Although Alternative S-3.3 would not meet the Zone 3 soil lead PRGs for I/C direct exposure and pollutant mobility these criteria would not apply because the engineering controls of Alternative S-3.3 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs. In addition, these cleanup criteria would not apply to leftover areas of inaccessible and/or environmentally isolated contaminated soil that could not be capped because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-3.3 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

Alternative S-3.3 would be technically implementable. Contractors qualified to install a cap are readily available, and this work could be performed with normal construction equipment. As noted earlier, the former Building 31 foundations have been left in place and already provide an adequate cover over the majority of the areas to be capped. However, very careful planning and execution would be required to prevent interference of the capping operations with ongoing activities at the Lower Subase. The presence of many underground structures such as utility lines and existing and former building foundations is not expected to significantly interfere with the placement of a cap because most are located below the shallow depth (2 feet) of the required pre-excavation. Off-site borrow locations for capping material and TSDFs for off-site treatment and disposal of the excavated soil would be available. Maintenance of building

foundations, paved areas, and needed monitoring wells and sampling and analysis of groundwater could be readily performed.

The administrative aspects of Alternative S-3.3 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for the capping activities. The off-site transportation and disposal of excavated soil would have to be properly documented, which could be readily accomplished. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

Estimated costs for Alternative S-3.3 are as follows:

Capital Cost	$461,000
NPW of O&M Costs	$297,000 (30 years)
NPW	$758,000 (30 years)

Within these costs, the estimated incremental capital cost for off-site treatment (chemical stabilization/ solidification) of highly contaminated soil would be $172,000.

A detailed cost estimate for this alternative is provided in Appendix E.

4.4.4 Alternative S-3.4: In-Situ Treatment (Stabilization/Solidification) to Allow I/C Site Use and Meet PMCs for I/C Site Use, LUCs (Engineering and Institutional Controls), and Monitoring

4.4.4.1 Description

Alternative S-3.4 would consist of three major components: (1) in-situ treatment to allow I/C site use and meet PMCs for I/C site use, (2) LUCs with engineering and institutional controls, and (3) monitoring.

Component 1: In-Situ Treatment to Allow I/C Site Use and Meet PMCs for I/C Site Use

Areas of soil with mass concentrations of lead greater than its I/C DEC (1,090 mg/kg) to a depth of 2 feet bgs (paved area), or with SPLP/TCLP concentrations of lead greater than its Zone 3 Alternative GB PMC for I/C site use (0.38 mg/L) in the remainder of the unsaturated zone would be treated using in-situ chemical stabilization/solidification to address CERCLA risks.

However, for the purpose of this alternative, it is assumed that areas of soil known to exceed either of these criteria but that are located beneath the former Building 31 foundations (now used as a parking area) would be classified as environmentally isolated and would not require in-situ treatment. In addition, much of the lead-contaminated soil beneath former Building 31 has already been treated by in-situ chemical stabilization/solidification to the water table as part of a previous remedial action (B&RE, 1995).

The area to be treated under this alternative is located on Albacore Road, west of former Building 31, and extends over an estimated total 8,800 square feet to a depth of 5 feet bgs, as shown on Figure 4-8. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

An LDA typically 6 to 10 feet in diameter would be used to blend the contaminated soil in that area with controlled amounts of a pozzolanic reagent such as Portland cement and water to chemically stabilize the lead within the soil matrix. Each application of the LDA would generate a column of treated soil approximately 6 to 10 feet in diameter, and this would be repeated with a slight column-to-column overlap until all areas of contaminated soil have been treated. The treated areas would be re-paved to match original surface conditions. An estimated 1,540 cubic yards of "high lead" soil would be treated in this way by blending in Portland cement and water at the rate of approximately 5 percent (by weight) and 2 percent (by weight), respectively, for a total estimated use of approximately 130 tons of Portland cement and 12,100 gallons of water. The blending action and addition of Portland cement would result in an increase in the volume of treated soil of approximately 160 cubic yards. Because the chemical stabilization/solidification would only take a few days to complete, this incremental volume of soil could be

disposed off site at a municipal solid waste landfill. Computations of treated soil volumes are provided in Appendix C, and conceptual design calculations for in-situ chemical stabilization/solidifications are provided in Appendix D.

Prior to treatment, treatability testing would be performed to determine the appropriate ratio of Portland cement and water to achieve a properly stabilized soil. Also prior to treatment, a detailed survey would be made of underground obstacles (e.g., underground pipes or cables) in the area to be treated and, when practical, these obstacles would be moved. If obstacles prevent the use of a blending auger in certain areas and if moving of these obstacles is not practical, the Portland cement and water would be manually worked into the soil to be treated using hand tools such as shovels, provided that the areas to be so treated are relatively small in size. Accordingly, it is assumed for the purpose of this FS that underground obstacles would not actually prevent the implementation of in-situ chemical stabilization/solidification.

Following treatment, confirmation samples would be collected beneath and around the treated area to verify that all contaminated soil has been treated. Additional confirmation samples would also be collected from the treated area within approximately one month and tested for SPLP concentrations of lead to verify that treated soil meets the Zone 3 Alternative GB PMC for I/C site use for this COC.

Component 2: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 3. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of building foundations that already cover inaccessible and/or environmentally isolated soil which cannot be treated. Similarly, another engineering control would be specified for the regular maintenance of the existing paved areas such that the assumptions used for the alternative PMC calculation are still applicable. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 3: Monitoring

Long-term groundwater monitoring would be conducted to confirm that soil contaminants are not mobilizing and migrating to groundwater at unacceptable concentrations.

4.4.4.2 Detailed Analysis

Overall Protection of Human Health and Environment

Alternative S-3.4 would be protective of human health and the environment under CERCLA. In-situ treatment with chemical stabilization/solidification would be protective because it would immobilize the lead content of the treated soil, which would prevent its potential migration to groundwater and reduce risk associated with direct exposure to contaminated soil. LUCs ensuring the regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by minimizing uncontrolled exposure of current site users to contaminated soil. In addition, LUCs restricting Zone 3 to its current I/C use would be protective by preventing the even greater risks that would result from exposure to contaminated soil by a wider range of human and ecological receptors under hypothetical future site use. Monitoring would be protective by detecting the potential migration of lead from soil to groundwater. Alternative S-3.4 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-3.4 would also indirectly achieve Soil RAO No.4.

Compliance with ARARs and TBCs

Alternative S-3.4 would comply with chemical-, location- and action-specific ARARs and TBCs, as summarized in Tables 4-17, 4-18, and 4-19, respectively.

Because the engineering controls of Alternative S-3.4 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil that could not be treated. In addition, chemical stabilization/solidification is considered to be an engineering control (pending CTDEP concurrence), so the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs would be satisfied.

Long-Term Effectiveness and Permanence

Alternative S-3.4 would be long-term effective and permanent under CERCLA. Although soil lead concentrations would not be actively reduced, risks to human health and the environment would be minimized through in-situ treatment, LUCs, and monitoring. In-situ treatment with chemical stabilization/solidification would effectively and permanently immobilize lead within the treated soil, which would prevent its potential migration to groundwater and reduce risk associated with direct exposure to contaminated soil. LUCs that ensure regular maintenance of building foundations and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 3 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Long-term monitoring would effectively verify that lead does not migrate from soil to groundwater.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternative S-3.4 would address CERCLA risks by reducing the toxicity and mobility of lead in soil through in-situ chemical stabilization/solidification. An estimated 1,540 cubic yards of "high lead" soil would be permanently and irreversibly treated by this technology. However, the degree of lead toxicity reduction achieved through chemical stabilization/solidification is likely to be significantly less than the reduction of mobility, and there would be no reduction of the quantity of lead in the treated soil. Because chemical stabilization/solidification is considered to be an engineering control (pending CTDEP concurrence), the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs would be satisfied.

Short-Term Effectiveness

Implementation of Alternative S-3.4 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during in-situ treatment activities and also as a result of monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-3.4 would have no adverse impact on the surrounding community or the environment.

Alternative S-3.4 could be implemented within approximately 6 months and would achieve Soil RAOs Nos. 1 to 3 upon implementation. By preventing hypothetical future residential development, Alternative S-3.4 would also indirectly achieve Soil RAO No. 4 upon implementation. Alternative S-3.4 would meet the Zone 3 soil lead PRG for I/C pollutant mobility but it would not meet the Zone 3 soil lead PRG for I/C direct exposure. In addition, these cleanup criteria would not apply to leftover areas of inaccessible and/or environmentally isolated contaminated soil that could not be treated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-3.4 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

Alternative S-3.4 would be technically implementable. Contractors qualified to perform in-situ chemical stabilization/solidification are readily available. Very careful planning and execution would be required to prevent interference with ongoing activities at the Lower Subase. In addition, implementation of the in-situ treatment may be significantly hindered, or even prevented, by the presence of many underground structures such as utility lines and existing and former building foundations. However, as previously mentioned, it is assumed for this alternative that no major underground obstacle would prevent implementation. Treatability tests would be required to determine the appropriate soil/pozzolanic reagent/water mix ratios prior to implementation. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of groundwater could be readily performed.

The administrative aspects of Alternative S-3.4 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for the in-situ treatment activities. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

Estimated costs for Alternative S-3.4 are as follows:

Capital Cost	$698,000
NPW of O&M Costs	$296,000 (30 years)
NPW	$994,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.4.5 Alternative S-3.5: Excavation to Meet DECs and PMCs for I/C Site Use, Off-Site Disposal (Stabilization/Solidification and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring

4.4.5.1 Description

Alternative S-3.5 would consist of four major components: (1) excavation to meet DECs and PMCs for I/C site use, (2) off-site disposal of excavated soil, (3) LUCs with engineering and institutional controls, and (4) monitoring.

Component 1: Excavation to Meet DECs and PMCs for I/C Site Use

Areas of soil with mass concentrations of lead greater than its I/C DEC (1,090 mg/kg) to a depth of 2 feet bgs (paved area), or with SPLP/TCLP concentrations of lead greater than its Zone 3 Alternative GB PMC for I/C site use (0.38 mg/L) in the remainder of the unsaturated zone would be excavated to address CERCLA risks.

However, for the purpose of this alternative, it is assumed that those areas of soil known to exceed either of these criteria but that are located beneath the former Building 31 foundations (now used as a parking area) would not require excavation because they would be classified as environmentally isolated.

The area to be excavated would be located on Albacore Road, west of former Building 31, and extend over an estimated total 8,800 square feet to a depth of up to 5 feet bgs, as illustrated on Figure 4-8. An estimated total of 1,620 cubic yards of contaminated soil and asphalt debris would be removed through excavation. Computations of excavation volumes are provided in Appendix C. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

Following excavation, confirmation samples would be collected from the bottoms and walls of the excavated areas to verify that contaminated soil has been removed. After confirmation sampling is complete, the excavated areas would be backfilled with clean soil and the site restored to its former condition.

Prior to excavation, a detailed survey would be made of underground obstacles (e.g., underground pipes or cables) in the areas to be excavated and, when practical, these obstacles would be moved. If obstacles prevent the use of a normal backhoe or grade-all in certain areas and if moving of these obstacles is not practical, a small backhoe or hand shovels would be used provided that the areas to be so excavated are relatively small in size. For this alternative, it is assumed that no underground obstacles would prevent the excavation of contaminated soil.

Because excavation of Zone 3 contaminated soil under this alternative would only extend to an estimated depth of 6 feet bgs, it is assumed that all excavation would take place above the water table and that only minimal shoring and no excavation dewatering would be required.

During excavation, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum. The excavated areas would be backfilled as soon as possible, and on-site staging and stockpiling of excavated soil would be kept to a minimum. Any on-site stockpiles of excavated soil would be covered with an impervious synthetic liner at the end of each day's work.

Component 2: Off-Site Disposal

Because under this alternative soil would be excavated above the water table, it is assumed that the excavated soil would contain minimal free water and would not have to be pretreated by on-site dewatering prior to off-site transportation and disposal.

Asphalt pavement debris would be segregated and recycled or, if required, disposed at an off-site construction material landfill. For this alternative, it is estimated that 80 cubic yards of asphalt debris would be removed from Zone 3.

To determine the proper method of disposal of the remaining 1,540 cubic yards of excavated soil, composite samples would be collected at the rate of approximately one sample per 100 cubic yards and analyzed for mass lead and SPLP/TCLP lead. Based on current soil characterization data, it is anticipated that the result of these analyses would show that the mass or TCLP concentrations of lead of all of the excavated soil would be greater than the I/C DEC (1,090 mg/kg) or RCRA toxicity characteristic (5 mg/L), respectively, for this COC. Therefore, it is anticipated that the 1,540 cubic yards of excavated soil would be identified as "high lead" and disposed at an off-site TSDF where it would undergo treatment by chemical stabilization/solidification prior to landfilling. Volume computations are provided in Appendix C.

During off-site transportation of contaminated soil, appropriate spill prevention and control measures would be taken, and DOT regulations would be followed.

Component 3: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 3. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of building foundations that already cover inaccessible and/or environmentally isolated soil which cannot be excavated. Similarly, another engineering control would be specified for the regular maintenance of the existing paved areas such that the assumptions used for the alternative PMC calculation are still applicable. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 4: Monitoring

Long-term groundwater monitoring would be conducted to confirm that soil contaminants are not mobilizing and migrating to groundwater at unacceptable concentrations.

4.4.5.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-3.5 would be protective of human health and the environment under CERCLA. Excavation and off-site disposal of soil with mass concentrations of lead greater than its I/C DEC or SPLP/TCLP concentrations of lead greater than its Zone 3 Alternative GB PMC for I/C site use would be protective by eliminating unacceptable risk from exposure of current site users to contaminated soil and minimizing the source of potential migration of lead from soil to groundwater. LUCs ensuring regular maintenance of paved surfaces and regulating the disturbance of contaminated soil would be protective by minimizing exposure of current site users to contaminated soil. In addition, LUCs restricting Zone 3 to its current I/C use would be protective by preventing the even greater risks that would result from exposure to contaminated soil by a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration of lead from soil to groundwater. Alternative S-3.5 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-3.5 would also indirectly achieve Soil RAO No.4.

Compliance with ARARs and TBCs

Alternative S-3.5 would comply with chemical-, location- and action-specific ARARs and TBCs, as summarized in Tables 4-8, 4-9, and 4-10, respectively.

Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-3.5 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil that could not be excavated.

Long-Term Effectiveness and Permanence

Alternative S-3.5 would be long-term effective and permanent under CERCLA. Excavation and off-site disposal would effectively and permanently remove soil with concentrations of lead to which current site users should not be exposed and such that lead could potentially migrate to groundwater at unacceptable levels. LUCs that ensure regular maintenance of paved surfaces, restrict disturbance of contaminated

soil, and prevent hypothetical future residential development of Zone 3 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-3.5 would not address CERCLA risks by reducing the toxicity, mobility, and volume of lead in soil through treatment.

Short-Term Effectiveness

Implementation of Alternative S-3.5 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during soil excavation. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-3.5 could also have a minimal adverse impact on the surrounding community and the environment as a result of the excavation and off-site transportation of contaminated soil. This impact would be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-3.5 could be implemented within approximately 6 months and would achieve Soil RAOs Nos. 1 to 3 upon implementation. By preventing hypothetical future residential development, Alternative S-3.5 would also indirectly achieve Soil RAO No. 4 upon implementation. Alternative S-3.5 would meet the Zone 3 soil lead PRGs for I/C direct exposure and pollutant mobility upon implementation. In addition, these cleanup criteria would not apply to leftover areas of inaccessible and/or environmentally isolated contaminated soil that could not be excavated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-3.5 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

Alternative S-3.5 would be technically implementable. Excavation could be performed with normal construction equipment by a wide range of contractors. Very careful planning and execution would be required to prevent interference with ongoing activities at the Lower Subase. In addition, excavation could be significantly hindered, or even prevented, by the presence of many underground structures such as utility lines and existing and former building foundations. However, as previously mentioned, it is assumed for this alternative that no major underground obstacle would prevent excavation. Because excavation would be limited to approximately 5 feet bgs and would not extend below the water table, the need for shoring would be minimal, and there would be no need for excavation dewatering. Off-site borrow locations for clean soil backfill and TSDFs for off-site treatment and disposal of the excavated soil would

be available. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of groundwater could be readily performed.

The administrative aspects of Alternative S-3.5 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for soil excavation. The off-site transportation and disposal of excavated soil would have to be properly documented, which could be readily accomplished. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

The estimated costs for Alternative S-3.5 are as follows:

Capital Cost	$817,000
NPW of O&M Costs	$297,000 (30 years)
NPW	$1,114,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

Within these costs, the estimated incremental capital cost for off-site treatment (chemical stabilization/ solidification) of highly contaminated soil would be $450,000.

4.4.6 Alternative S-3.6: Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/Solidification, LTTD, and Landfilling)

4.4.6.1 Description

Alternative S-3.6 would consist of three major components: (1) excavation to meet Residential DECs and PMCs, (2) on-site dewatering, and (3) off-site disposal.

Component 1: Excavation to Meet Residential DECs and PMCs

Areas of soil up to 15 feet deep with mass concentrations of PAHs or lead greater than their respective Residential DECs (1 mg/kg and 500 mg/kg) and the areas of unsaturated soil with SPLP/TCLP concentrations of lead greater than its Zone 3 Alternative GB PMC for Residential use (0.15 mg/L) would be excavated to address CERCLA risks. In addition, areas of soil with mass concentrations of TPH greater than its Residential DEC (500 mg/kg) would also be excavated to address State petroleum concerns. These areas are located along and west of Albacore Road, within the footprint of former Building 31, and in the vicinity of sampling locations 13TB7/13MW12 and TB4-3RI and extend over an estimated total of 26,900 square feet to a depth of 10 to 15 feet bgs, as shown on Figure 4-9. An estimated total of 11,900 cubic yards of contaminated soil, uncontaminated soil, and asphalt and concrete debris would be removed through excavation. Computations of excavation volumes are provided in Appendix C. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

Following excavation, confirmation samples would be collected from the bottoms and walls of excavated areas located above the water table to verify that soil with SPLP/TCLP lead concentrations greater than the Zone 3 PMC and/or mass concentrations of PAHs, TPH, or lead greater than their respective residential DECs have been removed. After confirmation sampling is complete, the excavated area would be backfilled with clean soil including a 6-inch layer of topsoil, and vegetated to minimize erosion.

Because this alternative would only be implemented prior to residential development of the site, it is assumed that existing underground obstacles (e.g., underground pipes or cables) would have been removed as part of site preparation for this development.

Because excavation of Zone 3 contaminated soil under this alternative would extend to an estimated depth of 15 feet bgs, some excavation would take place below the water table and significant shoring would be required. However, as discussed in Section 3.2.4, dewatering of the excavated areas would not be practical and excavation would be performed with equipment adapted to underwater work, such as a clamshell.

During excavation, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum. The excavated areas would be backfilled as soon as possible, and on-site staging and stockpiling of excavated soil would be kept to a minimum. Any on-site stockpiles of excavated soil would be covered with an impervious synthetic liner at the end of each day's work.

Component 2: On-Site Dewatering

Within Zone 3, it is assumed that excavation beyond a depth of approximately 6 feet bgs would take place below the water table. Therefore, it is also assumed that wet soil excavated below that depth would equal approximately 1.5 times its in-situ volume and would contain an average of 53 percent of free water by volume. This wet soil would require gravity-induced passive dewatering by on-site stockpiling prior to off-site disposal, as discussed in Section 3.2.6.1.

Gravity-induced stockpile dewatering would be performed at a DW/WWT facility located as close to the excavation area as possible. A typical DW/WWT facility would consist of a dewatering stockpile and associated drainage water treatment system including bag filtration and liquid-phase GAC adsorption. A more detailed description of this facility is provided in the description of Alternative S-1.5 (see Section 4.2.5.1).

DW/WWT monitoring would consist of collecting one sample of the treatment system influent and effluent for every day of system operation and analyzing these samples for PAHs, metals, and total suspended solids.

An estimated in-situ soil volume of 5,900 cubic yards would be excavated below the water table, yielding approximately 8,900 cubic yards of wet excavated soil that would be dewatered to its original in-situ volume of 5,900 cubic yards (or 10,600 tons). This would require an estimated 30 dewatering stockpile operating sequences, or approximately 90 operating days with one dewatering stockpile. The total volume of drainage water treated and discharged would be an estimated 599,700 gallons. Conceptual design calculations for the on-site dewatering of soil are provided in Appendix D.

Component 3: Off-Site Disposal

Concrete foundations and asphalt pavement debris would be segregated and recycled or, if required, disposed at an off-site construction material landfill. For this alternative, it is estimated that 140 cubic yards of concrete debris and 160 cubic yards of asphalt debris would be removed from Zone 3.

To determine the proper method of disposal of the remaining 11,600 cubic yards of excavated soil, composite samples would be collected at the rate of approximately one sample per 250 cubic yard. These samples would be analyzed for mass concentrations of PAHs, TPH, and lead and SPLP/TCLP concentrations of lead to sort the excavated soil into the following categories:

- Soil with mass concentrations of PAHs, TPH, or lead less than their respective Residential DECs (1 mg/kg, 500 mg/kg, and 400 mg/kg), or with SPLP/TCLP concentrations of lead less than its Zone 3 Alternative GB PMC for Residential use (0.15 mg/L) would be identified as non-contaminated and would be reused on site as backfill. For this alternative, it is estimated that 1,900 cubic yards of soil excavated from Zone 3 would fall into this category.

- Soil with mass concentrations of TPH or lead greater than their respective Residential DECs but less than their respective I/C DECs (2,500 mg/kg and 1,090 mg/kg) or with TCLP concentrations of lead greater than its Zone 3 Alternative GB PMC for Residential use but less than its RCRA toxicity characteristic (5 mg/L) would be identified as contaminated but not requiring treatment. This soil would be disposed off site at a municipal solid waste landfill. For this alternative, it is estimated that no soil excavated from Zone 3 would fall into this category.

- Soil with mass concentrations of PAHs or TPH greater than their respective I/C DECs would be identified as contaminated and requiring treatment. This soil would be disposed at an off-site TSDF where it would undergo treatment by LTTD prior to landfilling. For this alternative, it is estimated that 4,500 cubic yards of soil excavated from Zone 3 would fall into this category with essentially all of it identified as "high PAH".

- Soil with mass concentrations of lead greater than its I/C DEC or TCLP concentrations of lead greater than its RCRA toxicity characteristic would be identified as "high lead". This soil would be disposed at an off-site TSDF where it would undergo treatment by chemical stabilization/solidification prior to landfilling. For this alternative, it is estimated that 5,200 cubic yards of soil excavated from Zone 3 would fall into this category.

Computations of volumes for the above categories are provided in Appendix C.

During off-site transportation of contaminated soil, appropriate spill prevention and control measures would be taken, and DOT regulations would be followed.

4.4.6.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-3.6 would be fully protective of human health and the environment under CERCLA under the current I/C exposure scenario and any other foreseeable site use. Excavation and off-site disposal of soil with mass concentrations of PAHs or lead greater than their respective Residential DECs would be protective because it would not only remove unacceptable risk from exposure of current site users to contaminated soil but it would also eliminate the future hypothetical human health risks from direct exposure to contaminated soil under a residential scenario. In addition, removal of soil with mass concentrations of SPLP/TCLP concentrations of lead greater than its respective Zone 3 Alternative GB PMC for Residential uses would also be protective because it would eliminate any potential for migration of lead from soil to groundwater. Alternative S-3.6 would achieve all four soil RAOs.

Alternative S-3.6 would also be protective under the Connecticut RSRs by preventing unacceptable human health risk from exposure to TPH contaminated soil and minimizing the source of potential migration of TPH from soil to groundwater.

Compliance with ARARs and TBCs

Alternative S-3.6 would comply with chemical-, location-, and action-specific ARARs and TBCs, as summarized in Tables 4-11, 4-12, and 4-13, respectively.

Long-Term Effectiveness and Permanence

Alternative S-3.6 would be long-term effective and permanent under CERCLA. Excavation and off-site disposal of soil with mass concentrations of PAHs or lead greater than their respective Residential DECs would effectively and permanently remove soil to which current site users and hypothetical future site residents should not be exposed. In addition, excavation and off-site disposal of soil with mass concentrations of SPLP/TCLP concentrations of lead greater than its respective Zone 3 Alternative GB PMCs for Residential use would effectively and permanently eliminate the potential for migration of lead from soil to groundwater.

In addition, Alternative S-3.6 would effectively and permanently address State petroleum concerns by removing soil with concentrations of TPH to which current site users should not be exposed and such that TPH could potentially migrate from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-3.6 would not address CERCLA risks by reducing the toxicity, mobility, and volume of PAHs and lead in soil through treatment, except through the treatment of water generated from the dewatering process prior to discharge to the Thames River.

Alternative S-3.6 would also not reduce the toxicity, mobility, and volume of TPH in soil through treatment.

Short-Term Effectiveness

Implementation of Alternative S-3.6 could result in significant short-term risks to on-site workers as a result of exposure to contamination during soil excavation. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-3.6 could also adversely impact the surrounding community and the environment as a result of the excavation and off-site transportation of contaminated soil. This adverse impact would also be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-3.6 could be implemented within approximately 9 months and would achieve the soil RAOs and meet the Zone 3 soil PRGs for residential direct exposure and pollutant mobility as well as the TPH Residential DEC and PMC upon implementation.

Implementability

Alternative S-3.6 would be technically difficult to implement. Excavation could be performed with normal construction equipment by a wide range of contractors. Because this alternative would only be implemented as part of hypothetical future residential development, excavation would not interfere with ongoing activities at the Lower Subase, and it is assumed that underground structures such as utility lines and existing and former building foundations would have been removed as part of site preparation for development. Because excavation would reach to a depth of approximately 10 feet bgs, extensive shoring would be required. In addition, because a significant portion of the excavation would extend below the water table, much of the excavated soil would have a high initial water content, and a relatively complex on-site dewatering operation would be required to make this soil amenable to further treatment and/or disposal. Also, post-excavation confirmation sampling would not be possible in the underwater excavated areas and would have to be replaced with pre-excavation sampling to verify the extent of contamination. Off-site borrow locations for clean soil backfill and solid waste landfills or TSDFs for off-site disposal of the excavated soil would be available.

The administrative aspects of Alternative S-3.6 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for soil excavation. The off-site transportation and disposal of the excavated soil would have to be properly documented, which could be readily accomplished. In addition, the substantive requirements of federal and State water discharge regulations would have to be met to discharge treated water from the on-site soil dewatering operation to the Thames River.

Cost

The estimated costs for Alternative S-3.6 are as follows:

Capital Cost	$5,704,000
NPW of O&M Costs	$0
NPW	$5,704,000 (1 year)

Within these costs, the estimated incremental capital cost for off-site treatment (chemical stabilization/ solidification and LTTD) of highly contaminated soil would be $2,578,000.

The above figures do not include the cost of demolition of existing structures and removal of underground obstacles that would be required for the implementation of this alternative. Instead, these costs are assumed to have been included as part of the hypothetical future residential development of Zone 3. A detailed cost estimate for this alternative is provided in Appendix E.

4.5 ASSEMBLY AND DETAILED ANALYSIS OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 4

The following soil remedial alternatives have been developed for Zone 4 of the Lower Subase:

Alternative S-4.1:	No Action.
Alternative S-4.2:	LUCs (Engineering and Institutional Controls) and Monitoring.
Alternative S-4.3:	Capping to Allow I/C Site Use and Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring.
Alternative S-4.4:	In-Situ Treatment (Enhanced Bioremediation or Stabilization/Solidification) to Allow I/C Site Use and Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring.
Alternative S-4.5:	Excavation to Meet I/C DECs and PMCs, Off-Site Disposal (Stabilization/Solidification, LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-4.6: Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/Solidification, LTTD, and Landfilling).

Alternative S-4.1 was developed and analyzed to serve as a baseline for other alternatives, as required by CERCLA and the NCP. Alternative S-4.2 was developed and analyzed to evaluate LUCs with engineering and institutional controls and monitoring. Alternatives S-4.3, S-4.4, and S-4.5 were developed and analyzed to evaluate the adequacy of a range of remedial actions to address environmental concerns under current site use. Alternative S-4.6 was developed and analyzed to evaluate contaminated soil cleanup for hypothetical future unrestricted site use. Descriptions and detailed analyses of these alternatives are provided in the following sections.

4.5.1 Alternative S-4.1: No Action

4.5.1.1 Description

No Action would not include any action under CERCLA and any existing administrative or engineering environmental controls would not be an enforceable part of a CERCLA remedy. This alternative is required under CERCLA to establish a basis for comparison with other alternatives. The only activity under this alternative would be the performance of five-year reviews. This alternative cannot be chosen because contamination remains on site.

4.5.1.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-4.1 would not be protective of human health and the environment under CERCLA. Unacceptable risk to current site users would be allowed to occur as a result of direct exposure to contaminated soil because the asphalt pavement that covers most of this soil would not be maintained, and disturbance of areas of contaminated soil would not be regulated. There would also be no protection against the even greater risks that would result from exposure to contaminated soil by a wider range of human and ecological receptors if hypothetical future residential use of the site would be allowed. In addition, Alternative S-4.1 could allow unacceptable human health and environmental risks to develop because the potential for migration of TPH and lead from soil to groundwater would continue to exist, and no monitoring would be performed to assess this potential migration. Alternative S-4.1 would not achieve the soil RAOs.

Compliance with ARARs and TBCs

Alternative S-4.1 would not comply with chemical-specific ARARs and TBCs because no action would be taken to reduce concentrations of COCs and TPH. Because Alternative S-4.1 would not involve any action, location- and action-specific ARARs and TBCs would not be relevant. A summary of Alternative S-4.1's compliance with chemical-specific ARARs and TBCs is provided in Table 4-1.

Long-Term Effectiveness and Permanence

Alternative S-4.1 would not be long-term effective and permanent. Paved areas would not be maintained and no controls would restrict contaminated soil disturbance, which could result in unacceptable risks to human receptors under current I/C site use. No controls would prevent hypothetical future residential development, which could result in even greater risks to a wider range of human and ecological receptors. In addition, because no monitoring would be performed, there would be no assessment of the potential migration of TPH and lead from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative S-4.1 would not reduce the toxicity, mobility, or volume of PAHs, TPH, or lead in soil through treatment because no treatment would occur.

Short-Term Effectiveness

Because no action would occur, implementation of Alternative S-4.1 would not result in any short-term risks to on-site workers or adversely impact the local community or the environment.

Alternative S-4.1 would not achieve the soil RAOs or meet the Zone 4 soil PRGs and TPH cleanup criterion for residential or I/C direct exposure and pollutant mobility.

Implementability

Technically, Alternative S-4.1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Cost

The estimated costs for Alternative S-4.1 are as follows:

Capital Cost	$0
NPW of O&M Costs	$55,000 (30 years)
NPW	$55,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.5.2 Alternative S-4.2: LUCs (Engineering and Institutional Controls) and Monitoring

4.5.2.1 Description

Alternative S-4.2 would consist of two major components: (1) LUCs with engineering and institutional controls and (2) monitoring.

Component 1: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 4. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of building foundations and paved areas. The LUC RD would also include procedures for performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 2: Monitoring

A groundwater monitoring program would be developed and implemented to evaluate the long-term potential migration of soil COCs to groundwater.

For the purpose of this FS, it was assumed that four groundwater samples would be regularly collected from strategic locations to be identified and that the collected samples would be analyzed for PAHs, TPH, and lead. Monitoring frequency would be quarterly for the first 2 years, semi-annual for the next 2 years, and annual thereafter.

Reviews would be performed every 5 years to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary. These site reviews are required because this alternative allows COCs to remain in soil at concentrations in excess of their I/C direct exposure and pollutant mobility PRGs.

4.5.2.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-4.2 would be protective of human health and the environment under CERCLA. Unacceptable risk from direct exposure of current site users to contaminated surface soil would be minimized by the asphalt pavement that covers most of this soil. LUCs ensuring regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by minimizing uncontrolled exposure of current site users to contaminated soil. In addition, LUCs restricting Zone 4 to its current I/C use would be protective by preventing the even greater risks that would result from exposure by a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration of lead from soil to groundwater. Alternative S-4.2 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-4.2 would also indirectly achieve Soil RAO No.4.

Alternative S-4.2 would also be protective under the Connecticut RSRs by preventing unacceptable human health risk from exposure to TPH contaminated soil and minimizing the source of potential migration of TPH from soil to groundwater.

Compliance with ARARs and TBCs

Alternative S-4.2 would comply with all location- and action-specific ARARs and TBCs. Alternative S-4.2 would also comply with federal chemical-specific TBCs (there are no federal chemical-specific ARARs) and with DECs and PMCs mandated by Connecticut RSRs. .A summary of Alternative S-4.2's compliance with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 4-2, 4-3, and 4-4, respectively.

Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-4.2 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil. See Appendix D.1.3 for engineering control calculations.

Long-Term Effectiveness and Permanence

Alternative S-4.2 would be long-term effective and permanent under CERCLA. Although soil concentrations of PAHs and lead would not be actively reduced, risks to human health and the environment would be minimized through LUCs and monitoring. LUCs that ensure regular maintenance of paved surfaces, restrict disturbance of contaminated soil, and prevent hypothetical future residential

development of Zone 4 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Long-term monitoring would effectively detect potential migration of lead from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-4.2 would not reduce the toxicity, mobility, or volume of PAHs or lead in soil through treatment because no treatment would occur.

Alternative S-4.2 would also not reduce the toxicity, mobility, and volume of TPH in soil through treatment.

Short-Term Effectiveness

Alternative S-4.2 would have minimal short-term effectiveness concerns. Any exposure of workers to contaminated soil during the maintenance and sampling of groundwater monitoring wells would be minimized by wearing of appropriate PPE and complying with site-specific health and safety procedures. Implementation of LUCs and monitoring would not adversely impact the surrounding community or the environment.

Alternative S-4.2 could be implemented within approximately 3 months and would achieve Soil RAOs Nos. 1 to 3 upon implementation. By preventing hypothetical future residential development, Alternative S-4.2 would also indirectly achieve Soil RAO No. 4 upon implementation. However, Alternative S-4.2 would meet none of the Zone 4 soil PRGs for I/C direct exposure and pollutant mobility and would not meet the TPH soil PMC or I/C DEC, but these cleanup criteria would not apply because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-4.2 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

The technical implementability of Alternative S-4.2 would be easy. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of groundwater could be readily performed.

The administrative aspects of Alternative S-4.2 would be simple to implement. No construction permit issued by NSB-NLON DPW would be required for this alternative. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

The estimated costs for Alternative S-4.2 are as follows:

Capital Cost	$47,000
NPW of O&M Costs	$413,000 (30 years)
NPW	$460,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.5.3 Alternative S-4.3: Capping to Allow I/C Site Use and Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring

4.5.3.1 Description

Alternative S-4.3 would consist of four major components: (1) capping to allow I/C site use and prevent leaching, (2) off-site disposal of excavated soil, (3) LUCs with engineering and institutional controls, and (4) monitoring.

Component 1: Capping to Allow I/C Site Use and Prevent Leaching

Areas of soil with mass concentrations of PAHs and lead greater than their respective I/C DECs (1 mg/kg and 1,090 mg/kg) to a depth of 2 feet bgs (paved area) and SPLP/TCLP concentrations of lead greater than its Zone 4 Alternative GB PMC for I/C site use (0.19 mg/L) at depths greater than 2 feet bgs but above the mean high water table would be capped with an impervious cover system to address CERCLA risks. In addition, areas of soil with mass concentrations of TPH greater than its I/C DEC (2,500 mg/kg) to

a depth of 2 feet or PMC (2,500 mg/kg) at depths greater than 2 feet bgs but above the mean high water table would also be capped to address State petroleum concerns. However, as noted below, the top 2 feet of soil will be excavated in any case in order to install the cap.

As shown on Figure 4-10, the areas to be capped extend over an estimated total of 33,400 square feet including 14,800 square feet of PAH-contaminated soil in the vicinity of soil sampling location MW1-4RI, 1,200 square feet of TPH-contaminated soil in the vicinity of soil sampling location 13TB4A, and 17,400 square feet of lead-contaminated soil in the vicinity of soil sampling locations 13TB3A (6,200 square feet) and WE4A (11,200 square feet). Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

To maintain the current topography of the site, surface preparation of the areas where the cap would be installed would require excavation to a depth equal to the thickness of the cap. Because the planned thickness of the cap is approximately 2 feet, this pre-excavation would result in the removal of all contaminated surface soil, leaving only contaminated subsurface soil to be capped. The areas to be capped would be covered with a 2-foot-thick layer of compacted soil with a permeability of 10^{-6} cm/sec. Alternately, because soil with such a low permeability may be very difficult and expensive to obtain, the cap could consist of a 2-foot layer of soil with a greater permeability (e.g., 10^{-5} cm/sec) overlying an impervious synthetic liner. The pre-excavated areas that do not require capping would be backfilled with clean fill. The capped and backfilled areas would be repaved to match original surface conditions.

It is estimated that approximately 2,480 cubic yards of surface soil would be excavated as part of site preparation from a total area of 33,400 square feet. Subsequently, an estimated 17,400 square feet of the exposed subsurface soil would be capped, and the remaining 16,000 square feet of excavated area would be backfilled with clean fill material. Computations of capping and excavation surface areas and volumes are provided in Appendix C.

During construction activities, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum. Appropriate controls such as silt curtains, sediment traps, and hay bales would also be used to minimize erosion and sedimentation. In addition, during the excavation of contaminated soil in close proximity to existing buildings, care would be taken not to undermine the foundations of these buildings.

Component 2: Off-Site Disposal

Because under this alternative soil would be excavated above the water table, it is assumed that the excavated soil would contain minimal free water and would not have to be pretreated by on-site dewatering prior to off-site transportation and disposal.

Asphalt pavement debris would be segregated and recycled or, if required, disposed at an off-site construction material landfill. For this alternative, it is estimated that 310 cubic yards of asphalt debris would be removed from Zone 4.

To determine the proper method of disposal of the remaining 2,170 cubic yards of excavated soil, composite samples would be collected at the rate of approximately one sample per 100 cubic yards. These samples would be analyzed for mass PAHs, TPH, and lead and for SPLP/TCLP lead to sort the excavated soil into the following categories:

- Soil with mass concentrations of PAHs, TPH, or lead less than their respective Residential DECs (1 mg/kg, 500 mg/kg, and 400 mg/kg) and/or SPLP/TCLP concentrations of lead less than its Zone 4 Alternative GB PMC for I/C use (0.19 mg/L) would be identified as non-contaminated and would be reused on site as backfill. For this alternative, it is estimated that no soil excavated from Zone 4 would fall into this category.

- Soil with mass concentrations of TPH or lead greater than their respective Residential DEC but less than their respective I/C DECs (2,500 mg/kg and 1,090 mg/kg) and/or with TCLP concentrations of lead greater than its Zone 4 Alternative GB PMC for I/C site use but less than its RCRA toxicity characteristic (5 mg/L) would be identified as contaminated and not requiring treatment. This soil would be disposed at an off-site municipal solid waste landfill. For this alternative, it is estimated that no soil excavated from Zone 4 would fall into this category.

- Soil with mass concentrations of PAHs or TPH greater than their respective I/C DECs would be identified as contaminated and requiring treatment. This soil would be disposed at an off-site TSDF where it would undergo treatment by LTTD prior to landfilling. For this alternative, it is estimated that 1,040 cubic yards of soil excavated from Zone 4 would fall into this category, including 960 cubic yards of "high PAH" soil and 80 cubic yards of "high TPH" soil.

- Soil with mass concentrations of lead greater than its I/C DEC and/or with TCLP concentrations of lead greater than its RCRA toxicity characteristic would be identified as "high lead". This soil would be disposed at an off-site TSDF where it would undergo treatment by chemical stabilization/solidification

prior to landfilling. For this alternative, it is estimated that 1,130 cubic yards of soil excavated from Zone 4 would fall into this category.

Computations of volumes for the above categories are provided in Appendix C.

During off-site transportation of contaminated soil, appropriate spill prevention and control measures would be taken, and DOT regulations would be followed.

Component 3: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 4. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of the caps and of building foundations areas that already cover inaccessible and/or environmentally isolated soil. Similarly, another engineering control would be specified for the regular maintenance of the existing paved areas such that the assumptions used for the alternative PMC calculation are still applicable. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 4: Monitoring

Long-term groundwater monitoring would be conducted to confirm that soil contaminants are not mobilizing and migrating to groundwater at unacceptable concentrations.

4.5.3.2 Detailed Analysis

Overall Protection of Human Health and Environment

Alternative S-4.3 would be protective of human health and the environment under CERCLA. Placement of a cap would be protective because it would isolate or remove soil with mass concentrations of PAHs and lead to which current site users should not be exposed. Placement of a cap would also be protective because it would minimize the potential for lead to migrate from soil to groundwater. LUCs ensuring regular maintenance of building foundations and capped and paved areas and regulating the disturbance of contaminated soil would be protective by minimizing uncontrolled exposure of current site users to contaminated soil. In addition, LUCs restricting Zone 4 to its current I/C use would be protective by

preventing the even greater risks that would result from exposure to contaminated soil by a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration of lead from soil to groundwater. Alternative S-4.3 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-2.3 would also indirectly achieve Soil RAO No.4.

Alternative S-4.3 would also be protective under the Connecticut RSRs by preventing unacceptable human health risk from exposure to TPH contaminated soil and minimizing the source of potential migration of TPH from soil to groundwater.

Compliance with ARARs and TBCs

Alternative S-4.3 would comply with chemical-, location-, and action-specific ARARs and TBCs, as summarized in Tables 4-14, 4-15, and 4-16, respectively.

Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-4.3 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil that could not be excavated.

Long-Term Effectiveness and Permanence

Alternative S-4.3 would be long-term effective under CERCLA. Installation of a cap would effectively isolate or remove from the site soil with concentrations of PAHs and lead to which current site users should not be exposed. The cap would also effectively minimize water infiltration, which is the primary pathway for potential migration of lead from soil to groundwater. LUCs that ensure regular maintenance of building foundations and capped and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 4 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Long-term monitoring would effectively verify that lead does not migrate from soil to groundwater.

In addition, Alternative S-4.3 would effectively and permanently address State petroleum concerns by capping soil with concentrations of TPH to which current site users should not be exposed and such that TPH could potentially migrate from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-4.3 would not address CERCLA risks by reducing the toxicity, mobility, and volume of PAHs and lead in soil through treatment.

Alternative S-4.3 would also not reduce the toxicity, mobility, and volume of TPH in soil through treatment.

Short-Term Effectiveness

Implementation of Alternative S-4.3 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during installation of a cap and also as a result of monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-4.3 could also have a minimal adverse impact on the surrounding community and the environment as a result of the excavation and off-site transportation of contaminated soil. This impact would also be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-4.3 could be implemented within approximately 9 months and would achieve Soil RAOs Nos. 1 to 3 upon implementation. By preventing hypothetical future residential development, Alternative S-4.3 would also indirectly achieve Soil RAO No. 4 upon implementation. Alternative S-4.3 would meet the Zone 4 soil PAH PRG for I/C direct exposure as well as the TPH I/C DEC and PMC. Although Alternative S-4.3 would not meet the Zone 4 soil lead PRG for I/C direct exposure and pollutant mobility these criteria would not apply because the engineering controls of Alternative S-4.3 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs. In addition, these cleanup criteria would not apply to leftover areas of inaccessible and/or environmentally isolated contaminated soil that could not be capped because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-4.3 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

Alternative S-4.3 would be technically implementable. Contractors qualified to install a cap are readily available, and this work could be performed with normal construction equipment. However, very careful planning and execution would be required to prevent interference of the capping operations with ongoing activities at the Lower Subase. The presence of many underground structures such as utility lines and existing and former building foundations would also interfere with the placement of a cap, although this might be somewhat mitigated because many of these structures are located below the shallow depth (2 feet) of the required pre-excavation. Off-site borrow locations for capping material and TSDFs for off-site treatment and disposal of the excavated soil would be available. Maintenance of building foundations, capped and paved areas, and needed monitoring wells and sampling and analysis of soil and groundwater could be readily performed.

The administrative aspects of Alternative S-4.3 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for the capping activities. The off-site transportation and disposal of excavated soil would have to be properly documented, which could be readily accomplished. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

Estimated costs for Alternative S-4.3 are as follows:

Capital Cost	$1,265,000
NPW of O&M Costs	$414,000 (30 years)
NPW	$1,679,000 (30 years)

Within these costs, the estimated incremental capital cost for off-site treatment (chemical stabilization/ solidification and LTTD) of highly contaminated soil would be $603,000.

A detailed cost estimate for this alternative is provided in Appendix E.

4.5.4 Alternative S-4.4: In-Situ Treatment (Enhanced Bioremediation and Stabilization/ Solidification) to Allow I/C Site Use and Meet PMCs for I/C Site Use, LUCs (Engineering and Institutional Controls), and Monitoring

4.5.4.1 Description

Alternative S-4.4 would consist of three major components: (1) in-situ treatment to allow I/C site use and meet PMCs for I/C site use, (2) LUCs (Engineering and Institutional Controls), and (3) monitoring.

Component 1: In-Situ Treatment to Allow I/C Site Use and Meet PMCs for I/C Site Use

In-situ treatment would include enhanced bioremediation to treat PAHs and TPH and chemical stabilization/solidification to treat lead. In-situ soil treatment computations are provided in Appendix D.

Enhanced Bioremediation

Areas of surface soil with mass concentrations of PAHs greater than its I/C DECs (1 mg/kg) would be treated using in-situ enhanced bioremediation to address CERCLA risks. In addition, areas of soil with mass concentrations of TPH greater than its PMC (2,500 mg/kg) would also be treated to address State petroleum concerns. These areas are located in the vicinity of soil sampling points MW1-4RI and 13TB4A, respectively, and extend over an estimated total of 16,000 square feet to a depth of 2 feet bgs, as shown on Figure 4-11. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

In-situ bioremediation would consist of using ORC to enhance the growth of indigenous microorganisms and augment the natural aerobic biodegradation of PAHs and TPH in soil. For the purposes of this alternative, it is assumed that an ORC such as magnesium peroxide would be blended in the areas of soil to be treated using a backhoe and that a single application would be required. An estimated 1,040 cubic yards of soil would be treated in this way by blending in magnesium peroxide as a 8-percent (by weight) solution at the rate of approximately 10 pounds of dry magnesium peroxide per pound of PAH or TPH to be removed, for a total estimated use of approximately 8,400 pounds of dry magnesium peroxide (or 11,600 gallons of 8-percent solution). The blending action and addition of ORC would result in an increase of the volume of treated soil which is estimated at approximately 105 cubic yards. Because the bioremediation process would take at least 1 year to complete, this incremental volume of soil would be kept on site and dispersed through appropriate regrading as necessary to accommodate existing buildings and other structures. The exact design of the treatment system would be verified through treatability testing prior to implementation. Conceptual design calculations for in-situ bioremediation are provided in Appendix D.

Chemical Stabilization/Solidification

The areas of unsaturated soil with mass concentrations of lead greater than its I/C DEC (1,090 mg/kg) or SPLP/TCLP concentrations of lead greater than its Zone 4 Alternative GB PMC for I/C site use (0.19 mg/L) would be treated using in-situ chemical stabilization/solidification. These areas are located in the vicinity of soil sampling points 13TB3A and WE4A and extend over an estimated 17,400 square feet to a depth of 5 feet bgs, as shown on Figure 4-11. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

An LDA typically 6 to 10 feet in diameter would be used to blend the contaminated soil in that area with controlled amounts of a pozzolanic reagent such as Portland cement and water to chemically stabilize the lead within the soil matrix. Each application of the LDA would generate a column of treated soil approximately 6 to 10 feet in diameter, and this would be repeated with a slight column-to-column overlap until the entire contaminated soil area has been treated. The treated areas would be repaved to match original surface conditions. An estimated 3,060 cubic yards of "high lead" soil would be treated in this way by blending in Portland cement and water at the rate of approximately 5 percent (by weight) and 2 percent (by weight), respectively, for a total estimated use of approximately 250 tons of Portland cement and 24,100 gallons of water. The blending action and addition of Portland cement would result in an increase in the volume of treated soil of approximately 310 cubic yards. Because the chemical stabilization/ solidification would only take a few days to complete, this incremental volume of soil could be disposed off site at a municipal solid waste landfill. Prior to treatment, treatability testing would be performed to determine the appropriate ratio of Portland cement and water to achieve a properly stabilized soil. Conceptual design calculations for in-situ chemical stabilization/solidification are provided in Appendix D.

Prior to treatment with either enhanced bioremediation or chemical stabilization/solidification, a detailed survey would be made of underground obstacles (e.g., underground pipes or cables) in the area to be treated and, when practical, these obstacles would be moved. If obstacles prevent the use of a blending auger in certain areas and if moving of these obstacles is not practical, the ORC or Portland cement and water would be manually worked into the soil to be treated using hand tools such as shovels, provided that the areas to be so treated are relatively small in size. Accordingly, it is assumed for the purpose of this FS that underground obstacles would not actually prevent the implementation of in-situ enhanced bioremediation or chemical stabilization/solidification.

Following treatment, confirmation samples would be collected beneath and around the treated areas to verify that all contaminated soil has been treated. Additional confirmation samples would also be collected within approximately one month from the areas treated with chemical stabilization/solidification and within a year from the areas treated with enhanced bioremediation. These additional samples would be tested

for SPLP concentrations of lead and for mass concentrations of PAHs, respectively, to verify that the treated soil meets the Zone 4 I/C PRGs.

Component 2: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 4. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of building foundations that cover inaccessible and/or environmentally isolated soil which cannot be treated. Similarly, another engineering control would be specified for the regular maintenance of the existing paved areas such that the assumptions used for the alternative PMC calculation are still applicable. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 3: Monitoring

Long-term groundwater monitoring would be conducted to confirm that soil contaminants are not mobilizing and migrating to groundwater at unacceptable concentrations.

4.5.4.2 Detailed Analysis

Overall Protection of Human Health and Environment

Alternative S-4.4 would be protective of human health and the environment under CERCLA. In-situ treatment with enhanced bioremediation and would be protective because it would actively remove soil concentrations of PAHs to which current site users should not be exposed. In-situ treatment with chemical stabilization/solidification would be protective because it would immobilize lead in the treated soil, which would prevent potential migration of these COCs to groundwater and minimize risk associated with direct exposure to contaminated soil. LUCs ensuring regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by minimizing uncontrolled exposure of current site users to contaminated soil. In addition, LUCs restricting Zone 4 to its current I/C use would be protective by preventing the even greater risks that would result from exposure to contaminated soil of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration of lead and TPH from soil to

groundwater. Alternative S-4.4 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-4.4 would also indirectly achieve Soil RAO No.4.

Alternative S-4.4 would also be protective under the Connecticut RSRs by preventing unacceptable human health risk from exposure to TPH contaminated soil and minimizing the source of potential migration of TPH from soil to groundwater.

Compliance with ARARs and TBCs

Alternative S-4.4 would comply with chemical-, location- and action-specific ARARs and TBCs, as summarized in Tables 4-17, 4-18, and 4-19, respectively.

Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-4.4 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil that could not be treated. In addition, chemical stabilization/solidification is considered to be an engineering control (pending CTDEP concurrence), so the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs would be satisfied.

Long-Term Effectiveness and Permanence

Alternative S-4.4 would be long-term effective and permanent under CERCLA. In-situ treatment with enhanced bioremediation would effectively remove PAHs from treated soil and prevent exposure to unacceptable concentrations of these COCs. However, as noted in Section 3.2.5.1, much of the TPH in Lower Subase contaminated soil is expected to be "weathered" and is no longer very biodegradable, and treatability testing would be required to verify the site-specific biodegradability of this TPH. In-situ treatment with chemical stabilization/solidification would effectively and permanently immobilize TPH and lead within the treated soil, which would prevent potential migration of these COCs to groundwater and minimize risk associated with direct exposure to contaminated soil. LUCs that ensure regular maintenance of paved surfaces, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 4 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Long-term monitoring would effectively verify that TPH and lead do not migrate from soil to groundwater.

In addition, Alternative S-4.4 would effectively and permanently address State petroleum concerns by preventing exposure to unacceptable concentrations of TPH by treating soil with concentrations of TPH to which current site users should not be exposed and such that TPH could potentially migrate from soil to groundwater.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternative S-4.4 would address CERCLA risks by reducing the toxicity, mobility and volume of PAHs and lead in soil through in-situ treatment. An estimated total of 1,040 cubic yards of "high PAH" (960 cubic yards) soil would be permanently and irreversibly treated by in-situ enhanced bioremediation. An estimated 3,060 cubic yards of "high lead" soil would be permanently and irreversibly treated by in-situ chemical stabilization/solidification. However, the degree of toxicity reduction achieved through chemical stabilization/ solidification is likely to be significantly less than the reduction of mobility, and there would be no reduction of the quantities of lead in the treated soil. Because chemical stabilization/solidification is considered to be an engineering control (pending CTDEP concurrence), the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs would be satisfied.

Alternative S-4.4 would also reduce the toxicity, mobility, and volume of TPH in soil through treatment. An estimated 80 cubic yards of "high TPH" soil would be permanently and irreversibly treated by in-situ enhanced bioremediation. In addition, TPH-contaminated soil co-mingled with the "high PAH" soil would be permanently and irreversibly removed from Zone 4 through treatment.

Short-Term Effectiveness

Implementation of Alternative S-4.4 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during in-situ treatment activities and also as a result of monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-4.4 would have no adverse impact on the surrounding community or the environment.

Alternative S-4.4 could be implemented within approximately 9 months and would achieve Soil RAOs Nos. 1 to 3 upon implementation. By preventing hypothetical future residential development, Alternative S-4.4 would also indirectly achieve Soil RAO No. 4 upon implementation. Alternative S-4.4 would meet the Zone 4 soil lead PRG for I/C pollutant mobility at completion and the Zone 4 soil PAH PRG for I/C direct exposure as well as the TPH PMC for I/C pollutant mobility within 3 to 5 years. However, Alternative S-4.4 would not meet the Zone 4 soil lead PRG for I/C direct exposure. In addition, these cleanup criteria would not apply to leftover areas of inaccessible and/or environmentally isolated contaminated soil that could not be excavated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-4.4 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

Alternative S-4.4 would technically implementable. Contractors qualified to perform in-situ enhanced bioremediation and chemical stabilization/solidification are readily available. However, very careful planning and execution would be required to prevent interference with ongoing activities at the Lower Subase. In addition, implementation of the in-situ treatment would be significantly hindered, and might even be prevented, by the presence of many underground structures such as utility lines and existing and former building foundations. Nonetheless, as previously mentioned, it is assumed for the purpose of this FS that ongoing base activities and underground obstacles would not actually prevent implementation of this alternative. The increase in soil volume resulting from soil blending and ORC addition would also require regrading of the in-situ enhanced bioremediation areas to accommodate existing buildings and other structures. Treatability testing would be required to verify the site-specific biodegradability of TPH and to confirm the appropriate ORC addition rate and soil/pozzolanic reagent/water mix ratios prior to implementation. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of soil and groundwater could be readily performed.

The administrative aspects of Alternative S-4.4 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for the in-situ treatment activities. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

Estimated costs for Alternative S-4.4 are as follows:

Capital Cost	$1,389,000
NPW of O&M Costs	$417,000 (30 years)
NPW	$1,806,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.5.5 Alternative S-4.5: Excavation to Meet DECs and PMCs for I/C Site Use, Off-Site Disposal (Stabilization/Solidification, LTTD, and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring

4.5.5.1 Description

Alternative S-4.5 would consist of four major components: (1) excavation to meet DECs and PMCs for I/C site use, (2) off-site disposal of excavated soil, (3) LUCs with engineering and institutional controls, and (4) monitoring.

Component 1: Excavation to Meet DECs and PMCs for I/C Site Use

Areas of soil with mass concentrations of PAHs and lead greater than their respective I/C DECs (1 mg/kg, and 1,090 mg/kg) to a depth of 2 feet bgs (paved area), or SPLP/TCLP concentrations of lead greater than its Zone 4 Alternative GB PMC for I/C site use (0.19 mg/L) in the remainder of the unsaturated zone would be excavated to address CERCLA risks. In addition, areas of soil with mass concentrations of TPH greater than its PMC (2,500 mg/kg) would also be excavated to address State petroleum concerns. These areas are located in the northwest and southwest corners of Zone 4 and extend over an estimated total of 30,400 square feet to a depth of up to 5 feet bgs, as shown on Figure 4-11. An estimated total of 4,400 cubic yards of contaminated soil and asphalt debris would be removed through excavation. Computations of excavation volumes are provided in Appendix C. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

Following excavation, confirmation samples would be collected from the bottoms and walls of the excavated areas to verify that contaminated soil has been removed. After confirmation sampling is complete, the excavated areas would be backfilled with clean soil and the site restored to its former condition.

Prior to excavation, a detailed survey would be made of underground obstacles (e.g., underground pipes or cables) in the areas to be excavated and, when practical, these obstacles would be moved. If obstacles prevent the use of a normal backhoe or grade-all in certain areas and if moving of these obstacles is not practical, a small backhoe or hand shovels would be used provided that the areas to be so excavated are relatively small in size. Accordingly, it is assumed for the purpose of this FS that underground obstacles would not actually prevent the excavation of contaminated soil.

Because excavation of Zone 4 contaminated soil under this alternative would only extend to an estimated depth of 5 feet bgs, it is assumed that all excavation would take place above the water table and that only minimal shoring and no excavation dewatering would be required.

During excavation, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum. The excavated areas would be backfilled as soon as possible, and on-site staging and stockpiling of excavated soil would be kept to a minimum. Any on-site stockpiles of excavated soil would be covered with an impervious synthetic liner at the end of each day's work.

Component 2: Off-Site Disposal

Because under this alternative soil would be excavated above the water table, it is assumed that the excavated soil would contain minimal free water and would not have to be pretreated by on-site dewatering prior to off-site transportation to disposal.

Asphalt pavement debris would be segregated and recycled or, if required, disposed at an off-site construction material landfill. For this alternative, it is estimated that 300 cubic yards of asphalt debris would be removed from Zone 4.

To determine the proper method of disposal of the remaining 4,100 cubic yards of excavated soil, composite samples would be collected at the rate of approximately one sample per 100 cubic yards. These samples would be analyzed for SPLP/TCLP lead and mass PAHs, TPH, and lead to sort the excavated soil into the following categories:

- Soil with mass concentrations of PAHs, TPH, or lead less than their respective Residential DECs (1 mg/kg, 500 mg/kg, and 400 mg/kg) and/or with SPLP/TCLP concentrations of lead less than its Zone 4 Alternative GB PMC for I/C use (0.19 mg/L) would be identified as non-contaminated and would be reused on site as backfill. For this alternative, it is estimated that no soil excavated from Zone 4 would fall into this category.

- Soil with mass concentrations of TPH or lead greater than their respective Residential DEC but less than their respective I/C DECs (2,500 mg/kg and 1,090 mg/kg) and/or with TCLP concentrations of lead greater than its Zone 4 Alternative GB PMC for I/C site use but less than its RCRA toxicity characteristic (5 mg/L) would be identified as contaminated but not requiring treatment. This soil would be disposed at an off-site municipal solid waste landfill. For this alternative, it is estimated that no soil excavated from Zone 4 would fall into this category.

- Soil with mass concentrations of PAHs or TPH greater than their respective I/C DECs would be identified as contaminated and requiring treatment. This soil would be disposed at an off-site TSDF where it would undergo treatment by LTTD prior to landfilling. For this alternative, it is estimated that 1,037 cubic yards of soil excavated from Zone 4 would fall into this category including 960 cubic yards identified as "high PAH" and 80 cubic yards identified as "high TPH".

- Soil with mass concentrations of lead greater than its I/C DEC and/or with TCLP concentrations of lead greater than its RCRA toxicity characteristic would be identified as "high lead". This soil would be disposed at an off-site TSDF where it would undergo treatment by chemical stabilization/solidification prior to landfilling. For this alternative, it is estimated that 3,060 cubic yards of soil excavated from Zone 4 would fall into this category.

Computations of volumes for the above categories are provided in Appendix C.

During off-site transportation of contaminated soil, appropriate spill prevention and control measures would be taken, and DOT regulations would be followed.

Component 3: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 4. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of building foundations that cover inaccessible and/or environmentally isolated soil which cannot be excavated. Similarly, another engineering control would be specified for the regular maintenance of the existing paved areas such that the assumptions used for the alternative PMC calculation are still applicable. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 4: Monitoring

Long-term groundwater monitoring would be conducted to confirm that soil contaminants are not mobilizing and migrating to groundwater at unacceptable concentrations.

4.5.5.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-4.5 would be protective of human health and the environment under CERCLA. Excavation and off-site disposal of soil with mass concentrations of PAHs or lead greater than their respective I/C DECs and with SPLP/TCLP concentrations of lead greater than its Zone 4 Alternative GB PMC for I/C site use would be protective by preventing unacceptable human health risk from exposure of current site users to contaminated soil and minimizing the source of potential migration of these COCs from soil to groundwater. LUCs ensuring the regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by minimizing uncontrolled exposure of current site users to contaminated soil. In addition, LUCs restricting Zone 4 to its current I/C use would be protective by preventing the even greater risks that would develop from exposure to contaminated soil by a wider range of human and ecological receptors under hypothetical future residential site use. Long-term monitoring would be protective by detecting the potential migration of lead from soil to groundwater. Alternative S-4.5 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-4.5 would also indirectly achieve Soil RAO No.4.

Alternative S-4.5 would also be protective under the Connecticut RSRs by preventing unacceptable human health risk from exposure to TPH contaminated soil and minimizing the source of potential migration of TPH from soil to groundwater.

Compliance with ARARs and TBCs

Alternative S-4.5 would comply with chemical-, location- and action-specific ARARs and TBCs, as summarized in Tables 4-8, 4-9, and 4-10, respectively.

Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-4.5 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil that could not be excavated.

Long-Term Effectiveness and Permanence

Alternative S-4.5 would be long-term effective and permanent under CERCLA. Excavation and off-site disposal would effectively and permanently remove soil with concentrations of PAHs and lead to which current site users should not be exposed and such that lead could potentially migrate from soil to groundwater. LUCs that ensure regular maintenance of building foundations and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 4 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Monitoring would effectively detect potential migration of lead from soil to groundwater.

In addition, Alternative S-4.5 would effectively and permanently address State petroleum concerns by removing soil with concentrations of TPH to which current site users should not be exposed and such that TPH could potentially migrate from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-4.5 would not address CERCLA risks by reducing the toxicity, mobility, and volume of PAHs and lead in soil through treatment.

Alternative S-4.5 would also not reduce the toxicity, mobility, and volume of TPH in soil through treatment.

Short-Term Effectiveness

Implementation of Alternative S-4.5 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during soil excavation. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-4.5 could also have a minimal adverse impact on the surrounding community and the environment as a result of the excavation and off-site transportation of contaminated soil. This impact would also be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-4.5 could be implemented within approximately 9 months and would achieve Soil RAOs Nos. 1 to 3 upon implementation. By preventing hypothetical future residential development, Alternative S-4.5 would also indirectly achieve Soil RAO No. 4 upon implementation. Alternative S-4.5 would meet the Zone 4 soil PRGs for I/C direct exposure and pollutant mobility as well as the TPH I/C DEC and PMC upon implementation. In addition, these cleanup criteria would not apply to leftover areas of inaccessible and/or environmentally isolated contaminated soil that could not be excavated because the engineering controls

(pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-4.5 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

Alternative S-4.5 would be technically implementable. Excavation could be performed with normal construction equipment by a wide range of contractors. However, very careful planning and execution would be required to prevent interference with ongoing activities at the Lower Subase. In addition, excavation would be significantly hindered, and might even be prevented, by the presence of many underground structures such as utility lines and existing and former building foundations. Nonetheless, as previously mentioned, it is assumed for the purpose of this FS that ongoing base activities and underground obstacles would not actually prevent excavation. Because excavation would be limited to approximately 5 feet bgs and would not extend below the water table, the need for shoring would be minimal, and there would be no need for excavation dewatering. Off-site borrow locations for clean soil backfill and TSDFs for the off-site treatment and disposal of the excavated soil would be available. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of soil and groundwater could be readily performed.

The administrative aspects of Alternative S-4.5 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for soil excavation. The off-site transportation and disposal of the excavated soil would have to be properly documented, which could be readily accomplished. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

The estimated costs for Alternative S-4.5 are as follows:

Capital Cost	$1,984,000
NPW of O&M Costs	$414,000 (30 years)
NPW	$2,398,000 (30 years)

Within these costs, the estimated incremental capital cost for off-site treatment (chemical stabilization/ solidification and LTTD) of highly contaminated soil would be $1,145,000.

A detailed cost estimate for this alternative is provided in Appendix E.

4.5.6 Alternative S-4.6: Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/Solidification, LTTD, and Landfilling)

4.5.6.1 Description

Alternative S-4.6 would consist of four major components: (1) excavation to meet Residential DECs and PMCs, (2) on-site dewatering, and (3) off-site disposal.

Component 1: Excavation to Meet Residential DECs and PMCs

Areas of soil up to 15 feet deep with mass concentrations of PAHs or lead greater than their respective Residential DECs (1 mg/kg and 400 mg/kg) and the areas of unsaturated soil with SPLP/TCLP lead concentrations greater than its Zone 4 Alternative GB PMC for Residential use (0.15 mg/L) would be excavated to address CERCLA risks. In addition, areas of soil with mass concentrations of TPH greater than its Residential DEC (500 mg/kg) would also be excavated to address State petroleum concerns. By so doing, the Zone 4 Alternative GB PMC for Residential use for TPH (2,500 mg/kg) would also be met to address State petroleum concerns. These areas are located in the northwestern and southwestern corners of Zone 4 and extend over an estimated total 60,000 square feet to a depth of up to 12 feet bgs, as shown on Figure 4-12. An estimated total of 21,300 cubic yards of contaminated soil, uncontaminated soil, and asphalt debris would be removed through excavation. Computations of excavation volumes are provided in Appendix C. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

Following excavation, confirmation samples would be collected from the bottoms and walls of the excavated areas located above the water table to verify that contaminated soil has been removed. After

confirmation sampling is complete, the excavated areas would be backfilled with clean soil including a 6-inch layer of topsoil, and vegetated to minimize erosion.

Because this alternative would only be implemented prior to residential development of the site, it is assumed that existing underground obstacles (e.g., underground pipes or cables) would have been removed as part of site preparation for this development.

Because excavation of Zone 4 contaminated soil under this alternative would extend to an estimated depth of 12 feet bgs, some excavation would take place below the water table, and significant shoring would be required. However, as discussed in Section 3.2.4, dewatering of the excavated areas would not be practical, and excavation would be performed with equipment adapted to underwater work, such as a clamshell.

During excavation, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum. The excavated areas would be backfilled as soon as possible, and on-site staging and stockpiling of excavated soil would be kept to a minimum. Any on-site stockpiles of excavated soil would be covered with an impervious synthetic liner at the end of each day's work.

Component 2: On-Site Dewatering

Within Zone 4, it is assumed that excavation beyond a depth of 6 feet bgs would take place below the water table. Therefore, it is also assumed that the wet soil excavated below that depth would equal approximately 1.5 times its in-situ volume and would contain an average of 53 percent of free water by volume. This wet soil would require gravity-induced passive dewatering by on-site stockpiling prior to off-site disposal, as discussed in Section 3.2.6.1.

Gravity-induced stockpile dewatering would be performed at a DW/WWT facility located as close to the excavation area as possible. A typical DW/WWT facility would consist of a dewatering stockpile and associated drainage water modular treatment system including bag filtration and liquid-phase GAC adsorption. A more detailed description of this facility is provided in the description of Alternative S-1.5 (see Section 4.2.5.1).

DW/WWT monitoring would consist of collecting one sample of the treatment system influent and effluent for every day of system operation and analyzing these samples for PAHs, metals, and total suspended solids.

An estimated in-situ soil volume of 9,300 cubic yards would be excavated below the water table, yielding approximately 13,950 cubic yards of wet excavated soil which would be dewatered to its original in-situ volume of 9,300 cubic yards (or 16,650 tons). This would require an estimated 47 dewatering stockpile operating sequences, or approximately 70 operating days with two dewatering stockpiles. The total volume of drainage water treated and discharged would be an estimated 939,300 gallons. Conceptual design calculations for the on-site dewatering of soil are provided in Appendix D.

Component 3: Off-Site Disposal

Asphalt pavement debris would be segregated and recycled or, if required, disposed at an off-site construction material landfill. For this alternative, it is estimated that 550 cubic yards of asphalt debris would be removed from Zone 4.

To determine the proper method of disposal of the remaining 20,750 cubic yards of excavated soil, composite samples would be collected at the rate of approximately one sample per 500 cubic yard. These samples would be analyzed for mass concentrations of PAHs, TPH, and lead and SPLP/TCLP concentrations of lead to sort the excavated soil into the following three disposal categories:

- Soil with mass concentrations of PAHs, TPH, or lead less than their respective Residential DECs (1 mg/kg, 500 mg/kg, and 400 mg/kg) and/or with SPLP/TCLP concentrations of lead less than its Zone 4 Alternative GB PMC for Residential use (0.15 mg/L) would be identified as non-contaminated and would be reused on site as backfill. For this alternative, it is estimated that 4,400 cubic yards of soil excavated from Zone 4 would fall into this category.

- Soil with mass concentrations of TPH or lead greater than their respective Residential DECs but less than their respective I/C DECs (2,500 mg/kg and 1,090 mg/kg) and/or with TCLP concentrations of lead greater than its Zone 4 Alternative GB PMC for Residential use but less than its RCRA toxicity characteristic (5 mg/L) would be identified as contaminated and not requiring treatment. This soil would be disposed at an off-site municipal solid waste landfill. For this alternative, it is estimated that 8,750 cubic yards of soil excavated from Zone 4 would fall into this category.

- Soil with mass concentrations of PAHs or TPH greater than their respective I/C DECs would be identified as contaminated and requiring treatment. This soil would be disposed at an off-site TSDF where it would undergo treatment by LTTD prior to landfilling. For this alternative, it is estimated that 3,400 cubic yards of soil excavated from Zone 4 would fall into this category including 2,600 cubic yards identified as "high PAH" and 800 cubic yards identified as "high TPH".

- Soil with mass concentrations of lead greater than its I/C DEC and/or TCLP concentrations of lead greater than its RCRA toxicity characteristic would be identified as "high lead". This soil would be disposed at an off-site TSDF where it would undergo treatment by chemical stabilization/solidification prior to landfilling. For this alternative, it is estimated that 4,200 cubic yards of soil excavated from Zone 4 would fall into this category.

Computations of volumes for the above categories are provided in Appendix C.

During off-site transportation of contaminated soil, appropriate spill prevention and control measures would be taken, and DOT regulations would be followed.

4.5.6.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-4.6 would be fully protective of human health and the environment under CERCLA under the current I/C exposure scenario and any other foreseeable site use. Excavation and off-site disposal of soil with mass concentrations of PAHs or lead greater than their respective Residential DECs would be protective because it would not only remove unacceptable risk from exposure of current site users to contaminated soil but it would also eliminate the future hypothetical human health risks from direct exposure to contaminated soil under a residential scenario. In addition, removal of soil with mass concentrations of PAHs or SPLP/TCLP concentrations of lead greater than their respective Zone 4 Alternative GB PMCs for Residential use would also be protective because it would eliminate any potential for migration of these COCs from soil to groundwater. Alternative S-4.6 would achieve all four soil RAOs.

Alternative S-4.6 would also be protective under the Connecticut RSRs by preventing unacceptable human health risk from exposure to TPH contaminated soil and minimizing the source of potential migration of TPH from soil to groundwater.

Compliance with ARARs and TBCs

Alternative S-4.6 would comply with chemical-, location-, and action-specific ARARs and TBCs, as summarized in Tables 4-11, 4-12, and 4-13, respectively.

Long-Term Effectiveness and Permanence

Alternative S-4.6 would be long-term effective and permanent. Excavation and off-site disposal of soil with mass concentrations of PAHs or lead greater than their respective Residential DECs would effectively and permanently remove soil to which current site users and hypothetical future site residents should not be

exposed. In addition, excavation and off-site disposal of soil with mass concentrations of PAHs and SPLP/TCLP concentrations of lead greater than their respective Zone 4 Alternative GB PMCs for Residential use would effectively and permanently eliminate the potential for migration of these COCs from soil to groundwater.

In addition, Alternative S-4.6 would effectively and permanently address State petroleum concerns by removing soil with concentrations of TPH to which current site users should not be exposed and such that TPH could potentially migrate from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-4.6 would not address CERCLA risks by reducing the toxicity, mobility, and volume of PAHs and lead in soil through treatment, except through the treatment of water generated from the dewatering process prior to discharge to the Thames River.

Alternative S-4.6 would also not reduce the toxicity, mobility, and volume of TPH in soil through treatment.

Short-Term Effectiveness

Implementation of Alternative S-4.6 could result in significant short-term risks to on-site workers as a result of exposure to contamination during soil excavation. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-4.6 could also adversely impact the surrounding community and the environment as a result of the excavation and off-site transportation of contaminated soil. This adverse impact would also be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-4.6 could be implemented within approximately 1 year and would achieve the soil RAOs and meet the Zone 4 soil PRGs for residential direct exposure and pollutant mobility as well as the TPH Residential DEC and PMC upon implementation.

Implementability

Alternative S-4.6 would be technically difficult to implement. Excavation could be performed with normal construction equipment by a wide range of contractors. Because this alternative would only be implemented as part of hypothetical future residential development, excavation would not interfere with ongoing activities at the Lower Subase, and it is assumed that underground structures such as utility lines and existing and former building foundations would have been removed as part of site preparation for

development. Because excavation would reach to a depth of up to 12 feet bgs, extensive shoring would be required. In addition, because a significant portion of the excavation would extend below the water table, much of the excavated soil would have a high initial water content, and a relatively complex on-site dewatering operation would be required to make this soil amenable to further treatment and/or disposal. Also, post-excavation confirmation sampling would not be possible in the underwater excavated areas and would have to be replaced with pre-excavation sampling to verify the extent of contamination. Off-site borrow locations for clean soil backfill and solid waste landfills or TSDFs for off-site disposal of the excavated soil would be available.

The administrative aspects of Alternative S-4.6 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for soil excavation. The off-site transportation and disposal of the excavated soil would have to be properly documented, which could be readily accomplished. In addition, the substantive requirements of federal and State water discharge regulations would have to be met to discharge treated water from the on-site soil dewatering operation to the Thames River.

Cost

The estimated costs for Alternative S-4.6 are as follows:

Capital Cost	$7,737,000
NPW of O&M Costs	$0
NPW	$7,737,000 (1 year)

Within these costs, the estimated incremental capital cost for off-site treatment (chemical stabilization/ solidification and LTTD) of highly contaminated soil would be $2,887,000.

The above figures do not include the cost of demolition of existing structures and removal of underground obstacles that would be required for the implementation of this alternative. Instead, these costs are assumed to have been included as part of the hypothetical future residential development of Zone 4. A detailed cost estimate for this alternative is provided in Appendix E.

4.6 ASSEMBLY AND DETAILED ANALYSIS OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 5

Even though there is uncertainty regarding Zone 5 soil presenting a CERCLA risk, the Navy has opted to develop and evaluate soil alternatives following the CERCLA process. Additional data will be collected during a Soil PDI that will be used to address the uncertainty regarding the risk and the appropriateness of

the CERCLA evaluation process for Zone 5 soil. The new data and updated evaluation will be captured in an addendum to this FS.

The following soil remedial alternatives have been developed for Zone 5 of the Lower Subase:

Alternative S-5.1:	No Action.
Alternative S-5.2:	LUCs (Engineering and Institutional Controls) and Monitoring.
Alternative S-5.3:	In-Situ Treatment (Enhanced Bioremediation) to Meet I/C DECs and PMCs, LUCs, (Engineering and Institutional Controls) and Monitoring.
Alternative S-5.4:	Excavation to Meet I/C DECs and PMCs, Off-Site Disposal (LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring.
Alternative S-5.5:	Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (LTTD and Landfilling).

Alternative S-5.1 was developed and analyzed to serve as a baseline for other alternatives, as required by CERCLA and the NCP. Alternative S-5.2 was developed and analyzed to evaluate LUCs with engineering and institutional controls and monitoring. Alternatives S-5.3 and S-5.4 were developed and analyzed to evaluate a range of remedial actions to address environmental concerns under current site use. Alternative S-5.5 was developed and analyzed to evaluate contaminated soil cleanup for hypothetical future unrestricted site use. Descriptions and detailed analyses of these alternatives are provided in the following sections.

4.6.1 Alternative S-5.1: No Action

4.6.1.1 Description

No Action would not include any action under CERCLA and any existing administrative or engineering environmental controls would not be an enforceable part of a CERCLA remedy. This alternative is required under CERCLA to establish a basis for comparison with other alternatives. The only activity under this alternative would be the performance of five-year reviews. This alternative cannot be chosen because contamination remains on site.

4.6.1.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-5.1 would not be protective of human health and the environment under CERCLA. Unacceptable risk to current site users would be allowed to occur as a result of direct exposure to contaminated soil because the asphalt pavement that covers most of this soil would not be maintained,

and disturbance of areas of contaminated soil would not be regulated. There would also be no protection against the even greater risk that would result from exposure to contaminated soil by a wider range of human and ecological receptors if hypothetical future residential use of the site would be allowed. In addition, Alternative S-5.1 could allow unacceptable human health and environmental risks to develop because the potential for migration of TPH from soil to groundwater would continue to exist and because no monitoring would be performed to assess this potential migration. Alternative S-5.1 would not achieve the soil RAOs.

Compliance with ARARs and TBCs

Alternative S-5.1 would not comply with chemical-specific ARARs and TBCs because no action would be taken to reduce concentrations of COCs and TPH. Because Alternative S-5.1 would not involve any action, location- and action-specific ARARs and TBCs would not be relevant. A summary of Alternative S-5.1's compliance with chemical-specific ARARs and TBCs is provided in Table 4-1.

Long-Term Effectiveness and Permanence

Alternative S-5.1 would not be long-term effective and permanent. Because paved surfaces would not be maintained and no controls would restrict contaminated soil disturbance, unacceptable risks to current site users could result from direct exposure to soil. Because hypothetical future residential development would not be prevented, the potential would exist for increased risk to human and ecological receptors. Because no monitoring would be performed, there would be no assessment of the potential migration of TPH from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative S-5.1 would not reduce the toxicity, mobility, or volume of COCs and TPH in soil through treatment because no treatment would occur.

Short-Term Effectiveness

Because no action would occur, implementation of Alternative S-5.1 would not result in any short-term risks to on-site workers or adversely impact the local community or the environment.

Alternative S-5.1 would not achieve the soil RAOs and TPH cleanup criterion for residential or I/C direct exposure and pollutant mobility.

Implementability

Technically, Alternative S-5.1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Cost

The estimated costs for Alternative S-5.1 are as follows:

Capital Cost	$0
NPW of O&M Costs	$55,000 (30 years)
NPW	$55,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.6.2 Alternative S-5.2: LUCs (Engineering and Institutional Controls) and Monitoring

4.6.2.1 Description

Alternative S-5.2 would consist of two major components: (1) LUCs with engineering and institutional controls and (2) monitoring.

Component 1: LUCs with Engineering and Institutional Controls

LUCs with engineering and institutional controls would be developed and implemented to address State petroleum concerns. A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 5. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of building foundations and paved areas. If there are any unpaved areas with TPH concentrations that exceed the TPH PMC, then these areas will be paved pending the results of a pre-design investigation. The LUC RD would also include procedures for the performance of regular site inspections to verify the continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 2: Monitoring

A groundwater monitoring program would be developed and implemented to evaluate the long-term potential migration of TPH from soil to groundwater.

For the purpose of this FS, it was assumed that four groundwater samples would be regularly collected from strategic locations to be identified and that the collected samples would be analyzed for TPH. Monitoring frequency would be quarterly for the first 2 years, semi-annual for the next 2 years, and annual thereafter.

Reviews would be performed every 5 years to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary. These site reviews are required because this alternative would allow TPH to remain in soil at concentrations in excess of its State cleanup criterion.

4.6.2.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-5.2 would be protective of human health and the environment under the Connecticut RSRs. Unacceptable risk from direct exposure of current site users to contaminated surface soil would be minimized by the asphalt pavement that covers most of this soil. LUCs ensuring the regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by minimizing uncontrolled exposure of current site users to contaminated soil. In addition, LUCs restricting Zone 5 to its current I/C use would be protective by preventing the even greater risks that would develop from exposure to contaminated soil by a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration of TPH from soil to groundwater. By preventing hypothetical future residential development, Alternative S-5.2 would indirectly achieve Soil RAO No.4.

Compliance with ARARs and TBCs

Alternative S-5.2 would comply with federal chemical-specific TBCs (there are no federal chemical-specific ARARs) for residential exposure. Because TPH is the only contaminant, there are no location- and action-specific ARARs and TBCs. A summary of Alternative S-5.2's compliance with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 4-2, 4-3, and 4-4, respectively.

Long-Term Effectiveness and Permanence

Alternative S-5.2 would effectively and permanently address State petroleum concerns. Although soil concentrations of TPH would not be actively reduced, risks to human health and the environment would be minimized through LUCs and monitoring. LUCs that ensure regular maintenance of paved surfaces, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 5 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Because the controls (pending CTDEP concurrence of the adequacy of the engineering controls) engineering controls of these LUCs would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, the TPH soil PMC and I/C DEC would not apply. See Appendix D.1.3 for engineering control calculations. Long-term monitoring would effectively detect potential migration of TPH from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-5.2 would not reduce the toxicity, mobility, or volume of TPH in soil through treatment because no treatment would occur.

Short-Term Effectiveness

Alternative S-5.2 would have minimal short-term effectiveness concerns. Any exposure of workers to contaminated soil during the maintenance and sampling of groundwater monitoring wells would be minimized by wearing of appropriate PPE and complying with site-specific health and safety procedures. Implementation of LUCs and monitoring would not adversely impact the surrounding community or the environment.

Alternative S-5.2 could be implemented within approximately 3 months. Although Alternative S-5.2 would not meet the TPH soil PMC and I/C DEC, these criteria would not apply because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of this alternative would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

The technical implementability of Alternative S-5.2 would be easy. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of groundwater could be readily performed.

The administrative aspects of Alternative S-5.2 would be simple to implement. No construction permit issued by NSB-NLON DPW would be required for this alternative. A LUC RD could readily be developed

and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

The estimated costs for Alternative S-5.2 are as follows:

Capital Cost	$27,000
NPW of O&M Costs	$276,000 (30 years)
NPW	$303,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.6.3 Alternative S-5.3: In-Situ Treatment (Enhanced Bioremediation) to Meet TPH PMC and I/C DEC, LUCs (Engineering and Institutional Controls), and Monitoring

4.6.3.1 Description

Alternative S-5.3 would consist of three major components: (1) in-situ treatment to meet the TPH PMC and I/C DEC, (2) LUCs with engineering and institutional controls, and (3) monitoring.

Component 1: In-Situ Treatment to Meet TPH PMC and I/C DEC

The area of unsaturated soil with mass concentrations of TPH greater than its I/C DEC (2,500 mg/kg) or PMC (2,500 mg/kg) would be treated using in-situ enhanced bioremediation to address State petroleum

concerns. This area is located in the vicinity of soil sampling point 19SS1 and extends over an estimated 2,200 square feet to a depth of 3 feet bgs, as shown on Figure 4-13. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

In-situ bioremediation would consist of using ORC to enhance the growth of indigenous microorganisms and augment the natural aerobic biodegradation of the TPH in soil. For the purposes of this alternative, it is assumed that an ORC such as magnesium peroxide would be blended in the areas of soil to be treated using a backhoe and that a single application would be required. An estimated 230 cubic yards of soil would be treated in this way by blending in magnesium peroxide as a 8-percent (by weight) solution at the rate of approximately 10 pounds of dry magnesium peroxide per pound of TPH to be removed, for a total estimated use of approximately 50,600 pounds of dry magnesium peroxide (or approximately 70,300 gallons of 8-percent solution). The blending action and addition of ORC would result in an increase in the volume of treated soil of approximately 25 cubic yards. Because the bioremediation process would take at least 1 year to complete, this incremental volume of soil would be kept on site and dispersed through appropriate regrading as necessary to accommodate existing buildings and other structures. The exact design of the treatment system would be verified through treatability testing prior to implementation. Computations of treated soil volumes are provided in Appendix C. Conceptual design calculations for in-situ bioremediation are provided in Appendix D.

Prior to treatment, a careful survey would be made of underground obstacles (e.g., underground pipes or cables) in the area to be treated and, when practical, these obstacles would be moved. If obstacles prevent the use of a blending auger in certain areas and if moving of these obstacles is not practical, the ORC could still be manually worked into the soil to be treated using hand tools such as shovels, provided that the areas to be so treated are relatively small in size. Accordingly, it is assumed for the purpose of this FS that underground obstacles would not actually prevent the implementation of in-situ enhanced bioremediation.

Following treatment, confirmation samples would be collected beneath and around the treated area to verify that all contaminated soil has been treated. Additional confirmation samples would also be collected from the treated area within approximately one year to verify that TPH have been removed.

Component 2: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 5. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of building foundations that cover inaccessible and/or environmentally isolated soil which cannot be treated. Similarly, another engineering control would be specified for the regular maintenance

of the existing paved areas such that the assumptions used for the alternative PMC calculation are still applicable. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 3: Monitoring

Long-term groundwater monitoring would be conducted to confirm that soil contaminants are not mobilizing and migrating to groundwater at unacceptable concentrations.

4.6.3.2 Detailed Analysis

Overall Protection of Human Health and Environment

Alternative S-5.3 would be protective of human health and the environment under the Connecticut RSRs. In-situ treatment with enhanced bioremediation would be protective because it would actively remove soil concentrations of TPH to which current site users should not be exposed and that could promote migration of this contaminant from soil to groundwater. LUCs ensuring the regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by preventing unacceptable risk to current site users. In addition, LUCs restricting Zone 5 to its current I/C use would be protective by preventing even greater risks to human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration of TPH from soil to groundwater. By preventing hypothetical future residential development, Alternative S-5.3 would indirectly achieve Soil RAO No.4.

Compliance with ARARs and TBCs

Alternative S-5.3 would comply with federal chemical-specific TBCs (there are no federal chemical-specific ARARs) for residential exposure. Because TPH is the only contaminant, there are no location- and action-specific ARARs and TBCs. A summary of Alternative S-5.3's compliance with chemical-, location-, and action-specific ARARs and TBCs is provided as summarized in Tables 4-5, 4-6, and 4-7, respectively.

Long-Term Effectiveness and Permanence

Alternative S-5.3 would effectively and permanently address State petroleum concerns. In-situ treatment with enhanced bioremediation would effectively remove TPH from treated soil and prevent unacceptable human health risk from exposure and migration of this COC from soil to groundwater. However as noted in Section 3.2.5.1, much of the TPH in Lower Subase contaminated soil is expected to be "weathered" and is no longer very biodegradable and treatability testing would be required to verify the site-specific biodegradability of this TPH. LUCs that ensure regular maintenance of building foundations and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 5 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of these LUCs would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, the TPH PMC and I/C DEC would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil left untreated. Long-term monitoring would effectively verify that TPH does not migrate from soil to groundwater.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternative S-5.3 would reduce the toxicity, mobility, and volume of TPH in soil through in-situ enhanced bioremediation. An estimated 230 cubic yards of "high TPH" soil would be permanently and irreversibly treated by this technology.

Short-Term Effectiveness

Implementation of Alternative S-5.3 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during in-situ treatment activities and also as a result of monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-5.3 would have no adverse impact on the surrounding community or the environment.

Alternative S-5.3 could be implemented within approximately 6 months and would meet the soil TPH PMC and I/C DEC within approximately 3 to 5 years. In addition, as noted earlier, these cleanup criteria would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil left untreated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-5.3 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

Alternative S-5.3 would be technically implementable. Contractors qualified to perform in-situ enhanced bioremediation are readily available. However, careful planning and execution would be required to prevent interference with ongoing activities at the Lower Subase. Implementation of in-situ treatment would also be hindered by the presence of many underground structures such as utility lines and existing and former building foundations. Nonetheless, as previously mentioned, it is assumed for the purpose of this FS that ongoing base activities and underground obstacles would not actually prevent implementation of this alternative. The increase in soil volume resulting from soil blending and ORC addition would also require regrading of the areas of treated soil to accommodate existing buildings and other structures. Treatability testing would be required to verify site-specific effectiveness and confirm operating parameters prior to implementation. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of soil and groundwater could be readily performed.

The administrative aspects of Alternative S-5.3 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for in-situ treatment activities. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

Estimated costs for Alternative S-5.3 are as follows:

Capital Cost	$1,175,000
NPW of O&M Costs	$279,000 (30 years)
NPW	$1,454,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.6.4 Alternative S-5.4: Excavation to Meet DECs and PMCs for I/C Site Use, Off-Site Disposal (LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring

4.6.4.1 Description

Alternative S-5.4 would consist of three major components: (1) excavation to meet DECs and PMCs for I/C site use, (2) off-site disposal of excavated soil, (3) LUCs with engineering and institutional controls, and (4) monitoring.

Component 1: Excavation to Meet DECs and PMCs for I/C Site Use

The area of unsaturated soil with mass concentrations of TPH greater than its I/C DEC (2,500 mg/kg) or I/C PMC (2,500 mg/kg) would be excavated to address State petroleum concerns. This area is located in the vicinity of soil sampling point 19SS1 and extends over an estimated 2,200 square feet to a depth of 3 feet bgs, as shown on Figure 4-13. An estimated total of 240 cubic yards of contaminated soil and asphalt debris would be removed through excavation. Computations of excavation volumes are provided in Appendix C. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

Following excavation, confirmation samples would be collected from the bottoms and walls of the excavated area to verify that contaminated soil has been removed. After confirmation sampling is complete, the excavated area would be backfilled with clean soil and the site restored to its former condition.

Prior to excavation, a detailed survey would be made of underground obstacles (e.g., underground pipes or cables) in the area to be excavated and, when practical, these obstacles would be moved. If obstacles prevent the use of a normal backhoe or grade-all in certain areas and if moving of these obstacles is not practical, a small backhoe or hand shovels would be used provided that the areas to be so excavated are

relatively small in size. Accordingly, it is assumed for the purpose of this FS that underground obstacles would not actually prevent the excavation of contaminated soil.

Because excavation of Zone 5 contaminated soil under this alternative would only extend to an estimated depth of 3 feet bgs, it is assumed that all excavation would take place above the water table and that only minimal shoring and no excavation dewatering would be required.

During excavation, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum. The excavated areas would be backfilled as soon as possible, and on-site staging and stockpiling of excavated soil would be kept to a minimum. Any on-site stockpiles of excavated soil would be covered with an impervious synthetic liner at the end of each day's work.

Component 2: Off-Site Disposal

Because under this alternative soil would be excavated above the water table, it is assumed that the excavated soil would contain minimal free water and would not have to be pretreated by on-site dewatering prior to off-site transportation to disposal.

Asphalt pavement debris would be segregated and recycled or, if required, disposed at an off-site construction material landfill. For this alternative, it is estimated that 10 cubic yards of asphalt debris would be removed from Zone 5.

To determine the proper method of disposal of the remaining 230 cubic yards of excavated soil, composite samples would be collected from the excavated material at the rate of one per 50 cubic yards and analyzed for mass TPH. Based on current soil characterization data, it is anticipated that the result of these analyses would show that TPH concentrations of all the excavated soil would be greater than the I/C DEC (2,500 mg/kg). Therefore, it is anticipated that the 230 cubic yards of excavated soil would be identified as "high TPH" and disposed at an off-site TSDF where it would undergo treatment by LTTD prior to landfilling. Volume computations are provided in Appendix C.

During off-site transportation of contaminated soil, appropriate spill prevention and control measures would be taken, and DOT regulations would be followed.

Component 3: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 5.

One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of building foundations that cover inaccessible and/or environmentally isolated soil which cannot be excavated. Similarly, another engineering control would be specified for the regular maintenance of the existing paved areas such that the assumptions used for the alternative PMC calculation are still applicable. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 4: Monitoring

Long-term groundwater monitoring would be conducted to confirm that soil contaminants are not mobilizing and migrating to groundwater at unacceptable concentrations.

4.6.4.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-5.4 would be protective of human health and the environment under the Connecticut RSRs. Excavation and off-site treatment and disposal of soil with mass concentrations of TPH greater than its PMC or I/C DEC would be protective by preventing unacceptable human health risk from exposure of current site users to contaminated soil and minimizing the potential migration of TPH from soil to groundwater. LUCs ensuring the regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by preventing unacceptable risk to current site users. In addition, LUCs restricting Zone 5 to its current I/C use would be protective by preventing even greater risks to human and ecological receptors under hypothetical future residential site use. Long-term monitoring would be protective by detecting potential migration of TPH from soil to groundwater. By preventing hypothetical future residential development, Alternative S-5.4 would also indirectly achieve Soil RAO No.4.

Compliance with ARARs and TBCs

Alternative S-5.4 would comply with federal chemical-specific TBCs (there are no federal chemical-specific ARARs) for residential exposure. Because TPH is the only contaminant, there are no location- and action-specific ARARs and TBCs. A summary of Alternative S-5.4's compliance with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 4-8, 4-9, and 4-10, respectively.

Long-Term Effectiveness and Permanence

Alternative S-5.4 would effectively and permanently address State petroleum concerns. Excavation and off-site treatment and disposal would effectively and permanently remove soil with concentrations of TPH to which current site users should not be exposed and such that this TPH could potentially migrate from soil to groundwater. LUCs that ensure regular maintenance of building foundations and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 5 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of these LUCs would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, the TPH PMC and I/C DEC would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil that could not be excavated. Long-term monitoring would effectively verify that TPH does not migrate from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-5.4 would not reduce the toxicity, mobility, and volume of TPH in soil through treatment.

Short-Term Effectiveness

Implementation of Alternative S-5.4 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during soil excavation. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-5.4 could also have a minimal adverse impact on the surrounding community and the environment as a result of the excavation and off-site transportation of contaminated soil. This impact would also be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-5.4 could be implemented within approximately 6 months and would meet the soil TPH PMC and I/C DEC upon implementation. In addition, as noted earlier, these cleanup criteria would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil that could not be excavated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-5.4 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

Alternative S-5.4 would be technically implementable. Excavation could be performed with normal construction equipment by a wide range of contractors. However, careful planning and execution would be required to prevent interference with ongoing activities at the Lower Subase. Excavation would also be hindered by the presence of many underground structures such as utility lines and existing and former building foundations. Nonetheless, as previously mentioned, it is assumed for the purpose of this FS that underground obstacles would not actually prevent excavation. Because excavation would be limited to approximately 3 feet bgs and would not extend below the water table, the need for shoring would be minimal, and there would be no need for excavation dewatering. Off-site borrow locations for clean soil backfill and solid waste landfills for off-site disposal of the excavated soil would be available. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of soil and groundwater could be readily performed.

The administrative aspects of Alternative S-5.4 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for soil excavation. The off-site transportation and disposal of the excavated soil would have to be properly documented, which could be readily accomplished. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

The estimated costs for Alternative S-5.4 are as follows:

Capital Cost	$220,000
NPW of O&M Costs	$276,000 (30 years)
NPW	$496,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

Within these costs, the estimated incremental capital cost for off-site treatment (LTTD) of highly contaminated soil would be $57,000.

4.6.5 Alternative S-5.5: Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (LTTD and Landfilling)

4.6.5.1 Description

Alternative S-5.5 would consist of three major components: (1) excavation to meet Residential DECs and PMCs, (2) on-site dewatering, and (3) off-site disposal.

Component 1: Excavation to Meet Residential DECs and PMCs

Areas of soil up to 15 feet deep with mass concentrations of TPH greater than its Residential DEC (500 mg/kg) would be excavated to address State petroleum concerns. By so doing, the Residential DEC for PAHs (1 mg/kg) and Zone 5 Alternative GB PMCs for Residential use for methylene chloride (1 mg/kg), 2-methylnaphthalene (12 mg/kg), and lead (0.15 mg/L) would also be met to address CERCLA risks. In addition, the PMC for TPH (2,500 mg/kg) would be met to address State petroleum concerns. These areas are located mostly in the central portion of Zone 5 and extend over an estimated total of 43,000 square feet to a depth of up to 8 feet bgs, as shown on Figure 4-14. An estimated total of 10,300 cubic yards of contaminated soil, uncontaminated soil, and asphalt debris would be removed through excavation. Computations of excavation volumes are provided in Appendix C. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

Following excavation, confirmation samples would be collected from the bottoms and walls of the excavated areas located above the water table to verify that contaminated soil has been removed. After confirmation sampling is complete, the excavated areas would be backfilled with clean soil including a 6-inch layer of topsoil, and vegetated to minimize erosion.

Because this alternative would only be implemented prior to residential development of the site, it is assumed that existing underground obstacles (e.g., underground pipes or cables) would have been removed as part of site preparation for this development.

Because excavation of Zone 5 contaminated soil under this alternative would extend to an estimated depth of 8 feet bgs, some excavation would take place below the water table, and significant shoring would be required. However, as discussed in Section 3.2.4, dewatering of the excavated areas would not be practical, and excavation would be performed with equipment adapted to underwater work, such as a clamshell.

During excavation, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum. The excavated areas would be backfilled as soon as possible, and on-site staging and stockpiling of excavated soil would be kept to a minimum. Any on-site stockpiles of excavated soil would be covered with an impervious synthetic liner at the end of each day's work.

Component 2: On-Site Dewatering

Within Zone 5, it is assumed that excavation beyond a depth of 3 feet bgs would take place below the water table. Therefore, it is also assumed that the wet soil excavated below that depth would equal approximately 1.5 times its in-situ volume and would contain an average of 53 percent of free water by volume. This wet soil would require gravity-induced passive dewatering by on-site stockpiling prior to off-site disposal, as discussed in Section 3.2.6.1.

Gravity-induced stockpile dewatering would be performed at a DW/WWT facility located as close to the excavation area as possible. A typical DW/WWT facility would consist of a dewatering stockpile with associated drainage water treatment system including bag filtration and liquid-phase GAC adsorption. A more detailed description of this facility is provided in the description of Alternative S-1.5 (see Section 4.2.5.1).

DW/WWT monitoring would consist of collecting one sample of the treatment system influent and effluent for every day of system operation and analyzing these samples for PAHs, metals, and total suspended solids.

An estimated in-situ soil volume of 5,500 cubic yards would be excavated below the water table, yielding approximately 8,300 cubic yards of wet excavated soil that would be dewatered to its original in-situ volume of 5,500 cubic yards (or 9,900 tons). This would require an estimated 28 dewatering stockpile operating sequences, or approximately 84 operating days with a single dewatering stockpile. The total

volume of drainage water treated and discharged would be an estimated 556,800 gallons. Conceptual design calculations for the on-site dewatering of soil are provided in Appendix D.

Component 3: Off-Site Disposal

Asphalt pavement debris would be segregated and recycled or, if required, disposed at an off-site construction material landfill. For this alternative, it is estimated that 400 cubic yards of asphalt debris would be removed from Zone 5.

To determine the proper method of disposal of the remaining 9,900 cubic yards of excavated soil, composite samples would be collected at the rate of approximately one sample per 200 cubic yards. These samples would be analyzed for mass concentrations of PAHs and TPH to sort the excavated soil into the following categories:

- Soil with mass concentrations of PAHs and TPH less than their respective Residential DECs (1 mg/kg and 500 mg/kg) would be identified as non-contaminated and would be reused on site as backfill. For this alternative, it is estimated that 600 cubic yards of soil excavated from Zone 5 would fall into this category.

- Soil with mass concentrations of TPH greater than its Residential DECs but less than its I/C DECs (2,500 mg/kg) would be identified as contaminated but not requiring treatment. This soil would be disposed at an off-site municipal solid waste landfill. For this alternative, it is estimated that 8,600 cubic yards of soil excavated from Zone 5 would fall into this category.

- Soil with mass concentrations of TPH greater than its I/C DEC would be identified as "high TPH". This soil would be disposed at an off-site TSDF where it would undergo treatment by LTTD prior to landfilling. For this alternative, it is estimated that 700 cubic yards of soil excavated from Zone 5 would fall into this category.

Computations of volumes for the above categories are provided in Appendix C.

During off-site transportation of contaminated soil, appropriate spill prevention and control measures would be taken, and DOT regulations would be followed.

4.6.5.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-5.5 would be fully protective of human health and the environment under CERCLA under the current I/C exposure scenario and any other foreseeable site use. Excavation and off-site disposal of soil with mass concentrations of PAHs, methylene chloride, 2-methylnaphalene, or lead greater than their Residential DECs would be protective because it would not only remove unacceptable risk from exposure of current site users to contaminated soil but it would also eliminate the future hypothetical human health risks from direct exposure to soil contaminated with COCs under a residential scenario. In addition, it would eliminate the potential migration of these COCs from soil to groundwater. Alternative S-5.5 would achieve all four soil RAOs.

Alternative S-5.5 would also be protective under the Connecticut RSRs by preventing unacceptable human health risk from exposure to TPH contaminated soil and minimizing the source of potential migration of TPH from soil to groundwater.

Compliance with ARARs and TBCs

Alternative S-5.5 would comply with chemical-, location-, and action-specific ARARs and TBCs. A summary of Alternative S-5.5's compliance with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 4-11, 4-12, and 4-13, respectively.

Long-Term Effectiveness and Permanence

Alternative S-5.5 would be long-term effective and permanent. Excavation and off-site disposal of soil with mass concentrations of COCs greater than their Residential DECs would effectively and permanently remove soil to which current site users and hypothetical future site residents should not be exposed. In addition, excavation and off-site disposal of soil with mass concentrations of COCs greater than their Residential DECs would effectively and permanently eliminate the potential for migration of any of the Zone 5 soil COCs to groundwater.

In addition, Alternative S-5.5 would effectively and permanently address State petroleum concerns by removing soil with concentrations of TPH to which current site users should not be exposed and such that TPH could potentially migrate from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-5.5 would not address CERCLA risks by reducing the toxicity, mobility, and volume of PAHs in soil through active removal, except through the treatment of water generated from the dewatering process prior to discharge to the Thames River.

Alternative S-5.5 would also not reduce the toxicity, mobility, and volume of TPH in soil through treatment.

Short-Term Effectiveness

Implementation of Alternative S-5.5 could result in significant short-term risks to on-site workers as a result of exposure to contamination during soil excavation. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-5.5 could also adversely impact the surrounding community and the environment as a result of the excavation and off-site transportation of contaminated soil. This adverse impact would be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-5.5 could be implemented within approximately 9 months and would achieve the soil RAOs and meet the Zone 5 soil PRGs for residential direct exposure and pollutant mobility as well as the TPH Residential DEC and PMC upon implementation.

Implementability

Alternative S-5.5 would be technically difficult to implement. Excavation could be performed with normal construction equipment by a wide range of contractors. Because this alternative would only be implemented as part of hypothetical future residential development, excavation would not interfere with ongoing activities at the Lower Subase, and it is assumed that underground structures such as utility lines and existing and former building foundations would have been removed as part of site preparation for development. Because excavation would reach to a depth of approximately 8 feet bgs, extensive shoring would be required. In addition, because a significant portion of the excavation would extend below the water table, much of the excavated soil would have a high initial water content, and a relatively complex on-site dewatering operation would be required to make this soil amenable to further treatment and/or disposal. Also, post-excavation confirmation sampling would not be possible in the underwater excavated areas and would have to be replaced with pre-excavation sampling to verify the extent of contamination. Off-site borrow locations for clean soil backfill and solid waste landfills or TSDFs for off-site disposal of the excavated soil would be available.

The administrative aspects of Alternative S-5.5 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for soil excavation. The off-site transportation and disposal of the excavated soil would have to be properly documented, which could be readily accomplished. In addition, the substantive requirements of federal and State water discharge regulations would have to be met to discharge treated water from the on-site soil dewatering operation to the Thames River.

Cost

The estimated costs for Alternative S-5.5 are as follows:

Capital Cost	$2,930,000
NPW of O&M Costs	$0
NPW	$2,930,000 (1 year)

Within these costs, the estimated incremental capital cost for off-site treatment (chemical stabilization/ solidification and LTTD) of highly contaminated soil would be $989,000.

The above figures do not include the cost of demolition of existing structures and removal of underground obstacles that would be required for the implementation of this alternative. Instead, these costs are assumed to have been included as part of the hypothetical future residential development of Zone 5. A detailed cost estimate for this alternative is provided in Appendix E.

4.7 ASSEMBLY AND DETAILED ANALYSIS OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 6

The following soil remedial alternatives have been developed for Zone 6 of the Lower Subase:

Alternative S-6.1:	LUCs (Engineering and Institutional Controls) and Monitoring.
Alternative S-6.2:	In-Situ Treatment (Enhanced Bioremediation) to Meet TPH PMC and I/C DEC, LUCs (Engineering and Institutional Controls), and Monitoring.
Alternative S-6.3:	Excavation to Meet TPH PMC and I/C DEC, Off-Site Disposal (LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring.
Alternative S-6.4:	Excavation to Meet TPH PMC and Residential DEC, On-Site Dewatering, and Off-Site Disposal (LTTD and Landfilling).

There is no CERCLA excess risk for Zone 6. All of the alternatives presented for Zone 6 address only state cleanup standards. Alternative S-6.1 was developed and analyzed to evaluate LUCs with engineering and institutional controls and monitoring. Alternatives S-6.2 and S-6.3 were developed and

analyzed to evaluate a range of remedial actions to address environmental concerns under current site use. Alternative S-6.4 was developed and analyzed to evaluate contaminated soil cleanup for hypothetical future unrestricted site use. Descriptions and detailed analyses of these alternatives are provided in the following sections.

4.7.1 Alternative S-6.1: LUCs (Engineering and Institutional Controls) and Monitoring

4.7.1.1 Description

Alternative S-6.1 would consist of two major components: (1) LUCs and (2) monitoring with engineering and institutional controls.

Component 1: LUCs with Engineering and Institutional Controls

LUCs with engineering and institutional controls would be developed and implemented to address State petroleum concerns. A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 6. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of building foundations and paved areas. The LUC RD would also include procedures for the performance of regular site inspections to verify the continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 2: Monitoring

A groundwater monitoring program would be developed and implemented to evaluate the long-term potential migration of TPH from soil to groundwater.

For the purpose of this FS, it was assumed that four groundwater samples would be regularly collected from strategic locations to be identified and that the collected samples would be analyzed for TPH. Monitoring frequency would be quarterly for the first 2 years, semi-annual for the next 2 years, and annual thereafter.

Reviews would be performed every 5 years to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary. These site reviews are required because this alternative allows TPH to remain in soil at concentrations in excess of its State cleanup criterion.

4.7.1.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-6.1 would be protective of human health and the environment under the Connecticut RSRs. Unacceptable risk from direct exposure of current site users to contaminated surface soil would be minimized by the asphalt pavement that covers most of this soil. LUCs ensuring the regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by minimizing uncontrolled exposure of current site users to contaminated soil. In addition, LUCs restricting Zone 6 to its current I/C use would be protective by preventing the even greater risks that would develop from exposure to contaminated soil by a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration of TPH from soil to groundwater.

Long-Term Effectiveness and Permanence

Alternative S-6.1 would effectively and permanently address State petroleum concerns. Although soil concentrations of TPH would not be actively reduced, risks to human health and the environment would be minimized through LUCs and monitoring. LUCs that ensure regular maintenance of paved surfaces, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 6 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of these LUCs would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, the TPH soil PMC and I/C DEC would not apply. See Appendix D.1.3 for engineering control calculations. Long-term monitoring would effectively detect potential migration of TPH from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-6.1 would not reduce the toxicity, mobility, or volume of TPH in soil through treatment because no treatment would occur.

Short-Term Effectiveness

Alternative S-6.1 would have minimal short-term effectiveness concerns. Any exposure of workers to contaminated soil during the maintenance and sampling of groundwater monitoring wells would be minimized by wearing of appropriate PPE and complying with site-specific health and safety procedures. Implementation of LUCs and monitoring would not adversely impact the surrounding community or the environment.

Alternative S-6.1 could be implemented within approximately 3 months. Although Alternative S-6.1 would not meet the TPH soil PMC and I/C DEC, these criteria would not apply because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of this alternative would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

The technical implementability of Alternative S-6.1 would be easy. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of groundwater could be readily performed.

The administrative aspects of Alternative S-6.1 would be simple to implement. No construction permit issued by NSB-NLON DPW would be required for this alternative. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

The estimated costs for Alternative S-6.1 are as follows:

Capital Cost	$27,000
NPW of O&M Costs	$297,000 (30 years)
NPW	$324,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.7.2 Alternative S-6.2: In-Situ Treatment (Enhanced Bioremediation) to Meet TPH PMC and I/C DEC, LUCs (Engineering and Institutional Controls), and Monitoring

4.7.2.1 Description

Alternative S-6.2 would consist of 3 major components: (1) in-situ treatment to meet the TPH PMC and I/C DEC, (2) LUCs with engineering and institutional controls, and (3) monitoring.

Component 1: In-Situ Treatment to Meet TPH PMC and I/C DEC

The area of unsaturated soil with mass concentrations of TPH greater than its I/C DEC (2,500 mg/kg) or PMC (2,500 mg/kg) would be treated using in-situ enhanced bioremediation to address State petroleum concerns. This area is located in the vicinity of soil sampling point MW5-6RI and extends over an estimated 7,200 square feet to a depth of 3 feet bgs, as shown on Figure 4-15. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

In-situ bioremediation would consist of using ORC to enhance the growth of indigenous microorganisms and augment the natural aerobic biodegradation of TPH in soil. For the purposes of this alternative, it is assumed that an ORC such as magnesium peroxide would be blended in the areas of soil to be treated using a backhoe and that a single application would be required. An estimated 730 cubic yards of soil would be treated in this way by blending in magnesium peroxide as a 8-percent (by weight) solution at the rate of approximately 10 pounds of dry magnesium peroxide per pound of TPH to be removed, for a total estimated use of approximately 89,450 pounds of dry magnesium peroxide (or approximately 124,200 gallons of 8-percent solution). The blending action and addition of ORC would result in an increase in the volume of treated soil of approximately 75 cubic yards. Because the bioremediation process would take at least one year to complete, this incremental volume of soil would be kept on site and dispersed through appropriate regrading as necessary to accommodate existing buildings and other structures. The exact design of the treatment system would be verified through treatability testing prior to implementation. Computations of treated soil volumes are provided in Appendix C. Conceptual design calculations for in-situ bioremediation are provided in Appendix D.

Prior to treatment, a detailed survey would be made of underground obstacles (e.g., underground pipes or cables) in the area to be treated and, when practical, these obstacles would be moved. If obstacles prevent the use of a blending auger in certain areas and if moving of these obstacles is not practical, the ORC could still be manually worked into the soil to be treated using hand tools such as shovels, provided that the areas to be so treated are relatively small in size. Accordingly, it is assumed for the purpose of

this FS that underground obstacles would not actually prevent the implementation of in-situ enhanced bioremediation.

Following treatment, confirmation samples would be collected beneath and around the treated area to verify that all contaminated soil has been treated. Additional confirmation samples would also be collected from the treated area within approximately one year to verify that TPH have been removed.

Component 2: LUCs with Engineering and Institutional Controls

This component would be similar to Component 1 of Alternative S-6.1. Residential development would be restricted for the entire site but engineering controls and additional institutional controls would only be required for any area of inaccessible and/or environmentally isolated contaminated soil that could not be treated. Similarly, another engineering control would be specified for the regular maintenance of the existing paved areas such that the assumptions used for the alternative PMC calculation are still applicable. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 3: Monitoring

This component would be identical to Component 2 of Alternative S-6.1. Long-term groundwater monitoring would be conducted to confirm that soil contaminants are not mobilizing and migrating to groundwater at unacceptable concentrations.

4.7.2.2 Detailed Analysis

Overall Protection of Human Health and Environment

Alternative S-6.2 would be protective of human health and the environment under the Connecticut RSRs. In-situ treatment with enhanced bioremediation and would be protective because it would actively remove soil concentrations of TPH to which current site users should not be exposed and that could promote migration of this contaminant from soil to groundwater. LUCs ensuring regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by preventing unacceptable risk to current site users. In addition, LUCs restricting Zone 6 to its current I/C use would be protective by preventing even greater risks to a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration of TPH from soil to groundwater.

Long-Term Effectiveness and Permanence

Alternative S-6.2 would effectively and permanently address State petroleum concerns. In-situ treatment with enhanced bioremediation would effectively remove TPH from treated soil and prevent unacceptable human health risk from exposure to and migration of this COC from soil to groundwater. However as noted in Section 3.2.5.1, much of the TPH in Lower Subase contaminated soil is expected to be "weathered" and is no longer very biodegradable, and treatability testing would be required to verify the site-specific biodegradability of this TPH. LUCs that ensure regular maintenance of building foundations and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 6 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of these LUCs would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, the TPH PMC and I/C DEC would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil left untreated. Long-term monitoring would effectively verify that TPH does not migrate from soil to groundwater.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternative S-6.2 would reduce the toxicity, mobility, and volume of TPH in soil through in-situ enhanced bioremediation. An estimated 730 cubic yards of "high TPH" soil would be permanently and irreversibly treated by this technology.

Short-Term Effectiveness

Implementation of Alternative S-6.2 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during in-situ treatment activities and also as a result of monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-6.2 would have no adverse impact on the surrounding community or the environment.

Alternative S-6.2 could be implemented within approximately 6 months and would meet the soil TPH PMC and I/C DEC upon implementation. In addition, as noted earlier, these cleanup criteria would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil left untreated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-6.2 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

Alternative S-6.2 would be technically implementable. Contractors qualified to perform in-situ enhanced bioremediation are readily available. However, careful planning and execution would be required to prevent interference with ongoing activities at the Lower Subase. Implementation of in-situ treatment would also be hindered by the presence of many underground structures such as utility lines and existing and former building foundations. Nonetheless, as previously mentioned, it is assumed for the purpose of this FS that underground obstacles would not actually prevent implementation of this alternative. The increase in soil volume resulting from soil blending and ORC addition would also require regrading of the areas of treated soil to accommodate existing buildings and other structures. Treatability testing would be required to verify the appropriate ORC addition rate prior to implementation. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of soil and groundwater could be readily performed.

The administrative aspects of Alternative S-6.2 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for the in-situ treatment activities. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

Estimated costs for Alternative S-6.2 are as follows:

Capital Cost	$2,192,000
NPW of O&M Costs	$300,000 (30 years)
NPW	$2,492,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.7.3 Alternative S-6.3: Excavation to Meet TPH PMC and I/C DEC, Off-Site Disposal (LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring

4.7.3.1 Description

Alternative S-6.3 would consist of four major components: (1) excavation to meet the TPH PMC and I/C DEC, (2) off-site disposal of excavated soil, (3) LUCs with engineering and institutional controls, and (4) monitoring.

Component 1: Excavation to Meet TPH PMC and I/C DEC

The area of unsaturated soil with TPH mass concentrations greater than its I/C DEC (2,500 mg/kg) or PMC (2,500 mg/kg) would be excavated to address State petroleum concerns. This area is located in the vicinity of soil sampling point MW5-6RI and extends over an estimated 7,200 square feet to a depth of 3 feet bgs, as shown on Figure 4-15. An estimated total 800 cubic yards of contaminated soil and asphalt debris would be removed through excavation. Computations of excavation volumes are provided in Appendix C. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

Following excavation, confirmation samples would be collected from the bottoms and walls of the excavated area to verify that soil with mass concentrations of TPH greater than its PMC or I/C DEC has been removed. After confirmation sampling is complete, the excavated area would be backfilled with clean soil and the site restored to its former condition.

Prior to excavation, a detailed survey would be made of underground obstacles (e.g., underground pipes or cables) in the area to be excavated and, when practical, these obstacles would be moved. If obstacles prevent the use of a normal backhoe or grade-all in certain areas and if moving of these obstacles is not practical, a small backhoe or hand shovels would be used provided that the areas to be so excavated are

relatively small in size. Accordingly, it is assumed for the purpose of this FS that underground obstacles would not actually prevent the excavation of contaminated soil.

Because excavation of Zone 6 contaminated soil under this alternative would only extend to an estimated depth of 3 feet bgs, it is assumed that all excavation would take place above the water table and that only minimal shoring and no excavation dewatering would be required.

During excavation, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum. The excavated areas would be backfilled as soon as possible, and on-site staging and stockpiling of excavated soil would be kept to a minimum. Any on-site stockpiles of excavated soil would be covered with an impervious synthetic liner at the end of each day's work.

Component 2: Off-Site Disposal

Because under this alternative soil would be excavated above the water table, it is assumed that the excavated soil would contain minimal free water and would not have to be pretreated by on-site dewatering prior to off-site transportation to disposal.

Asphalt pavement debris would be segregated and recycled or, if required, disposed at an off-site construction material landfill. For this alternative, it is estimated that 70 cubic yards of asphalt debris would be removed from Zone 6.

To determine the proper method of disposal of the remaining 730 cubic yards of excavated soil, composite samples would be collected at the rate of approximately one sample per 50 cubic yards and analyzed for mass TPH. Based on current soil characterization data, it is anticipated that the result of these analyses would show that TPH concentrations of all of the excavated soil would be greater than the I/C DEC (2,500 mg/kg). Therefore, it is anticipated that the 730 cubic yards of excavated soil would be identified as "high TPH" and disposed at an off-site TSDF where it would undergo treatment by LTTD prior to landfilling. Volume computations are provided in Appendix C.

During off-site transportation of contaminated soil, appropriate spill prevention and control measures would be taken, and DOT regulations would be followed.

Component 3: LUCs

This component would be similar to Component 1 of Alternative S-6.1. Residential development would be restricted for the entire site but engineering controls and additional institutional controls would only be

required for any area of inaccessible and/or environmentally isolated contaminated soil that could not be excavated. Similarly, another engineering control would be specified for the regular maintenance of the existing paved areas such that the assumptions used for the alternative PMC calculation are still applicable. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 4: Monitoring

This component would be similar to Component 2 of Alternative S-6.1. Long-term groundwater monitoring would be conducted to confirm that soil contaminants are not mobilizing and migrating to groundwater at unacceptable concentrations.

4.7.3.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-6.3 would be protective of human health and the environment under the Connecticut RSRs. Excavation and off-site disposal of soil with mass concentrations of TPH greater than its PMC or I/C DEC would be protective by preventing unacceptable human health risk from exposure of current site users to contaminated soil and minimizing the potential migration of TPH from soil to groundwater. LUCs ensuring regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by preventing unacceptable risk to current site users. In addition, LUCs restricting Zone 6 to its current I/C use would be protective by preventing even greater risks to a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting potential migration of TPH from soil to groundwater

Long-Term Effectiveness and Permanence

Alternative S-6.3 would effectively and permanently address State petroleum concerns. Excavation and off-site disposal would effectively and permanently remove soil with concentrations of TPH to which current site users should not be exposed and such that this TPH could potentially migrate from soil to groundwater. LUCs that ensure regular maintenance of building foundations and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 6 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of these LUCs would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, the TPH PMC and I/C DEC would not apply to those areas of inaccessible and/or environmentally isolated

contaminated soil that could not be excavated. Long-term monitoring would effectively verify that TPH does not migrate from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-6.3 would not reduce the toxicity, mobility, and volume of TPH in soil through treatment.

Short-Term Effectiveness

Implementation of Alternative S-6.3 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during soil excavation. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-6.3 could also have a minimal adverse impact on the surrounding community and the environment as a result of the excavation and off-site transportation of contaminated soil. This impact would be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-6.3 could be implemented within approximately 6 months and would meet the soil TPH PMC and I/C DEC upon implementation. In addition, as noted earlier, these cleanup criteria would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil that could not be excavated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-6.3 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

Alternative S-6.3 would be technically implementable. Excavation could be performed with normal construction equipment by a wide range of contractors. However, careful planning and execution would be required to prevent interference with ongoing activities at the Lower Subase. Excavation would also be hindered by the presence of many underground structures such as utility lines and existing and former building foundations. Nonetheless, as previously mentioned, it is assumed for the purpose of this FS that ongoing base activities and underground obstacles would not actually prevent excavation. Because excavation would be limited to approximately 3 feet bgs and would not extend below the water table, the need for shoring would be minimal, and there would be no need for excavation dewatering. Off-site borrow locations for clean soil backfill and TSDFs for off-site LTTD treatment and disposal of the excavated soil would be readily available. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of soil and groundwater could be readily performed.

The administrative aspects of Alternative S-6.3 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for soil excavation. The off-site transportation and disposal of the excavated soil would have to be properly documented, which could be readily accomplished. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

The estimated costs for Alternative S-6.3 are as follows:

Capital Cost	$427,000
NPW of O&M Costs	$297,000 (30 years)
NPW	$724,000 (30 years)

Within these costs, the estimated incremental capital cost for off-site treatment (LTTD) of highly contaminated soil would be $178,000.

A detailed cost estimate for this alternative is provided in Appendix E.

4.7.4 Alternative S-6.4: Excavation to Meet TPH PMC and Residential DEC, On-Site Dewatering, and Off-Site Disposal (LTTD and Landfilling)

4.7.4.1 Description

Alternative S-6.4 would consist of three major components: (1) excavation to meet the TPH PMC and Residential DEC, (2) on-site dewatering, and (3) off-site disposal.

Component 1: Excavation to Meet TPH PMC and Residential DEC

Areas of soil up to 15 feet deep with mass concentrations of TPH greater than its Residential DEC (500 mg/kg) would be excavated to address State petroleum concerns. By so doing, the TPH PMC (2,500 mg/kg) would also be met. The areas to be excavated extend over an estimated total of 59,100 square feet including a 41,700 square feet area in the vicinity of soil sampling points MW4-6RI and MW5-6RI in the northwestern corner of Zone 6 which is to be excavated to a depth of 4 feet bgs and a 17,400 square feet area in the vicinity of soil sampling points MW2-6RI and MW3-6RI in the southwest corner of Zone 6, which is to be excavated to a depth of 8 feet bgs, as shown on Figure 4-16. An estimated total of 11,300 cubic yards of contaminated soil, uncontaminated soil, and asphalt debris would be removed through excavation. Computations of excavation volumes are provided in Appendix C. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

Following excavation, confirmation samples would be collected from the bottoms and walls of the excavated areas located above the water table to verify that contaminated soil has been removed. After confirmation sampling is complete, the excavated areas would be backfilled with clean soil, including a 6-inch layer of topsoil, and vegetated to minimize erosion.

Because this alternative would only be implemented prior to residential development of the site, it is assumed that existing underground obstacles (e.g., underground pipes or cables) would have been removed as part of site preparation for this development.

Because excavation of Zone 6 contaminated soil under this alternative would extend to an estimated depth of up to 8 feet bgs, some excavation would take place below the water table and significant shoring would be required. However, as discussed in Section 3.2.4, dewatering of the excavated areas would not be practical, and excavation would be performed with equipment adapted to underwater work, such as a clamshell.

During excavation, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum. The excavated areas would be backfilled as soon as possible, and on-site staging and stockpiling of excavated soil would be kept to a minimum. Any on-site stockpiles of excavated soil would be covered with an impervious synthetic liner at the end of each day's work.

Component 2: On-Site Dewatering

Within Zone 6, it is assumed that excavation beyond a depth of approximately 3 feet bgs would take place below the water table. Therefore, it is also assumed that the wet soil excavated below that depth would equal approximately 1.5 times its in-situ volume and would contain an average of 53 percent of free water by volume. This wet soil would require gravity-induced passive dewatering by on-site stockpiling prior to off-site disposal, as discussed in Section 3.2.6.1.

Gravity-induced stockpile dewatering would be performed at a DW/WWT facility located as close to the excavation area as possible. A typical DW/WWT facility would consist of a dewatering stockpile with associated drainage water treatment system including bag filtration and liquid-phase GAC adsorption. A more detailed description of this facility is provided in the description of Alternative S-1.5 (see Section 4.2.5.1).

DW/WWT monitoring would consist of collecting one sample of the treatment system influent and effluent for every day of system operation and analyzing these samples for PAHs, metals, and total suspended solids.

An estimated in-situ soil volume of 4,800 cubic yards would be excavated below the water table, yielding approximately 7,200 cubic yards of wet excavated soil that would be dewatered to its original in-situ volume of 4,800 cubic yards (or 8,500 tons). This would require an estimated 24 dewatering stockpile operating sequences, or approximately 72 operating days with a single dewatering stockpile. The total volume of drainage water treated and discharged would be an estimated 481,700 gallons. Conceptual design calculations for the on-site dewatering of soil are provided in Appendix D.

Component 3: Off-Site Disposal

Asphalt pavement debris would be segregated and recycled or, if required, disposed at an off-site construction material landfill. For this alternative, it is estimated that 550 cubic yards of asphalt debris would be removed from Zone 6.

To determine the proper method of disposal of the remaining 10,750 cubic yards of excavated soil, composite samples would be collected at the rate of approximately one sample per 200 cubic yards. These samples would be analyzed for mass concentrations of TPH to sort the excavated soil into the following categories:

- Soil with mass concentrations of TPH less than its Residential DEC (500 mg/kg) would be identified as non-contaminated and would be reused on site as backfill. For this alternative, it is estimated that 2,400 cubic yards of soil excavated from Zone 6 would fall into this category.

- Soil with mass concentrations of TPH greater than its Residential DEC but less than its I/C DEC (2,500 mg/kg) would be identified as contaminated but not requiring treatment. This soil would be disposed at an off-site municipal solid waste landfill. For this alternative, it is estimated that 7,600 cubic yards of soil excavated from Zone 6 would fall into this category.

- Soil with mass concentrations of TPH greater than its I/C DEC would be identified as "high TPH". This soil would be disposed at an off-site TSDF where it would undergo treatment by LTTD prior to landfilling. For this alternative, it is estimated that 750 cubic yards of soil excavated from Zone 6 would fall into this category.

Computations of volumes for the above categories are provided in Appendix C.

During off-site transportation of contaminated soil, appropriate spill prevention and control measures would be taken, and DOT regulations would be followed.

4.7.4.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-6.4 would be fully protective of human health and the environment under the current I/C exposure scenario and any other foreseeable site use. Excavation and off-site disposal of soil with mass concentrations of TPH greater than its PMC and Residential DEC would eliminate both the current risk of direct exposure to TPH-contaminated soil and TPH migration from soil to groundwater and the increased future hypothetical human health risks from direct exposure to TPH-contaminated soil under a residential scenario.

Long-Term Effectiveness and Permanence

Alternative S-6.54 would be long-term effective and permanent. Excavation and off-site disposal would effectively and permanently remove soil with concentrations of TPH to which current site users or hypothetical future site residents should not be exposed and with concentrations of TPH such that this TPH could potentially migrate to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-6.4 would not reduce the toxicity, mobility, and volume of TPH in soil through treatment, except through the treatment of water generated from the dewatering process prior to discharge to the Thames River.

Short-Term Effectiveness

Implementation of Alternative S-6.4 could result in significant short-term risks to on-site workers as a result of exposure to contamination during soil excavation. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-6.4 could also adversely impact the surrounding community and the environment as a result of the excavation and off-site transportation of contaminated soil. This adverse impact would be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-6.4 could be implemented within approximately 9 months and would meet the TPH soil PMC and Residential DEC upon implementation.

Implementability

Alternative S-6.4 would be technically difficult to implement. Excavation could be performed with normal construction equipment by a wide range of contractors. Because this alternative would only be implemented as part of hypothetical future residential development, excavation would not interfere with ongoing activities at the Lower Subase, and it is assumed that underground structures such as utility lines and existing and former building foundations would have been removed as part of site preparation for development. Because excavation would reach to a depth of approximately 6 feet bgs, extensive shoring would be required. In addition, because a significant portion of the excavation would extend below the water table, much of the excavated soil would have a high initial water content, and a relatively complex on-site dewatering operation would be required to make this soil amenable to further treatment and/or disposal. Also, post-excavation confirmation sampling would not be possible in the underwater excavated areas and would have to be replaced with pre-excavation sampling to verify the extent of contamination. Off-site borrow locations for clean soil backfill and solid waste landfills or TSDFs for off-site disposal of the excavated soil would be available.

The administrative aspects of Alternative S-6.4 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for soil excavation. The off-site transportation and disposal of the excavated soil would have to be properly documented, which could be readily

accomplished. In addition, the substantive requirements of federal and State water discharge regulations would have to be met to discharge treated water from the on-site soil dewatering operation to the Thames River.

Cost

The estimated costs for Alternative S-6.4 are as follows:

Capital Cost	$2,812,000
NPW of O&M Costs	$0
NPW	$2,812,000 (1 year)

Within these costs, the estimated incremental capital cost for off-site treatment (LTTD) of highly contaminated soil would be $912,000.

The above figures do not include the cost of demolition of existing structures and removal of underground obstacles that would be required for the implementation of this alternative. Instead, these costs are assumed to have been included as part of the hypothetical future residential development of Zone 6. A detailed cost estimate for this alternative is provided in Appendix E.

4.8 ASSEMBLY AND DETAILED ANALYSIS OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 7

The following soil remedial alternatives have been developed for Zone 7 of the Lower Subase:

Alternative S-7.1:	No Action.
Alternative S-7.2:	LUCs (Engineering and Institutional Controls) and Monitoring.
Alternative S-7.3:	Capping to Allow I/C Site Use and Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring.
Alternative S-7.4:	In-Situ Treatment (Stabilization/Solidification) to Allow I/C Site Use and Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring.
Alternative S-7.5:	Excavation to Meet I/C DEC and PMCs, Off-Site Disposal (Stabilization/Solidification and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring.
Alternative S-7.6:	Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/Solidification, LTTD and Landfilling).

Alternative S-7.1 was developed and analyzed to serve as a baseline for other alternatives, as required by CERCLA and the NCP. Alternative S-7.2 was developed and analyzed to evaluate LUCs with engineering

and institutional controls and monitoring. Alternative S-7.3 was developed and analyzed to evaluate the adequacy of containment, particularly that provided by existing building foundations acting as caps. Alternatives S-7.4 and S-7.5 were developed and analyzed to evaluate a range of remedial actions to address environmental concerns under current site use. Alternative S-7.6 was developed and analyzed to evaluate contaminated soil cleanup for hypothetical future unrestricted site use. Descriptions and detailed analyses of these alternatives are provided in the following sections.

4.8.1 Alternative S-7.1: No Action

4.8.1.1 Description

No Action would not include any action under CERCLA and any existing administrative or engineering environmental controls would not be an enforceable part of a CERCLA remedy. This alternative is required under CERCLA to establish a basis for comparison with other alternatives. The only activity under this alternative would be the performance of five-year reviews. This alternative cannot be chosen because contamination remains on site.

4.8.1.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-7.1 would not be protective of human health and the environment under CERCLA. Unacceptable risk to current site users would be allowed to occur as a result of direct exposure to contaminated soil because the asphalt pavement that covers most of this soil would not be maintained and the disturbance of areas of contaminated soil would not be regulated. There would also be no protection against the even greater risk that would result from exposure to contaminated soil by a wider range of human and ecological receptors if hypothetical future residential use of the site was allowed. In addition, Alternative S-7.1 would allow unacceptable human health and environmental risks to develop because the potential for migration of soil COCs to groundwater would continue to exist, and no monitoring would be performed to assess this potential migration. Alternative S-7.1 would not achieve the soil RAOs.

Compliance with ARARs and TBCs

Alternative S-7.1 would not comply with chemical-specific ARARs and TBCs because no action would be taken to reduce concentrations of COCs. Because Alternative S-7.1 would not involve any action, location- and action-specific ARARs and TBCs would not be relevant. A summary of Alternative S-7.1's compliance with chemical-specific ARARs and TBCs is provided in Table 4-1.

Long-Term Effectiveness and Permanence

Alternative S-7.1 would not be long-term effective and permanent. Paved surfaces would not be maintained and no controls would restrict contaminated soil disturbance, which could result in unacceptable risks to current site users. No controls would prevent hypothetical future residential development, which could result in even greater risks to a wider range of human and ecological receptors. In addition, because no monitoring would be performed, there would be no assessment of the potential migration of soil COCs to groundwater.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative S-7.1 would not reduce toxicity, mobility, or volume of soil COCs through treatment because no treatment would occur.

Short-Term Effectiveness

Because no action would occur, implementation of Alternative S-7.1 would not result in any short-term risks to on-site workers or adversely impact the local community and the environment.

Alternative S-7.1 would not achieve the soil RAOs or meet the Zone 7 soil lead or antimony PRGs for I/C direct exposure and pollutant mobility.

Implementability

Technically, Alternative S-7.1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Cost

The estimated costs for Alternative S-7.1 are as follows:

Capital Cost	$0
NPW of O&M Costs	$55,000 (30 years)
NPW	$55,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.8.2 Alternative S-7.2: LUCs (Engineering and Institutional Controls) and Monitoring

4.8.2.1 Description

Alternative S-7.2 would consist of two major components: (1) LUCs with engineering and institutional controls and (2) monitoring.

Component 1: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 7. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of building foundations and paved areas. The LUC RD would also include procedures for the performance of regular site inspections to verify the continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 2: Monitoring

A groundwater monitoring program would be developed and implemented to evaluate the long-term potential migration of soil COCs to groundwater.

For the purpose of this FS, it was assumed that four groundwater samples would be regularly collected from strategic locations to be identified. Groundwater samples would be analyzed for PAHs, antimony, and lead. Monitoring frequency would be quarterly for the first 2 years, semi-annual for the next 2 years, and annual thereafter.

Reviews would be performed every 5 years to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary. These site reviews are required because this alternative would allow COCs to remain in soil at concentrations in excess of PRGs.

4.8.2.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-7.2 would be protective of human health and the environment under CERCLA. Unacceptable risk from direct exposure of current site users to contaminated surface soil would be

minimized by the asphalt pavement that covers most of this soil. LUCs ensuring regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by minimizing uncontrolled exposure of current site users to contaminated soil. In addition, LUCs restricting Zone 7 to its current I/C use would be protective by preventing even greater risks that would develop from exposure to contaminated soil by a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration of benzo(b)fluoranthene, antimony, or lead from soil to groundwater. Alternative S-7.2 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-7.2 would also indirectly achieve Soil RAO No.4.

Compliance with ARARs and TBCs

Alternative S-7.2 would comply with all location- and action-specific ARARs and TBCs. Alternative S-7.2 would also comply with federal chemical-specific TBCs (there are no federal chemical-specific ARARs), and with the DECs and PMCs mandated by Connecticut RSRs. A summary of Alternative S-7.2's compliance with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 4-2, 4-3, and 4-4, respectively.

Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-7.2 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil. See Appendix D.1.3 for engineering control calculations.

Long-Term Effectiveness and Permanence

Alternative S-7.2 would be long-term effective and permanent under CERCLA. Although soil concentrations of PAHs, antimony, and lead would not be actively reduced, risks to human health and the environment would be minimized through LUCs and monitoring. LUCs that ensure regular maintenance of building foundations and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 7 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Long-term monitoring would effectively detect potential migration of benzo(b)fluoranthene, antimony, and lead from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-7.2 would not reduce the toxicity, mobility, or volume of PAHs, antimony and lead in soil through treatment because no treatment would occur.

Short-Term Effectiveness

Alternative S-7.2 would have minimal short-term effectiveness concerns. Any exposure of workers to contaminated soil during the maintenance and sampling of groundwater monitoring wells would be minimized by wearing of appropriate PPE and complying with site-specific health and safety procedures. Implementation of LUCs and monitoring would not adversely impact the surrounding community or the environment.

Alternative S-7.2 could be implemented within approximately 3 months and would achieve Soil RAOs Nos. 1 to 3 immediately upon implementation. By preventing hypothetical future residential development, Alternative S-7.2 would also indirectly achieve Soil RAO No. 4 upon implementation. Alternative S-7.2 would not meet the Zone 7 soil PAHs, antimony, and lead PRGs for I/C direct exposure and pollutant mobility, but these cleanup criteria would not apply because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-7.2 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

The technical implementability of Alternative S-7.2 would be easy. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of groundwater could be readily performed.

The administrative aspects of Alternative S-7.2 would be simple to implement. No construction permit issued by NSB-NLON DPW would be required for this alternative. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

The estimated costs for Alternative S-7.2 are as follows:

Capital Cost	$79,000
NPW of O&M Costs	$648,000 (30 years)
NPW	$727,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.8.3 Alternative S-7.3: Capping to Allow I/C Site Use and Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring

4.8.3.1 Description

Alternative S-7.3 would consist of four major components: (1) capping to allow I/C site use and prevent leaching, (2) off-site disposal of excavated soil, (3) LUCs with engineering and institutional controls, and (4) monitoring.

Component 1: Capping to Allow I/C Site Use and Prevent Leaching

Areas of surface soil with mass concentrations of PAHs or lead greater than their respective I/C DECs (1 mg/kg and 1,090 mg/kg), to a depth of 2 feet bgs in paved areas and 4 feet bgs in unpaved areas, or mass concentrations of benzo(b)fluoranthene greater than its Zone 7 Alternative GB PMC for I/C site use (7.7 mg/kg) and SPLP/TCLP concentrations of lead greater than its Zone 7 Alternative GB PMC for I/C site use (0.26 mg/L) at depths greater than 2 feet bgs but above the mean high water table would be capped with an impervious cover system to prevent direct exposure to contaminated soil and potential migration of soil COCs to groundwater to address CERCLA risks. By so doing, soil with mass concentrations of antimony greater than its I/C DEC (410 mg/kg) or with SPLP/TCLP concentrations of antimony greater than its Zone 7 Alternative GB PMC for I/C site use (0.08 mg/L) would also be capped. However, as noted below, the top two feet of soil will be excavated in any case in order to install the cap.

Contaminated soil are located in nine discrete areas that cover most of the central and southern part of Zone 7 and extend over an estimated 87,400 square feet, as shown on Figure 4-17. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

To maintain the current topography of the site, surface preparation of the areas where the cap would be installed would require excavation to a depth equal to the thickness of the cap. Because the planned thickness of the cap is approximately 2 feet, this pre-excavation would result in the removal of all contaminated surface soil, leaving only contaminated subsurface soil to be capped. The areas to be capped would be covered with a 2-foot-thick layer of compacted soil with a permeability of 10^{-6} cm/sec. Alternately, because soil with such a low permeability may be very difficult and expensive to obtain, the cap could consist of a 2-foot layer of soil with a greater permeability (e.g., 10^{-5} cm/sec) overlying an impervious synthetic liner. The pre-excavated areas that do not require capping would be backfilled with clean fill. The capped and backfilled areas would be repaved to match original surface conditions.

It is estimated that, as part of site preparation, a total of 6,500 cubic yards of contaminated soil and asphalt debris would be excavated from an overall surface area of 87,400 square feet. Subsequently, an estimated 27,600 square feet of the exposed subsurface soil would be capped and the remaining 59,800 square feet of excavated area would be backfilled with clean fill material. Computations of capping and excavation surface areas and volumes are provided in Appendix C.

During construction activities, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum. Appropriate controls such as silt fences, sediment traps, and hay bales would also be used to minimize erosion and sedimentation. In addition, during the excavation of contaminated soil in close proximity to existing buildings, care would be taken not to undermine the foundations of these buildings.

Component 2: Off-Site Disposal

Because under this alternative soil would be excavated above the water table, it is assumed that the excavated soil would contain minimal free water and would not have to be pretreated by on-site dewatering prior to transportation for off-site disposal.

Asphalt pavement debris would be segregated and recycled or, if required, disposed at an off-site construction material landfill. For this alternative, it is estimated that 800 cubic yards of asphalt debris would be removed from Zone 7.

To determine the proper method of disposal of the remaining 5,700 cubic yards of excavated soil, composite samples would be collected at the rate of approximately one sample per 100 cubic yards. These samples would be analyzed for SPLP/TCLP antimony and lead to sort the excavated soil into the following categories:

- Soil with mass concentrations of PAHs, antimony, or lead less than their respective Residential DECs (1 mg/kg, 31 mg/kg, and 400 mg/kg) would be identified as non-contaminated and would be reused on site as backfill. For this alternative, it is estimated that no soil excavated from Zone 7 would fall into this category.

- Soil with mass concentrations of PAHs, antimony, or lead greater than their Residential DECs but less than their I/C DEC (1 mg/kg, 410 mg/kg, and 1,090 mg/kg), or SPLP/TCLP concentrations of antimony greater than its Zone 7 Alternative GB PMC for I/C site use (0.08 mg/L), or TCLP concentrations of lead greater than its Zone 7 Alternative GB PMC for I/C site use (0.26 mg/L) but less than its RCRA toxicity characteristic (5 mg/L) would be identified as contaminated but not requiring treatment. This soil would be disposed at an off-site municipal solid waste landfill. For this alternative, it is estimated that 1,100 cubic yards of the soil excavated from Zone 7 would fall into this category.

- Soil with mass concentrations of PAHs greater than its I/C DEC would be identified as "high PAH" and would be disposed at an off-site TSDF where it would undergo treatment by LTTD prior to landfilling. For this alternative, it is estimated that 3,900 cubic yards of soil excavated from Zone 7 would fall into this category.

- Soil with mass concentrations of antimony or lead greater than their respective I/C DEC or TCLP concentrations of lead greater than its RCRA toxicity characteristic would be identified as "high lead" and would be disposed at an off-site TSDF where it would undergo treatment by chemical stabilization/solidification prior to landfilling. For this alternative, it is estimated that 700 cubic yards of the soil excavated from Zone 7 would fall into this category.

Computations of volumes for the above categories are provided in Appendix C.

During off-site transportation of contaminated soil, appropriate spill prevention and control measures would be taken and DOT regulations would be followed.

Component 3: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 7. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of the caps and of building foundations that already cover inaccessible and/or environmentally isolated soil. Similarly, another engineering control would be specified for the regular maintenance of the existing paved areas such that the assumptions used for the alternative PMC

calculation are still applicable. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 4: Monitoring

Long-term groundwater monitoring would be conducted to confirm that soil contaminants are not mobilizing and migrating to groundwater at unacceptable concentrations.

4.8.3.2 Detailed Analysis

Overall Protection of Human Health and Environment

Alternative S-7.3 would be protective of human health and the environment under CERCLA. Placement of a cap would be protective because it would isolate or remove soil with mass concentrations of PAHs, antimony, or lead to which current site users should not be exposed. Placement of a cap would also be protective because it would minimize the potential for benzo(b)fluoranthene, antimony, and lead from soil to groundwater. LUCs ensuring regular maintenance of building foundations and capped and paved areas and regulating the disturbance of contaminated soil would be protective by preventing unacceptable risk to current site users. In addition, LUCs restricting Zone 7 to its current I/C use would be protective by preventing even greater risks to human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration of lead from soil to groundwater. Alternative S-7.3 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-7.3 would also indirectly achieve Soil RAO No.4.

Compliance with ARARs and TBCs

Alternative S-7.3 would comply with chemical-, location-, and action-specific ARARs and TBCs, as summarized in Tables 4-14, 4-15, and 4-16, respectively.

Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-7.3 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil that could not be excavated.

Long-Term Effectiveness and Permanence

Alternative S-7.3 would be long-term effective under CERCLA. The cap would effectively prevent exposure of current site users to unacceptable concentrations of PAHs, antimony, or lead. The cap would also effectively minimize water infiltration, which is the primary pathway for potential migration of benzo(b) fluoranthene, antimony, and lead from soil to groundwater. LUCs that ensure regular maintenance of building foundations and capped and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 7 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Long-term monitoring would effectively verify that benzo(b)fluoranthene, antimony, or lead do not migrate from soil to groundwater.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternative S-7.3 would not address CERCLA risks by reducing the toxicity, mobility, and volume of benzo(b)fluoranthene, antimony, and lead in soil through treatment.

Short-Term Effectiveness

Implementation of Alternative S-7.3 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during installation of a cap and also as a result of monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-7.3 could also have a minimal adverse impact on the surrounding community or the environment as a result of the excavation and off-site transportation of contaminated soil. This impact would also be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-7.3 could be implemented within approximately 1 year and would achieve Soil RAOs Nos. 1 to 3 upon implementation. By preventing hypothetical future residential development, Alternative S-7.3 would also indirectly achieve Soil RAO No. 4 upon implementation. Although Alternative S-7.3 would not meet the Zone 7 soil antimony and lead PRGs for I/C direct exposure and pollutant mobility these criteria would not apply because the engineering controls of Alternative S-7.3 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs. In addition, these cleanup criteria would not apply to leftover areas of inaccessible and/or environmentally isolated contaminated soil that could not be capped because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-7.3 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

Alternative S-7.3 would be technically implementable. Contractors qualified to install a cap are readily available and this work could be performed with normal construction equipment. However, very careful planning and execution would be required to prevent interference of the capping operations with ongoing activities at the Lower Subase. The presence of many underground structures such as utility lines and existing and former building foundations would also interfere with the placement of a cap, although this might be somewhat mitigated because many of these structures are located below the shallow depth (2 feet) of the required pre-excavation. Off-site borrow locations for clean soil backfill and TSDFs for off-site treatment and disposal of the excavated soil would be available. Maintenance of building foundations, capped and paved areas, and needed monitoring wells and sampling and analysis of soil and groundwater could be readily performed.

The administrative aspects of Alternative S-7.3 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for the capping activities. The off-site transportation and disposal of the excavated soil would have to be properly documented, which could be readily accomplished. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

Estimated costs for Alternative S-7.3 are as follows:

Capital Cost	$2,745,000
NPW of O&M Costs	$648,000 (30 years)
NPW	$3,393,000 (30 years)

Within these costs, the estimated incremental capital cost for off-site treatment (chemical stabilization/ solidification and LTTD) of highly contaminated soil would be $1,193,000.

A detailed cost estimate for this alternative is provided in Appendix E.

4.8.4 Alternative S-7.4: In-Situ Treatment (Enhanced Bioremediation and Stabilization/ Solidification) to Allow I/C Site Use and Meet PMCs for I/C Site Use, LUCs (Engineering and Institutional Controls), and Monitoring

4.8.4.1 Description

Alternative S-7.4 would consist of three major components: (1) in-situ treatment to allow I/C site use and meet PMCs for I/C site use, (2) LUCs with engineering and institutional controls, and (3) monitoring.

Component 1: In-Situ Treatment to Allow I/C Site Use and Meet PMCs for I/C Site Use

In-situ treatment would include enhanced bioremediation and chemical stabilization/solidification. Computations of treated soil volumes are provided in Appendix D.

Enhanced Bioremediation

Areas of soil with mass concentrations of PAHs greater than its I/C DEC (1 mg/kg), to a depth of 2 feet bgs in paved areas and 4 feet bgs in unpaved areas, or mass concentrations of benzo(b)fluoranthene greater than its Zone 7 Alternative GB PMC for I/C site use (7.7 mg/kg) in the remainder of the unsaturated zone would be treated using in-situ enhanced bioremediation to address CERCLA risks. Contaminated soil is located in two areas in the central and southern parts of Zone 7 and extend over an estimated 59,800 square feet to a depth of up to 4 feet bgs, as shown on Figure 4-18. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

In-situ bioremediation would consist of using ORC to enhance the growth of indigenous microorganisms and augment the natural aerobic biodegradation of PAHs in soil. For the purposes of this alternative, it is assumed that an ORC such as magnesium peroxide would be blended in the areas of soil to be treated

using a backhoe to treat soil up to 3 feet deep and an LDA for deeper application. It is also assumed that a single application would be required. An estimated 3,900 cubic yards of soil would be treated in this way by blending in magnesium peroxide as a 8-percent (by weight) solution at the rate of approximately 10 pounds of dry magnesium peroxide per pound of PAHs to be removed, for a total estimated use of approximately 1,400 pounds of dry magnesium peroxide (or approximately 1,950 gallons of 8-percent solution). The blending action and addition of ORC would result in an increase in the volume of treated soil of approximately 400 cubic yards. Because the bioremediation process would take at least 1 year to complete, this incremental volume of soil would be kept on site and dispersed through appropriate regrading as necessary to accommodate existing buildings and other structures. The exact design of the treatment system would be verified through treatability testing prior to implementation. Conceptual design calculations for in-situ bioremediation are provided in Appendix D.

Chemical Stabilization/Solidification

Areas of soil with mass concentrations of lead greater than its I/C DEC (1,090 mg/kg), to a depth of 2 feet bgs in paved areas and 4 feet bgs in unpaved areas, or with SPLP/TCLP concentrations of lead greater than its Zone 7 Alternative GB PMC for I/C site use (0.26 mg/L) in the remainder of the unsaturated zone would be treated using in-situ chemical stabilization/solidification to address CERCLA risks. By so doing, soil with mass concentrations of antimony greater than its I/C DEC (410 mg/kg) or with SPLP/TCLP concentrations of antimony greater than its Zone 7 Alternative GB PMC for I/C site use (0.08 mg/L) would also be treated. Contaminated soil extend over a total estimated area of 27,500 square feet to a depth of up to 7 feet, including two large areas in the east-central part of Zone 7 (20MW6 and MW5-7RI) covering an estimated 27,100 square feet and a much smaller 400 square feet rectangular area along the eastern edge of Zone 7 (20TB7), as shown on Figure 4-18. Pre-treatment sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

An LDA typically 6- to 10 feet in diameter would be used to blend the contaminated soil in these areas with controlled amounts of a pozzolanic reagent such as Portland cement and water to chemically stabilize the lead within the soil matrix. An estimated 5,600 cubic yards of contaminated soil would be treated in this way by blending in Portland cement and water at the rate of approximately 5 percent (by weight) and 2 percent (by weight), respectively, for a total estimated use of approximately 460 tons of Portland cement and 44,000 gallons of water. The blending action and addition of Portland cement would result in an increase in the volume of treated soil of approximately 560 cubic yards. Because the chemical stabilization/solidification would only take a few days to complete, this incremental volume of soil would be disposed off site at a municipal solid waste landfill. Prior to treatment, treatability testing would be performed to determine the appropriate ratio of Portland cement and water to achieve a properly stabilized soil. Computations of treated soil volumes are provided in Appendix C and conceptual design calculations for in-situ chemical stabilization/solidification are provided in Appendix D.

Prior to treatment with either enhanced bioremediation or chemical stabilization/solidification, a detailed survey would be made of underground obstacles (e.g., underground pipes or cables) in the area to be treated and, when practical, these obstacles would be moved. If obstacles prevent the use of a blending auger in certain areas and if moving of these obstacles is not practical, the ORC or Portland cement and water would be manually worked into the soil to be treated using hand tools such as shovels, provided that the areas to be so treated are relatively small in size. Accordingly, it is assumed for the purpose of this FS that underground obstacles would not actually prevent the implementation of in-situ enhanced bioremediation or chemical stabilization/solidification.

Following treatment, confirmation samples would be collected beneath and around the treated area to verify that all contaminated soil has been treated. Additional confirmation samples would also be collected from the treated area within approximately one month from the areas treated with chemical stabilization/solidification and within a year from the areas treated with enhanced bioremediation. These additional samples would be tested for SPLP concentrations of antimony and lead and for mass concentrations of PAHs, respectively, to verify that the treated soil meets the Zone 7 I/C PRGs.

Component 2: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 7. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of building foundations that cover inaccessible and/or environmentally isolated soil which cannot be treated. Similarly, another engineering control would be specified for the regular maintenance of the existing paved areas such that the assumptions used for the alternative PMC calculation are still applicable. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 3: Monitoring

Long-term groundwater monitoring would be conducted to confirm that soil contaminants are not mobilizing and migrating to groundwater at unacceptable concentrations.

4.8.4.2 Detailed Analysis

Overall Protection of Human Health and Environment

Alternative S-7.4 would be protective of human health and the environment under CERCLA. In-situ treatment with enhanced bioremediation and chemical stabilization/solidification would be protective because it would remove or isolate concentrations of PAHs, antimony or lead to which current site users should not be exposed. In-situ treatment would also be protective because it would remove or immobilize the benzo(b)fluoranthene, antimony, and lead content of the treated soil and minimize their potential migration to groundwater. LUCs ensuring regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by preventing unacceptable risk to current site users. In addition, LUCs restricting Zone 7 to its current I/C use would be protective by preventing even greater risks to a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting the potential migration of PAHs, antimony or lead from soil to groundwater. Alternative S-7.4 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-7.4 would also indirectly achieve Soil RAO No.4.

Compliance with ARARs and TBCs

Alternative S-7.4 would comply with chemical-, location- and action-specific ARARs and TBCs, as summarized in Tables 4-17, 4-18, and 4-19, respectively.

Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-7.4 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil that could not be treated. In addition, chemical stabilization/solidification is considered to be an engineering control (pending CTDEP concurrence), so the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs would be satisfied.

Long-Term Effectiveness and Permanence

Alternative S-7.4 would be long-term effective and permanent under CERCLA. In-situ enhanced bioremediation would effectively reduce concentrations of PAHs and in-situ chemical stabilization/solidification would effectively and permanently isolate and immobilize antimony and lead, which would minimize risks from exposure to current site users and potential migration to groundwater. LUCs that ensure regular maintenance of building foundations and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 7 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. Long-term monitoring

would effectively verify that benzo(b)fluoranthene, antimony, or lead do not migrate from soil to groundwater.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternative S-7.4 would address CERCLA risks by reducing the toxicity, mobility and volume of PAHs, antimony, and lead in soil through in-situ treatment. An estimated 3,900 cubic yards of "high PAH" soil would be permanently and irreversibly treated by in-situ enhanced bioremediation, and an estimated 5,600 cubic yards of "high lead" soil would be permanently and irreversibly treated by in-situ chemical stabilization/solidification. However, the degree of antimony and lead toxicity reduction achieved through chemical stabilization/solidification is likely to be significantly less than the reduction of mobility, and there would be no reduction of the quantity of these metals in the treated soil. Because chemical stabilization/solidification is considered to be an engineering control (pending CTDEP concurrence), the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs would be satisfied.

Short-Term Effectiveness

Implementation of Alternative S-7.4 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during in-situ treatment activities and also as a result of monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-7.4 would have no adverse impact on the surrounding community or the environment.

Alternative S-7.4 could be implemented within approximately 1 year and would achieve Soil RAOs Nos. 1 to 3 upon implementation. By preventing hypothetical future residential development, Alternative S-7.4 would also indirectly achieve Soil RAO No. 4 upon implementation. Alternative S-7.4 would meet the Zone 7 soil antimony and lead PRGs for I/C pollutant mobility at completion and the Zone 7 soil PAHs PRG for I/C direct exposure and Zone 7 soil benzo(b)fluoranthene PRG for I/C pollutant mobility within an estimated 3 to 5 years. However, Alternative S-7.4 would not meet the Zone 7 soil antimony and lead PRGs for I/C direct exposure. In addition, these cleanup criteria would not apply to leftover areas of inaccessible and/or environmentally isolated contaminated soil that could not be treated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-7.4 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

Alternative S-7.4 would be technically implementable. Contractors qualified to perform in-situ enhanced bioremediation and chemical stabilization/solidification are readily available. However, very careful planning and execution would be required to prevent interference with ongoing activities at the Lower

Subase. In addition, implementation of the in-situ treatment would be significantly hindered, and might even be prevented, by the presence of many underground structures such as utility lines and existing and former building foundations. Nonetheless, as previously mentioned, it is assumed for the purpose of this FS that ongoing base activities and underground obstacles would not actually prevent implementation. The increase in soil volume resulting from soil blending and ORC addition would require regrading of the in-situ enhanced bioremediation areas to accommodate existing buildings and other structures. Treatability tests would be required to determine the appropriate ORC dosage and soil/pozzolanic reagent/water mix ratios prior to implementation. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of soil and groundwater could be readily performed.

The administrative aspects of Alternative S-7.4 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for the in-situ treatment activities. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

Estimated costs for Alternative S-7.4 are as follows:

Capital Cost	$2,388,000
NPW of O&M Costs	$660,000 (30 years)
NPW	$3,048,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.8.5 Alternative S-7.5: Excavation to Meet DECs and PMCs for I/C Site Use, Off-Site Disposal (LTTD and Stabilization/Solidification and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring

4.8.5.1 Description

Alternative S-7.5 would consist of four major components: (1) excavation to meet DECs and PMCs for I/C site use, (2) off-site disposal of excavated soil, (3) LUCs with engineering and institutional controls, and (4) monitoring.

Component 1: Excavation to Meet DECs and PMCs for I/C Site Use

Areas of surface soil with mass concentrations of PAHs or lead greater than their respective I/C DECs (1 mg/kg and 1,090 mg/kg), to a depth of 2 feet bgs in paved areas and 4 feet bgs in unpaved areas, or mass concentrations of benzo(b)fluoranthene greater than its Zone 7 Alternative GB PMC for I/C site use (7.7 mg/kg) and SPLP/TCLP concentrations of lead greater than its Zone 7 Alternative GB PMC for I/C site use (0.26 mg/L) would be excavated to address CERCLA risks. By so doing, soil with mass concentrations of antimony greater than its I/C DEC (410 mg/kg) or with SPLP/TCLP concentrations of antimony greater than its Zone 7 Alternative GB PMC for I/C site use (0.08 mg/L) would also be removed. These areas are located in the central and southern areas of Zone 7 and extend over an estimated 87,400 square feet to a depth of up to 7 feet bgs, as illustrated on Figure 4-18. An estimated total of 10,600 cubic yards of contaminated soil and asphalt debris would be removed through excavation. Note that this volume includes 300 cubic yards of soil with relatively low contamination that can be used as backfill, which is described further below. Computations of excavation volumes are provided in Appendix C. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

Following excavation, confirmation samples would be collected from the bottoms and walls of the excavated areas to verify that contaminated soil has been removed. After confirmation sampling is complete, the excavated areas would be backfilled with clean soil and the site restored to its former condition.

Prior to excavation, a detailed survey would be made of underground obstacles (e.g., underground pipes or cables) in the areas to be excavated and, when practical, these obstacles would be moved. If obstacles prevent the use of a normal backhoe or grade-all in certain areas and if moving of these obstacles is not practical, a small backhoe or hand shovels would be used provided that the areas to be

so excavated are relatively small in size. Accordingly, it is assumed for the purpose of this FS that underground obstacles would not actually prevent the excavation of contaminated soil.

Excavation of Zone 7 contaminated soil under this alternative would extend to an estimated depth of 7 feet bgs, which is assumed to be above the water table. Accordingly, shoring of the excavated areas would be required, but not dewatering.

During excavation, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum. The excavated areas would be backfilled as soon as possible and on-site staging and stockpiling of excavated soil would be kept to a minimum. Any on-site stockpiles of excavated soil would be covered with an impervious synthetic liner at the end of each day's work.

Component 2: Off-Site Disposal

Because under this alternative soil would be excavated above the water table, it is assumed that the excavated soil would contain minimal free water and would not have to be pretreated by on-site dewatering prior to transportation for off-site disposal.

Asphalt pavement debris would be segregated and recycled or, if required, disposed at an off-site construction material landfill. For this alternative, it is estimated that 800 cubic yards of asphalt debris would be removed from Zone 7.

To determine the proper method of disposal of the remaining 9,800 cubic yards of excavated soil, composite samples would be collected at the rate of approximately one sample per 200 cubic yards. These samples would be analyzed for mass lead and SPLP/TCLP lead to sort the excavated soil into the following categories:

- Soil with mass concentrations of PAHs, antimony, or lead less than their Residential DECs (1 mg/kg, 31 mg/kg, and 400 mg/kg) would be identified as non-contaminated and would be reused on site as backfill. For this alternative, it is estimated no soil excavated from Zone 7 would fall into this category.

- Soil with mass concentrations of BAP equivalents, antimony, or lead greater than their Residential DECs but less than their I/C DECs (1 mg/kg, 410 mg/kg, and 1,090 mg/kg), or SPLP/TCLP concentrations of antimony greater than its Zone 7 Alternative GB PMC for I/C site use (0.08 mg/L), or with TCLP concentrations of lead greater than its Zone 7 I/C DEC (0.26 mg/L) but less than its RCRA toxicity characteristic (5 mg/L) would be identified as contaminated and not requiring treatment. This

soil would be disposed at an off-site municipal solid waste landfill. For this alternative, it is estimated that 100 cubic yards of the soil excavated from Zone 7 would fall into this category.

- Soil with mass concentrations of lead greater than its Residential DEC but less than its I/C DEC (1,090 mg/kg), and SPLP/TCLP concentrations of lead less than its Zone 7 Alternative GB PMC for I/C site use (0.26 mg/L). This soil would be reused as backfill in the excavation. For this alternative, it is estimated that 300 cubic yards of the soil excavated from Zone 7 would fall into this category.

- Soil with mass concentrations of PAHs greater than their I/C DEC would be identified as "high PAH" and would be disposed at an off-site TSDF where it would undergo treatment by LTTD prior to landfilling. For this alternative, it is estimated that 3,900 cubic yards of soil excavated from Zone 7 would fall into this category.

- Soil with mass concentrations of antimony or lead greater than their respective I/C DEC or TCLP concentrations of lead greater than its RCRA toxicity characteristic would be identified as "high lead" and would be disposed at an off-site TSDF where it would undergo treatment by chemical stabilization/solidification prior to landfilling. For this alternative, it is estimated that 5,500 cubic yards of soil excavated from Zone 7 would fall into this category.

Computations of volumes for the above categories are provided in Appendix C.

During off-site transportation of contaminated soil, appropriate spill prevention and control measures would be taken, and DOT regulations would be followed.

Component 3: LUCs with Engineering and Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to restrict the disturbance of contaminated soil and to prevent residential development of Zone 7. One of the principal engineering controls that would be specified in the LUC RD would be the regular maintenance of building foundations that cover inaccessible and/or environmentally isolated soil which cannot be excavated. Similarly, another engineering control would be specified for the regular maintenance of the existing paved areas such that the assumptions used for the alternative PMC calculation are still applicable. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 4: Monitoring

Long-term groundwater monitoring would be conducted to confirm that soil contaminants are not mobilizing and migrating to groundwater at unacceptable concentrations.

4.8.5.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-7.5 would be protective of human health and the environment under CERCLA. Excavation and off-site disposal of soil with mass concentrations of PAHs, antimony, or lead greater than their respective I/C DECs would prevent unacceptable risk from exposure of current site users to these COCs. Excavation and off-site disposal of soil with mass concentrations of benzo(b)fluoranthene greater than its Zone 7 Alternative GB PMC for I/C site use or SPLP/TCLP concentrations of antimony or lead greater than their respective Zone 7 Alternative GB PMCs for I/C site use would be protective by eliminating the source of potential migration of these COCs from soil to groundwater. LUCs ensuring regular maintenance of building foundations and paved areas and regulating the disturbance of contaminated soil would be protective by preventing unacceptable risk to current site users. In addition, LUCs restricting Zone 7 to its current I/C use would be protective by preventing even greater risks to a wider range of human and ecological receptors under hypothetical future residential site use. Monitoring would be protective by detecting potential migration of benzo(b)fluoranthene, antimony, and lead from soil to groundwater. Alternative S-7.5 would achieve Soil RAOs Nos. 1 to 3. By preventing hypothetical future residential development, Alternative S-7.5 would also indirectly achieve Soil RAO No.4.

Compliance with ARARs and TBCs

Alternative S-7.5 would comply with chemical-, location- and action-specific ARARs and TBCs, as summarized in Tables 4-8, 4-9, and 4-10, respectively.

Long-Term Effectiveness and Permanence

Alternative S-7.5 would be long-term effective and permanent under CERCLA. Excavation and off-site disposal would effectively and permanently remove soil with concentrations of PAHs, antimony or lead to which current site users should not be exposed. Excavation and off-site disposal would also effectively and permanently remove soil with concentrations of benzo(b)fluoranthene, antimony, and lead such that these COCs could potentially migrate from soil to groundwater. LUCs that ensure regular maintenance of building foundations and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 7 would effectively and permanently prevent unacceptable risk

from direct exposure to contaminated soil. Monitoring would effectively verify that benzo(b)fluoranthene, antimony, or lead are not migrating from soil to groundwater.

Because the engineering controls of Alternative S-7.5 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil that could not be excavated.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-7.5 would not address CERCLA risks by reducing the toxicity, mobility, and volume of PAHs, antimony, and lead in soil through treatment.

Short-Term Effectiveness

Implementation of Alternative S-7.5 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during soil excavation. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-7.5 could also have a minimal adverse impact on the surrounding community and the environment as a result of the excavation and off-site transportation of contaminated soil. This impact would be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-7.5 could be implemented within approximately 1 year and would achieve Soil RAOs Nos. 1 to 3 upon implementation. By preventing hypothetical future residential development, Alternative S-7.5 would also indirectly achieve Soil RAO No. 4 upon implementation. Alternative S-7.5 would meet the Zone 7 soil PRGs for I/C direct exposure and pollutant mobility upon implementation. In addition, these cleanup criteria would not apply to leftover areas of inaccessible and/or environmentally isolated contaminated soil that could not be excavated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternative S-7.5 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Implementability

Alternative S-7.5 would be technically implementable. Excavation could be performed with normal construction equipment by a wide range of contractors. However, very careful planning and execution would be required to prevent interference with ongoing activities at the Lower Subase. In addition, excavation would be significantly hindered, and might even be prevented, by the presence of many underground structures such as utility lines and existing and former building foundations. Nonetheless, as

previously mentioned, it is assumed for the purpose of this FS that ongoing base activities and underground obstacles would not actually prevent excavation. Because excavation would be limited to approximately 7 feet bgs and would not extend below the water table, shoring would be required but there would be no need for excavation dewatering. Off-site borrow locations for clean soil backfill and TSDFs for off-site treatment and disposal of the excavated soil would be available. Maintenance of building foundations, paved areas, and needed monitoring wells and sampling and analysis of soil and groundwater could be readily performed.

The administrative aspects of Alternative S-7.5 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for soil excavation. The off-site transportation and disposal of the excavated soil would have to be properly documented, which could be readily accomplished. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

The resources, equipment, and materials required for all of these activities are readily available.

Cost

The estimated costs for Alternative S-7.5 are as follows:

Capital Cost	$4,488,000
NPW of O&M Costs	$648,000 (30 years)
NPW	$5,136,000 (30 years)

Within these costs, the estimated incremental capital cost for off-site treatment (chemical stabilization/ solidification and LTTD) of highly contaminated soil would be $2,552,000.

A detailed cost estimate for this alternative is provided in Appendix E.

4.8.6 Alternative S-7.6: Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/Solidification, LTTD and Landfilling)

4.8.6.1 Description

Alternative S-7.6 would consist of three major components: (1) excavation to meet Residential DECs and PMCs, (2) on-site dewatering, and (3) off-site disposal.

Component 1: Excavation to Meet Residential DECs and PMCs

The areas of soil up to 15 feet deep with mass concentrations of PAHs or lead greater than their respective Residential DECs (1 mg/kg and 400 mg/kg) would be excavated to address CERCLA risks. By so doing, the Residential DECs for antimony (31 mg/kg), arsenic (10 mg/kg), and copper (3,130 mg/kg), and the Zone 7 Alternative GB PMCs for Residential use for PAHs, antimony, and lead (2.8 to 7.4 mg/kg, 0.06 mg/L, and 0.15 mg/L) would also be met. In addition, areas of soil with mass concentrations of TPH greater than its Residential DEC (500 mg/kg) would also be excavated to address State petroleum concerns. These areas are located throughout Zone 7 and extend over an estimated 213,800 square feet to a depth of 8 feet bgs, as shown on Figure 4-19. An estimated total of 63,300 cubic yards of contaminated soil, uncontaminated soil, and asphalt debris would be removed through excavation. Computations of excavation volumes are provided in Appendix C. Sampling and analysis would be performed as part of the PDI to verify the estimated extent of the contaminated soil.

Following excavation, confirmation samples would be collected from the bottoms and walls of excavated areas located above the water table to verify that contaminated soil has been removed. After confirmation sampling is complete, the excavated area would be backfilled with clean soil, including a 6-inch layer of topsoil, and vegetated to minimize erosion.

Because this alternative would only be implemented prior to residential development of the site, it is assumed that existing underground obstacles (e.g., underground pipes or cables) would have been removed as part of site preparation for this development.

Because excavation of Zone 7 contaminated soil under this alternative would extend to an estimated depth of 8 feet bgs, a significant portion of that excavation would take place below the water table and extensive shoring would be required. However, as discussed in Section 3.2.4, dewatering of the

excavated areas would not be practical, and excavation would be performed with equipment adapted to underwater work, such as a clamshell.

During excavation, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum. The excavated areas would be backfilled as soon as possible, and on-site staging and stockpiling of excavated soil would be kept to a minimum. Any on-site stockpiles of excavated soil would be covered with an impervious synthetic liner at the end of each day's work.

Component 2: On-Site Dewatering

Within Zone 7, it is assumed that excavation beyond a depth ranging from approximately 6 feet bgs would take place below the water table. Therefore, it is also assumed that the wet soil excavated below that depth would equal approximately 1.5 times its in-situ volume and would contain an average of 53 percent of free water by volume. This wet soil would require gravity-induced passive dewatering by on-site stockpiling prior to off-site disposal, as discussed in Section 3.2.6.1.

Gravity-induced stockpile dewatering would be performed at a DW/WWT facility located as close to the excavation area as possible. A typical DW/WWT facility would consist of a dewatering stockpile with associated drainage water treatment system including bag filtration and liquid-phase GAC adsorption. A more detailed description of this facility is provided in the description of Alternative S-1.5 (see Section 4.2.5.1).

DW/WWT monitoring would consist of collecting one sample of the treatment system influent and effluent for every day of system operation and analyzing these samples for PAHs, metals, and total suspended solids.

An estimated in-situ soil volume of 38,000 cubic yards would be excavated below the water table, yielding approximately 57,000 cubic yards of wet excavated soil that would be dewatered to its original in-situ volume of 38,000 cubic yards (or 68,000 tons). This would require an estimated 190 dewatering stockpile operating sequences, or approximately 114 operating days with five dewatering stockpiles. The total volume of drainage water treated and discharged would be an estimated 3,838,200 gallons. Conceptual design calculations for the on-site dewatering of soil are provided in Appendix D.

Component 3: Off-Site Disposal

Asphalt pavement debris would be segregated and recycled or, if required, disposed at an off-site construction material landfill. For this alternative, it is estimated that 1,900 cubic yards of asphalt debris would be removed from Zone 7.

To determine the proper method of disposal of the remaining 61,400 cubic yards of excavated soil, composite samples would be collected at the rate of approximately one sample per 500 cubic yard. These samples would be analyzed for mass concentrations of PAHs, TPH, antimony, arsenic, and lead and SPLP/TCLP concentrations of antimony and lead to sort the excavated soil into the following categories:

- Soil with mass concentrations of PAHs, TPH, antimony, arsenic, or lead less than their respective Residential DECs (1 mg/kg, 500 mg/kg, 31 mg/kg, 10 mg/kg, and 400 mg/kg) and/or with SPLP/TCLP concentrations of antimony or lead less than their respective Zone 7 Alternative GB PMCs for Residential use (0.06 mg/L and 0.15 mg/L) would be identified as non-contaminated and would be reused on-site as backfill. For this alternative, it is estimated that 400 cubic yards of soil excavated from Zone 7 would fall into this category.

- Soil with mass concentrations of PAHs, TPH, antimony, arsenic, or lead greater than their respective Residential DECs but less than their respective I/C DECs (1 mg/kg, 2,500 mg/kg, 8,200 mg/kg, 10 mg/kg, and 1,090 mg/kg) and/or with SPLP/TCLP concentrations of antimony or lead greater than their respective Zone 7 Alternative GB PMCs for Residential use but with TCLP concentrations of lead less than its RCRA toxicity characteristic (5 mg/L) would be identified as contaminated but not requiring treatment. This soil would be disposed at an off-site municipal solid waste landfill. For this alternative, it is estimated that 20,700 cubic yards of soil excavated from Zone 7 would fall into this category.

- Soil with mass concentrations of PAHs or TPH greater than their respective I/C DECs would be identified as "high PAH" or "high TPH" and would be disposed at an off-site TSDF where it would undergo treatment by LTTD prior to landfilling. For this alternative, it is estimated that a total of 19,600 cubic yards of soil excavated from Zone 7 would fall into this category, all of it identified as "high PAH".

- Soil with mass concentrations of arsenic or lead greater than their respective I/C DECs and/or with TCLP concentrations of lead greater than its RCRA toxicity characteristic would be identified as "high lead" and would be disposed at an off-site TSDF where it would undergo treatment by chemical

stabilization/solidification prior to landfilling. For this alternative, it is estimated that 20,700 cubic yards of soil excavated from Zone 7 would fall into this category.

Computations of volumes for the above categories are provided in Appendix C.

During off-site transportation of contaminated soil, appropriate spill prevention and control measures would be taken, and DOT regulations would be followed.

4.8.6.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative S-7.6 would be fully protective of human health and the environment under CERCLA under the current I/C exposure scenario and any other foreseeable site use. Excavation and off-site disposal of soil with mass concentrations of PAHs antimony, arsenic, copper, or lead greater than their respective Residential DECs would be protective because it would not only remove unacceptable risk from exposure of current site users to contaminated soil but it would also eliminate the future hypothetical human health risks from direct exposure to contaminated soil under a residential scenario. In addition, removal of soil with mass concentrations of PAHs or SPLP/TCLP concentrations of antimony or lead greater than their respective Zone 7 Alternative GB PMCs for Residential use would also be protective because it would eliminate any potential for migration of these COCs from soil to groundwater. Alternative S-7.6 would achieve all four soil RAOs.

Alternative S-7.6 would also be protective under the Connecticut RSRs by preventing unacceptable human health risk from exposure to TPH contaminated soil and minimizing the source of potential migration of TPH from soil to groundwater.

Compliance with ARARs and TBCs

Alternative S-7.6 would comply with chemical-, location-, and action-specific ARARs and TBCs, as summarized in Tables 4-11, 4-12, and 4-13, respectively.

Long-Term Effectiveness and Permanence

Alternative S-7.6 would be long-term effective and permanent. Excavation and off-site disposal of soil with mass concentrations of PAHs antimony, arsenic, copper, or lead greater than their respective Residential DECs would effectively and permanently remove soil to which current site users and hypothetical future site residents should not be exposed. In addition, excavation and off-site disposal of soil with mass concentrations of PAHs and SPLP/TCLP concentrations of antimony or lead greater than their respective

Zone 7 Alternative GB PMCs for Residential use would effectively and permanently eliminate the potential for migration of these COCs from soil to groundwater.

In addition, Alternative S-7.6 would effectively and permanently address State petroleum concerns by removing soil with concentrations of TPH to which current site users should not be exposed and such that TPH could potentially migrate from soil to groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-7.6 would not address CERCLA risks by reducing the toxicity, mobility, and volume of PAHs antimony, arsenic, copper, and lead in soil through treatment, except through the treatment of water generated from the dewatering process prior to discharge to the Thames River.

Alternative S-7.6 would also not reduce the toxicity, mobility, and volume of TPH in soil through treatment.

Short-Term Effectiveness

Implementation of Alternative S-7.6 could result in significant short-term risks to on-site workers as a result of exposure to contamination during soil excavation. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative S-7.6 could also adversely impact the surrounding community and the environment as a result of the excavation and off-site transportation of contaminated soil. This adverse impact would be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-7.6 could be implemented within approximately 18 months and would achieve the soil RAOs and meet the Zone 7 soil PRGs for residential direct exposure and pollutant mobility as well as the TPH Residential DEC and PMC upon implementation.

Implementability

Alternative S-7.6 would be technically difficult to implement. Excavation could be performed with normal construction equipment by a wide range of contractors. Because this alternative would only be implemented as part of a hypothetical future residential development, excavation would not interfere with ongoing activities at the Lower Subase, and it is assumed that underground structures such as utility lines and existing and former building foundations would have been removed as part of site preparation for development. Because excavation would reach to a depth of approximately 14 feet bgs, extensive shoring would be required. In addition, because a significant portion of the excavation would extend below

the water table, much of the excavated soil would have a high initial water content, and a relatively complex on-site dewatering operation would be required to make this soil amenable to further treatment and/or disposal. Also, post-excavation confirmation sampling would not be possible in the underwater excavated areas and would have to be replaced with pre-excavation sampling to verify the extent of contamination. Off-site borrow locations for clean soil backfill and solid waste landfills or TSDFs for off-site disposal of the excavated soil would be readily available.

The administrative aspects of Alternative S-7.6 would be simple to implement. A construction permit issued by NSB-NLON DPW would have to be obtained for soil excavation. The off-site transportation and disposal of the excavated soil would have to be properly documented, which could be readily accomplished. In addition, the substantive requirements of federal and State water discharge regulations would have to be met to discharge the treated water from the on-site soil dewatering operation to the Thames River.

Cost

The estimated costs for Alternative S-7.6 are:

Capital Cost	$22,979,000
NPW of O&M Costs	$0
NPW	$22,979,000 (1 year)

Within these costs, the estimated incremental capital cost for off-site treatment (chemical stabilization/ solidification and LTTD) of highly contaminated soil would be $12,672,000.

The above figures do not include the cost of demolition of existing structures and removal of underground obstacles that would be required for the implementation of this alternative. Instead, these costs are assumed to have been included as part of the hypothetical future residential development of Zone 7. A detailed cost estimate for this alternative is provided in Appendix E.

4.9 ASSEMBLY AND DETAILED ANALYSIS OF GROUNDWATER REMEDIAL ALTERNATIVES FOR ZONE 1

Even though there is uncertainty regarding Zone 1 groundwater presenting a CERCLA risk, the Navy has opted to develop and evaluate groundwater alternatives following the CERCLA process. Additional data will be collected during a Groundwater PDI that will be used to address the uncertainty regarding the risk and the appropriateness of the CERCLA evaluation process for Zone 1 groundwater. The new data and updated evaluation will be captured in an addendum to this FS.

The following alternatives have been developed for groundwater remediation at Zone 1:

Alternative GW-1.1: No Action.

Alternative GW-1.2: Natural Attenuation, LUCs (Institutional Controls), and Monitoring.

Alternative GW-1.3: In-Situ Treatment (Enhanced Bioremediation and Chemical Precipitation and Oxidation), LUCs (Institutional Controls), and Monitoring.

Alternative GW-1-4: Extraction, Discharge and Disposal to Off-Site POTW, LUCs (Institutional Controls), and Monitoring.

Alternative GW-1.5: Extraction, On-Site Treatment (Filtration, Oxidative Filtration, and Liquid-Phase GAC Adsorption), Discharge to Thames River, LUCs (Institutional Controls), and Monitoring.

Alternative GW-1.1 was developed and analyzed to serve as a baseline for other alternatives, as required by CERCLA and the NCP. Alternative GW-1.2 was developed and analyzed to evaluate LUCs with institutional controls, natural attenuation, and monitoring. Alternatives GW-1.3, GW-1.4, and GW-1.5 were developed and analyzed to evaluate active remediation, with Alternative GW-1.3 representing a relatively innovative in-situ treatment approach and Alternatives GW-1.4 and GW-1.5 representing a more traditional pump-and-treat approach with alternate discharge/disposal options. Descriptions and detailed analyses of these alternatives are provided in the following sections.

4.9.1 Alternative GW-1.1 - No Action

4.9.1.1 Description

No Action would not include any action under CERCLA and any existing administrative or engineering environmental controls would not be an enforceable part of a CERCLA remedy. This alternative is required under CERCLA to establish a basis for comparison with other alternatives. The only activity under this alternative would be the performance of five-year reviews. This alternative cannot be chosen because contamination remains on site.

4.9.1.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative GW-1.1 would not be protective of human health and the environment under CERCLA. Although the aquifer beneath the Lower Subase is classified as GB and unfit for human consumption and there are no unacceptable human health risks from exposure to contaminated groundwater under the current I/C site use, Alternative GW-1.1 would not prevent unacceptable human health risks that could result from uncontrolled groundwater access and use. In addition, in the absence of monitoring, the

progress of the natural attenuation of groundwater COCs and TPH would remain unknown and potential future migration of these COCs and TPH to the nearby Thames River would remain undetected, which could cause additional human health and environmental risks. Alternative GW-1.1 would not achieve the groundwater RAOs.

Compliance with ARARs and TBCs

Alternative GW-1.1 would not comply with chemical-specific ARARs or TBCs because no action would be taken to reduce concentrations of COCs. Chemical-specific ARARs and TBCs might eventually be met through natural attenuation, but this would not be verified through monitoring. There are no location-specific ARARs or TBCs for groundwater, and action-specific ARARs or TBCs are not relevant for this alternative. A summary of Alternative GW-1.1's compliance with chemical-specific ARARs and TBCs is provided in Table 4-20.

Long-Term Effectiveness and Permanence

Alternative GW-1.1 would not effectively and permanently address CERCLA risks because it would not involve any action and it would allow unrestricted groundwater access and use which could result in unacceptable human health risks. In addition, because there would be no monitoring, the progress of the natural attenuation of groundwater COCs and TPH would remain unknown and the potential migration of these COCs and TPH to the nearby Thames River would not be detected.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW-1.1 would not reduce the toxicity, mobility, or volume of groundwater COCs and TPH through treatment because no treatment would occur.

Short-Term Effectiveness

Because no action would occur, implementation of Alternative GW-1.1 would not pose any short-term risks to on-site workers or result in adverse impact to the local community or the environment.

Alternative GW-1.1 would not achieve the groundwater RAOs, and although the groundwater PRGs and TPH cleanup criterion might eventually be met through natural attenuation, this would not be verified through monitoring.

Implementability

Technically, Alternative GW-1.1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Cost

The estimated costs for Alternative GW-1.1 are as follows:

Capital Cost	$0
NPW of O&M Costs	$55,000 (30 years)
NPW	$55,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.9.2 Alternative GW-1.2: Natural Attenuation, LUCs (Institutional Controls), and Monitoring

4.9.2.1 Description

Alternative GW-1.2 would consist of three major components: (1) natural attenuation, (2) LUCs with institutional controls, and (3) monitoring.

Component 1: Natural Attenuation

Natural attenuation would rely on naturally occurring processes within the aquifer to address CERCLA risks by reducing groundwater concentrations of metals COCs. Natural attenuation would also rely on naturally occurring processes to address State petroleum concerns by reducing groundwater concentrations of TPH. Biodegradation, dispersion, and dilution through aquifer movement and adsorption onto soil particles are expected to be the processes primarily responsible for this natural attenuation. Aquifer conditions and quality would be regularly monitored to track the progress of remediation. It is estimated that natural attenuation will achieve the cleanup standards within the compliance boundary of the Zone in 219 years.

Component 2: LUCs with Institutional Controls

LUCs with institutional controls would be developed and implemented to address CERCLA risks and State petroleum concerns. A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish and implement methods and procedures to reinforce the state-issued GB classification of the surficial aquifer by prohibiting its use for human consumption at Zone 1. In addition, regular site

inspections would be performed to verify the continued implementation of LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be integrated within and implemented as part of NSB-NLON SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 3: Monitoring

Monitoring would include performance and migration monitoring. For the purpose of this FS, it was assumed that performance monitoring would consist of regularly collecting groundwater samples from two new or existing wells located within the Zone 1 points of groundwater contamination (see Figure 2-15) and analyzing these samples for arsenic, copper, TPH, and natural attenuation parameters to assess the natural attenuation of these COCs. Performance monitoring would take place over a period of 30 years and sampling frequency would be quarterly for the first two years, semi-annual for the next 2 years, and annual thereafter.

For the purpose of this FS, it was assumed that migration monitoring would consist of regularly collecting groundwater samples from a total of four new or existing wells located downgradient of the leading edges of the Zone 1 points of groundwater contamination and analyzing these samples for arsenic, copper, and TPH to detect potential migration of these COCs to the Thames River. Migration monitoring would take place over a period of 30 years and sampling frequency would be quarterly for the first 2 years, semi-annual for the next 2 years, and annual thereafter.

Reviews would be performed every 5 years to evaluate the status of the site, assess the continued adequacy of remedial activities, determine if LUCs can be lifted, and determine whether further action is necessary. These site reviews are required because this alternative would allow COCs to remain in groundwater at concentrations in excess of their PRGs.

4.9.2.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative GW-1.2 would not be protective of human health and the environment under CERCLA. Natural attenuation would not be protective because it would very slowly reduce concentrations of groundwater COCs in the two Zone 1 points of groundwater contamination until the groundwater PRGs are eventually achieved, at which point these two areas would no longer constitute potential sources of migration of groundwater COCs to the Thames River. LUCs would be protective because they would prevent unacceptable human health risks from exposure to contaminated groundwater as a result of

uncontrolled access and use. Monitoring would be protective because it would assess the progress of natural attenuation and also because it would detect the potential migration of groundwater COCs to the Thames River, which would allow the prevention of unacceptable human health and environmental risks. Alternative GW-1.2 would not achieve the groundwater RAOs.

However, Alternative GW-1.2 would be protective under the Connecticut RSRs by reducing concentrations of TPH in the Zone 1 copper/TPH groundwater point of contamination through natural attenuation, by preventing unacceptable human health risk from exposure to TPH contaminated groundwater, and by warning of the potential migration of TPH to surface water.

Compliance with ARARs and TBCs

Alternative GW-1.2 would not comply in the short term with chemical-specific ARARs and TBCs, and eventual compliance through natural attenuation would require an unacceptably long time. There are no location-specific ARARs and TBCs for this groundwater alternative. Alternative GW-1.2 would comply with action-specific ARARs and TBCs. A summary of Alternative GW-1.2's compliance with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 4-21, 4-22, and 4-23, respectively.

Long-Term Effectiveness and Permanence

Alternative GW-1.2 would address CERCLA risks in a moderately effective and permanent way. As confirmed by the modeling performed for this FS (see Appendix D), natural attenuation is not considered to be effective because of the long timeframe, although natural attenuation would very slowly reduce concentrations of groundwater COCs and eventually achieve the PRGs as verified through monitoring. LUCs would effectively prevent uncontrolled groundwater access and use which could result in unacceptable human health risk. Monitoring would effectively verify achievement of the groundwater PRGs and determine whether or not groundwater COCs are migrating to the Thames River, which might result in unacceptable human health and ecological risks.

However, Alternative GW-1.2 would address State petroleum concerns in an effective and permanent way. Natural attenuation would effectively reduce TPH groundwater concentrations and eventually achieve the State cleanup criterion as verified through monitoring. LUCs would effectively prevent exposure to TPH contaminated groundwater access and monitoring would effectively verify achievement of the groundwater TPH cleanup criterion and determine whether or not TPH is migrating to the Thames River.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW-1.2 would not reduce the toxicity, mobility, and volume of groundwater COCs or TPH through treatment.

Short-Term Effectiveness

Implementation of Alternative GW-1.2 could result in minimal short-term risks to on-site workers as a result of exposure to contamination during monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative GW-1.2 would also not adversely impact the surrounding community or the environment.

Alternative GW-1.2 could be implemented within approximately 3 months and would achieve the groundwater RAOs upon achieving groundwater cleanup standards beyond the compliance boundary for the waste management area within the Zone. Based on the results of natural attenuation modeling performed for this FS (see Appendix D), Alternative GW-1.2 would meet the groundwater PRGs within an estimated 42 years for the co-mingled Zone 1 copper/TPH point of groundwater contamination and within an estimated 219 years for the Zone 1 arsenic/copper points of groundwater contamination (80 years for arsenic and 219 years for copper). Modeling also predicts that Alternative GW-1.2 would meet the groundwater TPH cleanup criterion in the co-mingled Zone 1 copper/TPH point of groundwater contamination within an estimated 27 years. Attainment of the groundwater PRGs and TPH cleanup criterion would be confirmed through monitoring. As noted in Section 3, these remediation time frames are extremely conservative because: (a) only maximum historical concentrations of unfiltered metals were used for this modeling and, in most cases, the corresponding filtered concentrations and/or subsequently detected concentrations were below PRGs and (b) the type of modeling used was relatively simple and has a tendency to overemphasize metal retardation.

Implementability

Alternative GW-1.2 would be easy to implement. A number of groundwater monitoring events have been implemented at the Lower Subase, and additional monitoring would be easy to perform.

The administrative aspects of Alternative GW-1.2 would be simple to implement. A LUC RD would be easy to prepare, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished. No construction permits issued by NSB-NLON DPW would be required for this alternative.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

Cost

The estimated costs for Alternative GW-1.2 are as follows:

Capital Cost	38,000
NPW of O&M Costs	$338,000 (30 years)
NPW	$376,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.9.3 Alternative GW-1.3: In-Situ Treatment (Enhanced Bioremediation and Chemical Precipitation and Oxidation), LUCs (Institutional Controls), and Monitoring

4.9.3.1 Description

Alternative GW-1.3 would consist of three major components: (1) in-situ treatment (2) LUCs with institutional controls, and (3) monitoring.

Component 1: In-Situ Treatment

In-situ treatment would consist of using enhanced bioremediation to address State petroleum concerns in the co-mingled Zone 1 copper/TPH point of groundwater contamination and chemical precipitation and oxidation for to address CERCLA risks in Zone 1 arsenic/copper points of groundwater contamination. Although it is primarily designed for the removal of TPH, enhanced bioremediation of the co-mingled Zone 1 copper/TPH point of groundwater contamination would also address CERCLA risks associated with elevated concentrations of copper. The Zone 1 copper/TPH point of groundwater contamination covers an estimated 7,900 square feet in the vicinity of monitoring well FOMW14 and contains an estimated 176,000 gallons of contaminated groundwater. The Zone 1 arsenic/copper points of

groundwater contamination cover an estimated combined 16,800 square feet in the vicinity of monitoring wells 13MW19, 13MW20, and 13MW21 and contain an estimated combined 376,000 gallons of contaminated groundwater. Computations of areas and volumes of contaminated groundwater and quantities of groundwater COCs and TPH are provided in Appendix C. Sampling and analysis will be performed as part of the PDI to verify the estimated extent of contaminated groundwater.

In-situ bioremediation would consist of using the DO-IT™ process to enhance the growth of indigenous microorganisms and to augment the natural biodegradation of TPH. The oxidation action provided by this process would also precipitate and immobilize soluble copper. As discussed in Section 3.5.4.1, this technology would consist of injecting oxygen and specialized bacterial cultures into the contaminated groundwater by recirculating a super-oxygenated and microorganism- and nutrient-amended stream of groundwater. As required, a copper precipitating agent would also be added.

Based on the information provided by the technology vendor (see Appendix D), it is assumed that four extraction wells and eight reinjection wells would be installed along the downgradient and upgradient edges of the Zone 1 copper/TPH point of groundwater contamination. The extraction wells would be screened within the first few feet of the water table (9 to 12 feet bgs) and each equipped with a 5-gpm submersible pump. The reinjection wells would be screened in the vadose zone (4 to 6 feet bgs). The 20-gpm recirculating groundwater stream would be processed in a SuperOx™ unit capable of delivering approximately 1,900 pounds per month of oxygen plus a variable amount (ranging from 200 to 500 pounds per month) of a proprietary nutrient blend (CBN™) with a 61-percent oxygen-equivalent capacity. In addition, the SuperOx™ unit would add a bacterial culture and, if required, a surfactant to the recirculating groundwater stream. It is estimated that the SuperOx™ unit would provide the oxygen or oxygen-equivalent required to aerobically biodegrade the TPH and precipitate the soluble copper in the Zone 1 copper/TPH point of groundwater contamination within 1 year or less. A typical flow diagram of the DO-IT™ process is illustrated on Figure 4-20, and the proposed locations of the groundwater extraction and reinjection wells are shown on Figure 4-21. Well locations would be optimized during remedial design and to take advantage of changes in site condition such as the demolition of Building 79. Conceptual design calculations for in-situ bioremediation are provided in Appendix D.

In-situ chemical precipitation and oxidation would consist of installing a DPT system covering the combined footprint of the Zone 1 arsenic/copper points of groundwater contamination and to perform two rounds of chemical injection in rapid succession. The first round of chemical injection would supply the ferric iron required for co-precipitation of the arsenic and copper, and the second round would provide the ORC to oxidize arsenic from the trivalent to the pentavalent state to form a stable arsenic ferro-oxide.

For the purpose of this FS, the conceptual design of this component was based on general experience with DPT injection systems for the remediation of areas of contaminated groundwater similar to those in

Zone 1. The DPT injection system would consist of a grid of 92 DPT injection points installed to a depth of 15 feet bgs. For the first round of injection, the DPT points would be used to inject an estimated total of 490 pounds of a 40-percent (by weight) solution of ferric chloride (45 gallons), which corresponds to a total ferric iron addition of 67 pounds, or 10 times the stochiometric demand for arsenic and copper co-precipitation. To promote dispersion, the ferric chloride solution would be diluted 100 to 1 providing approximately 45 gallons of dilute solution to be injected at each DPT point. For the second round of injection, 40 pounds of ORC would be injected in each of the DPT points, for a total injection of 3,700 pounds. The proposed in-situ treatment area for the Zone 1 arsenic/copper points of groundwater contamination is shown on Figure 4-22. Conceptual design calculations are provided in Appendix D.

As discussed in Section 3.5.4, treatability testing would be required to verify the site-specific effectiveness of both the in-situ enhanced bioremediation and in-situ chemical oxidation and precipitation and to evaluate the impact of the relatively high salinity of the Lower Subase aquifer on these processes.

Component 2: LUCs with Institutional Controls

This component would be identical to Component 2 of Alternative GW-1.2.

Component 3: Monitoring

This component would be similar to Component 3 of Alternative GW-1.2, except that monitoring would only be performed for a period of 5 years. Additional monitoring wells can be installed, if needed.

4.9.3.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative GW-1.3 would be protective of human health and the environment under CERCLA. In-situ treatment of the Zone 1 points of groundwater contamination would be protective because it would actively remediate two areas of contaminated groundwater that might act as sources of COC migration to the Thames River. LUCs would be protective because they would prevent unacceptable human health risks from exposure to contaminated groundwater as a result of uncontrolled access and use. Monitoring would be protective because it would assess the progress of in-situ treatment and also because it would detect potential migration of groundwater COCs to the Thames River, which would allow the prevention of possible unacceptable human health and ecological risks. Alternative GW-1.3 would achieve the groundwater RAOs.

Alternative GW-1.3 would also be protective under the Connecticut RSRs because in-situ bioremediation would actively remediate an area of groundwater that might act as a source of TPH migration to the

Thames River. LUCs would be protective because they would prevent unacceptable human health risks from exposure to contaminated groundwater as a result of uncontrolled access and use. Monitoring would be protective because it would assess the progress of in-situ treatment and also because it would detect potential migration of TPH to the Thames River.

Compliance with ARARs and TBCs

Alternative GW-1.3 would comply with chemical-specific ARARs and TBCs through active in-situ treatment. Alternative GW-1.3 would also comply with location- and action-specific ARARs and TBCs. A summary of Alternative GW-1.3's compliance with chemical- and action-specific ARARs and TBCs is provided in Tables 4-24, 4-25, and 4-26, respectively.

Long-Term Effectiveness and Permanence

Alternative GW-1.3 would effectively and permanently address CERCLA risks. In-situ treatment of the Zone 1 points of groundwater contamination would effectively and permanently reduce concentrations of groundwater COCs to their PRGs within these areas of contaminated groundwater. However, the site-specific effectiveness of the proposed in-situ treatment processes would have to be confirmed through treatability testing to assess the impact of the relatively high salinity of the Lower Subase aquifer on the chemical precipitation and oxidation processes. In addition, there would also be a slight possibility that the metals COCs that had been removed from groundwater and immobilized in the surrounding soil could be redissolved and remobilized over the long term as a result of naturally occurring changes in groundwater chemistry. LUCs would effectively prevent uncontrolled groundwater access and use which could result in unacceptable human health risk. Monitoring would effectively verify achievement of the groundwater PRGs and determine whether or not groundwater COCs are migrating to the Thames River, which might result in unacceptable human health and ecological risks.

Alternative GW-1.3 would also effectively and permanently address State petroleum concerns. In-situ enhanced bioremediation of the co-mingled Zone 1 copper/TPH point of groundwater contamination would effectively and permanently reduce groundwater concentrations of TPH to its State cleanup criterion. However, the site-specific effectiveness of bioremediation would have to be confirmed through treatability testing to verify the site-specific biodegradability of weathered TPH and to assess the impact of the relatively high salinity of the Lower Subase aquifer on the aerobic biodegradation process. LUCs would effectively prevent uncontrolled groundwater access and use which could result in unacceptable human health risk. Monitoring would effectively verify achievement of the groundwater TPH cleanup criterion and determine whether or not TPH is migrating to the Thames River.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW-1.3 would reduce the toxicity, mobility, and volume of groundwater COCs through active treatment. An estimated 0.04 pound of arsenic and 0.4 pounds of copper would be removed from groundwater and immobilized through in-situ chemical precipitation and oxidation. However, as noted earlier, there is a slight possibility that this immobilization might not be completely permanent and irreversible. Alternative GW-1.3 would not generate any treatment residue.

Alternative GW-1.3 would also reduce the toxicity, mobility, and volume of TPH in groundwater through in-situ treatment. An estimated 5,300 pounds of TPH would be permanently and irreversibly removed from Zone 1 groundwater through in-situ enhanced bioremediation.

Short-Term Effectiveness

Implementation of Alternative GW-1.3 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during installation and O&M of the in-situ treatment systems and as a result of monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative GW-1.3 would also not adversely impact the surrounding community or the environment.

Alternative GW-1.3 could be implemented within approximately 1 year and would achieve the groundwater RAOs upon implementation. Based on technology vendor information, Alternative GW-1.3 should meet the PRGs in the Zone 1 copper/TPH and arsenic/copper points of groundwater contamination and the TPH cleanup criterion in the Zone 1 copper/TPH point of groundwater contamination within approximately 1 year.

Implementability

Alternative GW-1.3 could be implemented. In-situ chemical precipitation and oxidation services as proposed for the Zone 1 arsenic/copper points of groundwater contamination are available from a number of qualified contractors; however, the DO-IT™ in-situ enhanced bioremediation process proposed for the Zone 1 copper/TPH point of groundwater contamination is only available from ETEC, LLC. Installation of the relatively limited number (12) of groundwater extraction and reinjection wells required for this process should not significantly interfere with the normal use of the area of Zone 1 where they would be installed. However, installation and operation of the much greater number of DPT injection points (92) required for in-situ chemical precipitation and oxidation would temporarily but significantly impact normal site activities, and existing structures and underground obstacles (particularly Building 29) would likely prevent the optimum positioning of several injection points. As previously mentioned, treatability testing would have to be performed to verify site-specific effectiveness and to confirm the design parameters for the in-situ

treatment processes. A number of groundwater monitoring events have been implemented at the Lower Subase, and additional monitoring would be easy to perform.

The administrative aspects of Alternative GW-1.3 would be simple to implement. A LUC RD would be easy to prepare, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished. A construction permit issued by NSB-NLON DPW would also be required for this alternative.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

Cost

The estimated costs for Alternative GW-1.3 are as follows:

Capital Cost	$482,000
NPW of O&M Costs	$619,000 (5 years)
NPW	$1,101,000 (5 years)

Detailed cost estimates for this alternative are provided in Appendix E.

4.9.4 Alternative GW-1.4: Extraction, Discharge and Disposal to Off-Site POTW, LUCs (Institutional Controls), and Monitoring

Alternative GW-1.4 would consist of four major components: (1) groundwater extraction, (2) discharge and disposal of untreated groundwater to the Town of Groton POTW, (3) LUCs with institutional controls, and (4) monitoring.

4.9.4.1 Detailed Description

Component 1: Groundwater Extraction

This component would consist of installing two Groundwater Extraction Systems to address CERCLA risks, one for the Zone 1 copper/TPH point of groundwater contamination and one for the Zone 1 arsenic/copper points of groundwater contamination. The Groundwater Extraction System for the Zone 1 copper/TPH point of groundwater contamination would also address State petroleum concerns. The Groundwater Extraction System for the Zone 1 copper/TPH point of groundwater contamination would be operated for an estimated 11 years after which TPH which is not effectively removed through groundwater extraction would require an additional 16 years to naturally attenuate. The Groundwater Extraction System for the Zone 1 arsenic/copper point of groundwater contamination would be operated for an estimated 26 years. Computations of areas and volumes of contaminated groundwater and quantities of groundwater COCs and TPH are provided in Appendix C. Sampling and analysis will be performed as part of the PDI to verify the estimated extent of contaminated groundwater. Conceptual design calculations for the Groundwater Extraction Systems are provided in Appendix D.

Based on the results of these calculations, the Groundwater Extraction System for the Zone 1 copper/TPH point of groundwater contamination would consist of a single centrally located 6-inch extraction well (EW-1.1) installed to a depth of 30 feet and screened from 5 to 30 feet bgs. The Groundwater Extraction System for the Zone 1 arsenic/copper points of groundwater contamination would consist of two 6-inch extraction wells (EW-1.2, EW-1.3) installed to a depth of 30 feet and screened from 5 to 30 feet bgs. The extraction well for the Zone 1 copper/TPH point of groundwater contamination would pump 16 gpm and each of the extraction wells for the Zone 1 arsenic/copper points of groundwater contamination would pump 20 gpm for a total extraction rate of 40 gpm. Proposed locations of the Zone 1 groundwater extraction wells are shown on Figure 4-23.

Centrifugal submersible extraction pumps (P-1.1 to P-1.3) equipped with level controls would be installed in each groundwater extraction well. Each of these pumps would be connected to a transfer pipeline that would convey the extracted groundwater to the nearest sanitary sewer manhole.

Component 2: Discharge and Disposal of Untreated Groundwater to Town of Groton POTW

The contaminated groundwater extracted from Zone 1 would be discharged to the Lower Subase sanitary sewer system and conveyed by this system to the Town of Groton POTW. At the POTW, TPH and metals in the contaminated groundwater would be removed through typical sanitary sewage treatment unit processes including primary gravity separation and secondary biological treatment. Ultimately, the treated groundwater would be discharged to the Thames River along with the Town of Groton treated sewage.

Component 3: LUCs with Institutional Controls

This component would be identical to Component 2 of Alternative GW-1.2.

Component 4: Monitoring

This component would be identical to Component 3 of Alternative GW-1.2.

4.9.4.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative GW-1.4 would be protective of human health and the environment under CERCLA. Extraction from the Zone 1 points of groundwater contamination and discharge and disposal of the extracted groundwater to the Town of Groton POTW would be protective by capturing and treating two areas of contaminated groundwater that might act as sources of arsenic and copper migration to the Thames River. LUCs would be protective because they would prevent unacceptable human health risks from exposure to contaminated groundwater as a result of uncontrolled access and use. Monitoring would be protective because it would assess the progress of active remediation and also because it would detect the potential migration of groundwater COCs to the Thames River, which would allow the prevention of unacceptable human health and ecological risks. Alternative GW-1.4 would achieve the groundwater RAOs.

Alternative GW-1.4 would also be protective under the Connecticut RSRs. Although TPH groundwater concentrations would not be effectively reduced by groundwater extraction, they would still decrease rapidly enough as a result of natural attenuation for this alternative to be considered protective. LUCs would be protective because they would prevent unacceptable human health risks from exposure to contaminated groundwater as a result of uncontrolled access and use. Monitoring would be protective because it would assess the progress of active remediation and also because it would detect the potential migration of TPH to the Thames River.

Compliance with ARARs and TBCs

Alternative GW-1.4 would comply with chemical-specific ARARs and TBCs through active removal. Alternative GW-1.4 would comply with location- and action-specific ARARs and TBCs. A summary of Alternative GW-1.4's compliance with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 4-27, 4-28, and 4-29, respectively.

Long-Term Effectiveness and Permanence

Alternative GW-1.4 would effectively and permanently address CERCLA risks. Based on the result of the modeling performed for this FS (see Appendix D), extraction from the Zone 1 points of groundwater contamination and discharge and disposal of the extracted groundwater to the Town of Groton POTW would effectively and permanently reduce concentrations of arsenic and copper within these points. Although groundwater extraction is a well-proven technology, its effectiveness is also known to have some limitations as discussed in Section 3.5.3.1. As a result, the capture of groundwater COCs might not be as rapid and complete as predicted. LUCs would effectively prevent uncontrolled groundwater access and use which could result in unacceptable human health risk. Monitoring would effectively verify achievement of the groundwater PRGs and determine whether or not groundwater COCs are migrating to the Thames River, which might result in unacceptable human health and ecological risks.

Alternative GW-1.4 would also effectively and permanently address State petroleum concerns. Although modeling indicates that groundwater extraction would not be particularly effective for the capture of TPH because of the retardation effect resulting from adsorption of that COC onto soil particles, significant reduction in TPH concentration would still be achieved by this alternative. LUCs would effectively prevent uncontrolled groundwater access and use which could result in unacceptable human health risk. Monitoring would effectively verify achievement of the groundwater TPH cleanup criterion and determine whether or not TPH is migrating to the Thames River.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW-1.4 would not reduce the toxicity, mobility, and volume of groundwater COCs or TPH through treatment.

Short-Term Effectiveness

Implementation of Alternative GW-1.4 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during construction and O&M of the two Groundwater Extraction Systems and as a result of monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative GW-1.4 could also result in minimal short-term risk to the surrounding community and the environment as a result of discharge of the groundwater extracted from the Zone 1 points of groundwater contamination to the Lower Subase sanitary sewer system and of the discharge of that groundwater to the Town of Groton POTW. However, these risks would be adequately mitigated by adherence to established sewage handling and treatment procedures.

Alternative GW-1.4 could be implemented within approximately 1 year and would achieve the groundwater RAOs upon implementation. Based on the results of groundwater extraction modeling performed for this FS (see Appendix D), Alternative GW-1.4 would meet the groundwater PRGs within an estimated 11 years for the Zone 1 copper/TPH point of groundwater contamination and within an estimated 26 years for the Zone 1 arsenic/copper points of groundwater contamination (9 years for arsenic and 26 years for copper). Alternative GW-1.4 would also meet the groundwater TPH cleanup criterion within an estimated 27 years for the Zone 1 copper/TPH point of groundwater contamination. As discussed earlier, these remediation time frames are very conservative because of the nature of the input data and type of model used.

Implementability

Alternative GW-1.4 would be relatively easy to implement. Resources, equipment, and materials are readily available for the construction of the two Groundwater Extraction Systems, but this would still require careful planning and coordination. Construction activities might also interfere, at least temporarily, with the normal use of the areas of Zone 1 where these activities would take place. O&M of the two Groundwater Extraction Systems would require the long-term use of skilled personnel. A number of groundwater monitoring events have been implemented at the Lower Subase, and additional monitoring would be easy to perform.

The administrative requirements of Alternative GW-1.4 would be somewhat difficult. A base construction permit would be required for installation of the two Groundwater Extraction Systems. The discharge and disposal of the untreated extracted groundwater to the Town of Groton POTW would also have to be negotiated. A LUC RD would be easy to prepare, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

Cost

The estimated costs for Alternative GW-1.4 are as follows:

Capital Cost	$329,000
NPW of O&M Costs	$3,561,000 (30 years)
NPW	$3,890,000 (30 years)

Detailed cost estimates for this alternative are provided in Appendix E.

4.9.5 Alternative GW-1.5: Extraction, On-Site Treatment (Filtration, Oxidative Filtration, Liquid-Phase GAC Adsorption), Discharge to Thames River, LUCs (Institutional Controls), and Monitoring

Alternative GW-1.5 would consist of five major components: (1) groundwater extraction (2) on-site treatment of extracted groundwater, (3) discharge of treated groundwater to the Thames River, (4) LUCs with institutional controls, and (5) monitoring.

4.9.5.1 Detailed Description

Component 1: Groundwater Extraction

This component would be identical to Component 1 of Alternative GW-1.4.

Component 2: On-Site Treatment of Extracted Groundwater

This component would consist of installing two On-Site Treatment Systems to address CERCLA risks, one for the Zone 1 copper/TPH point of groundwater contamination and the other for the Zone 1 arsenic/copper points of groundwater contamination. The On-Site Treatment System for the Zone 1 copper/TPH point of groundwater contamination would also address State petroleum concerns. As for the corresponding Groundwater Extraction Systems, it is estimated that the On-Site Treatment System for the Zone 1 copper/TPH point of groundwater contamination would be operated for 11 years, after which TPH which is not effectively removed through groundwater extraction would require an additional 16 years to naturally attenuate. The On-Site Treatment System for the Zone 1 arsenic/copper point of groundwater contamination would be operated for 26 years. PFDs of these two On-Site Treatment Systems are provided on Figures 4-24 and 4-25. Computations of areas and volumes of contaminated groundwater and quantities of groundwater COCs and TPH are provided in Appendix C. Sampling and analysis will be performed as part of the PDI to verify the estimated extent of contaminated groundwater. Conceptual design calculations for the On-Site Treatment Systems are provided in Appendix D.

The On-Site Treatment System for the Zone 1 copper/TPH point of groundwater contamination would consist of the following process units in order of flow through:

- A Bag Filter (BF-1.1) to remove insoluble TPH and other naturally occurring suspended material
- A liquid-phase GAC Adsorption Unit (GAC-1.1) to remove soluble TPH
- An Oxidative Filter System (OFS-1.1) to remove soluble copper

The design flow of the On-Site Treatment System for the Zone 1 copper/TPH point of groundwater contamination would be 16 gpm and the system would be housed in a 1,000-square-foot pre-engineered and pre-fabricated shelter located as close to the point as practical. Alternately, because the Zone 1 points of groundwater contamination are relatively close to each other, the On-Site Treatment Systems for both groups of points could be housed instead in a single centrally located 1,500-square-foot shelter. However, this option would probably require significantly more groundwater transfer piping.

The purpose of the Bag Filter would be to remove insoluble TPH (oil) and other suspended solids that might otherwise interfere with the efficient operation of the downstream Oxidative Filter and liquid-phase GAC Adsorption Unit. The Bag Filter would be a multi-element unit designed for a filter element replacement frequency of once a week. Total filter area would be approximately 53 square feet.

The filtered groundwater would flow, still under pressure, to a liquid-phase GAC Adsorption Unit consisting of a vertical cylindrical pressurized vessel where the groundwater would percolate through granular GAC that would adsorb and remove soluble TPH from the groundwater. The GAC might also adsorb some soluble copper. The GAC Adsorption Unit vessel would be approximately 4 feet in diameter and 8.5 feet high and would hold approximately 1,500 pounds of liquid-phase GAC. As the removal of TPH and other adsorbable chemicals proceeds, the active sites of the GAC medium would gradually fill and it eventually would have to be replaced. Based on available analytical data, it is anticipated that the replacement frequency of the Zone 1 copper/TPH point of groundwater contamination GAC Adsorption Unit would be approximately once every month.

The effluent from the GAC Adsorption Unit would flow, still under pressure, to the Oxidative Filter System. Inside that system, groundwater would percolate through a bed of a special granular reactive filter medium [such as Siemens/US Filter's Granulated Ferric Hydroxide (GFH®) or equivalent] that would oxidize copper, bring it out of solution, and trap it within its pores. The Oxidative Filter System would consist of twin pressurized 20-inch-diameter units operating in parallel. Each unit would hold approximately 5.5 cubic feet of reactive medium and would be equipped with an electrically or pneumatically operated multi-port valve system and time clock controller for automatic operation. As copper removal proceeds,

precipitated material would gradually accumulate within the reactive medium of the Oxidative Filter System until this accumulation could result in loss of treatment effectiveness and an excessive operating pressure drop through the units. To prevent this, the Oxidative Filter System units would be regularly taken out of service and backwashed with a countercurrent of water to flush out accumulated solids from the reactive medium. Backwash frequency would be initially set based on design assumptions and then adjusted as necessary based on operating experience. Backwash operations would be automatically regulated by the time clock controller. For this FS, it is estimated that the Oxidative Filter System would require backwashing once a month and that backwashing of each unit would require 16 gpm of water for approximately 15 minutes. It is assumed that the wastewater from backwashing operations (approximately 480 gallons per month) would be collected into a tanker truck and disposed off site. It is also anticipated that the reactive medium would have to be replaced once every 5 years.

The treated groundwater effluent would then be conveyed under residual pressure to the nearest inlet of the Lower Subase storm sewer system.

The On-Site Treatment System for the Zone 1 arsenic/copper points of groundwater contamination would consist of the following process units in order of flow through:

- A Bag Filter (BF-1.2) to remove naturally occurring suspended material
- An Oxidative Filter System (OFS-1.2) to remove soluble arsenic and copper

The design flow of the On-Site Treatment System for the Zone 1 arsenic/copper points of groundwater contamination would be 40 gpm, and the system would be housed in a 500-square-foot, pre-engineered, and pre-fabricated shelter located as close to the points as practical. As previously mentioned, both Zone 1 On-Site Treatment Systems could also be housed in a single 1,500-square-foot shelter.

The purpose of the Bag Filter would be to remove naturally occurring suspended solids that might otherwise interfere with the efficient operation of the downstream Oxidative Filter. The Bag Filter would be similar to that for the Zone 1 copper/TPH point of groundwater contamination On-Site Treatment System, except that total filter area would be approximately 75 square feet. Estimated frequency of filter element replacement would also be once per week.

The effluent from the Bag Filter would flow under pressure to the Oxidative Filter System. Inside that system, groundwater would percolate through a bed of a special granular reactive filter medium that would oxidize arsenic and copper, bring these metals COCs out of solution, and trap them within its pores. The Oxidative Filter System would be similar to that for the Zone 1 copper/TPH point of groundwater contamination On-Site Treatment System, except that the twin units would be 30 inches in diameter and would each hold 15 cubic feet of reactive medium. Backwash frequency would also be once per month,

and backwashing would require 40 gpm of water for approximately 15 minutes for each unit and generate 1,200 gallons per month of waste water which would be collected in a tanker truck for off-site disposal. It is also anticipated that the reactive medium would have to be replaced once every 5 years.

The treated groundwater effluent would then be conveyed under residual pressure to the nearest inlet of the Lower Subase storm sewer system.

As discussed in Section 3.5.5, treatability testing would be required to verify the site-specific effectiveness of both oxidative filtration and liquid-phase GAC adsorption and to evaluate the impact of the relatively high salinity of the Lower Subase aquifer on these processes.

Performance of the On-Site Treatment Systems would be monitored by collecting weekly water samples from the inlet and outlet of each treatment system and analyzing these samples for metals COCs and general water-quality parameters including suspended solids and pH. Samples from the Zone 1 copper/TPH point of groundwater contamination On-Site Treatment System would also be analyzed for TPH.

Component 3: Discharge of Treated Groundwater to Thames River

The Lower Subase storm sewer system would convey the treated groundwater from each On-Site Treatment System to the Thames River.

Component 4: LUCs with Institutional Controls

This component would be identical to Component 2 of Alternative GW-1.2.

Component 5: Monitoring

This component would be identical to Component 3 of Alternative GW-1.2.

4.9.5.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative GW-1.5 would be protective of human health and the environment under CERCLA. Extraction of groundwater from the Zone 1 points of groundwater contamination and on-site treatment and direct discharge of the extracted groundwater would be protective by capturing and treating these two areas of contaminated groundwater that might act as sources of arsenic and copper migration to the Thames River. LUCs would be protective because they would prevent unacceptable human health risks from

exposure to contaminated groundwater as a result of uncontrolled access and use. Monitoring would be protective because it would assess the progress of active remediation and also because it would detect the potential migration of groundwater COCs to the Thames River, which would allow the prevention of unacceptable human health and ecological risks. Alternative GW-1.5 would achieve the groundwater RAOs.

Alternative GW-1.5 would also be protective under the Connecticut RSRs. Although TPH groundwater concentrations would not be effectively reduced by groundwater extraction, they would still decrease rapidly enough as a result of natural attenuation for this alternative to be considered protective. LUCs would be protective because they would prevent unacceptable human health risks from exposure to contaminated groundwater as a result of uncontrolled access and use. Monitoring would be protective because it would assess the progress of active remediation and also because it would detect the potential migration of TPH to the Thames River.

Compliance with ARARs and TBCs

Alternative GW-1.5 would comply with chemical-specific ARARs and TBCs through active removal. Alternative GW-1.5 would comply with location- and action-specific ARARs and TBCs. A summary of Alternative GW-1.5's compliance with chemical-, location, and action-specific ARARs and TBCs is provided in Tables 4-30, 4-31, and 4-32, respectively.

Long-Term Effectiveness and Permanence

Alternative GW-1.5 would effectively and permanently address CERCLA risks. Based on the result of the modeling performed for this FS (see Appendix D), extraction from the Zone 1 points of groundwater contamination with on-site treatment and direct discharge of the extracted groundwater would effectively and permanently reduce concentrations of arsenic and copper within these points. Although groundwater extraction is a well-proven technology, its effectiveness is also known to have some limitations as discussed in Section 3.5.3.1. As a result, the capture of groundwater COCs might not be as rapid and complete as predicted. In addition, the site-specific effectiveness of the proposed oxidative filtration would have to be confirmed through treatability testing, particularly to assess the impact of the relatively high salinity of the Lower Subase aquifer on this process. LUCs would effectively prevent uncontrolled groundwater access and use which could result in unacceptable human health risk. Monitoring would effectively verify achievement of the groundwater PRGs and determine whether or not groundwater COCs are migrating to the Thames River, which might result in unacceptable human health and ecological risks.

Alternative GW-1.5 would also effectively and permanently address State petroleum concerns. Although modeling indicates that groundwater extraction would not be particularly effective for the capture of TPH

because of the retardation effect resulting from adsorption of that COC onto soil particles, significant reduction in TPH concentration would still be achieved by this alternative. The site-specific effectiveness of the proposed liquid-phase GAC adsorption would have to be confirmed through treatability testing, particularly to assess the impact of the relatively high salinity of the Lower Subase aquifer on this process. LUCs would effectively prevent uncontrolled groundwater access and use which could result in unacceptable human health risk. Monitoring would effectively verify achievement of the groundwater TPH cleanup criterion and determine whether or not TPH is migrating to the Thames River.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW-1.5 would reduce the toxicity, mobility, and volume of groundwater COCs through treatment. An estimated 0.04 pound of arsenic and 0.4 pound of copper would eventually be removed from Zone 1 groundwater and treated on site, and this removal would be permanent and irreversible.

Short-Term Effectiveness

Implementation of Alternative GW-1.5 could result in significant short-term risks to on-site workers as a result of exposure to contamination during construction and O&M of the two Groundwater Extraction Systems and the two On-Site Treatment Systems and as a result of long-term monitoring activities. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative GW-1.5 could also result in minimal short-term risk to the surrounding community and the environment as a result of off-site transportation and disposal of treatment residuals. However, these risks would be adequately mitigated by adherence to spill prevention procedures and compliance with DOT regulations.

Alternative GW-1.5 could be implemented within approximately 18 months and would achieve the groundwater RAOs upon implementation. Based on the results of groundwater extraction modeling performed for this FS (see Appendix D), Alternative GW-1.5 would meet the groundwater PRGs within an estimated 11 years for the Zone 1 copper/TPH point of groundwater contamination and within an estimated 26 years for the Zone 1 arsenic/copper points of groundwater contamination (9 years for arsenic and 26 years for copper). Alternative GW-1.5 would also meet the groundwater TPH cleanup criterion within an estimated 27 years for the Zone 1 copper/TPH point of groundwater contamination. As discussed earlier, these remediation time frames are very conservative because of the nature of the input data and type of model used.

Implementability

Alternative GW-1.5 would be fairly complex to implement. Resources, equipment, and materials are readily available for the construction of the two Groundwater Extraction Systems and two On-Site

Treatment Systems, but this would still require careful planning and coordination of multiple activities over a significant period of time. Construction activities might also interfere, at least temporarily, with the normal use of the areas of Zone 1 where these activities would take place. O&M of the two Groundwater Extraction Systems and two On-Site Treatment Systems would require the long-term use of skilled personnel. A number of groundwater monitoring events have been implemented at the Lower Subase, and additional monitoring would be easy to perform. As previously mentioned, treatability testing would be required to verify the site-specific effectiveness and design parameters of the proposed treatment processes.

The administrative requirements of Alternative GW-1.5 would be somewhat difficult. Base construction permits would be required for installation of the two Groundwater Extraction Systems and construction of the two On-Site Treatment Systems. The substantive requirements of federal and State water discharge regulations would have to be met for discharge of treated groundwater to the Thames River. A LUC RD would be easy to prepare, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

Cost

The estimated costs for Alternative GW-1.5 are as follows:

Capital Cost	$942,000
NPW of O&M Costs	$2,011,000 (30 years)
NPW	$2,953,000 (30 years)

Detailed cost estimates for this alternative are provided in Appendix E.

4.10 ASSEMBLY AND DETAILED ANALYSIS OF GROUNDWATER REMEDIAL ALTERNATIVES FOR ZONE 4

Even though there is uncertainty regarding Zone 4 groundwater presenting a CERCLA risk, the Navy has opted to develop and evaluate groundwater alternatives following the CERCLA process. Additional data will be collected during a Groundwater PDI that will be used to address the uncertainty regarding the risk and the appropriateness of the CERCLA evaluation process for Zone 4 groundwater. The new data and updated evaluation will be captured in an addendum to this FS.

The following alternatives have been developed for groundwater remediation at Zone 4:

Alternative GW-4.1: No Action.

Alternative GW-4.2: Natural Attenuation, LUCs (Institutional Controls), and Monitoring.

Alternative GW-4.3: In-Situ Treatment (Enhanced Bioremediation and Chemical Precipitation and Oxidation), LUCs (Institutional Controls), and Monitoring.

Alternative GW-4-4: Extraction, Discharge and Disposal to Off-Site POTW, LUCs (Institutional Controls), and Monitoring.

Alternative GW-4.5: Extraction, On-Site Treatment (Filtration, Oxidative Filtration, Chemical Precipitation, and Liquid-Phase GAC Adsorption), Discharge to Thames River, LUCs (Institutional Controls), and Monitoring.

Alternative GW-4.1 was developed and analyzed to serve as a baseline for other alternatives, as required by CERCLA and the NCP. Alternative GW-4.2 was developed and analyzed to evaluate LUCs with institutional controls, natural attenuation, and monitoring. Alternatives GW-4.3, GW-4.4, and GW-4.5 were developed and analyzed to evaluate active remediation, with Alternative GW-4.3 representing a relatively innovative in-situ treatment approach and Alternatives GW-4.4 and GW-4.5 representing a more traditional pump-and-treat approach with alternate discharge/disposal options. Descriptions and detailed analyses of these alternatives are provided in the following sections.

4.10.1 Alternative GW-4.1 - No Action

4.10.1.1 Description

No Action would not include any action under CERCLA and any existing administrative or engineering environmental controls would not be an enforceable part of a CERCLA remedy. This alternative is required under CERCLA to establish a basis for comparison with other alternatives. The only activity under this alternative would be the performance of five-year reviews. This alternative cannot be chosen because contamination remains on site.

4.10.1.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative GW-4.1 would not be protective of human health and the environment under CERCLA. Although the aquifer beneath the Lower Subase is classified as GB and unfit for human consumption and there are no unacceptable human health risks from exposure to contaminated groundwater under the current I/C site use, Alternative GW-4.1 would not prevent unacceptable human health risks that could result from uncontrolled groundwater access and use. In addition, in the absence of monitoring, the progress of the natural attenuation of groundwater COCs and TPH would remain unknown and potential future migration of these COCs and TPH to the nearby Thames River would remain undetected, which could cause additional human health and environmental risks. Alternative GW-4.1 would not achieve the groundwater RAOs.

Compliance with ARARs and TBCs

Alternative GW-4.1 would not comply with chemical-specific ARARs or TBCs because no action would be taken to reduce concentrations of COCs. Chemical-specific ARARs and TBCs might eventually be met through natural attenuation, but this would not be verified through monitoring. There are no location-specific ARARs or TBCs for groundwater, and action-specific ARARs or TBCs are not relevant for this alternative. A summary of Alternative GW-4.1's compliance with chemical-specific ARARs and TBCs is provided in Table 4-20.

Long-Term Effectiveness and Permanence

Alternative GW-4.1 would not effectively and permanently address CERCLA risks because it would not involve any action and it would allow uncontrolled groundwater access and use which could result in unacceptable human health risks. In addition, because there would be no monitoring, the progress of the natural attenuation of groundwater COCs and TPH would remain unknown, and the potential migration of these COCs and TPH to the nearby Thames River would not be detected.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW-4.1 would not reduce the toxicity, mobility, or volume of groundwater COCs and TPH through treatment because no treatment would occur.

Short-Term Effectiveness

Because no action would occur, implementation of Alternative GW-4.1 would not pose any short-term risks to on-site workers or result in adverse impact to the local community or the environment.

Alternative GW-4.1 would not achieve the groundwater RAOs, and although the groundwater PRGs and TPH cleanup criterion might eventually be met through natural attenuation, this would not be verified through monitoring.

Implementability

Technically, Alternative GW-4.1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Cost

The estimated costs for Alternative GW-4.1 are as follows:

Capital Cost	$0
NPW of O&M Costs	$55,000 (30 years)
NPW	$55,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.10.2 Alternative GW-4.2: Natural Attenuation, LUCs (Institutional Controls), and Monitoring

4.10.2.1 Description

Alternative GW-4.2 would consist of three major components: (1) natural attenuation, (2) LUCs with institutional controls, and (3) monitoring.

Component 1: Natural Attenuation

Natural attenuation would rely on naturally occurring processes within the aquifer to address CERCLA risks by reducing groundwater concentrations of metals COCs. Natural attenuation would also rely on naturally occurring processes to address State petroleum concerns by reducing groundwater concentrations of TPH. Biodegradation, dispersion, and dilution through aquifer movement and adsorption on soil particles are expected to be the processes primarily responsible for this natural attenuation. Aquifer conditions and quality would be continually monitored to track the progress of

remediation. It should be noted that the natural attenuation processes of this component are different from those discussed in the well-publicized OSWER Directive 9200.4-17P which discusses monitored natural attenuation of chlorinated volatile organic compounds through reductive dechlorination.

Component 2: LUCs with Institutional Controls

LUCs with institutional controls would be developed and implemented to address CERCLA risks and State petroleum concerns. A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish and implement methods and procedures to reinforce the state-issued GB classification of the surficial aquifer by prohibiting its use for human consumption at Zone 4. In addition, regular site inspections would be performed to verify the continued implementation of LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be integrated within and implemented as part of NSB-NLON SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 3: Monitoring

Monitoring would include performance and migration monitoring. For the purpose of this FS, it was assumed that performance monitoring would consist of regularly collecting groundwater samples from two new or existing wells located within the Zone 4 points of groundwater contamination (see Figure 2-16) and analyzing these samples for arsenic, lead, TPH, and natural attenuation parameters to assess the natural attenuation of these COCs. Performance monitoring would take place over a period of 30 years and sampling frequency would be quarterly for the first 2 years, semi-annual for the next 2 years, and annual thereafter.

For the purpose of this FS, it was assumed that migration monitoring would consist of regularly collecting groundwater samples from a total of four new or existing wells located downgradient of the leading edges of the Zone 4 points of groundwater contamination and analyzing these samples for arsenic, lead, and TPH to detect potential migration of these COCs to the Thames River. Migration monitoring would take place over a period of 30 years and sampling frequency would be quarterly for the first two years, semi-annual for the next 2 years, and annual thereafter.

Reviews would be performed every 5 years to evaluate the status of the site, assess the continued adequacy of remedial activities, determine if LUCs can be lifted, and determine whether further action is necessary. These site reviews are required because this alternative would allow COCs to remain in groundwater at concentrations in excess of their PRGs.

4.10.2.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative GW-4.2 would not be protective of human health and the environment under CERCLA. Natural attenuation would not be protective because it would very slowly reduce concentrations of groundwater COCs in the two Zone 4 points of groundwater contamination until the groundwater PRGs are eventually achieved, at which point these two areas would no longer constitute potential sources of migration of groundwater COCs to the Thames River. LUCs would be protective because they would prevent unacceptable human health risks from exposure to contaminated groundwater as a result of inappropriate use. Monitoring would be protective because it would assess the progress of natural attenuation and also because it would detect the potential migration of groundwater COCs to the Thames River, which would allow the prevention of unacceptable human health and environmental risks. Alternative GW-4.2 would not achieve the groundwater RAOs.

However, Alternative GW-4.2 would be protective under the Connecticut RSRs by reducing concentrations of TPH in the Zone 4 copper/TPH groundwater point of contamination through natural attenuation, by preventing unacceptable human health risk from exposure to TPH contaminated groundwater, and by warning of the potential migration of TPH to surface water.

Compliance with ARARs and TBCs

Alternative GW-4.2 would not comply in the short term with chemical-specific ARARs and TBCs, and eventual compliance through natural attenuation would require an unacceptably long time. There are no location-specific ARARs and TBCs for this groundwater alternative. Alternative GW-4.2 would comply with action-specific ARARs and TBCs. A summary of Alternative GW-4.2's compliance with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 4-21, 4-22, and 4-23, respectively.

Long-Term Effectiveness and Permanence

Alternative GW-4.2 would address CERCLA risks in a moderately effective and permanent way. As shown by the modeling performed for this FS (see Appendix D), natural attenuation is not considered to be effective because of the long timeframe, although natural attenuation would very slowly reduce concentrations of groundwater COCs and eventually achieve the PRGs, as verified through monitoring. LUCs would effectively prevent uncontrolled groundwater access and use which could result in unacceptable human health risk. Monitoring would effectively verify achievement of the groundwater PRGs and determine whether or not groundwater COCs are migrating to the Thames River, which might result in unacceptable human health and ecological risks.

However, Alternative GW-4.2 would address State petroleum concerns in an effective and permanent way. Natural attenuation would effectively reduce TPH groundwater concentrations and eventually achieve the State cleanup criterion as verified through monitoring. LUCs would effectively prevent exposure to TPH contaminated groundwater access and monitoring would effectively verify achievement of the groundwater TPH cleanup criterion and determine whether or not TPH is migrating to the Thames River.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW-4.2 would not reduce the toxicity, mobility, and volume of groundwater COCs or TPH through treatment.

Short-Term Effectiveness

Implementation of Alternative GW-4.2 could result in minimal short-term risks to on-site workers as a result of exposure to contamination during monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative GW-4.2 would also not adversely impact the surrounding community or the environment.

Alternative GW-4.2 could be implemented within approximately 3 months and would achieve the groundwater RAOs upon achieving groundwater cleanup standards beyond the compliance boundary for the waste management area within the Zone. Based on the results of natural attenuation modeling performed for this FS (see Appendix D), Alternative GW-4.2 would meet the groundwater PRGs within an estimated 22 years for the co-mingled Zone 4 arsenic/TPH points of groundwater contamination and within an estimated 548 years for the Zone 4 lead point of groundwater contamination. Modeling also predicts that Alternative GW-4.2 would meet the groundwater TPH cleanup criterion in the co-mingled Zone 1 arsenic/TPH points of groundwater contamination within an estimated 11 years. Attainment of the groundwater PRGs and TPH cleanup criterion would be confirmed through monitoring. As noted in Section 3, these remediation time frames are extremely conservative because: (a) only maximum historical concentrations of unfiltered metals were used for this modeling and, in most cases, the corresponding filtered concentrations and/or subsequently detected concentrations were below PRGs and (b) the type of modeling used was relatively simple and has a tendency to overemphasize metal retardation.

Implementability

Alternative GW-4.2 would be easy to implement. A number of groundwater monitoring events have been implemented at the Lower Subase, and additional monitoring would be easy to perform.

The administrative aspects of Alternative GW-4.2 would be simple to implement. A LUC RD would be easy to prepare, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished. No construction permits issued by NSB-NLON DPW would be required for this alternative.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

Cost

The estimated costs for Alternative GW-4.2 are as follows:

Capital Cost	$33,000
NPW of O&M Costs	$338,000 (30 years)
NPW	$371,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.10.3 Alternative GW-4.3: In-Situ Treatment (Enhanced Bioremediation and Chemical Precipitation and Oxidation), LUCs (Institutional Controls), and Monitoring

4.10.3.1 Description

Alternative GW-4.3 would consist of three major components: (1) in-situ treatment (2) LUCs with institutional controls, and (3) monitoring.

Component 1: In-Situ Treatment

In-situ treatment would address CERCLA risks through chemical precipitation and oxidation for the Zone 4 arsenic/TPH points of groundwater contamination and through chemical precipitation for the Zone 4 lead point of groundwater contamination. In-situ treatment would also address State petroleum concerns through enhanced bioremediation for the Zone 4 arsenic/TPH points of groundwater contamination. The Zone 4 arsenic/TPH points of groundwater contamination cover an estimated combined 29,600 square feet in the vicinity of monitoring wells 13MW13, 13MW15, 13MW16, WE-5, and NESO10, and contain an estimated combined 663,000 gallons of contaminated groundwater. The Zone 4 lead point of groundwater contamination covers an estimated 7,900 square feet in the vicinity of monitoring well NESO11 and contains an estimated 176,000 gallons of contaminated groundwater. Computations of areas and volumes of contaminated groundwater and quantities of groundwater COCs and TPH are provided in Appendix C. Sampling and analysis will be performed as part of the PDI to verify the estimated extent of contaminated groundwater.

In-situ bioremediation of the Zone 4 arsenic/TPH points of groundwater contamination would consist of using the DO-IT™ process to enhance the growth of indigenous microorganisms and to augment the natural biodegradation of TPH. The oxidation action provided by this process would also precipitate and immobilize soluble copper. As discussed in Section 3.5.4.1, this technology would consist of injecting oxygen and specialized bacterial cultures into the contaminated groundwater by recirculating a super-oxygenated and microorganism- and nutrient- amended stream of groundwater. As required, a copper precipitating agent would also be added.

Based on the information provided by the technology vendor (see Appendix D), it is assumed that four extraction wells and eight reinjection wells would be installed along the downgradient and upgradient edges of the TPH exceedance area within the Zone 4 arsenic/TPH points of groundwater contamination. The extraction wells would be screened within the first few feet of the water table (4 to 6 feet bgs) and each equipped with a 5-gpm submersible pump. The reinjection wells would be screened in the vadose zone (2 to 3 feet bgs). The 20-gpm recirculating groundwater stream would be processed in a SuperOx™ unit capable of delivering approximately 1,910 pounds per month of oxygen plus a variable amount (ranging from 200 to 500 pounds per month) of a proprietary nutrient blend (CBN™) with a 61-percent oxygen-equivalent capacity. In addition, the SuperOx™ unit would add a bacterial culture and, if required, a surfactant to the recirculating groundwater stream. It is estimated that the SuperOx™ unit would provide the oxygen or oxygen-equivalent required to aerobically biodegrade the TPH in the Zone 4 arsenic/TPH points of groundwater contamination within 9 months. As with Alternative GW-1.3 for the Zone 1 copper/TPH point of groundwater contamination, it is assumed that application of the DO-IT™ process in the area of TPH exceedance would also oxidize and immobilize arsenic in that area. A typical flow diagram of the DO-IT™ process is illustrated on Figure 4-20, and the proposed locations of the

groundwater extraction and reinjection wells are shown on Figure 4-26. Well locations would be optimized during remedial design and to take advantage of changes in site condition such as the demolition of buildings. Conceptual design calculations for in-situ bioremediation are provided in Appendix D.

In-situ chemical oxidation and precipitation of the Zone 4 arsenic/TPH points of groundwater contamination would consist of installing a DPT system to cover the remainder of the footprint of these points and to perform two rounds of chemical injection in rapid succession. The first round of chemical injection would supply the ferric iron required for co-precipitation of arsenic, and the second round would provide the ORC to oxidize arsenic from the trivalent to the pentavalent state to form a stable arsenic ferro-oxide. The DPT injection system would consist of a grid of 119 DPT injection points installed to a depth of 15 feet bgs. For the first round of injection, the DPT points would be used to inject an estimated total of 145 pounds of a 40-percent (by weight) solution of ferric chloride (12.4 gallons), which corresponds to a total ferric iron addition of 20 pounds, or 10 times the stochiometric demand for arsenic and copper co-precipitation. To promote dispersion, the ferric chloride solution would be diluted 100 to 1 providing approximately 10.4 gallons of dilute solution to be injected at each DPT point. For the second round of injection, 40 pounds of ORC would be injected in each of the DPT points for a total injection of 4,760 pounds. The proposed in-situ treatment area for the Zone 4 arsenic/TPH points of groundwater contamination is shown on Figure 4-27. Conceptual design calculations are provided in Appendix D.

In-situ chemical precipitation of the Zone 4 lead point of groundwater contamination would be similar to that of the Zone 4 arsenic/TPH points of groundwater contamination, with the difference that ammonium phosphate precipitation would be used instead of iron co-precipitation with ORC oxidation. A DPT injection system consisting of a grid of 43 injection points would be installed, and an estimated 5.3 gallons of a 1-percent (by weight) solution of ammonium phosphate (total of 19.5 pounds) would be fed into each injection point. The proposed in-situ treatment area for the Zone 4 lead point of groundwater contamination is shown on Figure 4-27. Conceptual design calculations are provided in Appendix D.

As discussed in Section 3.5.4, treatability testing would be required to verify the site-specific effectiveness of both in-situ enhanced bioremediation and in-situ chemical oxidation and precipitation and to evaluate the impact of the relatively high salinity of the Lower Subase aquifer on these processes.

Component 2: LUCs with Institutional Controls

This component would be identical to Component 2 of Alternative GW-4.2.

Component 3: Monitoring

This component would be similar to Component 3 of Alternative GW-4.2, except that monitoring would only take place for a period of 5 years. Additional monitoring wells can be installed, if needed.

4.10.3.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative GW-4.3 would be protective of human health and the environment under CERCLA. In-situ treatment of the Zone 4 points of groundwater contamination would be protective because it would actively remediate two areas of contaminated groundwater that might act as sources of COCs migration to the Thames River. LUCs would be protective because they would prevent unacceptable human health risks from exposure to contaminated groundwater as a result of uncontrolled access and use. Monitoring would be protective because it would assess the progress of in-situ treatment and also because it would detect potential migration of groundwater COCs to the Thames River, which would allow the prevention of possible unacceptable human health and ecological risks. Alternative GW-4.3 would achieve the groundwater RAOs.

Alternative GW-4.3 would also be protective under the Connecticut RSRs because in-situ bioremediation would actively remediate an area of groundwater that might act as a source of TPH migration to the Thames River. LUCs would be protective because they would prevent unacceptable human health risks from exposure to contaminated groundwater as a result of uncontrolled access and use. Monitoring would be protective because it would assess the progress of in-situ treatment and also because it would detect potential migration of TPH to the Thames River.

Compliance with ARARs and TBCs

Alternative GW-4.3 would comply with chemical-specific ARARs and TBCs through active in-situ treatment. Alternative GW-4.3 would also comply with location- and action-specific ARARs and TBCs. A summary of Alternative GW-4.3's compliance with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 4-24, 2-25, and 4-26, respectively.

Long-Term Effectiveness and Permanence

Alternative GW-4.3 would effectively and permanently address CERCLA risks. In-situ treatment of the Zone 4 points of groundwater contamination would effectively and permanently reduce concentrations of groundwater COCs to their PRGs within these areas of contaminated groundwater. However, the site-specific effectiveness of the proposed in-situ treatment processes would have to be confirmed through

treatability testing to assess the impact of the relatively high salinity of the Lower Subase aquifer on the chemical oxidation and precipitation processes. In addition, there would be a slight possibility that the metals COCs (particularly arsenic) that had been removed from groundwater and immobilized in the surrounding soil could be redissolved and remobilized over the long term as a result of naturally occurring changes in groundwater chemistry. LUCs would effectively prevent uncontrolled groundwater access and use which could result in unacceptable human health risk. Monitoring would effectively verify achievement of the groundwater PRGs and determine whether or not groundwater COCs are migrating to the Thames River, which might result in unacceptable human health and ecological risks.

Alternative GW-4.3 would also effectively and permanently address State petroleum concerns. In-situ enhanced bioremediation of the co-mingled Zone 4 arsenic/TPH points of groundwater contamination would effectively and permanently reduce groundwater concentrations of TPH to its State cleanup criterion. However, the site-specific effectiveness of bioremediation would have to be confirmed through treatability testing to verify the site-specific biodegradability of weathered TPH and to assess the impact of the relatively high salinity of the Lower Subase aquifer on the aerobic biodegradation process. LUCs would effectively prevent uncontrolled groundwater access and use which could result in unacceptable human health risk. Monitoring would effectively verify achievement of the groundwater TPH cleanup criterion and determine whether or not TPH is migrating to the Thames River.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW-4.3 would reduce the toxicity, mobility, and volume of groundwater COCs through active treatment. An estimated 0.1 pound of arsenic and 4.06 pounds of lead would be removed from groundwater and immobilized with in-situ chemical oxidation and precipitation. However, as noted earlier, there is a slight possibility that this immobilization might not be completely permanent and irreversible, especially for arsenic.

Alternative GW-4.3 would also reduce the toxicity, mobility, and volume of TPH in groundwater through in-situ treatment. An estimated 1,030 pounds of TPH would be permanently and irreversibly removed from Zone 4 groundwater through in-situ enhanced bioremediation.

Alternative GW-4.3 would not generate any treatment residue.

Short-Term Effectiveness

Implementation of Alternative GW-4.3 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during installation and O&M of the in-situ treatment systems and as a result of monitoring. However, these risks would be adequately mitigated by the wearing of appropriate

PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative GW-4.3 would also not adversely impact the surrounding community or the environment.

Alternative GW-4.3 could be implemented within approximately 1 year and would achieve the groundwater RAOs upon implementation. Based on technology vendor information, Alternative GW-4.3 is expected to meet the PRGs in the Zone 4 arsenic/TPH and lead points of groundwater contamination and the TPH cleanup criterion in the Zone 4 arsenic/TPH points of groundwater contamination within approximately 1 year.

Implementability

Alternative GW-4.3 could be implemented. In-situ chemical oxidation and precipitation services are available from a number of qualified contractors; however, the DO-IT™ in-situ enhanced bioremediation process proposed for the Zone 4 arsenic/TPH points of groundwater contamination is only available from ETEC, LLC. Installation of the relatively limited number (12) of groundwater extraction and reinjection wells required for this process should not significantly interfere with the normal use of the area of Zone 4 where it would be installed. However, installation and operation of the much greater number of DPT injection points (162) required for in-situ chemical precipitation and oxidation would temporarily but significantly impact normal site activities and existing structures and underground obstacles would likely prevent the optimum positioning of a several injection points. As previously mentioned, treatability testing would have to be performed to verify site-specific effectiveness and to confirm the design parameters for the in-situ treatment processes. A number of groundwater monitoring events have been implemented at the Lower Subase, and additional monitoring would be easy to perform.

The administrative aspects of Alternative GW-4.3 would be simple to implement. A LUC RD would be easy to prepare, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished. A construction permit issued by NSB-NLON DPW would also be required for this alternative.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the

ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

Cost

The estimated costs for Alternative GW-4.3 are as follows:

Capital Cost	$548,000
NPW of O&M Costs	$445,000 (5 years)
NPW	$993,000 (5 years)

Detailed cost estimates for this alternative are provided in Appendix E.

4.10.4 Alternative GW-4.4: Extraction, Discharge and Disposal to Off-Site POTW, LUCs (Institutional Controls), and Monitoring

Alternative GW-4.4 would consist of four major components: (1) groundwater extraction, (2) discharge and disposal of untreated groundwater to the Town of Groton POTW, (3) LUCs with institutional controls, and (4) monitoring.

4.10.4.1 Detailed Description

Component 1: Groundwater Extraction

This component would consist of installing two Groundwater Extraction Systems to address CERCLA risks, one for the Zone 4 arsenic/TPH points of groundwater contamination and one for the Zone 4 lead point of groundwater contamination. The Groundwater Extraction System for the Zone 4 arsenic/TPH points of groundwater contamination would also address State petroleum concerns. The Groundwater Extraction System for the Zone 4 arsenic/TPH points of groundwater contamination would be operated for an estimated 11 years and the Groundwater Extraction System for the Zone 4 lead point of groundwater contamination would be operated for an estimated 27 years. Computations of areas and volumes of contaminated groundwater and quantities of groundwater COCs and TPH are provided in Appendix C. Sampling and analysis will be performed as part of the PDI to verify the estimated extent of contaminated groundwater. Conceptual design calculations for the Groundwater Extraction Systems are provided in Appendix D.

Based on the results of these calculations, the Groundwater Extraction System for the Zone 4 arsenic/TPH points of groundwater contamination would consist of three 6-inch extraction wells (EW-4.1 to EW-4.3) installed to a depth of 30 feet and screened from 5 to 30 feet bgs. The Groundwater

Extraction System for the Zone 4 lead point of groundwater contamination would consist of three 6-inch extraction wells (EW-4.4 to EW-4.6) installed to a depth of 30 feet and screened from 5 to 30 feet bgs. Each of the extraction wells for the Zone 4 arsenic/TPH points of groundwater contamination would pump 10 gpm for a total extraction rate of 30 gpm and each of the extraction wells for the Zone 4 lead point of groundwater contamination would pump 40 gpm for a total extraction rate of 120 gpm. Proposed locations of the Zone 4 groundwater extraction wells are shown on Figure 4-28.

Centrifugal submersible extraction pumps (P-4.1 to P-1.6) equipped with level controls would be installed in each groundwater extraction well. Each of these pumps would be connected to a transfer pipeline that would convey the extracted groundwater to the nearest sanitary sewer manhole.

Component 2: Discharge and Disposal of Untreated Groundwater to Town of Groton POTW

The contaminated groundwater extracted from Zone 4 would be discharged to the Lower Subase sanitary sewer system and conveyed by this system to the Town of Groton POTW. At the POTW, the TPH and metals in the contaminated groundwater would be removed through typical sanitary sewage treatment unit processes including primary gravity separation and secondary biological treatment. Ultimately, the treated groundwater would be discharged to the Thames River along with the Town of Groton treated sewage.

Component 3: LUCs with Institutional Controls

This component would be identical to Component 2 of Alternative GW-4.2.

Component 4: Monitoring

This component would be similar to Component 3 of Alternative GW-4.2, except that monitoring would only take place for a period of 15 years for the Zone 4 arsenic/TPH points of groundwater contamination and 30 years for the Zone 4 lead point of groundwater contamination.

4.10.4.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative GW-4.4 would be protective of human health and the environment under CERCLA. Extraction from the Zone 4 points of groundwater contamination and discharge and disposal of the extracted groundwater to the Town of Groton POTW would be protective by capturing and treating two areas of contaminated groundwater that might act as sources of arsenic and lead migration to the Thames River. LUCs would be protective because they would prevent unacceptable human health risks from exposure to contaminated groundwater as a result of uncontrolled access and use. Monitoring would be protective

because it would assess the progress of active remediation and also because it would detect the potential migration of groundwater COCs to the Thames River, which would allow the prevention of unacceptable human health and ecological risks. Alternative GW-4.4 would achieve the groundwater RAOs.

Alternative GW-4.4 would also be protective under the Connecticut RSRs. Although TPH groundwater concentrations would not be effectively reduced by groundwater extraction, they would still decrease rapidly enough as a result of natural attenuation for this alternative to be considered protective. LUCs would be protective because they would prevent unacceptable human health risks from exposure to contaminated groundwater as a result of uncontrolled access and use. Monitoring would be protective because it would assess the progress of active remediation and also because it would detect the potential migration of TPH to the Thames River.

Compliance with ARARs and TBCs

Alternative GW-4.4 would comply with chemical-specific ARARs and TBCs through active removal. Alternative GW-4.4 would comply with location- and action-specific ARARs and TBCs. A summary of Alternative GW-4.4's compliance with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 4-27, 4-28, and 4-29 respectively.

Long-Term Effectiveness and Permanence

Alternative GW-4.4 would effectively and permanently address CERCLA risks. Based on the result of the modeling performed for this FS (see Appendix D), extraction from the Zone 4 points of groundwater contamination and discharge and disposal of the extracted groundwater to the Town of Groton POTW would effectively and permanently reduce concentrations of arsenic and lead within these points. Although groundwater extraction is a well-proven technology, its effectiveness is known to have some limitations, as discussed in Section 3.5.3.1. As a result, the capture of groundwater COCs might not be as rapid and complete as predicted. LUCs would effectively prevent uncontrolled groundwater access and use which could result in unacceptable human health risk. Monitoring would effectively verify achievement of the groundwater PRGs and determine whether or not groundwater COCs are migrating to the Thames River, which might result in unacceptable human health and ecological risks.

Alternative GW-4.4 would also effectively and permanently address State petroleum concerns. Although modeling indicates that groundwater extraction would not be particularly effective for the capture of TPH because of the retardation effect resulting from adsorption of that COC onto soil particles, significant reduction in TPH concentration would still be achieved by this alternative. LUCs would effectively prevent uncontrolled groundwater access and use which could result in unacceptable human health risk.

Monitoring would effectively verify achievement of the groundwater TPH cleanup criterion and determine whether or not TPH is migrating to the Thames River.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW-4.4 would not reduce the toxicity, mobility, and volume of groundwater COCs or TPH through treatment.

Short-Term Effectiveness

Implementation of Alternative GW-4.4 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during construction and O&M of the two Groundwater Extraction Systems and as a result of monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative GW-4.4 could also result on minimal short-term risk to the surrounding community and the environment as a result of discharge of the groundwater extracted from the Zone 4 points of groundwater contamination to the Lower Subase sanitary sewer system and of the discharge of that groundwater to the Town of Groton POTW. However, these risks would be adequately mitigated by adherence to established sewage handling and treatment procedures.

Alternative GW-4.4 could be implemented within approximately 1 year and would achieve the groundwater RAOs upon implementation. Based on the results of groundwater extraction modeling performed for this FS (see Appendix D), Alternative GW-4.4 would meet the groundwater PRGs within an estimated 11 years for the Zone 4 arsenic/TPH points of groundwater contamination and within an estimated 27 years for the Zone 4 lead point of groundwater contamination. Alternative GW-4.4 would also meet the groundwater TPH cleanup criterion within an estimated 11 years for the Zone 4 arsenic/TPH points of groundwater contamination. As discussed earlier, these remediation time frames are very conservative because of the nature of the input data and type of model used.

Implementability

Alternative GW-4.4 would be relatively easy to implement. Resources, equipment, and materials are readily available for the construction of the two Groundwater Extraction Systems, but this would still require careful planning and coordination. Construction activities might also interfere, at least temporarily, with the normal use of the areas of Zone 4 where these activities would take place. O&M of the two Groundwater Extraction Systems would require the long-term use of skilled personnel. A number of groundwater monitoring events have been implemented at the Lower Subase, and additional monitoring would be easy to perform.

The administrative requirements of Alternative GW-4.4 would be somewhat difficult. A base construction permit would be required for installation of the two Groundwater Extraction Systems. The discharge and disposal of the untreated extracted groundwater to the Town of Groton POTW would also have to be negotiated. A LUC RD would be easy to prepare, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

Cost

The estimated costs for Alternative GW-4.4 are as follows:

Capital Cost	$518,000
NPW of O&M Costs	$7,777,000 (30 years)
NPW	$8,295,000 (30 years)

Detailed cost estimates for this alternative are provided in Appendix E.

4.10.5 Alternative GW-4.5: Extraction, On-Site Treatment (Filtration, Oxidative Filtration, Chemical Precipitation, Liquid-Phase GAC Adsorption), Discharge to Thames River, LUCs (Institutional Controls), and Monitoring

Alternative GW-4.5 would consist of five major components: (1) groundwater extraction (2) on-site treatment of extracted groundwater, (3) discharge of treated groundwater to the Thames River, (4) LUCs with institutional controls, and (5) monitoring.

4.10.5.1 Detailed Description

Component 1: Groundwater Extraction

This component would be identical to Component 1 of Alternative GW-4.4.

Component 2: On-Site Treatment of Extracted Groundwater

This component would consist of installing two On-Site Treatment Systems to address CERCLA risks, one for the Zone 4 arsenic/TPH points of groundwater contamination and the other for the Zone 4 lead point of groundwater contamination. The On-Site Treatment System for the Zone 4 arsenic/TPH points of groundwater contamination would also address State petroleum concerns. As for the corresponding Groundwater Extraction Systems, it is estimated that the On-Site Treatment System for the Zone 4 arsenic/TPH points of groundwater contamination would be operated for 11 years, and the On-Site Treatment System for the Zone 4 lead point of groundwater contamination would be operated for 27 years. PFDs of these two On-Site Treatment Systems are provided on Figures 4-29 and 4-30. Computations of areas and volumes of contaminated groundwater and quantities of groundwater COCs and TPH are provided in Appendix C. Sampling and analysis will be performed as part of the PDI to verify the estimated extent of contaminated groundwater. Conceptual design calculations for the On-Site Treatment Systems are provided in Appendix D.

The On-Site Treatment System for the Zone 4 arsenic/TPH points of groundwater contamination would consist of the following process units in order of flow through:

- An Equalization Tank (T-4.1) to blend the extracted groundwater streams and an Equalization Transfer Pump (P-4.7)
- A Bag Filter (BF-4.1) to remove insoluble TPH and other naturally occurring suspended material
- A liquid-phase GAC Adsorption Unit (GAC-4.1) to remove soluble TPH
- An Oxidative Filter System (OFS-4.1) to remove soluble arsenic

The design flow of the On-Site Treatment System for the Zone 4 arsenic/TPH points of groundwater contamination would be 30 gpm and it would be housed in a 1,500-square-foot pre-engineered and pre-fabricated shelter located as close to the points as practical. Alternately, because the Zone 4 points of groundwater contamination are relatively close to each other, the On-Site Treatment Systems for both groups of points could be housed in a single centrally-located 4,000-square-foot shelter. However, this option would probably require significantly more groundwater transfer piping.

The extracted groundwater would enter the On-Site Treatment System through the Equalization Tank, which would be to blend the groundwater from the various extraction wells to equalize the quality of the influent (particularly the TPH) to the downstream unit processes. The Equalization Tank would be approximately 5 feet in diameter and 8 feet high with a working capacity of 1,000 gallons to provide approximately 30 minutes of detention time under design flow conditions. The Equalization Tank would also be equipped with a vented cover and top-mounted mixer.

The equalized groundwater flow would be pumped from the Equalization Tank to a Bag Filter by a 30-gpm horizontal centrifugal Equalization Transfer Pump. The purpose of the Bag Filter System would be to remove insoluble TPH (oil) and other suspended solids that might otherwise interfere with the efficient operation of the downstream Oxidative Filter and liquid-phase GAC Adsorption Unit. The Bag Filter System would be a multi-element unit designed for a filter element replacement frequency of once a week. Total filter area would be approximately 53 square feet.

The effluent from the Bag Filter would flow under pressure to a liquid-phase GAC Adsorption Unit consisting of a vertical cylindrical pressurized vessel where the groundwater would percolate through granular GAC that would adsorb and remove soluble TPH from the groundwater. The GAC might also remove some soluble arsenic. The GAC Adsorption Unit vessel would be approximately 5 feet in diameter and 10 feet high and would hold approximately 2,500 pounds of liquid-phase GAC. As the removal of TPH and other adsorbable chemicals proceeds, the active sites of the GAC medium would gradually fill and it eventually would have to be replaced. Based on available analytical data, it is anticipated that the replacement frequency of the Zone 4 arsenic/TPH points of groundwater contamination GAC Adsorption Unit would be approximately once every 6 months.

The effluent from the GAC Adsorption Unit would flow still under pressure to the Oxidative Filter System. Inside that system, groundwater would percolate through a bed of a special granular reactive filter medium (such as Siemens/US Filter's GFH®, or equivalent) that would oxidize arsenic, bring it out of solution, and trap it within its pores. The Oxidative Filter System would consist of twin pressurized 24-inch-diameter units operating in parallel and each holding 10 cubic feet of reactive medium. Backwash frequency would be once per month and backwashing would require 40 gpm of water for approximately 15 minutes for each unit and generate 900 gallons per month of waste water that would be collected in a tanker truck for off-site disposal. It is also anticipated that the reactive medium would have to be replaced once every 5 years.

The treated groundwater effluent would then be conveyed under residual pressure to the nearest inlet of the Lower Subase storm sewer system.

The On-Site Treatment System for the Zone 4 lead point of groundwater contamination would include the following process units in order of flow through:

- A Chemical Precipitation System consisting of a Reaction Tank (T-4.2), Chemical Feed System (CFS-4.1), and Transfer Pump (P-4.8) to remove soluble lead

- A Bag Filter System (BF-4.2 to BF-4.4) to remove naturally occurring and chemically precipitated suspended material

The total design flow of the On-Site Treatment System for the Zone 4 lead point of groundwater contamination would be 120 gpm. The On-Site Treatment System would be housed in a 2,500-square-foot pre-engineered and pre-fabricated shelter located as close to the point as practical. As previously mentioned, both Zone 4 On-Site Treatment Systems could also be housed in a single 4,000-square-foot shelter.

The extracted groundwater would be collected into a Reaction Tank that would be similar to the Equalization Tank of the Zone 4 arsenic/TPH point of groundwater contamination On-Site Treatment System, with the difference that it would be 10 feet in diameter and 14 feet high with a working capacity of 7,500 gallons to provide 60 minutes of detention time. The Reaction Tank would also be equipped with a 3-hp top-mounted mixer. A 1-percent (by weight) solution of ammonium phosphate would be metered into the Reaction Tank to precipitate lead as a lead phosphate. The ammonium phosphate solution would be prepared, stored, and fed by a Chemical Feed System consisting of a 400-gallon mixed dissolution and storage tank and a diaphragm-type feed pump with a manually adjustable feed rate of 1 to 5 gallons per hour. Ammonium phosphate use is estimated at approximately 47 gallons of 1-percent solution per day or 4 pounds of dry chemical. The chemically precipitated groundwater would be transferred from the Reaction Tank to the Bag Filter by a 120-gpm horizontal centrifugal pump.

The purpose of the Bag Filter System would be to remove precipitated lead phosphate and other suspended materials to meet surface water discharge criteria. The Bag Filter System would consist of three multi-element units operating in parallel and designed for an element replacement frequency of once per week. Total filter area would be 300 square feet.

The treated groundwater effluent would then flow under residual pressure to the nearest inlet of the Lower Subase storm sewer system.

As discussed in Section 3.5.5, treatability testing would be required to verify the site-specific effectiveness of oxidative filtration, liquid-phase GAC adsorption, and phosphate precipitation and to evaluate the impact of the relatively high salinity of the Lower Subase aquifer on these processes.

Performance of the On-Site Treatment Systems would be monitored. Performance monitoring would consist of collecting weekly water samples from the inlet and outlet of each On-Site Treatment System and analyzing these samples for metals COCs and general water-quality parameters including suspended solids and pH. Samples from the On-Site Treatment System for the Zone 4 arsenic/TPH points of groundwater contamination would also be analyzed for TPH.

Component 3: Discharge of Treated Groundwater to Thames River

The Lower Subase storm sewer system would convey the treated groundwater from each On-Site Treatment System to the Thames River.

Component 4: LUCs with Institutional Controls

This component would be identical to Component 2 of Alternative GW-4.2.

Component 5: Monitoring

This component would be similar to Component 3 of Alternative GW-4.2, except that monitoring would only take place for a period of 15 years for the Zone 4 arsenic/TPH points of groundwater contamination and 30 years for the Zone 4 lead point of groundwater contamination.

4.10.5.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative GW-4.5 would be protective of human health and the environment under CERCLA. Extraction from the Zone 4 points of groundwater contamination and on-site treatment and direct discharge of the extracted groundwater would be protective by capturing and treating these two areas of contaminated groundwater that might act as sources of arsenic and lead migration to the Thames River. LUCs would be protective because they would prevent unacceptable human health risks from exposure to contaminated groundwater as a result of uncontrolled access and use. Monitoring would be protective because it would assess the progress of active remediation and also because it would detect the potential migration of groundwater COCs to the Thames River, which would allow the prevention of unacceptable human health and ecological risks. Alternative GW-4.5 would achieve the groundwater RAOs.

Alternative GW-4.5 would also be protective under the Connecticut RSRs. Although TPH groundwater concentrations would not be effectively reduced by groundwater extraction, they would still decrease rapidly enough as a result of natural attenuation for this alternative to be considered protective. LUCs

would be protective because they would prevent unacceptable human health risks from exposure to contaminated groundwater as a result of uncontrolled access and use. Monitoring would be protective because it would assess the progress of active remediation and also because it would detect the potential migration of TPH to the Thames River.

Compliance with ARARs and TBCs

Alternative GW-4.5 would comply with chemical-specific ARARs and TBCs through active removal. Alternative GW-4.5 would comply with location- and action-specific ARARs and TBCs. A summary of Alternative GW-4.5's compliance with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 4-30, 4-31, and 4-32, respectively.

Long-Term Effectiveness and Permanence

Alternative GW-4.5 would effectively and permanently address CERCLA risks. Based on the result of the modeling performed for this FS (see Appendix D), extraction from the Zone 4 points of groundwater contamination with on-site treatment and direct discharge of the extracted groundwater would effectively and permanently reduce concentrations of arsenic and lead within these points. Although groundwater extraction is a well-proven technology, its effectiveness is known to have some limitations, as discussed in Section 3.5.3.1. As a result, the capture of groundwater COCs might not be as rapid and complete as predicted. In addition, the site-specific effectiveness of the proposed oxidative filtration and phosphate precipitation would have to be confirmed through treatability testing, particularly to assess the impact of the relatively high salinity of the Lower Subase aquifer on these processes. LUCs would effectively prevent uncontrolled groundwater access and use which could result in unacceptable human health risk. Monitoring would effectively verify achievement of the groundwater PRGs and determine whether or not groundwater COCs are migrating to the Thames River, which might result in unacceptable human health and ecological risks.

Alternative GW-4.5 would also effectively and permanently address State petroleum concerns. Although modeling indicates that groundwater extraction would not be particularly effective for the capture of TPH because of the retardation effect resulting from adsorption of that COC onto soil particles, significant reduction in TPH concentration would still be achieved by this alternative. The site-specific effectiveness of the proposed liquid-phase GAC adsorption would have to be confirmed through treatability testing, particularly to assess the impact of the relatively high salinity of the Lower Subase aquifer on this process. LUCs would effectively prevent uncontrolled groundwater access and use which could result in unacceptable human health risk. Monitoring would effectively verify achievement of the groundwater TPH cleanup criterion and determine whether or not TPH is migrating to the Thames River.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW-4.5 would reduce the toxicity, mobility, and volume of groundwater COCs through treatment. An estimated 0.1 pound of arsenic and 4.06 pounds of lead would eventually be removed from Zone 4 groundwater and treated on site, and this removal would be permanent and irreversible.

Short-Term Effectiveness

Implementation of Alternative GW-4.5 could result in significant short-term risks to on-site workers as a result of exposure to contamination during construction and O&M of the two Groundwater Extraction Systems and the two On-Site Treatment Systems and as a result of long-term monitoring activities. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative GW-4.5 could also result in minimal short-term risk to the surrounding community and the environment as a result of off-site transportation and disposal of treatment residuals. However, these risks would be adequately mitigated by adherence to spill prevention procedures and compliance with DOT regulations.

Alternative GW-4.5 could be implemented within approximately 18 months and would achieve the groundwater RAOs upon implementation. Based on the results of groundwater extraction modeling performed for this FS (see Appendix D), Alternative GW-4.5 would meet the groundwater PRGs within an estimated 11 years for the Zone 4 arsenic/TPH points of groundwater contamination and within an estimated 27 years for the Zone 4 lead point of groundwater contamination. Alternative GW-4.5 would also meet the groundwater TPH cleanup criterion within an estimated 11 years for the Zone 4 arsenic/TPH points of groundwater contamination. As discussed earlier, these remediation time frames are very conservative because of the nature of the input data and type of model used.

Implementability

Alternative GW-4.5 would be fairly complex to implement. Resources, equipment, and materials are readily available for the construction of the two Groundwater Extraction Systems and two On-Site Treatment Systems, but this would still require careful planning and coordination of multiple activities over a significant period of time. Construction activities might also interfere, at least temporarily, with the normal use of the areas of Zone 4 where these activities would take place. O&M of the two Groundwater Extraction Systems and two On-Site Treatment Systems would require the long-term use of skilled personnel. A number of groundwater monitoring events have been implemented at the Lower Subase, and additional monitoring would be easy to perform. As previously mentioned, treatability testing would be required to verify the site-specific effectiveness and design parameters of the proposed treatment processes.

The administrative requirements of Alternative GW-4.5 would be somewhat difficult. Base construction permits would be required for installation of the two Groundwater Extraction Systems and construction of the two On-Site Treatment Systems. The substantive requirements of federal and State water discharge regulations would have to be met for discharge of treated groundwater to the Thames River. A LUC RD would be easy to prepare, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

Cost

The estimated costs for Alternative GW-4.5 are as follows:

Capital Cost	$1,535,000
NPW of O&M Costs	$2,641,000 (30 years)
NPW	$4,176,000 (30 years)

Detailed cost estimates for this alternative are provided in Appendix E.

4.11 ASSEMBLY AND DETAILED ANALYSIS OF GROUNDWATER REMEDIAL ALTERNATIVES FOR ZONE 7

Even though there is uncertainty regarding Zone 7 groundwater presenting a CERCLA risk, the Navy has opted to develop and evaluate groundwater alternatives following the CERCLA process. Additional data will be collected during a Groundwater PDI that will be used to address the uncertainty regarding the risk and the appropriateness of the CERCLA evaluation process for Zone 7 groundwater. The new data and updated evaluation will be captured in an addendum to this FS.

The following alternatives have been developed for groundwater remediation at Zone 7:

Alternative GW-7.1: No Action.

Alternative GW-7.2: Natural Attenuation, LUCs (Institutional Controls), and Monitoring.

Alternative GW-7.3: In-Situ Treatment (Chemical Precipitation and Oxidation), LUCs (Institutional Controls), and Monitoring.

Alternative GW-7-4: Extraction, Discharge and Disposal to Off-Site POTW, LUCs (Institutional Controls), and Monitoring.

Alternative GW-7.5: Extraction, On-Site Treatment (Filtration and Oxidative Filtration), Discharge to Thames River, LUCs (Institutional Controls), and Monitoring.

Alternative GW-7.1 was developed and analyzed to serve as a baseline for other alternatives, as required by CERCLA and the NCP. Alternative GW-1.2 was developed and analyzed to evaluate LUCs with institutional controls, natural attenuation, and monitoring. Alternatives GW-7.3, GW-7.4, and GW-7.5 were developed and analyzed to evaluate active remediation, with Alternative GW-7.3 representing a relatively innovative in-situ treatment approach and Alternatives GW-7.4 and GW-7.5 representing a more traditional pump-and-treat approach with alternate discharge/disposal options. Descriptions and detailed analyses of these alternatives are provided in the following sections.

4.11.1 Alternative GW-7.1 - No Action

4.11.1.1 Description

No Action would not include any action under CERCLA and any existing administrative or engineering environmental controls would not be an enforceable part of a CERCLA remedy. This alternative is required under CERCLA to establish a basis for comparison with other alternatives. The only activity under this alternative would be the performance of five-year reviews. This alternative cannot be chosen because contamination remains on site.

4.11.1.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative GW-7.1 would not be protective of human health and the environment under CERCLA. Although the aquifer beneath the Lower Subase is classified as GB and unfit for human consumption and there are no unacceptable human health risks from exposure to contaminated groundwater under the current I/C site use, Alternative GW-7.1 would not prevent unacceptable human health risks that could result from uncontrolled groundwater access and use. In addition, in the absence of monitoring, the progress of arsenic natural attenuation would remain unknown, and potential future migration of this

groundwater COC to the nearby Thames River would remain undetected, which could cause additional human health and environmental risks. Alternative GW-7.1 would not achieve the groundwater RAOs.

Compliance with ARARs and TBCs

Alternative GW-7.1 would not comply with chemical-specific ARARs or TBCs because no action would be taken to reduce concentrations of arsenic in groundwater. Chemical-specific ARARs and TBCs might eventually be met through natural attenuation, but this would not be verified through monitoring. There are no location-specific ARARs or TBCs for groundwater, and action-specific ARARs or TBCs are not relevant for this alternative. A summary of Alternative GW-7.1's compliance with chemical-specific ARARs and TBCs is provided in Table 4-20.

Long-Term Effectiveness and Permanence

Alternative GW-7.1 would not effectively and permanently address CERCLA risks because it would not involve any action and it would allow unrestricted groundwater access and use which could result in unacceptable human health risks. In addition, because there would be no monitoring, the progress of arsenic natural attenuation would remain unknown and the potential migration of this groundwater COC to the nearby Thames River would not be detected.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW-7.1 would not reduce the toxicity, mobility, or volume of arsenic in groundwater through treatment because no treatment would occur.

Short-Term Effectiveness

Because no action would occur, implementation of Alternative GW-7.1 would not pose any short-term risks to on-site workers or result in adverse impact to the local community or the environment.

Alternative GW-7.1 would not achieve the groundwater RAOs, and although the groundwater arsenic PRG might eventually be met through natural attenuation, this would not be verified through monitoring.

Implementability

Technically, Alternative GW-7.1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Cost

The estimated costs for Alternative GW-7.1 are as follows:

Capital Cost	$0
NPW of O&M Costs	$55,000 (30 years)
NPW	$55,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.11.2 Alternative GW-7.2: Natural Attenuation, LUCs (Institutional Controls), and Monitoring

4.11.2.1 Description

Alternative GW-7.2 would consist of three major components: (1) natural attenuation, (2) LUCs with institutional controls, and (3) monitoring.

Component 1: Natural Attenuation

Natural attenuation would rely on naturally occurring processes within the aquifer to address CERCLA risks by reduce the concentrations of arsenic. Dispersion and dilution through aquifer movement and adsorption on soil particles are expected to be the processes primarily responsible for this natural attenuation. Aquifer conditions and quality would be continually monitored to track the progress of remediation. It should be noted that the natural attenuation processes of this component are different from those discussed in the well-publicized OSWER Directive 9200.4-17P which discusses monitored natural attenuation of chlorinated volatile organic compounds through reductive dechlorination.

Component 2: LUCs with Institutional Controls

LUCs with institutional controls would be developed and implemented to address CERCLA risks. A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish and implement methods and procedures to reinforce the state-issued GB classification of the surficial aquifer by prohibiting its use for human consumption at Zone 7. In addition, regular site inspections would be performed to verify the continued implementation of LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be integrated within and implemented as part of NSB-NLON SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

Component 3: Monitoring

Monitoring would include performance and migration monitoring. For the purpose of this FS, it was assumed that performance monitoring would consist of regularly collecting groundwater samples from two new or existing wells located within the Zone 7 arsenic points of groundwater contamination (see Figure 2-17) and analyzing these samples for arsenic to assess the natural attenuation of this COC. Performance monitoring would take place over a period of 30 years, and sampling frequency would be quarterly for the first 2 years, semi-annual for the next 2 years, and annual thereafter.

For the purpose of this FS, it was assumed that migration monitoring would consist of regularly collecting groundwater samples from a total of four new or existing wells located downgradient of the leading edge of the Zone 7 arsenic points of groundwater contamination and analyzing these samples for arsenic to detect potential migration of this COC to the Thames River. Migration monitoring would take place over a period of 30 years and sampling frequency would be quarterly for the first two years, semi-annual for the next 2 years, and annual thereafter.

Reviews would be performed every 5 years to evaluate the status of the site, assess the continued adequacy of remedial activities, determine if LUCs can be lifted, and determine whether further action is necessary. These site reviews are required because this alternative would allow arsenic to remain in groundwater at concentrations greater than its PRG.

4.11.2.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative GW-7.2 would be protective of human health and the environment under CERCLA. Natural attenuation would be protective because it would very slowly reduce concentrations of arsenic in the Zone 7 groundwater until the PRG is eventually achieved, at which point this area would no longer constitute a potential source of migration of arsenic to the Thames River. LUCs would be protective because they would prevent unacceptable human health risks from exposure to contaminated groundwater as a result of uncontrolled access and use. Monitoring would be protective because it would assess the progress of natural attenuation and also because it would detect the potential migration of arsenic from groundwater to the Thames River, which would allow the prevention of unacceptable human health and environmental risks. Alternative GW-7.2 would achieve the groundwater RAOs.

Compliance with ARARs and TBCs

Alternative GW-7.2 would not comply in the short term with chemical-specific ARARs and TBCs, and eventual compliance through natural attenuation would require a long time. There are no location-specific

ARARs and TBCs for this groundwater alternative. Alternative GW-7.2 would comply with action-specific ARARs and TBCs. A summary of Alternative GW-7.2's compliance with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 4-21, 4-22, and 4-23, respectively.

Long-Term Effectiveness and Permanence

Alternative GW-7.2 would address CERCLA risks in an effective and permanent way. As shown by the modeling performed for this FS (see Appendix D), natural attenuation is considered to be effective, although natural attenuation would very slowly reduce concentrations of arsenic and eventually achieve its PRG, as verified through monitoring. LUCs would effectively prevent uncontrolled groundwater access and use could result in unacceptable human health risk. Monitoring would effectively verify achievement of the arsenic groundwater PRG and determine whether or not arsenic is migrating to the Thames River, which might result in unacceptable human health and ecological risks.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW-7.2 would not reduce the toxicity, mobility, and volume of arsenic in groundwater through treatment.

Short-Term Effectiveness

Implementation of Alternative GW-7.2 could result in minimal short-term risks to on-site workers as a result of exposure to contamination during monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative GW-7.2 would not adversely impact the surrounding community or the environment.

Alternative GW-7.2 could be implemented within approximately 3 months and would achieve the groundwater RAOs upon achieving groundwater cleanup standards beyond the compliance boundary for the waste management area within the Zone. Based on the results of natural attenuation modeling performed for this FS (see Appendix D), Alternative GW-7.2 would meet the arsenic groundwater PRG within an estimated 34 years, and this would be confirmed through monitoring. As noted in Section 3, this remediation time frame is very conservative because: (a) only maximum historical concentrations of unfiltered arsenic were used for this modeling and, in most cases, the corresponding filtered concentrations and/or subsequently detected concentrations were below PRG and (b) the type of modeling used was relatively simple and has a tendency to overemphasize metal retardation.

Implementability

Alternative GW-7.2 would be easy to implement. A number of groundwater monitoring events have been implemented at the Lower Subase, and additional monitoring would be easy to perform.

The administrative aspects of Alternative GW-7.2 would be simple to implement. A LUC RD would be easy to prepare, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished. No construction permits issued by NSB-NLON DPW would be required for this alternative.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

Cost

The estimated costs for Alternative GW-7.2 are as follows:

Capital Cost	$24,000
NPW of O&M Costs	$318,000 (30 years)
NPW	$342,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.11.3 Alternative GW-7.3: In-Situ Treatment (Chemical Precipitation and Oxidation), LUCs (Institutional Controls), and Monitoring

4.11.3.1 Description

Alternative GW-7.3 would consist of three major components: (1) in-situ treatment (2) LUCs with institutional controls, and (3) monitoring.

Component 1: In-Situ Treatment

In-situ treatment would consist of using chemical precipitation and oxidation to address CERCLA risks. The chemical reactions are relatively rapid (compared to biological processes), so the treatment timeframe is expected to be short. The Zone 7 arsenic points of groundwater contamination cover an estimated combined 13,500 square feet in the vicinity of monitoring wells 20MW7 and MW4-7RI, and contain an estimated combined 302,000 gallons of contaminated groundwater. Computations of areas and volumes of contaminated groundwater and quantities of groundwater COCs are provided in Appendix C. Sampling and analysis will be performed as part of the PDI to verify the estimated extent of contaminated groundwater.

In-situ chemical precipitation and oxidation of the Zone 7 arsenic points of groundwater contamination would consist of installing a DPT system to cover the footprint of these points and performing two rounds of chemical injection in rapid succession. The first round of chemical injection would supply the ferric iron required for co-precipitation of the arsenic, and the second round would provide the ORC to oxidize arsenic from the trivalent to the pentavalent state to form a stable arsenic ferro-oxide. The DPT injection system would consist of a grid of 74 DPT injection points installed to a depth of 15 feet bgs. For the first round of injection, the DPT points would be used to inject an estimated total of 54 pounds of a 40-percent (by weight) solution of ferric chloride (4.6 gallons), which corresponds to a total ferric iron addition of 21.5 pounds, or 10 times the stochiometric demand for arsenic precipitation. To promote dispersion, the ferric chloride solution would be diluted 100 to 1 providing approximately 6.2 gallons of dilute solution to be injected at each DPT point. For the second round of injection, 40 pounds of ORC would be injected in each of the DPT points for a total injection of 2,960 pounds. The proposed in-situ treatment area for the Zone 7 arsenic points of groundwater contamination is shown on Figure 4-31. Conceptual design calculations are provided in Appendix D.

As discussed in Section 3.5.4, treatability testing would be required to verify the site-specific effectiveness of in-situ chemical precipitation and oxidation and to evaluate the impact of the relatively high salinity of the Lower Subase aquifer on this process.

Component 2: LUCs with Institutional Controls

This component would be identical to Component 2 of Alternative GW-7.2.

Component 3: Monitoring

This component would be similar to Component 3 of Alternative GW-7.2, except that monitoring would only be performed for a period of 5 years.

4.11.3.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative GW-7.3 would be protective of human health and the environment under CERCLA. In-situ treatment of the Zone 1 arsenic points of groundwater contamination would be protective because it would actively remediate an area of contaminated groundwater that might act as a source of arsenic migration to the Thames River. LUCs would be protective because they would prevent unacceptable human health risks from exposure to contaminated groundwater as a result of uncontrolled access and use. Monitoring would be protective because it would assess the progress of in-situ treatment and also because it would detect potential migration of arsenic from groundwater to the Thames River, which would allow the prevention of possible unacceptable human health and ecological risks. Alternative GW-7.3 would achieve the groundwater RAOs.

Compliance with ARARs and TBCs

Alternative GW-7.3 would comply with chemical-specific ARARs and TBCs through active in-situ treatment. There are no location-specific ARARs and TBCs for this groundwater alternative. Alternative GW-7.3 would also comply with action-specific ARARs and TBCs. A summary of Alternative GW-7.3's compliance with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 4-24, 4-25, and 4-26, respectively.

Long-Term Effectiveness and Permanence

Alternative GW-7.3 would effectively and permanently address CERCLA risks. In-situ treatment of the Zone 7 arsenic points of groundwater contamination would effectively and permanently reduce concentrations of arsenic in groundwater to its PRG. However, the site-specific effectiveness of the proposed in-situ chemical precipitation and oxidation would have to be confirmed through treatability testing to assess the impact of the relatively high salinity of the Lower Subase aquifer on that process. There would also be a slight possibility that the arsenic removed from groundwater and immobilized in the surrounding soil could be redissolved and remobilized over the long term as a result of naturally occurring changes in groundwater chemistry. LUCs would effectively prevent uncontrolled groundwater access and use which could result in unacceptable human health risk. Monitoring would effectively verify achievement of the arsenic groundwater PRG and determine whether or not that COC is migrating from groundwater to the Thames River, which might result in unacceptable human health and ecological risks.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW-7.3 would reduce the toxicity and mobility of arsenic in groundwater through active treatment. An estimated 0.04 pound of arsenic would be removed from groundwater and immobilized through in-situ chemical oxidation and precipitation. However, as noted earlier, there is a slight possibility that this immobilization might not be completely permanent and irreversible. Alternative GW-7.3 would not generate any treatment residue.

Short-Term Effectiveness

Implementation of Alternative GW-7.3 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during installation and O&M of the in-situ treatment system and as a result of monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative GW-7.3 would also not adversely impact the surrounding community or the environment.

Alternative GW-7.3 could be implemented within approximately 1 year and would achieve the groundwater RAOs and arsenic groundwater PRG upon implementation. The chemical reactions are relatively rapid (compared to biological processes), so the treatment timeframe is short.

Implementability

Alternative GW-7.3 could be implemented. In-situ chemical oxidation and precipitation services as proposed for the Zone 7 arsenic points of groundwater contamination are available from a number of qualified contractors. However, installation and operation of the numerous DPT injection points (74) required for in-situ chemical oxidation, and precipitation would temporarily but significantly impact normal site activities and existing structures and underground obstacles would likely prevent the optimum positioning of several injection points. As previously mentioned, treatability testing would have to be performed to verify site-specific effectiveness and to confirm the design parameters for the in-situ treatment process. A number of groundwater monitoring events have been implemented at the Lower Subase, and additional monitoring would be easy to perform.

The administrative aspects of Alternative GW-7.3 would be simple to implement. A LUC RD would be easy to prepare, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished. A construction permit issued by NSB-NLON DPW would also be required for this alternative.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

Cost

The estimated costs for Alternative GW-7.3 are as follows:

Capital Cost	$282,000
NPW of O&M Costs	$149,000 (5 years)
NPW	$431,000 (5 years)

Detailed cost estimates for this alternative are provided in Appendix E.

4.11.4 Alternative GW-7.4: Extraction, Discharge and Disposal to Off-Site POTW, LUCs (Institutional Controls), and Monitoring

Alternative GW-7.4 would consist of four major components: (1) groundwater extraction, (2) discharge and disposal of untreated groundwater to the Town of Groton POTW, (3) LUCs with institutional controls, and (4) monitoring.

4.11.4.1 Detailed Description

Component 1: Groundwater Extraction

This component would consist of installing a Groundwater Extraction System to address CERCLA risks for the Zone 7 arsenic points of groundwater contamination and operating that system for an estimated 18 years. Computations of areas and volumes of contaminated groundwater and quantities of groundwater COCs are provided in Appendix C. Sampling and analysis will be performed as part of the PDI to verify the estimated extent of contaminated groundwater. Conceptual design calculations for the Groundwater Extraction System are provided in Appendix D.

Based on the results of these calculations, the Groundwater Extraction System for the Zone 7 arsenic points of groundwater contamination would consist of a two 6-inch extraction wells (EW-7.1 and EW-7.2) installed to a depth of 30 feet and screened from 5 to 30 feet bgs. Each extraction well would pump 14 gpm for a total extraction rate of 28 gpm. Proposed locations of the Zone 7 groundwater extraction wells are shown on Figure 4-32.

Centrifugal submersible extraction pumps (P-7.1 and P-7.2) equipped with level controls would be installed in each groundwater extraction well. Each of these pumps would be connected to a transfer pipeline that would convey the extracted groundwater to the nearest sanitary sewer manhole.

Component 2: Discharge and Disposal of Untreated Groundwater to Town of Groton POTW

The contaminated groundwater extracted from Zone 7 would be discharged to the Lower Subase sanitary sewer system and conveyed by this system to the Town of Groton POTW. At the POTW, arsenic in the contaminated groundwater would be removed through typical sanitary sewage treatment unit processes including primary gravity separation and secondary biological treatment. Ultimately, the treated groundwater would be discharged to the Thames River along with the Town of Groton treated sewage.

Component 3: LUCs with Institutional Controls

This component would be identical to Component 2 of Alternative GW-7.2.

Component 4: Monitoring

This component would be similar to Component 3 of Alternative GW-7.2, except that monitoring would only take place for a period of 20 years.

4.11.4.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative GW-7.4 would be protective of human health and the environment under CERCLA. Extraction from the Zone 7 arsenic points of groundwater contamination and discharge and disposal of the extracted groundwater to the Town of Groton POTW would be protective by capturing and treating an area of contaminated groundwater that might act as a source of arsenic migration to the Thames River. LUCs would be protective because they would prevent unacceptable human health risks from exposure to contaminated groundwater as a result of uncontrolled access and use. Monitoring would be protective because it would assess the progress of active remediation and also because it would detect the potential migration of arsenic from groundwater to the Thames River, which would allow the prevention of

unacceptable human health and ecological risks. Alternative GW-7.4 would achieve the groundwater RAOs.

Compliance with ARARs and TBCs

Alternative GW-7.4 would comply with chemical-specific ARARs and TBCs through active removal. Alternative GW-7.4 would comply with location- and action-specific ARARs and TBCs. A summary of Alternative GW-7.4's compliance with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 4-27, 4-28, and 4-29, respectively.

Long-Term Effectiveness and Permanence

Alternative GW-7.4 would effectively and permanently address CERCLA risks. Based on the results of the modeling performed for this FS (see Appendix D), extraction from the Zone 7 arsenic points of groundwater contamination and discharge and disposal of the extracted groundwater to the Town of Groton POTW would effectively and permanently reduce concentrations of arsenic in Zone 7 groundwater. However, although groundwater extraction is a well-proven technology, its effectiveness is known to have some limitations as discussed in Section 3.5.3.1. As a result, the capture of groundwater arsenic might not be as rapid and complete as predicted. LUCs would effectively prevent uncontrolled groundwater access and use which could result in unacceptable human health risk. Monitoring would effectively verify achievement of the arsenic groundwater PRG and determine whether or not this COC is migrating from groundwater to the Thames River, which might result in unacceptable human health and ecological risks.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW-7.4 would not reduce the toxicity, mobility, and volume of the arsenic in groundwater through treatment.

Short-Term Effectiveness

Implementation of Alternative GW-7.4 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during construction and O&M of the Groundwater Extraction System and as a result of monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative GW-7.4 could also result in minimal short-term risk to the surrounding community and the environment as a result of discharge of the groundwater extracted from the Zone 7 arsenic points of groundwater contamination to the Lower Subase sanitary sewer system and the discharge of that groundwater to the Town of Groton POTW. However, these risks would be adequately mitigated by adherence to established sewage handling and treatment procedures.

Alternative GW-7.4 could be implemented within approximately 1 year and would achieve the groundwater RAOs upon implementation. Based on the results of groundwater extraction modeling performed for this FS (see Appendix D), Alternative GW-7.4 would meet the arsenic groundwater PRG within an estimated 18 years. As discussed earlier, this remediation time frame is very conservative because of the nature of the input data and type of model used.

Implementability

Alternative GW-7.4 would be relatively easy to implement. Resources, equipment, and materials are readily available for the construction of a Groundwater Extraction System, but this would still require careful planning and coordination. Construction activities might also interfere, at least temporarily, with the normal use of the areas of Zone 7 where these activities would take place. O&M of the Groundwater Extraction System would require the long-term use of skilled personnel. A number of groundwater monitoring events have been implemented at the Lower Subase, and additional monitoring would be easy to perform.

The administrative requirements of Alternative GW-7.4 would be somewhat difficult. A base construction permit would be required for installation of the Groundwater Extraction System. The discharge and disposal of the untreated extracted groundwater to the Town of Groton POTW would also have to be negotiated. A LUC RD would be easy to prepare, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

Cost

The estimated costs for Alternative GW-7.4 are as follows:

Capital Cost	$265,000
NPW of O&M Costs	$1,938,000 (30 years)
NPW	$2,203,000 (30 years)

Detailed cost estimates for this alternative are provided in Appendix E.

4.11.5 Alternative GW-7.5: Extraction, On-Site Treatment (Filtration, Oxidative Filtration), Discharge to Thames River, LUCs (Institutional Controls), and Monitoring

Alternative GW-7.5 would consist of five major components: (1) groundwater extraction, (2) on-site treatment of extracted groundwater, (3) discharge of treated groundwater to the Thames River, (4) LUCs with institutional controls, and (5) monitoring.

4.11.5.1 Detailed Description

Component 1: Groundwater Extraction

This component would be identical to Component 1 of Alternative GW-7.4.

Component 2: On-Site Treatment of Extracted Groundwater

This component would consist of installing an On-Site Treatment System to address CERCLA risks for the Zone 7 arsenic points of groundwater contamination. As for the corresponding Groundwater Extraction System, it is estimated that this On-Site Treatment System would be operated for 18 years. A PFD of the On-Site Treatment System is provided on Figure 4-33. Computations of areas and volumes of contaminated groundwater and quantities of groundwater COCs are provided in Appendix C. Sampling and analysis will be performed as part of the PDI to verify the estimated extent of contaminated groundwater. Conceptual design calculations for the On-Site Treatment System are provided in Appendix D.

The On-Site Treatment System for the Zone 7 arsenic points of groundwater contamination would consist of the following process units in order of flow through:

- A Bag Filter (BF-7.1) to remove naturally occurring suspended material
- An Oxidative Filter System (OFS-7.1) to remove soluble arsenic

The design flow of the On-Site Treatment System for the Zone 7 arsenic points of groundwater contamination would be 30 gpm and it would be housed in a 1,500-square-foot pre-engineered and pre-fabricated shelter located as close to the points as practical.

The purpose of the Bag Filter would be to remove naturally occurring suspended solids that might otherwise interfere with the efficient operation of the downstream Oxidative Filter. The Bag Filter would be a multi-element unit designed for a filter element replacement frequency of once a week. Total filter area would be approximately 53 square feet.

The effluent from the GAC Adsorption Unit would flow, still under pressure, to the Oxidative Filter System. Inside that system, groundwater would percolate through a bed of a special granular reactive filter medium (such as Siemens/US Filter's GFH®, or equivalent) that would oxidize arsenic, bring it out of solution, and trap it within its pores. The Oxidative Filter System would consist of twin pressurized 24-inch-diameter units operating in parallel and each holding 10 cubic feet of reactive medium. Backwash frequency would be once per month, and backwashing would require 40 gpm of water for approximately 15 minutes for each unit and generate 900 gallons per month of waste water, which would be collected in a tanker truck for off-site disposal. It is also anticipated that the reactive medium would have to be replaced once every 5 years.

The treated groundwater effluent would then be conveyed under residual pressure to the nearest inlet of the Lower Subase storm sewer system.

As discussed in Section 3.5.5, treatability testing would be required to verify the site-specific effectiveness of the oxidative filtration and to evaluate the impact of the relatively high salinity of the Lower Subase aquifer on this process.

Performance of the On-Site Treatment System would be monitored by collecting weekly water samples from the inlet and outlet of the treatment system and analyzing these samples for arsenic and general water-quality parameters including suspended solids and pH.

Component 3: Discharge of Treated Groundwater to Thames River

The Lower Subase storm sewer system would convey the treated groundwater from the On-Site Treatment System to the Thames River.

Component 4: LUCs with Institutional Controls

This component would be identical to Component 2 of Alternative GW-7.2.

Component 5: Monitoring

This component would be similar to Component 3 of Alternative GW-7.2, except that monitoring would only take place for a period of 20 years.

4.11.5.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative GW-7.5 would be protective of human health and the environment under CERCLA. Extraction from the Zone 7 points of groundwater contamination and on-site treatment and direct discharge of the extracted groundwater would be protective by capturing and treating this area of contaminated groundwater that might act as a source of arsenic migration to the Thames River. LUCs would be protective because they would prevent unacceptable human health risks from exposure to contaminated groundwater as a result of uncontrolled access and use. Monitoring would be protective because it would assess the progress of active remediation and also because it would detect the potential migration of arsenic from groundwater to the Thames River, which would allow the prevention of unacceptable human health and ecological risks. Alternative GW-7.5 would achieve the groundwater RAOs.

Compliance with ARARs and TBCs

Alternative GW-7.5 would comply with chemical-specific ARARs and TBCs through active removal. Alternative GW-7.5 would comply with location- and action-specific ARARs and TBCs. A summary of Alternative GW-7.5's compliance with chemical-, location- and action-specific ARARs and TBCs is provided in Tables 4-30, 4-31, and 4-32, respectively.

Long-Term Effectiveness and Permanence

Alternative GW-7.5 would effectively and permanently address CERCLA risks. Based on the result of the modeling performed for this FS (see Appendix D), extraction from the Zone 7 arsenic points of groundwater contamination with on-site treatment and direct discharge of the extracted groundwater would effectively and permanently reduce concentrations of arsenic within the Zone 7 groundwater. However, although groundwater extraction is a well-proven technology, its effectiveness is known to have some limitations, as discussed in Section 3.5.3.1. As a result, the capture of arsenic in the Zone 7 groundwater might not be as rapid and complete as predicted. In addition, the site-specific effectiveness

of the proposed oxidative filtration would have to be confirmed through treatability testing, particularly to assess the impact of the relatively high salinity of the Lower Subase aquifer on this process. LUCs would effectively prevent uncontrolled groundwater access and use which could result in unacceptable human health risk. Monitoring would effectively verify achievement of the arsenic groundwater PRG and determine whether or not arsenic is migrating from groundwater to the Thames River, which might result in unacceptable human health and ecological risks.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW-7.5 would not reduce the toxicity, mobility, and volume of arsenic in groundwater through treatment.

Short-Term Effectiveness

Implementation of Alternative GW-7.5 could result in significant short-term risks to on-site workers as a result of exposure to contamination during construction and O&M of the Groundwater Extraction System and On-Site Treatment System and as a result of long-term monitoring activities. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative GW-7.5 could also result in minimal short-term risk to the surrounding community and the environment as a result of off-site transportation and disposal of treatment residuals. However, these risks would be adequately mitigated by adherence to spill prevention procedures and compliance with DOT regulations.

Alternative GW-7.5 could be implemented within approximately 18 months and would achieve the groundwater RAOs upon implementation. Based on the results of groundwater extraction modeling performed for this FS (see Appendix D), Alternative GW-7.5 would meet the arsenic groundwater PRG within an estimated 18 years. As discussed earlier, this remediation time frame is very conservative because of the nature of the input data and type of model used.

Implementability

Alternative GW-7.5 would be fairly complex to implement. Resources, equipment, and materials are readily available for the construction of the Groundwater Extraction System and On-Site Treatment System, but this would still require careful planning and coordination of multiple activities over a significant period of time. Construction activities might also interfere, at least temporarily, with the normal use of the areas of Zone 7 where these activities would take place. O&M of the Groundwater Extraction Systems and On-Site Treatment System would require the long-term use of skilled personnel. A number of groundwater monitoring events have been implemented at the Lower Subase, and additional monitoring

would be easy to perform. As previously mentioned, treatability testing would be required to verify the site-specific effectiveness and design parameters of the proposed treatment process.

The administrative requirements of Alternative GW-7.5 would be somewhat difficult. Base construction permits would be required for installation of the Groundwater Extraction System and construction of the On-Site Treatment System. The substantive requirements of federal and State water discharge regulations would have to be met for discharge of treated groundwater to the Thames River. A LUC RD would be easy to prepare, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

Cost

The estimated costs for Alternative GW-7.5 are as follows:

Capital Cost	$499,000
NPW of O&M Costs	$929,000 (30 years)
NPW	$1,428,000 (30 years)

Detailed cost estimates for this alternative are provided in Appendix E.

4.12 ASSEMBLY AND DETAILED ANALYSIS OF SEDIMENT REMEDIAL ALTERNATIVES FOR ZONE 4 AND OUTER PIER 1

The following sediment remedial alternatives have been developed for Zone 4 and a small area of Outer Pier 1, as described below (see Section 4.12.4.1 and Figure 4-39):

Alternative SD-1: No Action.

Alternative SD-3: Capping with Pre-Dredging to Meet RAOs, Dewatering, On-Site Treatment and Discharge of Dewatering Fluid, Off-Site Disposal of Dewatered Sediment, LUCs (Institutional Controls), and Monitoring.

Alternative SD-4: Capping with Pre-Dredging to Meet RAOs, Dewatering, Off-Site Disposal of Dewatered Sediment and Dewatering Fluid, LUCs (Institutional Controls), and Monitoring.

Alternative SD-6: Dredging to Meet PRGs, Dewatering, On-Site Treatment and Discharge of Dewatering Fluid, and Off-Site Disposal of Dewatered Sediment.

Alternative SD-7: Dredging to Meet PRGs, Dewatering, and Off-Site Disposal of Dewatered Sediment and Dewatering Fluid.

Alternatives SD-2 and SD-5 which were evaluated in a previous version of this FS have now been eliminated because their distinctive technology component was disposal of contaminated sediment in an existing CAD which proved unacceptable to CTDEP as further explained in Section 3.8.7.1.

Alternative SD-1 was developed and analyzed to serve as a baseline for other alternatives, as required by CERCLA and the NCP. Alternatives SD-3 and SD-4 were developed and analyzed to evaluate the limited action to isolate contaminated sediment. Alternatives SD-6 and SD-7 were developed and analyzed to evaluate complete removal of contaminated sediment. Descriptions and detailed analyses of these alternatives are provided in the following sections.

4.12.1 Alternative SD-1: No Action

4.12.1.1 Description

No Action would not include any action under CERCLA and any existing administrative or engineering environmental controls would not be an enforceable part of a CERCLA remedy. This alternative is required under CERCLA to establish a basis for comparison with other alternatives. The only activity under this alternative would be the performance of five-year reviews. This alternative cannot be chosen because contamination remains on site.

4.12.1.2 Detailed Analysis

Overall Protection of Human Health and the Environment

There are no unacceptable human health risks from direct exposure to contaminated sediment at the Lower Subase under the current site use scenario. However, Alternative SD-1 would not be protective of the environment under CERCLA because it would allow sediment COCs (PAHs, PCBs, pesticides, and

metals) to remain on site at concentrations that would result in unacceptable risks to ecological receptors such as benthic macroinvertebrates and piscivorous birds. Alternative SD-1 would also not be protective of the environment because it would allow the migration of contaminated sediment to previously uncontaminated areas as a result of natural causes (e.g., current and tidal movements) or human actions (e.g., boat movements and maintenance dredging and disposal). Alternative SD-1 would not achieve the sediment RAOs.

Compliance with ARARs and TBCs

Alternative SD-1 would not comply with chemical-specific ARARs and TBCs. Because Alternative SD-1 would not involve any action, location- and action-specific ARARs and TBCs would not be relevant. A summary of Alternative SD-1's compliance with chemical-specific ARARs and TBCs is provided in Table 4-33.

Long-Term Effectiveness and Permanence

Alternative SD-1 would not be long-term effective and permanent. Not only would unacceptable ecological risks continue to exist in Zone 4 and Outer Pier 1, but these risks could be also spread to other areas of the Thames River as a result of natural causes (e.g., current and tidal movements) or human actions (e.g., boat movements and maintenance dredging and disposal). In addition, because no long-term monitoring would be performed, there would be no ongoing assessment of the quality of sediment.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative SD-1 would not reduce the toxicity, mobility, or volume of sediment COCs through treatment because no treatment would occur.

Short-Term Effectiveness

Because no action would occur, implementation of Alternative SD-1 would not result in any short-term risks to on-site workers or adversely impact the local community or the environment.

Alternative SD-1 would not achieve the sediment RAOs or meet the sediment PRGs.

Implementability

Technically, Alternative SD-1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Cost

The estimated costs for Alternative SD-1 are as follows:

Capital Cost	$0
NPW of O&M Costs	$55,000 (30 years)
NPW	$55,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.12.2 Alternative SD-3: Capping with Pre-Dredging to Meet RAOs, Dewatering, On-Site Treatment and Discharge of Dewatering Fluid, Off-Site Disposal of Dewatered Sediment, LUCs (Institutional Controls), and Monitoring

4.12.2.1 Description

Alternative SD-3 would consist of six major components: (1) capping with pre-dredging, (2) dewatering of dredged sediment, (3) on-site treatment and discharge of dewatering fluid, (4) off-site disposal of dewatered sediment, (5), LUCs with institutional controls, and (6) monitoring. As noted in Section 3.8.3, a natural cap already exists above contaminated sediment at Outer Pier 1; therefore, Components 1 through 4 of this alternative only apply to Zone 4 sediment.

Component 1: Capping with Pre-Dredging

Areas of surface sediment with concentrations of COCs greater than PRGs would be capped to prevent exposure and meet RAOs. As shown on Figure 4-34, one such area was identified in Zone 4 but none in Outer Pier 1. The Zone 4 area is a 420-foot-long strip extending along the quay wall from approximately 100 feet south of Pier 6 to Pier 2. The width of this strip varies from 15 to 90 feet, and it covers an estimated surface area of 18,180 square feet. Computations of areas and volumes of contaminated sediment are provided in Appendix C.

Prior to capping, a 2-foot-thick layer of sediment would be dredged from the areas to be capped. The primary purpose of this pre-dredging would be to adjust the depth of the sediment so that the placement of a cap would not result in unacceptably shallow conditions. Another purpose for pre-dredging would be removal of the typically lighter and softer top layer of sediment to provide better support for the cap. An estimated total in-situ volume of 12,200 cubic yards of contaminated sediment with an estimated solids content of 50 percent by weight would be removed using a barge-mounted excavator equipped with an environmental bucket. Because this dredging process would typically entrain water and would also result

in a bulking of the volume of the dredged sediment, it is estimated that the total volume of the dredged material would be twice that of the in-situ sediment, or approximately 24,400 cubic yards, with an estimated solids content of 29 percent by weight.

To ensure that resuspended sediment is not released beyond the dredged areas, a 600-foot silt curtain would be deployed at the western limit of the removal action area. As may be required because of river current, a weighed type of curtain would be used. The silt curtain would remain in place during capping. As further discussed below, monitoring would also be performed during pre-dredging operations to verify that no migration of COCs is occurring.

Capping would consist of placing a layer of clean well-graded angular sand or sand and gravel with a minimum thickness of 3 feet over the contaminated sediment. Assuming a settling factor of approximately 20 percent following the placement of the capping material, an estimated total volume of 2,400 cubic yards (3,300 tons) of capping material would be required. The relatively small size of the area to be capped and the significant depth of the water column would require precise placement of the capping material. Therefore, it is anticipated that the capping material would have to be placed with a barge-mounted mechanical clamshell bucket or tremie. Because of the significant lateral slope (2.5 horizontal to 1 vertical) of the area to be capped and to avoid excessive displacement of contaminated sediment, the cap material would be placed in multiple lifts of 6 inches or less. Capping would be performed in accordance with EPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (EPA, 2005c) and the Navy's Implementation Guide for Assessing and Managing Contaminated Sediment at Navy Facilities (Navy, 2005). A cross-section of the proposed sediment cap is shown on Figure 4-35.

For the purpose of this FS, it is assumed that the short-term decrease in the thickness of the sediment layer accumulated against the quay wall that would occur between dredging and capping would not compromise the structural integrity of that wall. A more detailed analysis of the impact of sediment dredging on the structural integrity of the quay wall would be performed as part of the remedial design.

The production rate for pre-dredging is estimated at approximately 400 in-situ cubic yards of sediment removed per 10-hour operating day. The production rate for capping is assumed to be in the same range.

Pre-construction monitoring would include establishing baseline turbidity conditions within Zone 4 to provide a basis of comparison for subsequent construction quality control monitoring. Baseline turbidity conditions would be established at one monitoring station with a buoy-mounted analyzer. Pre-construction monitoring would also include performance of a pre-removal action bathymetric survey.

During construction, turbidity monitoring would be conducted continuously beyond the southern perimeter of the dredge area (i.e., beyond the silt curtain) with buoy-mounted analyzers to assess potential

suspension of contaminated sediment and to verify the integrity of the silt curtain. In addition, turbidity would also be monitored just inside the silt curtain with a hand-held analyzer prior to any barge movement through the curtain. Because the movement of contamination would be expected to be entirely correlated to the movement of suspended solids, turbidity monitoring data would be used to determine the potential for contaminant mobilization beyond the removal action area and the need for corrective action. For purposes of developing a removal action approach and related costs, it is assumed that construction monitoring would be implemented using two buoy-mounted continuous turbidity analyzers located inside the silt curtain and one hand-held turbidimeter inside the silt curtain.

Post-construction monitoring would include performance of a bathymetric survey to verify that the cap is properly in place. Post-dredging confirmatory sediment sampling and analysis would not be required because it is understood that pre-dredging would expose an area of contaminated sediment that would be subsequently capped.

Computations of capping and pre-dredging areas and volumes are provided in Appendix D.

Component 2: Dewatering of Dredged Sediment

The purpose of on-site dewatering would be to remove excess water entrained by the dredging process and as much additional water as can be practically expressed from the dredged sediment to make this material more suitable for transportation and off-site disposal.

As discussed in Section 3.8.6.1, it is assumed for the purpose of this FS that on-site dewatering would consist of a two-step process including passive gravity drainage of free water followed by use of dewatering additives. It is also assumed that passive gravity drainage would be performed on modified barges.

Several barges would be modified by using concrete Jersey barriers to form an enclosure within the barges and this enclosure would be lined with a geotextile material that would let water filter through but would retain sediment particles. The enclosure would have a capacity of 200 to 300 cubic yards, which would be adequate to hold and dewater 1 day's production of dredged sediment. Mixing and aerating would potentially be required to distribute wet dredged sediment and accelerate dewatering. Dredged sediment would not be completely dried, as the primary purpose of dewatering would be to drain the free water entrained by the dredging process and to recompact the sediment to its original in-situ volume and moisture content.

The rate of static sediment dewatering is unknown at this time. For the purpose of this FS, it is assumed that the above-described passive dewatering process would drain all free water and recompact the

sediment to its original in-situ volume within 1 day or less. A bench- or pilot-scale dewaterability study would be useful to determine the effectiveness and rate of dewatering and to confirm the need for additives to enhance or sufficiently complete dewatering.

When the dewatering barge is full, it would be brought to shore and the dewatered sediment would be characterized for disposal via sampling and staged into stockpiles. The proposed location of this staging area is shown on Figure 4-36. It is estimated that a total of 61 barges full of dewatered sediment would be processed over 31 operating days. A dewatering additive such as fly ash or Portland cement would be added to the dewatered sediment to adsorb any residual free water and further stabilize the material for transportation and disposal. For the purpose of this FS, it assumed that fly ash in the proportion of approximately 8 percent (by weight) would be added to the dewatered sediment prior to off-site transportation and disposal. It is also assumed that fly ash addition would result in an increase of approximately 10 percent in the volume of sediment to be disposed.

As discussed in Section 3.8.6.1, the drainage water filtering through the geotextile liner would be allowed to discharge back into the Thames River. For the purpose of this FS, it is also assumed that approximately 10 percent of the water released by the dewatering process would not readily drain and filter through the geotextile liner and might pool on top of the dewatered sediment. This dewatering fluid would be removed by pumping, containerized in appropriate holding structures (e.g., frac tank), characterized through sampling and analysis, and treated by an on-site treatment system before being discharged to the Thames River as further discussed below.

Component 3: On-Site Treatment and Discharge of Dewatering Fluid

The dewatering fluid containerized on the dewatering barge would be conveyed to an on-site water treatment system. For the purpose of developing a reasonable technical approach and costs, it was assumed that the treatment system would consist of a sediment pre-filter and liquid-phase GAC adsorption unit operating in series, with all necessary piping and instrument controls. This treatment system would remove the COCs likely to leach from dredged contaminated sediment and would allow discharge of the treated dewatering fluid to the Thames River. Alternatively, effluent could be discharged to the NSB-NLON oily water treatment system or to the sewer system to which the oily water treatment system currently discharges. However, for purposes of this FS, direct discharge to the Thames River was assumed.

Based on current projections of dredged sediment volume, it is estimated that a total volume of approximately 246,000 gallons of dewatering fluid would have to be treated and discharged. For the purpose of this FS, it is assumed that the on-site dewatering fluid treatment system would be designed for a capacity of 10,000 gallons per day (gpd) using commercially available units. The treatment system

would consist of two 50-square-foot pressure bag filter units (one operating and one stand-by) followed by two 5,000-pound liquid-phase GAC adsorption units (one operating, one stand-by). The treatment system would be operated for an estimated 31 days and would require replacement of the operating GAC unit every 4 days and of the bag elements in the operating filter every 3 days. Conceptual design calculations for this system are provided in Appendix D, and a PFD for the treatment system is shown on Figure 4-37. The on-site dewatering fluid treatment system would be located in the same area as that proposed for the on-shore staging and stabilization of dewatered sediment, as shown on Figure 4-36. The treatment system area would be secured with fencing and other controls necessary to prevent any potential direct exposure risk to NSB-NLON personnel.

Dewatering fluid treatment monitoring would consist of collecting one sample of the treatment system influent and effluent for every day of system operation and analyzing these samples for PCBs, PAHs, pesticides, metals, and total suspended solids.

Component 4: Off-Site Disposal of Dewatered Sediment

To determine the proper method of disposal, composite samples would be collected from the dewatered sediment prior to addition of fly ash at the rate of approximately one sample per barge full. These samples would be analyzed for mass PAHs, PCBs, and metallic COCs (arsenic, lead, mercury, and zinc) and TCLP arsenic, lead, and mercury.

Based on available sediment characterization data, it is anticipated that the result of these analyses would show that the mass concentrations of PAHs, PCBs, arsenic, lead, mercury, and zinc of all dewatered sediment would be greater than their respective Residential DECs (1 mg/kg, 1 mg/kg, 10 mg/kg, 400 mg/kg, 20 mg/kg, 20,000 mg/kg) but that the mass concentrations of PCBs, arsenic, lead, and zinc would be less than their respective I/C DECs (1 mg/kg, 10 mg/kg, 1,090 mg/kg, 610,000 mg/kg) and that the TCLP concentrations of arsenic, lead, and mercury would be less than their respective RCRA hazardous toxicity characteristics (5 mg/L, 5 mg/L, 0.2 mg/L). Therefore, it is also anticipated that the 13,400 cubic yards of dewatered sediment would be identified as contaminated and not requiring treatment. This sediment would be disposed at an off-site municipal solid waste landfill.

During off-site transportation of stabilized dewatered sediment, appropriate spill prevention and control measures would be taken, and DOT regulations would be followed.

Component 5: LUCs with Institutional Controls

A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to establish methods to prevent the uncontrolled disturbance of the capped area of contaminated sediment. One of

the principal controls that would be specified in the LUC RD would be procedures, such as establishment of a "Safety Zone" or "No Anchor Zone" around the capped area, to avoid cap damage as a result of maintenance dredging activities and to repair such damage if it occurs. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of the LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the ROD.

As long as access to the capped area is controlled by the Navy, these LUCs would be implemented in accordance with a post-ROD LUC RD that will be prepared by the Navy as the LUC component of the remedy, in coordination with the State, which owns the subtidal area. If the property is transferred out of federal ownership, the LUCs would be converted into deed restrictions, which would comply with State recording standards. If the property is transferred to another federal agency, the Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required. Monitoring of compliance with LUCs will occur at least yearly.

Component 6: Monitoring

A long-term sediment and surface water monitoring program would be developed and implemented to verify the continued effectiveness of the cap. For the purpose of this FS, it was assumed that sediment and surface water samples would be regularly collected from a total of six locations in and around the capped areas. The collected samples would be analyzed for the sediment COCs (PAHs, PCBs, pesticides, arsenic, lead, mercury, and zinc). Monitoring frequency would be semi-annual for the first 2 years and annual thereafter.

Reviews would be performed every 5 years to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary. These site reviews are required because this alternative would allow COCs to remain in sediment at concentrations in excess of their PRGs.

4.12.2.2 Detailed Analysis

Overall Protection of Human Health and the Environment

There are no unacceptable human health risks under CERCLA from direct exposure to contaminated sediment at the Lower Subase under the current site use scenarios. Alternative SD-3 would be protective of the environment because capping would prevent direct exposure of benthic macroinvertebrates to contaminated sediment and indirect exposure of piscivorous birds to sediment COCs through the food chain. In addition, placement of a cap would be protective because it would require the removal and off-site disposal of a significant amount (12,200 in-situ cubic yards) of contaminated sediment. LUCs would be protective of the environment because they would prevent uncapping and/or spreading of contaminated sediment as a result maintenance dredging or any other human disturbance. Monitoring would also be indirectly protective of the environment by verifying the continued effectiveness of the sediment cap. Alternative SD-3 would achieve the sediment RAOs.

Compliance with ARARs and TBCs

Alternative SD-3 would comply with chemical-, location- and action-specific ARARs and TBCs, as summarized in Tables 4-34, 4-35, and 4-36, respectively.

Long-Term Effectiveness and Permanence

Alternative SD-3 would effectively and permanently address CERCLA risks. Capping would effectively minimize exposure of ecological receptors to contaminated sediment. The pre-dredging and off-site disposal associated with cap construction would effectively and permanently remove a significant proportion of the contaminated sediment from the site. On-site liquid-phase GAC adsorption would effectively and permanently remove COCs from contaminated dewatering fluid prior to discharge to the Thames River. LUCs would effectively prevent the accidental damaging of the sediment cap and the spreading of contaminated sediment. In addition, monitoring would be an effective means of assessing the long-term integrity of the sediment cap.

Reduction of Toxicity, Mobility, or Volume through Treatment

Although the dredging and capping components of Alternative SD-3 will not reduce toxicity, mobility, and volume of contaminants through treatment, the treatment of the COCs contained in sediment dewatering fluid through on-site treatment with liquid-phase GAC adsorption will partially meet this criterion. An estimated 246,000 gallons of contaminated dewatering fluid would be treated in this manner before discharge to the Thames River.

Short-Term Effectiveness

Implementation of Alternative SD-3 could result in significant short-term risks to on-site workers from exposure to contaminated sediment during pre-dredging, cap installation, and monitoring, and more significantly during sediment dewatering, fly ash addition, and treatment of dewatering fluid. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative SD-3 could also have an adverse impact on the surrounding community as a result of dredging and off-site transportation of contaminated sediment. However, the impact of dredging would be mitigated by engineering controls (silt curtains) and perimeter water monitoring, and the impact of off-site transportation would be mitigated by adherence to spill prevention procedures and by compliance with DOT regulations.

The short-term impact of the pre-dredging and capping of Alternative SD-3 would be destructive of ecological receptors in the immediate area of remedial activities (i.e., benthic macroinvertebrate). However, placement of a cap would also create conditions favorable for the re-colonization of expanded populations of these same receptors. Impact to the surrounding environment and ecological receptors would be mitigated by engineering controls such as silt curtains that would minimize contaminant migration and by administrative controls such as the restriction of dredging operations to the period from October 1 to January 31 that corresponds to minimal ecological activity.

Alternative SD-3 could be implemented within approximately 4 months and would achieve the sediment RAOs and PRGs upon implementation.

Implementability

The technical implementability of Alternative SD-3 would be fairly difficult. Dredging and capping are well-established and well-proven technologies that can be implemented by a number of qualified contractors. However, precise dredging of a fairly steeply sloping area and subsequent placement of a cap over that same area in a congested marine environment such as the shore of Zone 4 at the Lower Subase would be technically challenging. CTDEP prefers that dredging be performed in the October to January timeframe, but dredging can also be done during other times of the year if the appropriate procedures are followed. Installation of an effective and stable cap over the dredged area would also be fairly difficult but implementable. Barge dewatering, fly ash addition, and treatment of dewatering fluid would be relatively easy to implement. Municipal solid waste landfills would be readily available for off-site disposal of the stabilized dewatered sediment. Periodic collection and analysis of sediment and surface water samples and performance of regular site inspections and five-year reviews could be readily accomplished. The resources, equipment, and materials required for all these activities are readily available.

The administrative aspects of Alternative SD-3 would be simple to implement. A construction permit issued by NSB-NLON DPW would be required for pre-dredging and cap installation and the substantive requirements of federal and State water discharge regulations would have to be met to discharge treated dewatering fluid to the Thames River. The off-site transportation and disposal of the stabilized dewatered sediment would have to be properly documented, which could be readily accomplished. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

As long as access to the capped area is controlled by the Navy, these LUCs would be implemented in accordance with a post-ROD LUC RD that will be prepared by the Navy as the LUC component of the remedy, in coordination with the State, which owns the subtidal area. If the property is transferred out of federal ownership, the LUCs would be converted into deed restrictions, which would comply with State recording standards. If the property is transferred to another federal agency, the Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required. Monitoring of compliance with LUCs will occur at least yearly.

Cost

The estimated costs for Alternative SD-3 are as follows:

Capital Cost	$5,716,000
NPW of O&M Costs	$398,000 (30 years)
NPW	$6,114,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.12.3 Alternative SD-4: Capping with Pre-Dredging to Meet RAOs, Dewatering, Off-Site Disposal of Dewatered Sediment and Dewatering Fluid, LUCs (Institutional Controls), and Monitoring

4.12.3.1 Description

Alternative SD-4 would consist of five major components: (1) capping with pre-dredging, (2) dewatering of dredged sediment, (3) off-site disposal of dewatered sediment and dewatering fluid, (4), LUCs with institutional controls, and (5) monitoring. As for Alternative SD-3, Components 1 through 4 of this

alternative only apply to Zone 4 sediment because a natural cap already exist above contaminated sediment at Outer Pier 1.

Component 1: Capping with Pre-Dredging

This component would be identical to Component 1 of Alternative SD-3.

Component 2: Dewatering of Dredged Sediment

This component would be identical to Component 2 of Alternative SD-3.

Component 3: Off-Site Disposal of Dewatered Sediment and Dewatering Fluid

Off-site disposal of dewatered sediment would be identical to that described for Component 4 of Alternative SD-3.

To characterize dewatering fluid prior to disposal, one sample would be collected for every 5,000 gallons to be disposed (i.e., one full tanker truck) and analyzed for PCBs, PAHs, pesticides, and metals. Because of the generally low solubility of the sediment COCs, it is expected that the dewatering fluid would be characterized as non-hazardous waste and would be disposed at an appropriate off-site wastewater treatment facility. An estimated 246,000 gallons of dewatering fluid would be disposed.

During off-site transportation of stabilized dewatered sediment and dewatering fluid, appropriate spill prevention and control measures would be taken, and DOT regulations would be followed.

Component 4: LUCs with Institutional Controls

This component would be identical to Component 5 of Alternative SD-3.

Component 5: Monitoring

This component would be identical to Component 6 of Alternative SD-3.

4.12.3.2 Detailed Analysis

Overall Protection of Human Health and the Environment

There are no unacceptable human health risks under CERCLA from direct exposure to contaminated sediment at the Lower Subase under the current site use scenarios. Alternative SD-4 would be protective of the environment. Capping would be protective of the environment because it would prevent direct

exposure of benthic macroinvertebrates to contaminated sediment and indirect exposure of piscivorous birds to sediment COCs through the food chain. In addition, placement of a cap would be protective because it would require the removal and off-site disposal of a significant amount (12,200 in-situ cubic yards) of contaminated sediment. LUCs would be protective of the environment because they would prevent uncapping and/or spreading of contaminated sediment as a result maintenance dredging or any other human disturbance. Monitoring would also be indirectly protective of the environment by verifying the continued effectiveness of the sediment cap. Alternative SD-4 would achieve the sediment RAOs.

Compliance with ARARs and TBCs

Alternative SD-4 would comply with chemical-, location- and action-specific ARARs and TBCs, as summarized in Tables 4-34, 4-35, and 4-36, respectively.

Long-Term Effectiveness and Permanence

Alternative SD-4 would be long-term effectively and permanently address CERCLA risks. Capping would effectively prevent exposure of ecological receptors to contaminated sediment. The pre-dredging and off-site disposal associated with cap construction would effectively and permanently remove a significant proportion of the contaminated sediment from the site. LUCs would effectively prevent the accidental damaging of the sediment cap and the spreading of contaminated sediment. In addition, monitoring would be an effective means of assessing the long-term integrity of the sediment cap.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative SD-4 would not address CERCLA risks by reducing the toxicity, mobility, and volume of sediment COCs through treatment.

Short-Term Effectiveness

Implementation of Alternative SD-4 could result in significant short-term risks to on-site workers from exposure to contaminated sediment during pre-dredging, cap installation, and monitoring, and more significantly during sediment dewatering and fly ash addition. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative SD-4 could also have an adverse impact on the surrounding community as a result of dredging and off-site transportation of contaminated sediment and dewatering fluid. However, the impact of dredging would be mitigated by engineering controls (silt curtains) and performance of perimeter water monitoring, and the impact of off-site transportation would be mitigated by adherence to spill prevention procedures and by compliance with DOT regulations.

The short-term impact of the pre-dredging and capping of Alternative SD-4 would be destructive of ecological receptors in the immediate area of remedial activities (i.e., benthic macro-invertebrate). However, placement of a cap would also create conditions favorable for the re-colonization of expanded populations of these same receptors. Impact to the surrounding environment and ecological receptors would be mitigated by engineering controls such as silt curtains that would minimize contaminant migration and by administrative controls such as the restriction of dredging operations to the period from October 1 to January 31 that corresponds to minimal ecological activity.

Alternative SD-4 could be implemented within approximately 4 months and would achieve the sediment RAOs and PRGs upon implementation.

Implementability

The technical implementability of Alternative SD-4 would be fairly difficult. Dredging and capping are well-established and well-proven technologies that can be implemented by a number of qualified contractors. However, precise dredging of a fairly steeply sloping area and subsequent placement of a cap over that same area in a congested marine environment such as the shore of Zone 4 at the Lower Subase would be technically challenging. CTDEP prefers that dredging be performed in the October to January timeframe, but dredging can also be done during other times of the year if the appropriate procedures are followed. Installation of an effective and stable cap over the dredged area would also be fairly difficult but implementable. Barge dewatering and fly ash addition would be relatively easy to implement. Municipal solid waste landfills would be readily available for off-site disposal of the stabilized dewatered sediment and dewatering fluid. Periodic collection and analysis of sediment and surface water samples and performance of regular site inspections and five-year reviews could be readily accomplished. The resources, equipment, and materials required for all these activities are readily available.

The administrative aspects of Alternative SD-4 would be simple to implement. A construction permit issued by NSB-NLON DPW would be required for pre-dredging and cap installation. The off-site transportation and disposal of the stabilized dewatered sediment and dewatering fluid would have to be properly documented, which could be readily accomplished. A LUC RD could readily be developed and implemented, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

As long as access to the capped area is controlled by the Navy, these LUCs would be implemented in accordance with a post-ROD LUC RD that will be prepared by the Navy as the LUC component of the remedy, in coordination with the State, which owns the subtidal area. If the property is transferred out of

federal ownership, the LUCs would be converted into deed restrictions, which would comply with State recording standards. If the property is transferred to another federal agency, the Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required. Monitoring of compliance with LUCs will occur at least yearly.

Cost

The estimated costs for Alternative SD-4 are as follows:

Capital Cost	$5,289,000
NPW of O&M Costs	$396,000 (30 years)
NPW	$5,685,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.12.4 Alternative SD-6: Dredging to Meet PRGs, On-Site Dewatering, On-Site Treatment and Discharge of Dewatering Fluid, and Off-Site Disposal of Dewatered Sediment

4.12.4.1 Description

Alternative SD-6 would consist of four major components: (1) dredging, (2) dewatering of dredged sediment, (3) on-site treatment and discharge of dewatering fluid, and (4) off-site disposal of dewatered sediment.

Component 1: Dredging

This component would be similar to the pre-dredging included in Component 1 of Alternative SD-3, with the difference that dredging would take place in both Zone 4 and Outer Pier 1 and that the areas and volumes of contaminated sediment to be dredged would be greater.

Areas of sediment east of the Dredge Buffer Zone with concentrations of COCs greater than PRGs and/or areas of sediment designated to be removed as part of maintenance dredging and also located east of the Dredge Buffer Zone would be dredged. Two such areas have been identified in Zone 4, as shown on Figure 4-38, and one has been identified in Outer Pier 1, as shown on Figure 4-39. The larger of the two areas of sediment to be dredged in Zone 4 comprises most of the space bounded by Pier 6 to the north and Pier 2 to the south and by the Dredge Buffer Zone to the west and the Zone 4 quay wall to the east. This area covers an estimated 70,700 square feet. The area of the Dredge Buffer Zone is 9,200 square

feet. The remaining area of contaminated sediment to be dredged in Zone 4 is triangular in shape, located immediately south of Pier 2 along the Zone 4 quay wall around sampling location TRZ4-SD-004, and covers and estimated 4,100 square feet. The area of contaminated sediment to be dredged in Outer Pier 1 is circular in shape, centered on sampling point TRP1-SD-005, and covers an estimated 13,500 square feet. Computations of areas and volumes of contaminated sediment are provided in Appendix C.

With the exception of the Dredge Buffer Zone and the 4,100 square feet area of contaminated sediment south of Pier 2, dredging would be performed to a depth of 4 to 9 feet to remove all of the contaminated and maintenance dredging sediment east of the Dredge Buffer Zone. Within the 9,200 square feet portion of the 30-foot-wide Dredge Buffer Zone that is to be dredged, dredging depth would vary from 6 feet at eastern boundary to none at the western boundary to remove the 1:5 sloped sediment remaining after previous maintenance dredging. In the 4,100 square feet area of contaminated sediment south of Pier 2, dredging depth would be limited to 6 feet because this is the maximum depth to which sediment contamination was detected in this area.

An estimated total in-situ volume of 23,000 cubic yards of contaminated sediment with an estimated solids content of 50 percent by weight would be removed using barge-mounted excavators equipped with environmental buckets. Because this dredging process would typically entrain water and would also result in a bulking of the volume of the dredged sediment, it is estimated that the total volume of the dredged material would be twice that of the in-situ sediment, or approximately 47,000 cubic yards, with an estimated solids content of 29 percent by weight.

To ensure that resuspended sediment is not released beyond the dredged areas, a 600-foot silt curtain would be deployed at the western limit Zone 4 and an 800-foot silt curtain would be deployed at the southern limit of Outer Pier 1. As may be required because of river current, weighed type curtains would be used. Monitoring would also be performed during pre-dredging operations to verify that no migration of COCs is occurring. Following dredging, confirmation samples would be collected and analyzed, as further discussed below, to verify that contaminated sediment has been adequately removed.

After confirmation sampling is complete, the dredged area extending along the Zone 4 quay wall would be backfilled with clean sediment to restore the two-in-five sloped sediment wedge that is required for structural support of that wall. Backfilling would consist of placing a 6-foot-thick layer of clean well-graded angular sand or sand and gravel on the 50-foot wide slope along the dredged frontage of the Zone 4 quay wall. Assuming a settling factor of approximately 20 percent following the placement of the backfill material, an estimated total volume of 10,300 cubic yards (13,900 tons) of backfill material would be required. For example, where 6 feet of clean fill would be required based on the dredging depth interval, and additional 18 inches of fill would be provided. The size of the area to be backfilled and the significant

depth of the water column would require precise placement of the backfill material. Therefore, it is anticipated that the backfill material would have to be placed with a barge-mounted mechanical clamshell bucket or tremie. Because of the significant lateral slope (2.5 horizontal to 1 vertical) of the area to be backfilled and to avoid excessive displacement of contaminated sediment, the backfill material would be placed in multiple lifts of 6 inches or less. A typical cross-section of the proposed Zone 4 sediment dredging area along the quay wall is shown on Figure 4-40.

For the purpose of this FS, it is assumed that the short-term decrease in the thickness of the sediment layer accumulated against the Zone 4 quay wall that would occur between dredging and backfilling would not compromise the structural integrity of the wall. A more detailed analysis of the impact of sediment dredging on the structural integrity of the quay wall would be performed as part of the remedial design.

The production rate for dredging is estimated at approximately 400 in-situ cubic yards of sediment removed per 10-hour operating day. The production rate for backfilling is assumed to be in the same range.

Computations of dredging and backfilling areas and volumes are provided in Appendix D.

Component 2: Dewatering of Dredged Sediment

This component would be similar to Component 2 of Alternative SD-3, with the difference that a greater volume of dredged sediment (47,000 cubic yards instead of 24,000 cubic yards) would be dewatered using the same barges modified to operate as passive drainage beds.

It is estimated that a total of 118 barges full of dewatered sediment would be processed over 58 operating days. Fly ash in the proportion of approximately 8 percent (by weight) would also be added to the dewatered sediment prior to off-site transportation and disposal. As for Alternative SD-3, it is assumed that fly ash would be added to the dewatered sediment at an on-shore staging area located in the Pier 1 area, as shown on Figure 4-36. Also as for Alternative SD-3, it is assumed that approximately 10 percent of the dewatering fluid, particularly any liquid that might pool on top of the dewatered sediment, would be contaminated and would have to be dealt with.

Component 3: On-Site Treatment and Discharge of Dewatering Fluid

This component would be similar to Component 3 of Alternative SD-3, with the difference that a much greater volume of contaminated dewatering fluid (471,000 gallons instead of 246,000 gallons) would be treated by a 10,000-gpd filtration and liquid-phase GAC adsorption system. The treatment system would consist of two 50-square-foot pressure bag filter units (one operating and one stand-by) followed by two

5,000-pound liquid-phase GAC adsorption units (one operating and one stand-by). This system would be operated for an estimated 58 days and, as for Alternative SD-3, the operating GAC unit would have to be replaced every 4 days, and the bag elements of the operating filter unit would have to be replaced every 3 days. Conceptual design calculations for this system are provided in Appendix D, and a PFD for the treatment system is shown on Figure 4-37. The on-site dewatering fluid treatment system would be located in the same area as that proposed for the on-shore staging and stabilization of dewatered sediment, as shown on Figure 4-36.

Dewatering fluid treatment monitoring would consist of collecting one sample of the treatment system influent and effluent for every day of system operation and analyzing these samples for PCBs, PAHs, pesticides, metals, and total suspended solids.

Component 4: Off-Site Disposal of Dewatered Sediment

This component would be similar to Component 4 of Alternative SD-3, with the difference that a larger quantity of dewatered sediment (30,000 tons instead of 15,700 tons) would be disposed off site at a municipal solid waste landfill.

During off-site transportation of stabilized dewatered sediment, appropriate spill prevention, and control measures would be taken and DOT regulations would be followed.

4.12.4.2 Detailed Analysis

Overall Protection of Human Health and the Environment

There are no unacceptable human health risks under CERCLA from direct exposure to contaminated sediment at the Lower Subase under the current site use scenario. The dredging and off-site disposal of contaminated sediment under Alternative SD-6 would be protective of the environment by removing from the site the source of unacceptable ecological risks. Alternative SD-6 would achieve the sediment RAOs.

Compliance with ARARs and TBCs

Alternative SD-6 would comply with the chemical-, location, and action-specific ARARs and TBCs, as summarized in Tables 4-34, 4-35, and 4-36, respectively.

Long-Term Effectiveness and Permanence

Alternative SD-6 would effectively and permanently address CERCLA risks. Dredging and off-site disposal of dredged sediment would effectively and permanently remove all contaminated sediment from

the site. In addition, on-site liquid-phase GAC adsorption would effectively and permanently remove COCs from contaminated dewatering fluid prior to discharge to the Thames River.

Reduction of Toxicity, Mobility, or Volume through Treatment

Although the dredging component of Alternative SD-6 will not reduce toxicity, mobility, and volume of contaminants through treatment, the treatment of the COCs contained in sediment dewatering fluid through on-site treatment with liquid-phase GAC adsorption will partially meet this criterion. An estimated 471,000 gallons of contaminated dewatering fluid would be treated in this manner before discharge to the Thames River.

Short-Term Effectiveness

Implementation of Alternative SD-6 could result in significant short-term risks to on-site workers from exposure to contaminated sediment during dredging, and more significantly during dewatering of dredged sediment, fly ash addition, and dewatering fluid treatment. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative SD-6 could also have an adverse impact on the surrounding community as a result of dredging and the off-site transportation of contaminated sediment. However, the impact from dredging would be mitigated by engineering controls (silt curtains) and perimeter water monitoring, and the impact of off-site transportation would be mitigated by adherence to spill prevention procedures and by compliance with DOT regulations.

The short-term impact of the dredging and backfilling of Alternative SD-6 would be destructive of ecological receptors in the immediate area of remedial activities (i.e., benthic macro-invertebrate). However, replacement of contaminated sediment with clean backfill material would also create conditions favorable for the re-colonization of expanded populations of these same receptors. Impact to the surrounding environment and ecological receptors would be mitigated by engineering controls such as silt curtains that would minimize contaminant migration and by administrative controls such as the restriction of dredging operations to the period from October 1 to January 31 that corresponds to minimal ecological activity.

Alternative SD-6 could be implemented within approximately 6 months and would achieve the sediment RAOs and meet the sediment PRGs upon implementation.

Implementability

The technical implementability of Alternative SD-6 would be fairly difficult, particularly in Zone 4. Dredging is a well-established and well-proven technology that can be implemented by a number of qualified

contractors. However, precise dredging of a fairly steeply sloping area in a congested marine environment such as the shore of Zone 4 at the Lower Subase would be technically challenging. CTDEP prefers that dredging be performed in the October to January timeframe, but dredging can also be done during other times of the year if the appropriate procedures are followed. Barge dewatering, fly ash addition, and on-site treatment of dewatering fluid would be relatively easy to implement. Municipal solid waste landfills would be readily available for off-site disposal of the stabilized dewatered sediment.

The administrative aspects of Alternative SD-6 would be simple to implement. A construction permit issued by NSB-NLON DPW would be required for the dredging. The off-site transportation and disposal of the dewatered sediment would have to be properly documented, which could be readily accomplished. In addition, the substantive requirements of federal and State water discharge regulations would have to be met to discharge treated dewatering fluid to the Thames River.

Cost

The estimated costs for Alternative SD-6 are as follows:

Capital Cost	$8,165,000
NPW of O&M Costs	$0
NPW	$8,165,000 (1 year)

A detailed cost estimate for this alternative is provided in Appendix E.

4.12.5 Alternative SD-7: Dredging to Meet PRGs, Dewatering, and Off-Site Disposal of Dewatered Sediment and Dewatering Fluid

4.12.5.1 Description

Alternative SD-7 would consist of three major components: (1) dredging, (2) dewatering of dredged sediment, and (3) off-site disposal of dewatered sediment and dewatering fluid.

Component 1: Dredging

This component would be identical to Component 1 of Alternative SD-6.

Component 2: Dewatering of Dredged Sediment

This component would be identical to Component 2 of Alternative SD-6.

Component 3: Off-Site Disposal of Dewatered Sediment and Dewatering Fluid

Off-site disposal of dewatered sediment would be identical to that described for Component 4 of Alternative SD-6.

Similar to Component 3 of SD-4, dewatering fluid would be characterized prior to disposal by collecting one sample for every 5,000 gallons to be disposed (i.e., one full tanker truck) and analyzing it for PCBs, PAHs, pesticides, and metals. Because of the generally low solubility of the sediment COCs, it is expected that the dewatering fluid would be characterized as non-hazardous waste and would be disposed at an appropriate wastewater treatment facility. An estimated 471,000 gallons of dewatering fluid would be disposed.

During off-site transportation of stabilized dewatered sediment and dewatering fluid, appropriate spill prevention and control measures would be taken, and DOT regulations would be followed.

4.12.5.2 Detailed Analysis

Overall Protection of Human Health and the Environment

There are no unacceptable human health risks under CERCLA from direct exposure to contaminated sediment at the Lower Subase under the current site use scenario. The dredging and off-site disposal of contaminated sediment under Alternative SD-7 would be protective by removing from the site the source of unacceptable ecological risks. Alternative SD-7 would achieve the sediment RAOs.

Compliance with ARARs and TBCs

Alternative SD-7 would comply with the chemical-, location, and action-specific ARARs and TBCs, as summarized in Tables 4-34, 4-35, and 4-36, respectively.

Long-Term Effectiveness and Permanence

Alternative SD-7 would effectively and permanently address CERCLA risks. Dredging and off-site disposal would effectively and permanently remove all contaminated sediment from the site.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative SD-7 does not reduce the toxicity, mobility, and volume of sediment COCs through treatment.

Short-Term Effectiveness

Implementation of Alternative SD-7 could result in significant short-term risks to on-site workers from exposure to contaminated sediment during dredging, and more significantly during dewatering of dredged sediment and fly ash addition. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative SD-7 could also have an adverse impact on the surrounding community as a result of dredging and off-site transportation of contaminated sediment and dewatering fluid. However, the impact from dredging would be mitigated by engineering controls (silt curtains) and perimeter water monitoring, and the impact of off-site transportation would be mitigated by adherence to spill prevention procedures and by compliance with DOT regulations.

The short-term impact of the dredging and backfilling of Alternative SD-7 would be destructive of ecological receptors in the immediate area of remedial activities (i.e., benthic macro-invertebrate). However, replacement of contaminated sediment with clean backfill material would also create conditions favorable for the re-colonization of expanded populations of these same receptors. Impact to the surrounding environment and ecological receptors would be mitigated by engineering controls such as silt curtains that would minimize contaminant migration and by administrative controls such as the restriction of dredging operations to the period from October 1 to January 31 that corresponds to minimal ecological activity.

Alternative SD-7 could be implemented within approximately 6 months and would achieve the sediment RAOs and meet the sediment PRGs upon implementation.

Implementability

The technical implementability of Alternative SD-7 would be fairly difficult, especially in Zone 4. Dredging is a well-established and well-proven technology that can be implemented by a number of qualified contractors. However, precise dredging of a fairly steeply sloping area in a congested marine environment such as the shore of Zone 4 at the Lower Subase would be technically challenging. CTDEP prefers that dredging be performed in the October to January timeframe, but dredging can also be done during other times of the year if the appropriate procedures are followed. Barge dewatering and fly ash addition would be relatively easy to implement. Municipal solid waste landfills would be readily available for off-site disposal of the stabilized dewatered sediment and dewatering fluid.

The administrative aspects of Alternative SD-7 would be simple to implement. A construction permit issued by NSB-NLON DPW would be required for the dredging. The off-site transportation and disposal

of the stabilized dewatered sediment and dewatering fluid would have to be properly documented, which could be readily accomplished.

Cost

The estimated costs for Alternative SD-7 are as follows:

Capital Cost	$7,359,000
NPW of O&M Costs	$0
NPW	$7,359,000 (1 year)

A detailed cost estimate for this alternative is provided in Appendix E.

4.13 ASSEMBLY AND DETAILED ANALYSIS OF LNAPL REMEDIAL ALTERNATIVES FOR ZONE 1

To address State petroleum concerns, the following LNAPL remedial alternatives have been developed for Zone 1 of the Lower Subase:

Alternative LN-1: Skimming, Off-Site Disposal (Incineration), LUCs (Institutional Controls), and Monitoring.

Alternative LN-2: In-Situ Treatment (Enhanced Bioremediation), LUCs (Institutional Controls), and Monitoring.

Alternative LN-1 was developed and analyzed to evaluate low-impact physical removal of LNAPL under current site use. Alternative LN-2 was developed and analyzed to evaluate the adequacy of comprehensive action to remediate both LNAPL and associated TPH-impregnated soil. Descriptions and detailed analyses of these alternatives are provided in the following sections.

4.13.1 Alternative LN-1: Skimming, Off-Site Disposal (Incineration), LUCs (Institutional Controls), and Monitoring

4.13.1.1 Description

Alternative LN-1 would consist of four major components: (1) skimming, (2) off-site disposal by incineration, (3) LUCs with institutional controls, and (4) monitoring.

Component 1: Skimming

Skimming would consist of operating passive skimmers in new wells installed within the area of LNAPL accumulation observed in the vicinity of existing well 13MW18. As illustrated on Figure 4-41, this area could cover up to approximately 9,900 square feet and hold an estimated 29,600 pounds (or 3,900 gallons) of LNAPL within its capillary (or smear) zone. Computations of surface area and volume for the Zone 1 area of LNAPL accumulation are provided in Appendix C, and computations for the estimate of the time to collect the LNAPL are provided in Appendix D. Sampling and analysis will be performed as part of the PDI to verify the estimated extent of LNAPL.

Skimmers would be installed in new 6-inch skimming wells advanced to a depth of 15 feet bgs. Assuming a skimming radius of influence (ROI) of 10 feet per well, it was estimated for the purpose of this FS that a total of 28 new skimming wells would be installed. Skimming well locations are illustrated on Figure 4-41.

As previously discussed in Section 3.11.3.1, it is assumed that passive skimmers including either a hydrocarbon capture hydrophobic filter with storage canister or an adsorbing element would first be used because the accumulation observed to date at Zone 1 has been neither very severe nor very widespread. If additional monitoring data indicate that the quantity of LNAPL present is significantly greater than originally anticipated, active skimmers would need to be considered.

Component 2: Off-Site Disposal

The LNAPL collected by the skimmers would be temporarily stored on site and periodically transported off site for disposal. For the purpose of this FS, it is assumed that the LNAPL collected under this alternative would be disposed by incineration at an off-site TSDF.

Component 3: LUCs with Institutional Controls

LUCs with institutional controls would be developed and implemented to address State petroleum concerns. A LUC RD would be prepared in accordance with the Navy's LUC Principles (DOD, 2004) to restrict the disturbance of soil and to prevent access to the water table in the vicinity of existing well 13MW18. The LUC RD would also include procedures for the performance of regular site inspections to verify continued implementation of LUCs. The areas to which the LUCs would apply would be identified and surveyed by a licensed professional surveyor. LUCs would be implemented as part of NSB-NLON's SOPA Instruction 5090.25 (current version). If ownership of NSB-NLON is transferred with contamination remaining in place, ELURs would be recorded in accordance with applicable law and the requirements of the LUC RD.

Component 4: Monitoring

An LNAPL monitoring program would be developed and implemented to evaluate long-term trends in the accumulation and movement of LNAPL. The skimming wells would be regularly checked for the presence of LNAPL, and records would be kept of the quantities of LNAPL removed from each skimming well. In addition, it was assumed for the purpose of this FS that a total of four existing Zone 1 monitoring wells located on the periphery of the area of LNAPL accumulation would be regularly checked for the presence of LNAPL to detect potential LNAPL migration. Monitoring frequency would be quarterly for the first year, semi-annual for the second and third years, and annual thereafter.

Reviews would be performed every 5 years to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary. These site reviews are required because this alternative would allow LNAPL to remain on site.

4.13.1.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative LN-1 would be protective of human health and the environment under the Connecticut petroleum regulations. Skimming would be protective because it would over time remove the current accumulation of LNAPL that could result in unacceptable human health risks through accidental exposure or that could migrate off site. LUCs would be protective by preventing unacceptable human health risk from exposure to LNAPL through unrestricted excavation. Monitoring would be protective by detecting the potential off-site migration of LNAPL. Alternative LN-1 would achieve LNAPL Remedial Goals Nos. 1 and 3 upon implementation, and LNAPL Remedial Goal No. 2 would eventually be achieved through skimming.

Long-Term Effectiveness and Permanence

Alternative LN-1 would effectively and permanently address State petroleum concerns. Skimming would effectively and permanently remove LNAPL from Zone 1. However, existing structures, including the foundation of Building 29 and Site 11 USTs, would interfere with efficient skimming and might entrap significant quantities of LNAPL, making it essentially inaccessible. LUCs that restrict disturbance of soil and prevent access to LNAPL would effectively and permanently prevent unacceptable risk from direct exposure to that LNAPL. Long-term monitoring would effectively detect potential off-site migration of LNAPL.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative LN-1 would not reduce the toxicity, mobility, or volume of LNAPL through treatment.

Short-Term Effectiveness

Implementation of Alternative LN-1 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during installation and O&M of skimming wells. However, these risks would be adequately mitigated by the wearing of appropriate PPE and compliance with site-specific health and safety procedures. Alternative LN-1 could also have a small impact on the surrounding community as a result of transportation of removed LNAPL to an off-site TSDF. This impact would be adequately mitigated by adherence to spill prevention procedures and by compliance with DOT regulations.

Alternative LN-1 could be implemented within approximately 6 months and would achieve LNAPL Remedial Goals Nos. 1 and 3 upon implementation. It is also estimated that Alternative LN-1 would remove LNAPL from Zone 1 and achieve LNAPL Remedial Goal No. 2 within an estimated 10 to 11 years. However, because Alternative LN-1 would only remove LNAPL without addressing the large quantity of soil-bound TPH associated with it, additional LNAPL might still be released beyond that time frame. LNAPL removal would be verified through monitoring

Implementability

The technical implementability of Alternative LN-1 would be relatively simple. Qualified contractors would be readily available to install skimming wells. Installation of a significant number (28) of skimming wells might interfere, at least temporarily, with the normal use of the area of Zone 1 where this would occur, especially installation of wells located within or next to existing structures. Operation of the skimming wells would not interfere with normal site use. Existing underground utilities and structures might also interfere with the desired placement of the skimming wells, particularly the previously mentioned foundation of Building 29 and Site 11 USTs. However, it was assumed that the required number of wells could be installed within the estimated area of LNAPL accumulation. A number of qualified off-site TSDFs would be available for incineration of the recovered LNAPL. Monitoring has been implemented at the Lower Subase, and additional monitoring could be performed.

The administrative aspects of Alternative LN-1 would be simple to implement. A construction permit issued by NSB-NLON DPW might be required for installation of the skimming wells. The off-site transportation and disposal of removed LNAPL would have to be properly documented. A LUC RD could readily be developed, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site

inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

Cost

The estimated costs for Alternative LN-1 are as follows:

Capital Cost	$337,000
NPW of O&M Costs	$1,543,000 (30 years)
NPW	$1,880,000 (30 years)

A detailed cost estimate for this alternative is provided in Appendix E.

4.13.2 Alternative LN-2: In-Situ Treatment (Enhanced Bioremediation), LUCs (Institutional Controls), and Monitoring

4.13.2.1 Description

Alternative LN-2 would consist of three major components: (1) In-situ enhanced bioremediation, (2) LUCs with institutional controls, and (3) monitoring.

Component 1: In-Situ Enhanced Bioremediation

This component would be similar to Component 1 of Alternative GW-3. In-situ enhanced bioremediation would consist of using the DO-IT™ process to promote the growth of indigenous microorganisms and augment the natural biodegradation of the TPH in the Zone 1 area of LNAPL accumulation. This technology would consist in injecting oxygen and specialized bacterial cultures in the area of LNAPL accumulation by recirculating a super-oxygenated and microorganism- and nutrient- amended stream of groundwater.

Based on the information provided by the technology vendor (see Appendix D), it is assumed that six extraction wells and 12 reinjection wells would be installed along the downgradient and upgradient edge of the area of LNAPL accumulation, respectively. The extraction wells would be screened within the first few feet of the water table (9 to 12 feet bgs) and each equipped with a 5-gpm submersible pump. The reinjection wells would be screened in the vadose zone (4 to 6 feet bgs). The 30-gpm recirculating groundwater stream would first be treated in an oil/water separator where any extracted LNAPL would be removed and disposed off site by incineration. The recirculating groundwater would then be processed in a SuperOx™ unit capable of delivering approximately 1,910 pounds per month of oxygen plus approximately 2,000 pounds per month of a proprietary nutrient blend (CBN™) with a 61-percent oxygen-equivalent capacity. In addition, the SuperOx™ unit would add a bacterial culture and, if required, a surfactant to the recirculating groundwater stream. It is estimated that the SuperOx™ unit would provide the oxygen or oxygen-equivalent required to aerobically biodegrade the TPH in the Zone 1 area of LNAPL accumulation within 8.5 years. A typical flow diagram of the DO-IT™ process is provided on Figure 4-20, and the proposed locations of the groundwater extraction and reinjection wells are shown on Figure 4-42. Computations of LNAPL and TPH-contaminated soil areas and volumes are provided in Appendix C. Sampling and analysis will be performed as part of the PDI to verify the estimated extent of LNAPL. Conceptual design calculations for in-situ enhanced bioremediation of LNAPL in Zone 1 are provided in Appendix D.

As discussed in Section 3.11.4.1, treatability testing would be required to verify the site-specific biodegradability of TPH and to evaluate the impact of the relatively high salinity of the Lower Subase aquifer on the aerobic biodegradation process.

Component 2: LUCs with Institutional Controls

LUCs with institutional controls would be developed and implemented to address State petroleum concerns. This component would be similar to Component 3 of Alternative LN-1 except that LUCs would only remain in place for the 8 to 10 years that are anticipated for this alternative to complete the treatment of LNAPL and LNAPL-impregnated soil.

Component 3: Monitoring

This component would be similar to Component 4 of Alternative LN-1 except that monitoring would only be performed for the 8 to 10 years that are anticipated for this alternative to complete the removal the LNAPL and soil-bound TPH associated with that LNAPL.

4.13.2.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative LN-2 would be protective of human health and the environment under the Connecticut petroleum regulations. In-situ enhanced bioremediation of the Zone 1 LNAPL and associated TPH-contaminated soil would be protective because it would actively remove LNAPL that could result in unacceptable human health risks through accidental exposure or that might migrate off site. LUCs would be protective because they would prevent the possibility of unacceptable human health risks from exposure to LNAPL through unrestricted excavation. Monitoring would be protective because it would assess the progress of in-situ bioremediation and also because it would detect the potential migration of TPH to the Thames River, which would allow the prevention of possible unacceptable human health and ecological risks. Alternative LN-2 would achieve the LNAPL Remedial Goals.

Long-Term Effectiveness and Permanence

Alternative LN-2 would effectively and permanently address State petroleum concerns. In-situ enhanced bioremediation should effectively and permanently remove LNAPL from Zone 1 and significantly reduce the volume of TPH-contaminated soil within that zone. However, existing structures, including the foundation of Building 29 and Site 11 USTs, would interfere with efficient recirculation and dispersion of oxygen and nutrients and might create a dead zone where no bioremediation would occur. In addition, the site-specific effectiveness of the proposed DO-IT™ process would have to be verified through treatability testing to verify the site-specific biodegradability of TPH and to assess the impact of the relatively high salinity of the Lower Subase aquifer on the aerobic biodegradation process. LUCs that restrict disturbance of soil and prevent access to LNAPL would effectively and permanently prevent unacceptable risk from direct exposure to that LNAPL. Long-term monitoring would effectively detect potential off-site migration of LNAPL.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative LN-2 would reduce the toxicity, mobility, and volume of LNAPL through enhanced bioremediation. An estimated 29,600 pounds (or 3,900 gallons) of LNAPL and an estimated 91,700 pounds of associated soil-bound TPH would be permanently and irreversibly removed from Zone 1 by this alternative.

Short-Term Effectiveness

Implementation of Alternative LN-2 could result in moderate short-term risks to on-site workers as a result of exposure to contamination during installation and O&M of the DO-IT™ SuperOx™ system and as a

result of monitoring. However, these risks would be adequately mitigated by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures. Alternative LN-2 would also not adversely impact the surrounding community or the environment.

Alternative LN-2 could be implemented within approximately 1 year and would achieve LNAPL Remedial Goals Nos. 1 and 3 upon implementation. Based on technology vendor information, Alternative LN-2 is expected to complete the removal of LNAPL and achieve LNAPL Remedial Goal No. 2 within 8 to 10 years.

Implementability

Alternative LN-2 would be relatively easy to implement. In-situ enhanced bioremediation services are available from a number of qualified contractors; however, the proposed DO-IT™ process is only available from ETEC, LLC. Installation of a significant number (18) of groundwater extraction and reinjection wells might interfere, at least temporarily, with the normal use of the area of Zone 1 where this would occur. In addition, existing structures and underground obstacles might prevent the optimum positioning of a few of these wells, particularly the previously mentioned foundation of Building 29 and Site 11 USTs. Treatability testing would have to be performed to verify site-specific effectiveness and to confirm the design parameters for the DO-IT™ process. A number of monitoring events have been implemented at the Lower Subase, and additional monitoring could be performed.

The administrative aspects of Alternative LN-2 would be simple to implement. A LUC RD would be easy to prepare, and a majority of the LUCs could be implemented through a survey and addendum to existing NSB-NLON SOPA Instruction 5090.25 (current version). Performance of regular site inspections to verify enforcement of the LUCs and of five-year reviews to assess the continued effectiveness of the remedy could be readily accomplished. A construction permit issued by NSB-NLON DPW would be required for this alternative.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

Cost

The estimated costs for Alternative LN-2 are as follows:

Capital Cost	$713,000
NPW of O&M Costs	$1,565,000 (10 years)
NPW	$2,278,000 (10 years)

Detailed cost estimates for this alternative are provided in Appendix E.

TABLE 4-1

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.1, S-2.1, S-3.1, S-4.1, S-5.1, S-6.1, AND S-7.1: NO ACTION
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Cancer Slope Factors (CSFs)	United States Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) and others	To Be Considered (TBC)	These are guidance values used in risk assessment to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Would not comply. The No Action alternatives would not maintain building foundations and paved areas, or regulate the disturbance of contaminated soil, or prevent hypothetical future residential development, either one of which could result in unacceptable carcinogenic risks. In addition, No Action would not warn of potential migration of soil chemicals of concern (COCs) to groundwater which could also result in unacceptable risk from exposure.
Reference Doses (RfDs)	EPA IRIS and others	TBC	These are guidance values used in risk assessment to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants.	Would not comply. The No Action alternatives would not maintain building foundations and paved areas, or regulate the disturbance of contaminated soil, or prevent hypothetical future residential development, either one of which could result in unacceptable non-carcinogenic risks. In addition, No Action would not warn of potential migration of soil COCs to groundwater which could also result in unacceptable risk from exposure.
Guidelines for Carcinogen Risk Assessment	EPA/630/P-03/001F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would not comply. The No Action alternatives would not maintain building foundations and paved areas, or regulate the disturbance of contaminated soil, or prevent hypothetical future residential development, either one of which could result in unacceptable carcinogenic risks. In addition, No Action would not warn of potential migration of soil COCs to groundwater which could also result in unacceptable risk from exposure.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	EPA/630/R-03/003F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would not comply. The No Action alternatives would not maintain building foundations and paved areas, or regulate the disturbance of contaminated soil, or prevent hypothetical future residential development, either one of which could result in unacceptable carcinogenic risks to children. In addition, No Action would not warn of potential migration of soil COCs to groundwater which could also result in unacceptable risk from exposure.

TABLE 4-1

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.1, S-2.1, S-3.1, S-4.1, S-5.1, S-6.1, AND S-7.1: NO ACTION
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL (continued)				
Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil	EPA-540-R-03-001, OSWER Dir #9285.7-54 (January 2003)	TBC	EPA guidance for evaluating the risks posed by lead in soil.	Would not comply. The No Action alternatives would not meet this standard because potential lead risk would not be addressed.
STATE OF CONNECTICUT				
Remediation Standard Regulations (RSRs)	Connecticut General Statutes (CGS) §22a-133k; Regulations of Connecticut State Agencies (RCSA) §22a-133k - 1 through 3	Applicable	These regulations establish Direct Exposure Criteria (DECs) and Pollutant Mobility Criteria (PMCs) for contaminated soil. Particularly, §22a-133k-2(c)(2)(E) allows for the development and use of Alternative PMCs for soil overlying groundwater classified as GB. These Alternative PMCs are equal to the GA PMCs multiplied by a site-specific dilution factor (DF) which is developed based on site-specific hydrogeologic characteristics.	Would not comply. The No Action alternatives would not remedy current exceedances of I/C DECs and PMCs. In addition, the No Action alternatives would not prevent hypothetical future residential development which would result in exceedances of Residential DECs.

TABLE 4-2

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.2, S-2.2, S-3.2, S-4.2, S-5.2, S-6.2, AND S-7.2: LUCs (ENGINEERING AND INSTITUTIONAL) AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Cancer Slope Factors (CSFs)	United States Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) and others	To Be Considered (TBC)	These are guidance values used in risk assessment to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Would comply. The land use controls (LUCs) of Alternatives S-1.2, S-2.2, S-3.2, S-4.2, S-5.2, S-6.2, and S-7.2 would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable industrial/ commercial (I/C) carcinogenic risks. In addition, the monitoring of these same alternatives would warn of potential migration of soil chemicals of concern (COCs) to groundwater, which would also minimize unacceptable risks.
Reference Doses (RfDs)	EPA IRIS and others	TBC	These are guidance values used in risk assessment to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants.	Would comply. The LUCs of Alternatives S-1.2, S-2.2, S-3.2, S-4.2, S-5.2, S-6.2, and S-7.2 would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable I/C non-carcinogenic risks. In addition, the monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.
Guidelines for Carcinogen Risk Assessment	EPA/630/P-03/001F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would comply. The LUCs of Alternatives S-1.2, S-2.2, S-3.2, S-4.2, S-5.2, S-6.2, and S-7.2 would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable I/C carcinogenic risks. In addition, the monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.

TABLE 4-2

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.2, S-2.2, S-3.2, S-4.2, S-5.2, S-6.2, AND S-7.2: LUCs (ENGINEERING AND INSTITUTIONAL) AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL (continued)				
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	EPA/630/R-03/003F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would comply. The LUCs of Alternatives S-1.2, S-2.2, S-3.2, S-4.2, S-5.2, S-6.2, and S-7.2 would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable I/C carcinogenic risks to children. In addition, the monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks to children.
Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil	EPA-540-R-03-001, OSWER Dir #9285.7-54 (January 2003)	TBC	EPA guidance for evaluating the risks posed by lead in soil.	Would comply. The LUCs of Alternatives S-1.2, S-2.2, S-3.2, S-4.2, S-5.2, S-6.2, and S-7.2 would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risk from exposure to lead contaminated soil. In addition, the monitoring of these same alternatives would warn of potential migration of lead from soil to groundwater, which would also minimize unacceptable risks.

TABLE 4-2

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.2, S-2.2, S-3.2, S-4.2, S-5.2, S-6.2, AND S-7.2: LUCs (ENGINEERING AND INSTITUTIONAL) AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT				
Remediation Standard Regulations (RSRs)	Connecticut General Statutes (CGS) §22a-133k; Regulations of Connecticut State Agencies (RCSA) §22a-133k - 1 through 3	Applicable	These regulations establish Direct Exposure Criteria (DECs) and Pollutant Mobility Criteria (PMCs) for contaminated soil. Particularly, §22a-133k-2(c)(2)(E) allows for the development and use of Alternative PMCs for soil overlying groundwater classified as GB. These Alternative PMCs are equal to the GA PMCs multiplied by a site-specific dilution factor (DF) which is developed based on site-specific hydrogeologic characteristics.	Alternatives S-1.2, S-2.2, S-3.2, S-4.2, S-5.2, S-6.2, and S-7.2 would not fully comply with the DECs and PMCs of these regulations because some of the soil with concentrations greater than the PRGs cannot be classified as inaccessible or environmentally isolated. However, the LUCs of these alternatives would minimize risks from these exceedances and prevent even greater risks from residential development. In addition, the groundwater monitoring from these alternatives would warn of potential migration of soil COCs to groundwater. The cover system will be established, monitored and maintained in compliance with these standards.

TABLE 4-3

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.2, S-2.2, S-3.2, S-4.2, AND S-7.2: LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Fish and Wildlife Coordination Act	16 USC Part 661 *et. seq.*, 40 CFR 122	Applicable	Protects fish and wildlife when actions at the site would result in the control or structural modification of a natural stream, body of water, wetlands, floodplain, or flood-prone areas. The statute requires federal agencies to take into account the effects of remedial actions and prevent loss or damage to resources.	Would comply. The groundwater monitoring of Alternatives S-1.2, S-2.2, S-3.2, S-4.2, and S-7.2 would provide adequate warning of the potential migration of soil chemicals of concern (COCs) to groundwater and surface water. Federal resource agencies would be consulted to prevent, mitigate, or compensate for loss of fish and wildlife.
Coastal Zone Management Act	16 USC Parts 1451 *et. seq.*	Applicable	Requires that any actions that affect a land or water use or water resource of the coastal zone must be conducted in a manner consistent to the maximum extent practical with enforceable policies of state-approved management programs.	Would comply. The monitoring activities and establishment and long-term maintenance of the cover system in Alternatives S-1.2, S-2.2, S-3.2, S-4.2, and S-7.2 would comply with the substantive requirements of this act.
Floodplain Management and Protection of Wetlands	44 CFR 9	Relevant and appropriate	FEMA regulations that set forth the policy, procedure and responsibilities to implement and enforce Executive Order 11988 Floodplain Management and Executive Order 11990, Protection of Wetlands.	Would comply. The monitoring activities and establishment and long-term maintenance of the cover system in Alternatives S-1.2, S-2.2, S-3.2, S-4.2, and S-7.2 will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.
STATE OF CONNECTICUT				
Coastal Management Act	Regulations of Connecticut State Agencies (RCSA) §22a-90 to 112	Applicable	The sites are in a coastal zone management area. Therefore, requirements for site planning must include approval of activities within the coastal zone to minimize project impacts to this area.	Would comply. The monitoring activities and establishment and long-term maintenance of the cover system in Alternatives S-1.2, S-2.2, S-3.2, S-4.2, and S-7.2 would comply with the substantive requirements of this act.
Tidal Wetlands and Watercourses	RCSA §22a-30-1 through 17	Applicable	These rules regulate all activities within or affecting tidal wetlands and watercourses.	Would comply. The monitoring activities and establishment and long-term maintenance of the cover system in Alternatives S-1.2, S-2.2, S-3.2, S-4.2, and S-7.2 would be managed to prevent erosion and other disturbance to tidal wetlands and the Thames River.
Flood Management Regulations	RCSA 25-68h-1 through 25-68h-3	Relevant and Appropriate	These regulations govern State activities in floodplains to minimize flood risk and prevent flood hazards. Also addresses stormwater runoff.	Would comply. The monitoring activities and establishment and long-term maintenance of the cover system in Alternatives S-1.2, S-2.2, S-3.2, S-4.2, and S-7.2 would consider the potential for disturbance of floodplains. Any work in floodplains would comply with the substantive provisions of the

TABLE 4-3

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.2, S-2.2, S-3.2, S-4.2, AND S-7.2: LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
				regulations.
STATE OF CONNECTICUT (Continued)				
Connecticut Endangered Species Act	CGS § 26-303 thru 314	Applicable	Remedial actions may not jeopardize the continued existence of state-listed endangered or threatened species, or adversely modify or destroy their critical habitat.	Would comply. The monitoring activities and establishment and long-term maintenance of the cover system in Alternatives S-1.2, S-2.2, S-3.2, S-4.2, and S-7.2 would not disturb aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon and would address risks posed by potential migration of soil COCs to the Thames River.

TABLE 4-4

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.2, S-2.2, S-3.2, S-4.2, AND S-7.2: LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis	Evaluation of Alternative Compliance with ARAR
FEDERAL				
CWA, Section 402, National Pollution Discharge Elimination System (NPDES)	USC 1342; 40 CFR 122 through 125	Applicable	These standards govern point source discharges of pollutants to surface water. Includes stormwater requirements for construction projects that disturb over one acre.	The stormwater standards under these regulations will be met during any establishment or maintenance of the cover system.
Clean Air Act (CAA), National Emissions Standards for Hazardous Air Pollutants (NESHAPs)	42 USC §12(b)(1); 40 CFR Part 61	Applicable	The regulations establish emissions standards for 189 hazardous air pollutants. Standards set for dust control and other release sources.	Activities during the establishment or maintenance of the cover system that would generate dust and air pollutants would comply with these regulations.
STATE OF CONNECTICUT				
Hazardous Waste Management: Generator and Handler Requirements, Listing and Identification	Regulations of Connecticut State Agencies (RCSA) §22a-449(c) 100-101	Applicable	Connecticut is delegated to administer the Federal Resource Conservation and Recovery Act (RCRA) statute through its state regulations. These sections establish standards for listing and identification of hazardous waste. The standards of 40 Code of Federal Regulations (CFR) 260-261 are incorporated by reference	Would comply. No significant excavation would be part of the monitoring and establishment and long-term maintenance of the cover system of Alternatives S-1.2, S-2.2, S-3.2, S-4.2, and S-7.2. However, excavated soil would be tested and any soil identified as hazardous would be managed in accordance with these regulations.
Hazardous Waste Management: Generator Standards	RCSA § 22a-449(c)-102	Applicable	This section establishes standards for various classes of generators. The standards of 40 CFR 262 are incorporated by reference.	Would comply. Any hazardous waste that would be generated from the monitoring activities and establishment and long-term maintenance of the cover system of Alternatives S-1.2, S-2.2, S-3.2, S-4.2, and S-7.2 would be handled and disposed in compliance with these standards.
Water Quality Standards	Regulations promulgated under Connecticut General Statutes (CGS) §22a-426	Applicable	Connecticut's Water Quality Standards establish specific numeric criteria, designated uses, and anti-degradation policies for groundwater and surface water. Groundwater at the site is classified under these regulations as GB. Includes stormwater requirements for construction projects that disturb over one acre.	Would comply. The long-term groundwater monitoring and establishment and long-term maintenance of the cover system of Alternatives S-1.2, S-2.2, S-3.2, S-4.2, and S-7.2 would ensure that groundwater quality standards for GB groundwater would be maintained outside of the compliance zone for the waste management area. Monitoring would also ensure that stormwater and groundwater standards would be met.

TABLE 4-4

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.2, S-2.2, S-3.2, S-4.2, AND S-7.2: LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT (Continued)				
Air Pollution Control	RCSA §22a-174 1-20	Applicable	These regulations pertain to construction and operation of specified types of emission sources and contain emission standards that must be met. Pollutant abatement controls may be required. Specific standards pertain to fugitive dust (18b).	Would comply. The monitoring activities and establishment and long-term maintenance of the cover system of Alternatives S-1.2, S-2.2, S-3.2, S-4.2, and S-7.2 would be performed so as to minimize fugitive emissions and would comply with the substantive requirements of these regulations. However, under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), actual permits would not be required.
Guidelines for Soil Erosion and Sediment Control	Connecticut Council on Soil and Water Conservation	To Be Considered (TBC)	Technical and administrative guidance for development, adoption and implementation of erosion and sediment control program.	Would comply. No significant excavation would be part of the monitoring and establishment and long-term maintenance of the cover system of Alternatives S-1.2, S-2.2, S-3.2, S-4.2, and S-7.2. Erosion and sedimentation control measures would be implemented as required.

TABLE 4-5

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.3, S-5.3, AND S-6.3
IN-SITU TREATMENT (ENHANCED BIOREMEDIATION) TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Cancer Slope Factors (CSFs)	United States Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) and others	To Be Considered (TBC)	These are guidance values used in risk assessment to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Would comply. Alternatives S-1.3, S-5.3, and S-6.3 would include in-situ enhanced bioremediation which would remove chemicals of concern (COCs) that could contribute to unacceptable industrial/ commercial (I/C) carcinogenic risks and migrate to groundwater. These alternatives would also include land use controls (LUCs) that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.
Reference Doses (RfDs)	EPA IRIS and others	TBC	These are guidance values used in risk assessment to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants.	Would comply. Alternatives S-1.3, S-5.3, and S-6.3 would include in-situ enhanced bioremediation which would remove COCs that could contribute in unacceptable I/C non-carcinogenic risks and migrate to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.

TABLE 4-5

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.3, S-5.3, AND S-6.3
IN-SITU TREATMENT (ENHANCED BIOREMEDIATION) TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL (continued)				
Guidelines for Carcinogen Risk Assessment	EPA/630/P-03/001F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would comply. Alternatives S-1.3, S-5.3, and S-6.3 would include in-situ enhanced bioremediation which would remove COCs that could contribute to unacceptable I/C carcinogenic risks and migrate to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	EPA/630/R-03/003F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would comply. Alternatives S-1.3, S-5.3, and S-6.3 would include in-situ enhanced bioremediation which would remove COCs that could contribute to unacceptable I/C carcinogenic risks and migrate to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.

TABLE 4-5

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.3, S-5.3, AND S-6.3
IN-SITU TREATMENT (ENHANCED BIOREMEDIATION) TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL (continued)				
Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil	EPA-540-R-03-001, OSWER Dir #9285.7-54 (January 2003)	TBC	EPA guidance for evaluating the risks posed by lead in soil.	Would comply. Alternatives S-1.3, S-5.3, and S-6.3 would include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks from exposure to lead contaminated soil. The monitoring of these same alternatives would also warn of potential migration of lead from soil to groundwater, which would also minimize unacceptable risks.
STATE OF CONNECTICUT				
Remediation Standard Regulations (RSRs)	Connecticut General Statutes (CGS) §22a-133k; Regulations of Connecticut State Agencies (RCSA) §22a-133k - 1 through 3 (Appendices A and B)	Applicable	These regulations establish Direct Exposure Criteria (DECs) and Pollutant Mobility Criteria (PMCs) for contaminated soil. Particularly, §22a-133k-2(c)(2)(E) allows for the development and use of Alternative PMCs for soil overlying groundwater classified as GB. These Alternative PMCs are equal to the GA PMCs multiplied by a site-specific dilution factor (DF) which is developed based on site-specific hydrogeologic characteristics.	Would comply. Alternatives S-1.3, S-5.3 and S-6.3 would include in-situ enhanced bioremediation which would remedy current exceedances of I/C DECs and PMCs. These alternatives would also include LUCs which would prevent risk from exposure under residential site use and monitoring which would warn of the potential migration of soil COCs to groundwater.

TABLE 4-6

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVE S-1.3
IN-SITU TREATMENT (ENHANCED BIOREMEDIATION) TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Fish and Wildlife Coordination Act	16 USC Part 661 *et. seq.*, 40 CFR 122	Applicable	Protects fish and wildlife when actions at the site would result in the control or structural modification of a natural stream, body of water, wetlands, floodplain, or flood-prone areas. The statute requires federal agencies to take into account the effects of remedial actions and prevent loss or damage to resources.	Would comply. The in-situ enhanced bioremediation of Alternative S-1.3 would remove soil chemical of concern (COCs) and prevent their potential migration to groundwater or surface water which could eventually impact fish and wildlife in the Thames River. In addition, the monitoring of these alternatives would provide warning of the potential migration of COCs from soil to groundwater and surface water. Federal resource agencies would be consulted to prevent, mitigate, or compensate for loss of fish and wildlife.
Coastal Zone Management Act	16 USC Parts 1451 *et. seq*.	Applicable	Requires that any actions that affect a land or water use or water resource of the coastal zone must be conducted in a manner consistent to the maximum extent practical with enforceable policies of state-approved management programs.	Would comply. The in-situ enhanced bioremediation and monitoring activities of Alternative S-1.3 would comply with the substantive requirements of this act.
Floodplain Management and Protection of Wetlands	44 CFR 9	Relevant and appropriate	FEMA regulations that set forth the policy, procedure and responsibilities to implement and enforce Executive Order 11988 Floodplain Management and Executive Order 11990, Protection of Wetlands.	Would comply. The in-situ enhanced bioremediation of Alternative S-1.3 will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.
STATE OF CONNECTICUT				
Connecticut Coastal Management Act	Regulations of Connecticut State Agencies (RCSA) §22a-90 to 112	Applicable	This act requires planning approval of activities within the coastal zone to minimize project impacts to these areas.	Would comply. The in-situ enhanced bioremediation and monitoring activities of Alternative S-1.3 would comply with the substantive requirements of this act.
Tidal Wetlands and Watercourses	RCSA §22a-30-1 through 17	Applicable	These rules regulate all activities within or affecting tidal wetlands and watercourses.	Would comply. The in-situ enhanced bioremediation and monitoring activities of Alternative S-1.3 would be managed to prevent erosion and other disturbance to tidal wetlands.
Flood Management Regulations	(RCSA 25-68h-1 through 25-68h-3)	Relevant and Appropriate	These regulations address activities in flood plains to minimize flood risk and prevent flood hazards. Also addresses stormwater runoff.	Would comply. The in-situ enhanced bioremediation and monitoring activities of Alternative S-1.3 would consider the potential for disturbance of floodplains. Any work in flood plains would comply with the substantive provisions of the regulations.

TABLE 4-6

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVE S-1.3
IN-SITU TREATMENT (ENHANCED BIOREMEDIATION) TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT (continued)				
Connecticut Endangered Species Act	CGS §26-303 through 314	Applicable	Remedial actions may not jeopardize the continued existence of state-listed endangered or threatened species, or adversely modify or destroy their critical habitat.	Would comply. The in-situ enhanced bioremediation and monitoring activities of Alternative S-1.3 would not disturb aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon and would address risks posed by potential migration of soil COCs to the Thames River.

TABLE 4-7

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVE S-1.3
IN-SITU TREATMENT (BIOREMEDIATION) TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis	Evaluation of Alternative Compliance with ARAR
FEDERAL				
RCRA, Interim Status TSDF Standards, Chemical, Physical and Biological Treatment	40 CFR § 265.401(b)	Relevant and Appropriate	Treatment reagents must not be placed in the treatment process or equipment if they could cause the treatment process or equipment to rupture, leak, corrode, or otherwise fail before the end of its intended life. Inspections are required to make sure treatment process is operating correctly.	Would comply. No reagents would be used in the in-situ bioremediation treatment of Alternative S-1.3 that could adversely affect the integrity of the system. In addition, inspections would be performed to ensure the treatment system is operating correctly.
CWA, Section 402, National Pollution Discharge Elimination System (NPDES)	USC 1342; 40 CFR 122 through 125	Applicable	These standards govern point source discharges of pollutants to surface water. Includes stormwater requirements for construction projects that disturb over one acre.	Would comply. Any construction activities during implementation of Alternative S-1.3 would be performed in accordance with the stormwater requirements of these standards.
STATE OF CONNECTICUT				
Hazardous Waste Management: Generator and Handler Requirements, Listing and Identification	Regulations of Connecticut State Agencies (RCSA) § 22a-449(c) 100-101	Applicable	Connecticut is delegated to administer the federal Resource Conservation and Recovery Act (RCRA) statute through its state regulations. These sections establish standards for listing and identification of hazardous waste. The standards of 40 Code of Federal Regulations (CFR) 260-261 are incorporated by reference	Would comply. Soil excavated as part of the in-situ bioremediation and monitoring of Alternative S-1.3 would be tested. Any soil identified as hazardous would be managed in accordance with these regulations. Confirmatory sampling would determine whether any soil with hazardous characteristic is left in place following treatment.
Hazardous Waste Management: Generator Standards	RCSA§ 22a-449(c)-102	Applicable	This section establishes standards for various classes of generators. The standards of 40 CFR 262 are incorporated by reference.	Would comply. Any hazardous waste that would be generated from the in-situ bioremediation and monitoring activities of Alternative S-1.3 would be handled and disposed in compliance with these standards.
Water Quality Standards	Regulations Promulgated under Connecticut General Statutes (CGS) §22a-426	Applicable	Connecticut's Water Quality Standards establish specific numeric criteria, designated uses, and anti-degradation policies for groundwater and surface water. Groundwater at the site is classified under these regulations as GB. Includes stormwater requirements for construction projects that disturb over one acre.	Would comply. The in-situ bioremediation and long-term groundwater monitoring of Alternative S-1.3 would ensure that groundwater quality standards for GB groundwater would be maintained. Monitoring would ensure that stormwater and groundwater standards were being met.

TABLE 4-7

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVE S-1.3
IN-SITU TREATMENT (BIOREMEDIATION) TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT (continued)				
Air Pollution Control	RCSA §22a-174 1-20	Applicable	These regulations pertain to construction and operation of specified types of emission sources and contain emission standards that must be met. Pollutant abatement controls may be required. Specific standards pertain to fugitive dust (18b).	Would comply. The in-situ bioremediation and monitoring activities of Alternative S-1.3 would be performed so as to minimize fugitive emissions and would comply with the substantive requirements of these regulations.
Water Pollution Control	RCSA §22a-430-3 and 4	Applicable	These regulations pertain to any chemical discharge to groundwater. A general permit is required for any chemical discharge to groundwater.	Would comply. The in-situ bioremediation and monitoring activities of Alternative S-1.3 would be performed in a manner that would meet the substantive environmental criteria contained in these regulations.
Connecticut Guidelines for Soil Erosion and Sediment Control	Connecticut Council on Soil and Water Conservation	To Be Considered (TBC)	Technical and administrative guidance for development, adoption and implementation of erosion and sediment control program.	Would comply. Any excavation activities associated with the in-situ bioremediation and monitoring of Alternative S-1.3 would include an appropriate erosion and sedimentation control program that would comply with this guidance.
Underground Injection Control	RCSA § 22a-430-3, 4, and 8	Applicable	These regulations address the discharge of wastes, chemicals or other substances into the subsurface.	The subsurface injection of chemical substances of Alternative S-1.3 for in-situ remediation would comply with these regulations.

TABLE 4-8

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.4, S-2.5, S-3.5, S-4.5, S-5.4, S-6.4, AND S-7.5
EXCAVATION TO MEET I/C PRGs, OFF-SITE TREATMENT AND DISPOSAL, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Cancer Slope Factors (CSFs)	United States Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) and others	To Be Considered (TBC)	These are guidance values used in risk assessment to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Would comply. Alternatives S-1.4, S-2.5, S-3.5, S-4.5, S-5.4, S-6.4, and S-7.5 would include excavation and off-site treatment and disposal of soil that could result in unacceptable industrial/commercial (I/C) carcinogenic risks and contribute to the migration of chemicals of concern (COCs) to groundwater. These alternatives would also include land use controls (LUCs) that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.
Reference Doses (RfDs)	EPA IRIS and others	TBC	These are guidance values used in risk assessment to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants.	Would comply. Alternatives S-1.4, S-2.5, S-3.5, S-4.5, S-5.4, S-6.4, and S-7.5 would include excavation and off-site treatment and disposal of soil that could result in unacceptable I/C non-carcinogenic risks and contribute to the migration of COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.

TABLE 4-8

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.4, S-2.5, S-3.5, S-4.5, S-5.4, S-6.4, AND S-7.5
EXCAVATION TO MEET I/C PRGs, OFF-SITE TREATMENT AND DISPOSAL, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL (continued)				
Guidelines for Carcinogen Risk Assessment	EPA/630/P-03/001F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would comply. Alternatives S-1.4, S-2.5, S-3.5, S-4.5, S-5.4, S-6.4, and S-7.5 would include excavation and off-site treatment and disposal of soil that could result in unacceptable I/C carcinogenic risks and contribute to the migration of COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	EPA/630/R-03/003F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would comply. Alternatives S-1.4, S-2.5, S-3.5, S-4.5, S-5.4, S-6.4, and S-7.5 would include excavation and off-site treatment and disposal of soil that could result in unacceptable I/C carcinogenic risks and contribute to the migration of COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.

TABLE 4-8

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.4, S-2.5, S-3.5, S-4.5, S-5.4, S-6.4, AND S-7.5
EXCAVATION TO MEET I/C PRGs, OFF-SITE TREATMENT AND DISPOSAL, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL (continued)				
Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil	EPA-540-R-03-001, OSWER Dir #9285.7-54 (January 2003)	TBC	EPA guidance for evaluating the risks posed by lead in soil.	Would comply. Alternatives S-1.4, S-2.5, S-3.5, S-4.5, S-5.4, S-6.4, and S-7.5 would meet this standard because potential lead risk from adult exposure would be addressed through excavation and off-site treatment and disposal of all lead-contaminated media exceeding risk levels. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks from exposure to lead contaminated soil. The monitoring of these same alternatives would also warn of potential migration of lead from soil to groundwater, which would also minimize unacceptable risks.
STATE OF CONNECTICUT				
Remediation Standard Regulations (RSRs)	Connecticut General Statutes (CGS) §22a-133k; Regulations of Connecticut State Agencies (RCSA) §22a-133k - 1 through 3 (Appendices A and B)	Applicable	These regulations establish Direct Exposure Criteria (DECs) and Pollutant Mobility Criteria (PMCs) for contaminated soil. Particularly, §22a-133k-2(c)(2)(E) allows for the development and use of Alternative PMCs for soil overlying groundwater classified as GB. These Alternative PMCs are equal to the GA PMCs multiplied by a site-specific dilution factor (DF) which is developed based on site-specific hydrogeologic characteristics.	Would comply. Alternatives S-1.4, S-2.5, S-3.5, S-4.5, S-5.4, S-6.4, and S-7.5 would include excavation and off-site treatment and disposal which would remedy current exceedances of I/C DECs and PMCs. These alternatives would also include LUCs which would prevent risk from exposure under residential site use and monitoring which would warn of the potential migration of soil COCs to groundwater.

TABLE 4-9

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.4, S-2.5, S-3.5, S-4.5, AND S-7.5
EXCAVATION TO MEET I/C PRGs, OFF-SITE TREATMENT AND DISPOSAL, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Fish and Wildlife Coordination Act	16 USC Part 661 *et. seq.*, 40 CFR 122	Applicable	Protects fish and wildlife when actions at the site would result in the control or structural modification of a natural stream, body of water, wetlands, floodplain, or flood-prone areas. The statute requires federal agencies to take into account the effects of remedial actions and prevent loss or damage to resources.	Would comply. The excavation and off-site treatment and disposal of Alternatives S-1.4, S-2.5, S-3.5, S-4.5, and S-7.5 would remove soil chemical of concern (COCs) and prevent their potential migration to groundwater or surface water which could eventually impact fish and wildlife in the Thames River. In addition, the monitoring of these alternatives would provide warning of the potential migration of COCs from soil to groundwater and surface water. Federal resource agencies would be consulted to prevent, mitigate, or compensate for loss of fish and wildlife.
Coastal Zone Management Act	16 USC Parts 1451 *et. seq*.	Applicable	Requires that any actions that affect a land or water use or water resource of the coastal zone must be conducted in a manner consistent to the maximum extent practical with enforceable policies of state-approved management programs.	Would comply. The excavation, off-site treatment and disposal, and monitoring activities of Alternatives S-1.4, S-2.5, S-3.5, S-4.5, and S-7.5 would comply with the substantive requirements of this act.
Floodplain Management and Protection of Wetlands	44 CFR 9	Relevant and appropriate	FEMA regulations that set forth the policy, procedure and responsibilities to implement and enforce Executive Order 11988 Floodplain Management and Executive Order 11990, Protection of Wetlands.	Would comply. The excavation and off-site treatment and disposal of Alternatives S-1.4, S-2.5, S-3.5, S-4.5, and S-7.5 will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.
STATE OF CONNECTICUT				
Connecticut Coastal Management Act	Regulations of Connecticut State Agencies (RCSA) §22a-90 to 112	Applicable	The sites are in a coastal zone management area; therefore, requirements for site planning approval of activities within the coastal zone to minimize project impacts to this area.	Would comply. The excavation, off-site treatment and disposal, and monitoring activities of Alternatives S-1.4, S-2.5, S-3.5, S-4.5, and S-7.5 would comply with the substantive requirements of this act.
Tidal Wetlands and Watercourses	RCSA §22a-30-1 through 17	Applicable	These rules regulate all activities within or affecting tidal wetlands and watercourses.	Would comply. The excavation, off-site treatment and disposal, and monitoring activities of Alternatives S-1.4, S-2.5, S-3.5, S-4.5, and S-7.5 would be managed to prevent erosion and other disturbance to tidal wetlands.

TABLE 4-9

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.4, S-2.5, S-3.5, S-4.5, AND S-7.5
EXCAVATION TO MEET I/C PRGs, OFF-SITE TREATMENT AND DISPOSAL, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT (continued)				
Flood Management Regulations	(RCSA 25-68h-1 through 25-68h-3)	Relevant and Appropriate	These regulations address activities in flood plains to minimize flood risk and prevent flood hazards. Also addresses stormwater runoff.	Would comply. The excavation, off-site treatment and disposal, and monitoring activities of Alternatives S-1.4, S-2.5, S-3.5, S-4.5, and S-7.5 would consider the potential for disturbance of floodplains. Any work in flood plains would comply with the substantive provisions of the regulations.
Connecticut Endangered Species Act	CGS §26-303 through 314	Applicable	Remedial actions may not jeopardize the continued existence of state-listed endangered or threatened species, or adversely modify or destroy their critical habitat.	Would comply. The excavation, off-site treatment and disposal, and monitoring activities of Alternatives S-1.4, S-2.5, S-3.5, S-4.5, and S-7.5 would not disturb aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon and would address risks posed by potential migration of soil COCs to the Thames River.

TABLE 4-10

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.4, S-2.5, S-3.5, S-4.5, AND S-7.5
EXCAVATION TO MEET I/C PRGs, OFF-SITE TREATMENT AND DISPOSAL, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Clean Air Act (CAA), National Emissions Standards for Hazardous Air Pollutants (NESHAPs)	42 USC §12(b)(1); 40 CFR Part 61	Applicable	The regulations establish emissions standards for 189 hazardous air pollutants. Standards set for dust control and other release sources.	Would comply. The soil excavated as part of Alternatives S-1.4, S-2.5, S-3.5, S-4.5, and S-7.5 would be performed in compliance with these standards. Engineering controls could be used, if necessary, to meeting this standard.
CWA, Section 402, National Pollution Discharge Elimination System (NPDES)	USC 1342; 40 CFR 122 through 125	Applicable	These standards govern point source discharges of pollutants to surface water. Includes stormwater requirements for construction projects that disturb over one acre.	Would comply. Any construction activities during implementation of Alternatives S-1.4, S-2.5, S-3.5, S-4.5, and S-7.5 would be performed in accordance with the stormwater requirements of these standards.
STATE OF CONNECTICUT				
Hazardous Waste Management: Generator and Handler Requirements, Listing and Identification	Regulations of Connecticut State Agencies (RCSA) §22a-449(c) 100-101	Applicable	Connecticut is delegated to administer the federal Resource Conservation and Recovery Act (RCRA) statute through its state regulations. These sections establish standards for listing and identification of hazardous waste. The standards of 40 Code of Federal Regulations (CFR) 260-261 are incorporated by reference.	Would comply. The soil excavated as part of Alternatives S-1.4, S-2.5, S-3.5, S-4.5, and S-7.5 would be tested and any soil identified as hazardous would be managed in accordance with these regulations. Confirmatory sampling would determine whether any soil with hazardous characteristic is left in place following excavation.
Hazardous Waste Management: Generator Standards	RCSA §22a-449(c)-102	Applicable	This section establishes standards for various classes of generators. The standards of 40 CFR 262 are incorporated by reference.	Would comply. Soil excavated as part of Alternatives S-1.4, S-2.5, S-3.5, S-4.5, and S-7.5 would be tested for hazardous characteristics. Any excavated soil identified as hazardous would be handled and disposed in compliance with these standards.
Water Quality Standards	Regulations Promulgated under Connecticut General Statutes (CGS) §22a-426	Applicable	Connecticut's Water Quality Standards establish specific numeric criteria, designated uses, and anti-degradation policies for groundwater and surface water. Groundwater at the site is classified under these regulations as GB. Includes stormwater requirements for construction projects that disturb over one acre.	Would comply. The excavation, off-site treatment and disposal, and long-term groundwater monitoring of Alternatives S-1.4, S-2.5, S-3.5, S-4.5, and S-7.5 would ensure that groundwater quality standards for GB groundwater would be maintained. Monitoring would ensure that stormwater and groundwater standards were being met.

TABLE 4-10

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.4, S-2.5, S-3.5, S-4.5, AND S-7.5
EXCAVATION TO MEET I/C PRGs, OFF-SITE TREATMENT AND DISPOSAL, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT (continued)				
Air Pollution Control	RCSA §22a-174 1-20	Applicable	These regulations pertain to construction and operation of specified types of emission sources and contain emission standards that must be met. Pollutant abatement controls may be required. Specific standards pertain to fugitive dust (18b).	Would comply. The excavation, off-site treatment and disposal, and long-term groundwater monitoring of Alternatives S-1.4, S-2.5, S-3.5, S-4.5, and S-7.5 would be performed so as to minimize fugitive emissions and would comply with the substantive requirements of these regulations.
Connecticut Guidelines for Soil Erosion and Sediment Control	Connecticut Council on Soil and Water Conservation	To Be Considered (TBC)	Technical and administrative guidance for development, adoption and implementation of erosion and sediment control program.	Would comply. Excavation activities associated with Alternatives S-1.4, S-2.5, S-3.5, S-4.5, and S-7.5 would include an appropriate erosion and sedimentation control program that would comply with this guidance.

TABLE 4-11

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, S-6.5, AND S-7.6
EXCAVATION TO MEET RESIDENTIAL PRGs AND OFF-SITE TREATMENT AND DISPOSAL
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Cancer Slope Factors (CSFs)	United States Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) and others	To Be Considered (TBC)	These are guidance values used in risk assessment to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Would comply. Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, S-6.5, and S-7.6 would include excavation and off-site treatment and disposal of soil which could result in unacceptable residential carcinogenic risks and contribute to the migration of chemicals of concern (COCs) to groundwater.
Reference Doses (RfDs)	EPA IRIS and others	TBC	These are guidance values used in risk assessment to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants.	Would comply. Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, S-6.5, and S-7.6 would include excavation and off-site treatment and disposal of soil which could result in unacceptable residential non-carcinogenic risks and contribute to the migration of COCs to groundwater.
Guidelines for Carcinogen Risk Assessment	EPA/630/P-03/001F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would comply. Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, S-6.5, and S-7.6 would include excavation and off-site treatment and disposal of soil which could result in unacceptable residential carcinogenic risks and contribute to the migration of COCs to groundwater.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	EPA/630/R-03/003F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would comply. Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, S-6.5, and S-7.6 would include excavation and off-site treatment and disposal of soil which could result in unacceptable residential carcinogenic risks and contribute to the migration of COCs to groundwater.
Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil	EPA-540-R-03-001, OSWER Dir #9285.7-54 (January 2003)	TBC	EPA guidance for evaluating the risks posed by lead in soil.	Would comply. Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, S-6.5, and S-7.6 would meet this standard because potential lead risk from adult exposure would be addressed through excavation and off-site treatment and disposal of all lead-contaminated media exceeding risk levels.

TABLE 4-11

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, S-6.5, AND S-7.6
EXCAVATION TO MEET RESIDENTIAL PRGs AND OFF-SITE TREATMENT AND DISPOSAL
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT				
Remediation Standard Regulations (RSRs)	Connecticut General Statutes (CGS) §22a-133k; Regulations of Connecticut State Agencies (RCSA) §22a-133k - 1 through 3 (Appendices A and B)	Applicable	These regulations establish Direct Exposure Criteria (DECs) and Pollutant Mobility Criteria (PMCs) for contaminated soil. Particularly, §22a-133k-2(c)(2)(E) allows for the development and use of Alternative PMCs for soil overlying groundwater classified as GB. These Alternative PMCs are equal to the GA PMCs multiplied by a site-specific dilution factor (DF) which is developed based on site-specific hydrogeologic characteristics.	Would comply. Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, S-6.5, and S-7.6 would include excavation and off-site treatment and disposal of contaminated soil which would remedy current exceedances of industrial/commercial (I/C) DECs and PMCs and hypothetical future exceedances of Residential DECs and PMCs.

TABLE 4-12

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, AND S-7.6
EXCAVATION TO MEET RESIDENTIAL PRGs AND OFF-SITE TREATMENT AND DISPOSAL
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Fish and Wildlife Coordination Act	16 USC Part 661 *et. seq.*, 40 CFR 122	Applicable	Protects fish and wildlife when actions at the site would result in the control or structural modification of a natural stream, body of water, wetlands, floodplain, or flood-prone areas. The statute requires federal agencies to take into account the effects of remedial actions and prevent loss or damage to resources.	Would comply. The excavation and off-site treatment and disposal of Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, and S-7.6 would remove soil chemicals of concern (COCs) and prevent their potential migration to groundwater or surface water which could eventually impact fish and wildlife in the Thames River. Federal resource agencies would be consulted to prevent, mitigate, or compensate for loss of fish and wildlife.
Coastal Zone Management Act	16 USC Parts 1451 *et. seq.*	Applicable	Requires that any actions that affect a land or water use or water resource of the coastal zone must be conducted in a manner consistent to the maximum extent practical with enforceable policies of state approved management programs.	Would comply. The excavation and off-site treatment and disposal of Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, and S-7.6 would comply with the substantive requirements of this act.
Floodplain Management and Protection of Wetlands	44 CFR 9	Relevant and appropriate	FEMA regulations that set forth the policy, procedure and responsibilities to implement and enforce Executive Order 11988 Floodplain Management and Executive Order 11990, Protection of Wetlands.	Would comply. The excavation and off-site treatment and disposal of Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, and S-7.6 would be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.
STATE OF CONNECTICUT				
Coastal Management Act	Regulations of Connecticut State Agencies (RCSA) 22a-90 to 112	Applicable	These regulations govern State activities in flood plains to minimize flood risk and prevent flood hazards. Also addresses stormwater runoff.	Would comply. The excavation and off-site treatment and disposal of Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, and S-7.6 would comply with the substantive requirements of this act.
Tidal Wetlands and Watercourses	RCSA §22a-30-1 through 17	Applicable	These rules regulate all activities within or affecting tidal wetlands and watercourses.	Would comply. The excavation and off-site treatment and disposal of Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, and S-7.6 would be managed to prevent erosion and other disturbance to tidal wetlands.

TABLE 4-12

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, AND S-7.6
EXCAVATION TO MEET RESIDENTIAL PRGs AND OFF-SITE TREATMENT AND DISPOSAL
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT (continued)				
Flood Management Regulations	(RCSA 25-68h-1 through 25-68h-3)	Relevant and Appropriate	These regulations address activities in flood plains to minimize flood risk and prevent flood hazards.	Would comply. The excavation and dewatering activities of Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, and S-7.6 would consider the potential for disturbance of floodplains. Any work in flood plains would comply with the substantive provisions of the regulations.
Connecticut Endangered Species Act	CGS § 26-303 thru 314	Applicable	Remedial actions may not jeopardize the continued existence of state-listed endangered or threatened species, or adversely modify or destroy their critical habitat.	Would comply. The excavation, discharge of treated water, and off site treatment and disposal activities associated with Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, and S-7.6 would not cause disturbance to aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon.

TABLE 4-13

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, AND S-7.6
EXCAVATION TO MEET RESIDENTIAL PRGs AND OFF-SITE TREATMENT AND DISPOSAL
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Clean Water Act, Section 402, National Pollution Discharge Elimination System (NPDES)	33 USC 1342; 40 CFR 122 through 125	Applicable	These standards govern point source discharges of pollutants to surface water. Includes stormwater requirements for construction projects that disturb over one acre.	Would comply. Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, and S-7.6 would include on-site dewatering of soil excavated below the water table before transportation of that soil for off-site treatment and disposal. The water generated by this soil dewatering would be treated to meet the standards of this act prior to discharge to the Thames River. Remedial measures taken will meet the stormwater standards under these regulations.
Clean Air Act (CAA), National Emissions Standards for Hazardous Air Pollutants (NESHAPs)	42 USC §12(b)(1); 40 CFR Part 61	Applicable	The regulations establish emissions standards for 189 hazardous air pollutants. Standards set for dust control and other release sources.	Applicable. Would comply. Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, and S-7.6 would be performed so as to minimize fugitive emissions and would comply with the substantive requirements of these regulations.
STATE OF CONNECTICUT				
Hazardous Waste Management: Generator and Handler Requirements, Listing and Identification	Regulations of Connecticut State Agencies (RCSA) § 22a-449(c) 100-101	Applicable	Connecticut is delegated to administer the Federal Resource Conservation and Recovery Act (RCRA) statute through its state regulations. These sections establish standards for listing and identification of hazardous waste. The standards of 40 Code of Federal Regulations (CFR) 260-261 are incorporated by reference	Would comply. Excavated soil and dewatering waste generated by Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, and S-7.6 would be tested for hazardous characteristics. Any soil or waste identified as hazardous would be handled and disposed in compliance with these standards.
Hazardous Waste Management: Generator Standards	RCSA § 22a-449(c)-102	Applicable	This section establishes standards for various classes of generators. The standards of 40 CFR 262 are incorporated by reference.	Would comply. Excavated soil and dewatering waste generated by Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, and S-7.6 would be tested for hazardous characteristics. Any soil or waste identified as hazardous would be handled and disposed in compliance with these standards.

TABLE 4-13

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, AND S-7.6
EXCAVATION TO MEET RESIDENTIAL PRGs AND OFF-SITE TREATMENT AND DISPOSAL
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT (continued)				
Water Pollution Control	RCSA §22a-430-1 through 8	Applicable	These rules regulate water discharge to surface water.	Would comply. The water generated by soil dewatering operations of Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, and S-7.6 would be treated to comply with these rules prior to discharge to the Thames River.
Water Quality Standards	Regulations promulgated under Connecticut General Statutes (CGS) §22a-426	Applicable	Connecticut's Water Quality Standards establish specific numeric criteria, designated uses, and anti-degradation policies for groundwater and surface water. Groundwater at the site is classified under these regulations as GB. Includes stormwater requirements for construction projects that disturb over one acre.	Would comply. The water generated by the soil dewatering operations of Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, and S-7.6 would be treated to comply with these rules prior to discharge to the Thames River. Monitoring would ensure that stormwater and groundwater standards were being met.
Air Pollution Control	RCSA §22a-174 1-20	Applicable	These regulations pertain to construction and operation of specified types of emission sources and contain emission standards that must be met. Pollutant abatement controls may be required. Specific standards pertain to fugitive dust (18b).	The excavation activities associated with Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, and S-7.6 would be performed so as to minimize fugitive emissions and would comply with the substantive requirements of these regulations.
Connecticut Guidelines for Soil Erosion and Sediment Control	Connecticut Council on Soil and Water Conservation	To Be Considered (TBC)	Technical and administrative guidance for development, adoption, and implementation of erosion and sediment control program.	The excavation activities associated with Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, and S-7.6 would include an appropriate erosion and sedimentation control program that would comply with this guidance.

TABLE 4-14

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-2.3, S-3.3, S-4.3, AND S-7.3: CAPPING TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Cancer Slope Factors (CSFs)	United States Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) and others	To Be Considered (TBC)	These are guidance values used in risk assessment to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Would comply. Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would include capping or removal of soil that could result in unacceptable industrial/commercial (I/C) carcinogenic risks and contribute to the migration of soil chemicals of concern (COCs) to groundwater. These alternatives would also include land use controls (LUCs) that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.
Reference Doses (RfDs)	EPA IRIS and others	TBC	These are guidance values used in risk assessment to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants.	Would comply. Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would include capping or removal of soil that could result in unacceptable I/C non-carcinogenic risks and contribute to the migration of soil COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.

TABLE 4-14

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-2.3, S-3.3, S-4.3, AND S-7.3: CAPPING TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL (continued)				
Guidelines for Carcinogen Risk Assessment	EPA/630/P-03/001F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would comply. Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would include capping or removal of soil that could result in unacceptable I/C carcinogenic risks and contribute to the migration of soil COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	EPA/630/R-03/003F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would comply. Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would include capping or removal of soil that could result in unacceptable I/C carcinogenic risks and contribute to the migration of soil COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.

TABLE 4-14

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-2.3, S-3.3, S-4.3, AND S-7.3: CAPPING TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL (continued)				
Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil	EPA-540-R-03-001, OSWER Dir #9285.7-54 (January 2003)	TBC	EPA guidance for evaluating the risks posed by lead in soil.	Would comply. Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would meet this standard because potential risk from adult exposure to lead would be addressed through in-situ chemical stabilization/solidification of soil that could contribute to unacceptable I/C risks. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks from exposure to lead contaminated soil. The monitoring of these same alternatives would warn of potential migration of lead from soil to groundwater, which would also minimize unacceptable risks.
STATE OF CONNECTICUT				
Remediation Standard Regulations (RSRs)	Connecticut General Statutes (CGS) §22a-133k; Regulations of Connecticut State Agencies (RCSA) 22a-133k - 1 through 3 (Appendices A and B)	Applicable	These regulations establish Direct Exposure Criteria (DECs) and Pollutant Mobility Criteria (PMCs) for contaminated soil. Particularly, §22a-133k-2(c)(2)(E) allows for the development and use of Alternative PMCs for soil overlying groundwater classified as GB. These Alternative PMCs are equal to the GA PMCs multiplied by a site-specific dilution factor (DF) which is developed based on site-specific hydrogeologic characteristics.	Would comply. Although Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would leave in place soil that exceeds I/C DECs and PMCs, areas of exceedance would either be capped with an impervious soil cover (if below 2 feet deep) or excavated and disposed off site (if less than 2 feet deep), thus eliminating the risk of exposure and minimizing the potential migration of soil COCs to groundwater. In addition, these alternatives would include groundwater monitoring to provide a warning of the potential migration of soil COCs to groundwater. The cap will be constructed, monitored, and maintained in compliance with these standards. Compliance with LUCs will also meet these standards.

TABLE 4-15

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-2.3, S-3.3, S-4.3, AND S-7.3: CAPPING TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Fish and Wildlife Coordination Act	16 USC Part 661 *et. seq.*, 40 CFR 122	Applicable	Protects fish and wildlife when actions at the site would result in the control or structural modification of a natural stream, body of water, wetlands, floodplain, or flood-prone areas. The statute requires federal agencies to take into account the effects of remedial actions and prevent loss of or damage to resources.	Would comply. The capping, excavation, and off-site disposal of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would minimize the potential migration of soil chemicals of concern (COCs) to groundwater or to surface water that could eventually impact fish and wildlife in the Thames River. Federal resource agencies would be consulted to prevent, mitigate, or compensate for loss to fish and wildlife.
Coastal Zone Management Act	16 USC Parts 1451 *et. seq.*	Applicable	Requires that any actions that affect a land or water use or water resource of the coastal zone must be conducted in a manner consistent to the maximum extent practical with enforceable policies of state-approved management programs.	Would comply. The capping, excavation, and off-site disposal of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would comply with the substantive requirements of this act.
Floodplain Management and Protection of Wetlands	44 CFR 9	Relevant and appropriate	FEMA regulations that set forth the policy, procedure and responsibilities to implement and enforce Executive Order 11988 Floodplain Management and Executive Order 11990, Protection of Wetlands.	Would comply The capping, excavation, and off-site disposal of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.
STATE OF CONNECTICUT				
Coastal Management Act	Regulations of Connecticut State Agencies (RCSA) §22a-90 to 112	Applicable	The sites are in a coastal zone management area; therefore, requirements for site planning must include approval of activities within the coastal zone to minimize project impacts to this area.	Would comply. The capping, excavation, and off-site disposal of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would comply with the substantive requirements of this act.

TABLE 4-15

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-2.3, S-3.3, S-4.3, AND S-7.3: CAPPING TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT (continued)				
Tidal Wetlands and Watercourses	RCSA §22a-30-1 through 17	Applicable	These rules regulate all activities within or affecting tidal wetlands and watercourses.	Would comply. The capping, excavation, and off-site disposal of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would be managed to prevent erosion and other disturbance to tidal wetlands and the Thames River.
Flood Management Regulations	RCSA 25-68h-1 through 25-68h-3	Relevant and Appropriate	These regulations address activities in flood plains to minimize flood risk and prevent flood hazards. Also addresses stormwater runoff.	Would comply. The capping, excavation, and off-site disposal of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would not adversely impact the floodplain resources. The cap would be designed, constructed, and maintained to be protective in the event of a 100-year storm event. The monitoring associated with these alternatives would be performed to minimize impact to floodplain resources.
Connecticut Endangered Species Act	CGS §26-303 through 314	Applicable	Remedial actions may not jeopardize the continued existance of state-listed endangered or threatened species, or adversely modify or destroy their critical habitat.	Would comply. The capping, excavation, and off-site disposal of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would not cause disturbance to aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon and would address risks posed by potential migration of soil COCs to the Thames River.

TABLE 4-16

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-2.3, S-3.3, S-4.3, AND S-7.3: CAPPING TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Clean Air Act (CAA), National Emissions Standards for Hazardous Air Pollutants (NESHAPs)	42 USC §12(b)(1); 40 CFR Part 61	Applicable	The regulations establish emissions standards for 189 hazardous air pollutants. Standards set for dust control and other release sources.	The soil excavated during the installation of a cap during implementation of Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would be performed in compliance with these standards. Engineering controls could be used, if necessary, to meet this standard.
CWA, Section 402, National Pollution Discharge Elimination System (NPDES)	USC 1342; 40 CFR 122 through 125	Applicable	These standards govern point source discharges of pollutants to surface water. Includes stormwater requirements for construction projects that disturb over one acre.	Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would include soil disturbance activities during the installation of the cap. If any soil disturbance activities are greater than one acre, they would be performed in accordance with this standard.
STATE OF CONNECTICUT				
Hazardous Waste Management: Generator and Handler Requirements, Listing and Identification	Regulations of Connecticut State Agencies (RCSA) § 22a-449(c) 100-101	Applicable	Connecticut is delegated to administer the Federal Resource Conservation and Recovery Act (RCRA) statute through its state regulations. These sections establish standards for listing and identification of hazardous waste. The standards of 40 Code of Federal Regulations (CFR) 260-261 are incorporated by reference.	Would comply. The soil excavated as part of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would be tested and any soil identified as hazardous would be managed in accordance with these regulations.
Hazardous Waste Management: Generator Standards	RCSA § 22a-449(c)-102	Applicable	This section establishes standards for various classes of generators. The standards of 40 CFR 262 are incorporated by reference.	Would comply. The soil excavated as part of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would be tested and any soil identified as hazardous would handled and disposed of in compliance with these standards.
Water Quality Standards	Regulations promulgated under Connecticut General Statutes (CGS) §22a-426	Applicable	Connecticut's Water Quality Standards establish specific numeric criteria, designated uses, and anti-degradation policies for groundwater and surface water. Groundwater at the site is classified under these regulations as GB. Includes stormwater requirements for construction projects that disturb over one acre.	Would comply. The capping and long-term groundwater monitoring of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would ensure that groundwater quality standards for GB groundwater would be maintained. Monitoring would ensure that stormwater and groundwater standards were being met.

TABLE 4-16

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-2.3, S-3.3, S-4.3, AND S-7.3: CAPPING TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT (continued)				
Air Pollution Control	RCSA §22a-174 1-20	Applicable	These regulations pertain to the construction and operation of specified types of emission sources and contain emission standards that must be met. Pollutant abatement controls may be required. Specific standards pertain to fugitive dust (18b).	Would comply. The capping and excavation of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would be performed so as to minimize fugitive emissions and would comply with the substantive requirements of these regulations. However, under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), actual permits would not be required.
Connecticut Guidelines for Soil Erosion and Sediment Control	Connecticut Council on Soil and Water Conservation	To Be Considered (TBC)	Technical and administrative guidance for development, adoption and implementation of erosion and sediment control program.	Would comply. The capping and excavation of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would include an appropriate erosion and sedimentation control program that would comply with this guidance.

TABLE 4-17

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-2.4, S-3.4, S-4.4, AND S-7.4
IN-SITU TREATMENT (CHEMICAL STABILIZATION/SOLIDIFICATION) TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Cancer Slope Factors (CSFs)	United States Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) and others	To Be Considered (TBC)	These are guidance values used in risk assessment to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Would comply. Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would include in-situ chemical stabilization/ solidification of soil that could result in unacceptable industrial/commercial (I/C) carcinogenic risks and contribute to the migration of soil chemicals of concern (COCs) to groundwater. These alternatives would also include land use controls (LUCs) that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.
Reference Doses (RfDs)	EPA IRIS and others	TBC	These are guidance values used in risk assessment to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants.	Would comply. Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would include in-situ chemical stabilization/ solidification of soil that could result in unacceptable I/C non-carcinogenic risks and contribute to the migration of soil COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.

TABLE 4-17

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-2.4, S-3.4, S-4.4, AND S-7.4
IN-SITU TREATMENT (CHEMICAL STABILIZATION/SOLIDIFICATION) TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL (continued)				
Guidelines for Carcinogen Risk Assessment	EPA/630/P-03/001F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would comply. Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would include in-situ chemical stabilization/ solidification of soil that could result in unacceptable I/C carcinogenic risks and contribute to the migration of soil COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	EPA/630/R-03/003F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would comply. Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would include in-situ chemical stabilization/ solidification of soil that could result in unacceptable I/C carcinogenic risks and contribute to the migration of soil COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.

TABLE 4-17

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-2.4, S-3.4, S-4.4, AND S-7.4
IN-SITU TREATMENT (CHEMICAL STABILIZATION/SOLIDIFICATION) TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL (continued)				
Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil	EPA-540-R-03-001, OSWER Dir #9285.7-54 (January 2003)	TBC	EPA guidance for evaluating the risks posed by lead in soil.	Would comply. Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would meet this standard because potential risk from adult exposure to lead would be addressed through capping or removal of soil that could contribute to unacceptable I/C risks. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks from exposure to lead contaminated soil. The monitoring of these same alternatives would warn of potential migration of lead from soil to groundwater, which would also minimize unacceptable risks.
STATE OF CONNECTICUT				
Remediation Standard Regulations (RSRs)	Connecticut General Statutes (CGS) §22a-133k; Regulations of Connecticut State Agencies (RCSA) §22a-133k - 1 through 3 (Appendices A and B)	Applicable	These regulations establish Direct Exposure Criteria (DECs) and Pollutant Mobility Criteria (PMCs) for contaminated soil. Particularly, §22a-133k-2(c)(2)(E) allows for the development and use of Alternative PMCs for soil overlying groundwater classified as GB. These Alternative PMCs are equal to the GA PMCs multiplied by a site-specific dilution factor (DF) which is developed based on site-specific hydrogeologic characteristics.	Would comply. The in-situ chemical stabilization/ solidification of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would remedy current exceedances of I/C PMCs. Although exceedances of I/C DECs would remain, the LUCs of these alternatives would minimize resulting risks and prevent even greater risks by prohibiting residential development. In addition, the groundwater monitoring from these alternatives would warn of potential migration of soil COCs to groundwater.

TABLE 4-18

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-2.4, S-3.4, S-4.4, AND S-7.4
IN-SITU TREATMENT (CHEMICAL STABILIZATION/SOLIDIFICATION) TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Fish and Wildlife Coordination Act	16 USC Part 661 *et. seq.*, 40 CFR 122	Applicable	Protects fish and wildlife when actions at the site would result in the control or structural modification of a natural stream, body of water, wetland, floodplain, or flood-prone area. The statute requires federal agencies to take into account the effects of remedial actions and prevent loss or damage to resources.	Would comply. The in-situ chemical stabilization/ solidification of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would prevent the potential migration of COCs from soil to groundwater or to surface water that could eventually impact fish and wildlife in the Thames River. In addition, the groundwater monitoring associated with these alternatives would provide a warning of potential migration of COCs. Federal resource agencies would be consulted to prevent, mitigate, or compensate for loss of fish and wildlife.
Coastal Zone Management Act	16 USC Parts 1451 *et. seq.*	Applicable	Requires that any actions that affect a land or water use or water resource of the coastal zone must be conducted in a manner consistent to the maximum extent practical with enforceable policies of state-approved management programs.	Would comply. The in-situ treatment and monitoring activities of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would comply with the substantive requirements of this act.
Floodplain Management and Protection of Wetlands	44 CFR 9	Relevant and appropriate	FEMA regulations that set forth the policy, procedure and responsibilities to implement and enforce Executive Order 11988 Floodplain Management and Executive Order 11990, Protection of Wetlands.	Would comply. The in-situ treatment and monitoring activities of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.
STATE OF CONNECTICUT				
Coastal Management Act	Regulations of Connecticut State Agencies (RCSA) §22a-90 to 112	Applicable	The sites are in a coastal zone management area. Therefore, requirements for site planning must include approval of activities within the coastal zone to minimize project impacts to this area.	Would comply. The in-situ treatment and monitoring activities of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would comply with the substantive requirements of this act.
Tidal Wetlands and Watercourses	RCSA §22a-30-1 through 17	Applicable	These rules regulate all activities within or affecting tidal wetlands and watercourses.	Would comply. The in-situ treatment and monitoring activities of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would be managed to prevent erosion and other disturbance to tidal wetlands and the Thames River.

TABLE 4-18

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-2.4, S-3.4, S-4.4, AND S-7.4
IN-SITU TREATMENT (CHEMICAL STABILIZATION/SOLIDIFICATION) TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT (continued)				
Flood Management Regulations	RCSA 25-68h-1 through 25-68h-3	Relevant and Appropriate	These regulations address activities in flood plains to minimize flood risk and prevent flood hazards. Also addresses stormwater runoff.	Would comply. The in-situ treatment and monitoring activities of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would consider the potential for disturbance of floodplains. Any work in flood plains would comply with the substantive provisions of the regulations.
Connecticut Endangered Species Act	CGS § 26-303 thru 314	Applicable	Remedial actions may not jeopardize the continued existence of state-listed endangered or threatened species, or adversely modify or destroy their critical habitat.	Would comply. The in-situ treatment and monitoring activities of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would not cause disturbance to aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon and would address risks posed by potential migration of soil COCs to the Thames River.

TABLE 4-19

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-2.4, S-3.4, S-4.4, AND S-7.4
IN-SITU TREATMENT (BIOREMEDIATION AND/OR STABILIZATION/SOLIDIFICATION) TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis	Evaluation of Alternative Compliance with ARAR
FEDERAL				
RCRA, Interim Status TSDF Standards, Chemical, Physical and Biological Treatment	40 CFR § 265.401(b)	Relevant and Appropriate	Treatment reagents must not be placed in the treatment process or equipment if they could cause the treatment process or equipment to rupture, leak, corrode, or otherwise fail before the end of its intended life. Inspections are required to make sure treatment process is operating correctly.	Would comply. Any reagents use in the in-situ treatment for Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would not be used if they adversely affected the treatment process. Inspections would be performed to ensure this.
CWA, Section 402, National Pollution Discharge Elimination System (NPDES)	USC 1342; 40 CFR 122 through 125	Applicable	These standards govern point source discharges of pollutants to surface water. Includes stormwater requirements for construction projects that disturb over one acre.	Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would include soil disturbance activities during the implementation of the in-situ treatment. If any soil disturbance activities are greater than one acre, they would be performed in accordance with this standard.
STATE OF CONNECTICUT				
Hazardous Waste Management: Generator and Handler Requirements, Listing and Identification	Regulations of Connecticut State Agencies (RCSA) §22a-449(c) 100-101	Applicable	Connecticut is delegated to administer the federal Resource Conservation and Recovery Act (RCRA) statute through its state regulations. These sections establish standards for listing and identification of hazardous waste. The standards of 40 CFR 260-261 are incorporated by reference.	Would comply. Soil excavated as part of the in-situ treatment and monitoring of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would be tested. Any soil identified as hazardous would be managed in accordance with these regulations. Confirmatory sampling would determine whether any soil with hazardous characteristics is left in place following treatment.
Hazardous Waste Management: Generator Standards	RCSA § 22a-449(c)-102	Applicable	This section establishes standards for various classes of generators. The standards of 40 CFR 262 are incorporated by reference.	Would comply. Any hazardous waste that would be generated from the in-situ treatment and monitoring activities of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would be handled and disposed in compliance with these standards.
Water Quality Standards	Regulations promulgated under Connecticut General Statutes (CGS) §22a-426	Applicable	Connecticut's Water Quality Standards establish specific numeric criteria, designated uses, and anti-degradation policies for groundwater and surface water. Groundwater at the site is classified under these regulations as GB. Includes stormwater requirements for construction projects that disturb over one acre.	Would comply. The in-situ treatment and long-term groundwater monitoring of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would ensure that groundwater quality standards for GB groundwater would be maintained. Monitoring would ensure that stormwater and groundwater standards were being met.

TABLE 4-19

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVES S-2.4, S-3.4, S-4.4, AND S-7.4
IN-SITU TREATMENT (BIOREMEDIATION AND/OR STABILIZATION/SOLIDIFICATION) TO MEET I/C PRGs, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT (Continued)				
Air Pollution Control	RCSA § 22a-174 1-20	Applicable	These regulations pertain to the construction and operation of specified types of emission sources and contain emission standards that must be met. Pollutant abatement controls may be required. Specific standards pertain to fugitive dust (18b).	Would comply. The in-situ treatment and monitoring activities of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would be performed so as to minimize fugitive emissions and would comply with the substantive requirements of these regulations.
Guidelines for Soil Erosion and Sediment Control	Connecticut Council on Soil and Water Conservation	To Be Considered (TBC)	Technical and administrative guidance for development, adoption, and implementation of erosion and sediment control program.	Would comply. Any excavation activities associated with the in-situ treatment and monitoring of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would include an appropriate erosion and sedimentation control program that would comply with this guidance.

TABLE 4-20

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.1, GW-4.1, AND GW-7.1: NO ACTION
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Cancer Slope Factors (CSFs)	United States Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) and others	To Be Considered (TBC)	These are guidance values used in risk assessment to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Would not comply. Although there are no unacceptable risks from exposure to contaminated groundwater under the current industrial/commercial (I/C) site use because the Lower Subase aquifer is classified as GB and its use is restricted, the No Action alternatives would not include a formal enforcement of this restriction and this could allow future groundwater uses that would result in unacceptable carcinogenic risks. In addition, the No Action alternatives would not provide any warning of the potential migration of groundwater chemicals of concern (COCs) to the Thames River.
Reference Doses (RfDs)	EPA IRIS and others	TBC	These are guidance values used in risk assessment to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants.	Would not comply. Although there are no unacceptable risks from exposure to contaminated groundwater under the current I/C site use because the Lower Subase aquifer is classified as GB and its use is restricted, the No Action alternatives would not include a formal enforcement of this restriction and this could allow future groundwater uses that would result in non-carcinogenic unacceptable risks. In addition, the No Action alternatives would not provide any warning of the potential migration of groundwater COCs to the Thames River.
Guidelines for Carcinogen Risk Assessment	EPA/630/P-03/001F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would not comply. Although there are no unacceptable risks from exposure to contaminated groundwater under the current I/C site use because the Lower Subase aquifer is classified as GB and its use is restricted, the No Action alternatives would not include a formal enforcement of this restriction and this could allow future groundwater uses that would result in unacceptable carcinogenic risks. In addition, the No Action alternatives would not provide any warning of the potential migration of groundwater COCs to the Thames River.

TABLE 4-20

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.1, GW-4.1, AND GW-7.1: NO ACTION
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL (continued)				
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	EPA/630/R-03/003F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would not comply. Although there are no unacceptable carcinogenic risks to children from exposure to contaminated groundwater under the current I/C site use because the Lower Subase aquifer is classified as GB and its use is restricted, the No Action alternatives would not include a formal enforcement of this restriction and this could allow future groundwater uses that would result in unacceptable carcinogenic risks to children. In addition, the No Action alternatives would not provide any warning of the potential migration of groundwater COCs to the Thames River.
STATE OF CONNECTICUT				
Remediation Standard Regulations (RSRs)	Connecticut General Statutes (CGS) §22a-133k; Regulations of Connecticut State Agencies (RCSA) §22a-133k - 1 through 3	Applicable	These regulations provide specific numerical cleanup criteria for contaminants in groundwater. Because the groundwater beneath the Lower Subase is classified as GB, only Surface Water Protection Criteria (SWPCs) apply. Section 22a-133k-3(b)(3) of these regulations establish the methodology for the development of the site-specific Alternative SWPCs that were used to establish groundwater Preliminary Remedial Goals (PRGs).	Would not comply. Historical exceedances of the Standard SWPC for copper and lead have been detected in Zones 1 and 4, respectively, and exceedances of the Alternative SWPC for arsenic have been detected in Zones 1, 4, and 7.

TABLE 4-21

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
GROUNDWATER REMEDIAL ALTERNATIVES GW-1.2, GW-4.2, AND GW-7.2: NATURAL ATTENUATION, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Cancer Slope Factors (CSFs)	United States Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) and others	To Be Considered (TBC)	These are guidance values used in risk assessment to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Would not comply.
Reference Doses (RfDs)	EPA IRIS and others	TBC	These are guidance values used in risk assessment to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants.	Would not comply.
Guidelines for Carcinogen Risk Assessment	EPA/630/P-03/001F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would not comply.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	EPA/630/R-03/003F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would not comply.

TABLE 4-21

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
GROUNDWATER REMEDIAL ALTERNATIVES GW-1.2, GW-4.2, AND GW-7.2: NATURAL ATTENUATION, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT				
Remediation Standard Regulations (RSRs)	Connecticut General Statutes (CGS) §22a-133k; Regulations of Connecticut State Agencies (RCSA) §22a-133k - 1 through 3	Applicable	These regulations provide specific numerical cleanup criteria for contaminants in groundwater. Because the groundwater beneath the Lower Subase is classified as GB, only Surface Water Protection Criteria (SWPCs) apply. Section 22a-133k-3(b)(3) of these regulations establish the methodology for the development of the site-specific Alternative SWPCs that were used to establish groundwater Preliminary Remedial Goals (PRGs).	Would not comply.

TABLE 4-22

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
GROUNDWATER REMEDIAL ALTERNATIVES GW-1.2, GW-4.2, AND GW-7.2: NATURAL ATTENUATION, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Coastal Zone Management Act	16 USC Parts 1451 *et. seq.*	Applicable	Requires that any actions that affect a land or water use or water resource of the coastal zone must be conducted in a manner consistent to the maximum extent practical with enforceable policies of state approved management programs.	Would comply. The implementation of Alternatives GW-1.2, GW-4.2, and GW-7.2 would comply with the substantive requirements of this act.
Floodplain Management and Protection of Wetlands	44 CFR 9	Relevant and appropriate	FEMA regulations that set forth the policy, procedure and responsibilities to implement and enforce Executive Order 11988 Floodplain Management and Executive Order 11990, Protection of Wetlands.	Would comply. Alternatives GW-1.2, GW-4.2, and GW-7.2 would be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.
Fish and Wildlife Coordination Act	16 USC Part 661 et. seq., 40 CFR 122	Applicable	Protects fish and wildlife when actions at the site would result in the control or structural modification of a natural stream, body of water, wetlands, floodplain, or flood-prone areas. The statute requires federal agencies to take into account the effects of remedial actions and prevent loss or damage to resources.	Would comply. Alternatives GW-1.2, GW-4.2, and GW-7.2 would provide adequate warning of the potential migration of groundwater chemicals of concern (COCs). Federal resource agencies would be consulted to prevent, mitigate, or compensate for loss of fish and wildlife.
STATE OF CONNECTICUT				
Coastal Management Act	Regulations of Connecticut State Agencies (RCSA) 22a-90 to 112	Applicable	These regulations govern State activities in floodplains to minimize flood risk and prevent flood hazards. Also addresses stormwater runoff.	Would comply. The implementation of Alternatives GW-1.2, GW-4.2, and GW-7.2 would comply with the substantive requirements of this act.
Tidal Wetlands and Watercourses	RCSA §22a-30-1 through 17	Applicable	These rules regulate all activities within or affecting tidal wetlands and watercourses.	Would comply. The implementation of Alternatives GW-1.2, GW-4.2, and GW-7.2 would be managed to prevent erosion and other disturbance to tidal wetlands.

TABLE 4-22

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
GROUNDWATER REMEDIAL ALTERNATIVES GW-1.2, GW-4.2, AND GW-7.2: NATURAL ATTENUATION, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
Flood Management Regulations	(RCSA 25-68h-1 through 25-68h-3)	Relevant and Appropriate	These regulations address activities in floodplains to minimize flood risk and prevent flood hazards.	Would comply. The implementation of Alternatives GW-1.2, GW-4.2, and GW-7.2 would consider the potential for disturbance of floodplains. Any work in floodplains would comply with the substantive provisions of the regulations.
Connecticut Endangered Species Act	CGS § 26-303 thru 314	Applicable	Remedial actions may not jeopardize the continued existence of state-listed endangered or threatened species, or adversely modify or destroy their critical habitat.	Would comply. The monitoring activities in Alternatives GW-1.2, GW-4.2, and GW-7.2 would not disturb aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon and would address risks posed by potential migration of soil COCs to the Thames River.

TABLE 4-23

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.2, GW-4.2, AND GW-7.2 NATURAL ATTENUATION, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites	OSWER Directive 9200.4-17P (April 21, 1999)	TBC	EPA guidance regarding the use of monitored natural attenuation for the cleanup of contaminated soil and groundwater. In particular, a reasonable time frame for achieving cleanup standard through monitored attenuation would be comparable to that which could be achieved through active restoration.	Would not comply. Monitored natural attenuation alternatives would only meet these standards if natural attenuation would attain all groundwater cleanup standards within a reasonable time frame. Metal cleanup criterion would be achieved within 219 years in Alternative GW-1.2, 548 years in Alternative 4.2, and 34 years in Alternative 7.2.
Floodplain Management and Protection of wetlands	44 C.F.R. 9	Relevant and appropriate	FEMA regulations that set forth the policy, procedure and responsibilities to implement and enforce Executive Order 11988 Floodplain Management and Executive Order 11990, Protection of Wetlands.	Would comply. Remedial alternatives conducted within the 500-year floodplain of the Thames River or within federal jurisdictional wetlands will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.

TABLE 4-23

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.2, GW-4.2, AND GW-7.2 NATURAL ATTENUATION, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT				
Hazardous Waste Management: Generator and Handler Requirements, Listing and Identification	Regulations of Connecticut State Agencies (RCSA) § 22a-449(c) 100-101	Applicable	Connecticut is delegated to administer the Federal Resource Conservation and Recovery Act (RCRA) statute through its state regulations. These sections establish standards for listing and identification of hazardous waste. The standards of 40 CFR 260-261 are incorporated by reference	Would comply. Hazardous waste determinations would be performed on wastes (contaminated soils, sediments and groundwater) created from the implementation of alternatives GW-1.2, GW-4.2, and GW-7.2. Any wastes determined to be hazardous would be managed in accordance with requirements of these regulations.
Water Quality Standards	Regulations promulgated under Connecticut General Statutes (CGS) §22a-426	Applicable	Connecticut's Water Quality Standards establish specific numeric criteria, designated uses, and anti-degradation policies for groundwater and surface water. Groundwater at the site is classified under these regulations as GB. Includes stormwater requirements for construction projects that disturb over one acre.	Would comply. Implementation of alternatives GW-1.2, GW-4.2, and GW-7.2 would be conducted in a manner that ensures that groundwater quality standards would be maintained. Monitoring would ensure that stormwater and groundwater standards were being met.
Hazardous Waste Management: Generator Standards	RCSA § 22a-449(c)-102	Applicable	This section establishes standards for various classes of generators. The standards of 40 CFR 262 are incorporated by reference.	Would comply. Any hazardous waste that is generated from treated groundwater would be handled and disposed of in compliance with these standards.

TABLE 4-24

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.3, GW-4.3, AND GW-7.3: IN-SITU TREATMENT, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Cancer Slope Factors (CSFs)	United States Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) and others	To Be Considered (TBC)	These are guidance values used in risk assessment to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Would comply. There are no unacceptable carcinogenic risks from direct exposure to contaminated groundwater under the current industrial site use. The aquifer beneath the Lower Subase has been classified as GB, and Alternatives GW-1.3, GW-4.3, and GW-7.3 would include in-situ treatment that would actively remove chemicals of concern (COCs) from the groundwater and land use controls (LUCs) that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.
Reference Doses (RfDs)	EPA IRIS and others	TBC	These are guidance values used in risk assessment to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants.	Would comply. There are no unacceptable non-carcinogenic risks from direct exposure to contaminated groundwater under the current industrial site use. The aquifer beneath the Lower Subase has been classified as GB, and Alternatives GW-1.3, GW-4.3, and GW-7.3 would include in-situ treatment that would actively remove COCs from the groundwater and LUCs that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.

TABLE 4-24

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.3, GW-4.3, AND GW-7.3: IN-SITU TREATMENT, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL (continued)				
Guidelines for Carcinogen Risk Assessment	EPA/630/P-03/001F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would comply. There are no unacceptable carcinogenic risks from direct exposure to contaminated groundwater under the current industrial site use. The aquifer beneath the Lower Subase has been classified as GB, and Alternatives GW-1.3, GW-4.3, and GW-7.3 would include in-situ treatment that would actively remove COCs from the groundwater and LUCs that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	EPA/630/R-03/003F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would comply. There are no unacceptable carcinogenic risks to children from direct exposure to contaminated groundwater under the current industrial site use. The aquifer beneath the Lower Subase has been classified as GB, and Alternatives GW-1.3, GW-4.3, and GW-7.3 would include in-situ treatment that would actively remove COCs from the groundwater and LUCs that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.

TABLE 4-24

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.3, GW-4.3, AND GW-7.3: IN-SITU TREATMENT, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT				
Remediation Standard Regulations (RSRs)	Connecticut General Statutes (CGS) §22a-133k; Regulations of Connecticut State Agencies (RCSA) §22a-133k - 1 through 3	Applicable	These regulations provide specific numerical cleanup criteria for contaminants in groundwater. Because the groundwater beneath the Lower Subase is classified as GB, only Surface Water Protection Criteria (SWPCs) apply. Section 22a-133k-3(b)(3) of these regulations establish the methodology for the development of the site-specific Alternative SWPCs that were used to establish groundwater Preliminary Remedial Goals (PRGs).	Would comply. Alternative GW-1.3 would actively treat groundwater contaminated with copper from Zone 1 and Alternative GW-4.3 would actively treat groundwater contaminated with lead from Zone 4 until the Standard SWPCs for these COCs are met. In addition, Alternatives GW-1.3, GW-4.3, and GW-7.3 would actively treat groundwater contaminated with arsenic from Zones 1, 4, and 7 until the Alternative SWPC for this COC is met.

TABLE 4-25

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.3, GW-4.3, AND GW-7.3: IN-SITU TREATMENT, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Coastal Zone Management Act	16 USC Parts 1451 *et. seq*.	Applicable	Requires that any actions that affect a land or water use or water resource of the coastal zone must be conducted in a manner consistent to the maximum extent practical with enforceable policies of state-approved management programs.	Would comply. The in-situ treatment, LUCs, and monitoring activities of Alternatives GW-1.3 and GW-4.3 would comply with the substantive requirements of this act. This act would not be applicable to Alternative GW-7.3 because there are no above ground structures or major physical disturbances of the landscape associated with it.
Floodplain Management and Protection of Wetlands	44 CFR 9	Relevant and appropriate	FEMA regulations that set forth the policy, procedure and responsibilities to implement and enforce Executive Order 11988 Floodplain Management and Executive Order 11990, Protection of Wetlands.	Remedial alternatives conducted within the 500-year floodplain of the Thames River or within federal jurisdictional wetlands will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.
STATE OF CONNECTICUT				
Coastal Management Act	Regulations of Connecticut State Agencies (RCSA) §22a-90 to 112	Applicable	The sites are in a coastal zone management area; therefore, requirements for site planning approval of activities within the coastal zone to minimize project impacts to this area.	Would comply. The in-situ treatment, LUCs, and monitoring activities of Alternatives GW-1.4, GW-4.4, and GW-7.4 would comply with the substantive requirements of this act. This act would not be applicable to Alternative GW-7.3 because there are no above ground structures or major physical disturbances of the landscape associated with it.
Tidal Wetlands and Watercourses	RCSA §22a-30-1 through 17	Applicable	These rules regulate all activities within or affecting tidal wetlands and watercourses.	Would comply. The in-situ treatment, LUCs, and monitoring activities of Alternatives GW-1.4, GW-4.4, and GW-7.4 would be managed to prevent erosion and other disturbance to tidal wetlands and the Thames River. This regulation would not be applicable to Alternative GW-7.3 because it will not physically affect tidal wetlands or watercourses.
Flood Management Regulations	(RCSA 25-68h-1 through 25-68h-3)	Relevant and Appropriate	These regulations address activities in flood plains to minimize flood risk and prevent flood hazards. Also addresses stormwater runoff.	Would comply. The in-situ treatment, LUCs, and monitoring activities of Alternatives GW-1.4, GW-4.4, and GW-7.4 would consider the potential for disturbance of floodplains. Any work in flood plains would comply with the substantive provisions of the regulations. This regulation would not be applicable to Alternative GW-7.3 because it will not physically alter the landscape and result in flooding or stormwater runoff issues.

TABLE 4-26

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.3, GW-4.3, AND GW-7.3: IN-SITU TREATMENT, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Underground Injection Control;	40 CFR 144, 146, 147.350	Relevant and Appropriate	These regulations address the discharge of wastes, chemicals or other substances into the subsurface. The federal UIC program designates injection wells incidental to aquifer remediation and experimental technologies as Class V wells authorized by rule that do not require a separate UIC permit. State requirements apply in this case; see RCSA § 22a-430-8 below.	Would comply. The subsurface injection of chemical substances for the purpose of in-situ remediation in Alternatives GW-1.3, GW-4.3, and GW-7.3 would comply with the general requirements of these standards.
Floodplain Management and Protection of wetlands	44 C.F.R. 9	Relevant and appropriate	FEMA regulations that set forth the policy, procedure and responsibilities to implement and enforce Executive Order 11988 Floodplain Management and Executive Order 11990, Protection of Wetlands.	Would comply. The subsurface injection of chemical substances for the purpose of in-situ remediation in Alternatives GW-1.3, GW-4.3, and GW-7.3 be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.
STATE OF CONNECTICUT				
Hazardous Waste Management: Generator and Handler Requirements, Listing and Identification	Regulations of Connecticut State Agencies (RCSA) § 22a-449(c) 100-101	Applicable	Connecticut is delegated to administer the Federal Resource Conservation and Recovery Act (RCRA) statute through its state regulations. These sections establish standards for listing and identification of hazardous waste. The standards of 40 CFR 260-261 are incorporated by reference	Would comply. Hazardous waste determinations would be performed on wastes (contaminated soils, sediments and groundwater) created from the implementation of Alternatives GW-1.3, GW-4.3, and GW-7.3. Any wastes determined to be hazardous would be managed in accordance with requirements of these standards.

TABLE 4-26

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.3, GW-4.3, AND GW-7.3: IN-SITU TREATMENT, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT (Continued)				
Hazardous Waste Management: Generator Standards	RCSA § 22a-449(c)-102	Applicable	This section establishes standards for various classes of generators. The standards of 40 CFR 262 are incorporated by reference.	Would comply. Any hazardous waste that is generated from treated groundwater would be handled and disposed of in compliance with these standards.
Underground Injection Control	RCSA § 22a-430-8	Applicable	These regulations address the discharge of wastes, chemicals or other substances into the subsurface.	Would comply. Alternatives GW-1.3, GW-4.3, and GW-7.3 involve the injection of chemical substances into the subsurface for the purpose of in-situ remediation. These actions would comply with the general requirements of these standards.
Water Quality Standards (WQSs)	Connecticut General Statutes (CGS) 22a-426	Potentially applicable	Establishes specific numeric criteria, designated uses, and anti-degradation policies for groundwater and surface water. Includes stormwater requirements for construction projects that disturb over one acre.	Would comply. Stormwater standards would be complied with under these regulations. If necessary, it would be used for monitoring standards for groundwater beyond the compliance boundary for any waste management area and to monitor the Thames River.
Water Pollution Control Act	RCSA §22a-430-3, 4, and 8	Applicable	These regulations govern the treatment and discharge of water into surface water bodies in the state. These regulations also govern the pretreatment and discharge of water to publicly owned treatment works (POTWs).	Alternative GW-3 would not include any groundwater extraction and discharge or disposal.

TABLE 4-27

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.4, GW-4.4, AND GW-7.4: EXTRACTION, DISCHARGE AND DISPOSAL TO OFF SITE POTW, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Cancer Slope Factors (CSFs)	United States Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) and others	To Be Considered (TBC)	These are guidance values used in risk assessment to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Would comply. There are no unacceptable carcinogenic risks from direct exposure to contaminated groundwater under the current industrial site use and the aquifer beneath the Lower Subase has been classified as GB. Alternatives GW-1.4, GW-4.4, and GW-7.4 would include extraction that would actively remove chemicals of concern (COCs) from groundwater and land use controls (LUCs) that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.
Reference Doses (RfDs)	EPA IRIS and others	TBC	These are guidance values used in risk assessment to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants.	Would comply. There are no unacceptable non-carcinogenic risks from direct exposure to contaminated groundwater under the current industrial site use and the aquifer beneath the Lower Subase has been classified as GB. Alternatives GW-1.4, GW-4.4, and GW-7.4 would include extraction that would actively remove COCs from groundwater and LUCs that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.

TABLE 4-27

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.4, GW-4.4, AND GW-7.4: EXTRACTION, DISCHARGE AND DISPOSAL TO OFF SITE POTW, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL (continued)				
Guidelines for Carcinogen Risk Assessment	EPA/630/P-03/001F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would comply. There are no unacceptable carcinogenic risks from direct exposure to contaminated groundwater under the current industrial site use and the aquifer beneath the Lower Subase has been classified as GB. Alternatives GW-1.4, GW-4.4, and GW-7.4 would include extraction that would actively remove COCs from groundwater and LUCs that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	EPA/630/R-03/003F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would comply. There are no unacceptable carcinogenic risks to children from direct exposure to contaminated groundwater under the current industrial site use and the aquifer beneath the Lower Subase has been classified as GB. Alternatives GW-1.4, GW-4.4, and GW-7.4 would include extraction that would actively remove COCs from groundwater and LUCs that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.

TABLE 4-27

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.4, GW-4.4, AND GW-7.4: EXTRACTION, DISCHARGE AND DISPOSAL TO OFF SITE POTW, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT				
Remediation Standard Regulations (RSRs)	Connecticut General Statutes (CGS) §22a-133k; Regulations of Connecticut State Agencies (RCSA) 2§2a-133k - 1 through 3	Applicable	These regulations provide specific numerical cleanup criteria for contaminants in groundwater. Because the groundwater beneath the Lower Subase is classified as GB, only Surface Water Protection Criteria (SWPCs) apply. Section 22a-133k-3(b)(3) of these regulations establish the methodology for the development of the site-specific Alternative SWPCs that were used to establish groundwater Preliminary Remedial Goals (PRGs).	Would eventually comply. Alternative GW-1.4 would actively remove and treat groundwater contaminated with copper from Zone 1 and Alternative GW-4.4 would actively remove and treat groundwater contaminated with lead from Zone 4 until the Standard SWPCs for these COCs are met. In addition, Alternatives GW-1.4, GW-4.4, and GW-7.4 would actively remove and treat groundwater contaminated with arsenic from Zones 1, 4, and 7 until the Alternative SWPC for this COC is met.

TABLE 4-28

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.4, GW-4.4, AND GW-7.4: EXTRACTION, DISCHARGE AND DISPOSAL TO OFF SITE POTW, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Coastal Zone Management Act	16 USC Parts 1451 *et. seq*.	Applicable	Requires that any actions that affect a land or water use or water resource of the coastal zone must be conducted in a manner consistent to the maximum extent practical with enforceable policies of state-approved management programs.	Would comply. The extraction, discharge and disposal to off-site POTW, LUCs, and monitoring activities of Alternatives GW-1.4, GW-4.4, and GW-7.4 would comply with the substantive requirements of this act.
Floodplain Management and Protection of Wetlands	44 CFR 9	Relevant and appropriate	FEMA regulations that set forth the policy, procedure and responsibilities to implement and enforce Executive Order 11988 Floodplain Management and Executive Order 11990, Protection of Wetlands.	Would comply. Alternative GW-1.4, GW-4.4, and GW-7.4 would be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.
STATE OF CONNECTICUT				
Coastal Management Act	Regulations of Connecticut State Agencies (RCSA) §22a-90 to 112	Applicable	The sites are in a coastal zone management area; therefore, requirements for site planning approval of activities within the coastal zone to minimize project impacts to this area.	Would comply. The extraction, discharge and disposal to off-site POTW, LUCs, and monitoring activities of Alternatives GW-1.4, GW-4.4, and GW-7.4 would comply with the substantive requirements of this act.
Tidal Wetlands and Watercourses	RCSA §22a-30-1 through 17	Applicable	These rules regulate all activities within or affecting tidal wetlands and watercourses.	Would comply. The treatment and monitoring activities of Alternatives GW-1.4, GW-4.4, and GW-7.4 would be managed to prevent erosion and other disturbance to tidal wetlands and the Thames River.
Flood Management Regulations	(RCSA 25-68h-1 through 25-68h-3)	Relevant and Appropriate	These regulations address activities in flood plains to minimize flood risk and prevent flood hazards. Also addresses stormwater runoff.	Would comply. The extraction, discharge and disposal to off-site POTW, LUCs, and monitoring activities of Alternatives GW-1.4, GW-4.4, and GW-7.4 would consider the potential for disturbance of floodplains. Any work in flood plains would comply with the substantive provisions of the regulations.

TABLE 4-29

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.4, GW-4.4, AND GW-7.4
EXTRACTION, DISCHARGE AND DISPOSAL TO OFF-SITE POTW, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Clean Water Act (CWA), Pretreatment Regulations	40 CFR § 403	Relevant and Appropriate	General pretreatment requirements for discharge to a publicly-owned treatment works (POTW). If remedial activities include such a discharge to the local sanitary sewer, pretreatment standards would be ARARs. Standards would be enforced through the State program.	Would comply. Alternative GW-1.4, GW-4.4, and GW-7.4 would include discharge of contaminated groundwater to the Lower Subase sanitary sewer system and from there to the Town of Groton POTW. These alternatives would comply with pretreatment standards.
STATE OF CONNECTICUT				
Hazardous Waste Management: Generator and Handler Requirements, Listing and Identification	Regulations of Connecticut State Agencies (RCSA) § 22a-449(c) 100-101	Applicable	Connecticut is delegated to administer the Federal Resource Conservation and Recovery Act (RCRA) statute through its state regulations. These sections establish standards for listing and identification of hazardous waste. The standards of 40 CFR 260-261 are incorporated by reference	Would comply. Alternative GW-1.4, GW-4.4, and GW-7.4 would require hazardous waste determination would be performed on contaminated groundwater removed to determine that the levels of regulated constituents do not exceed applicable limits.
Hazardous Waste Management: Generator Standards	RCSA § 22a-449(c)-102	Applicable	This section establishes standards for various classes of generators. The standards of 40 CFR 262 are incorporated by reference.	Would comply. Alternative GW-1.4, GW-4.4, and GW-7.4 would require any hazardous waste that is generated (groundwater) would be handled and disposed of in compliance with these standards.
Water Quality Standards (WQSs)	Connecticut General Statutes (CGS) 22a-426	Applicable	Establishes specific numeric criteria, designated uses, and anti-degradation policies for groundwater and surface water. Includes stormwater requirements for construction projects that disturb over one acre.	Would comply. Stormwater standards would be complied with under these regulations. If necessary, it would be used for monitoring standards for groundwater beyond the compliance boundary for any waste management area and to monitor the Thames River.

TABLE 4-29

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.4, GW-4.4, AND GW-7.4
EXTRACTION, DISCHARGE AND DISPOSAL TO OFF-SITE POTW, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT (continued)				
Water Pollution Control	RCSA §22a-430-1 to 8	Applicable	These regulations govern the treatment and discharge of water into surface water bodies in the state. These regulations also govern the pretreatment and discharge of water to publicly owned treatment works (POTWs).	Would comply. Alternatives GW-1.4, GW-4.4, and GW-7.4 would include groundwater extraction and discharge to the Lower Subase sanitary sewer system and from there to the Town of Groton POTW. These alternatives would comply with applicable pretreatment requirements.

TABLE 4-30

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.5, GW-4.5, AND GW-7.5
EXTRACTION, ON SITE TREATMENT, DISCHARGE TO THAMES RIVER, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Cancer Slope Factors (CSFs)	United States Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) and others	To Be Considered (TBC)	These are guidance values used in risk assessment to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Would comply. There are no unacceptable carcinogenic risks from direct exposure to contaminated groundwater under the current industrial site use and the aquifer beneath the Lower Subase has been classified as GB. Alternatives GW-1.5, GW-4.5, and GW-7.5 would include extraction that would actively remove chemicals of concern (COCs) from groundwater and land use controls (LUCs) that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.
Reference Doses (RfDs)	EPA IRIS and others	TBC	These are guidance values used in risk assessment to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants.	Would comply. There are no unacceptable non-carcinogenic risks from direct exposure to contaminated groundwater under the current industrial site use and the aquifer beneath the Lower Subase has been classified as GB. Alternatives GW-1.5, GW-4.5, and GW-7.5 would include extraction that would actively remove COCs from groundwater and LUCs that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.

TABLE 4-30

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.5, GW-4.5, AND GW-7.5
EXTRACTION, ON SITE TREATMENT, DISCHARGE TO THAMES RIVER, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL (Continued)				
Guidelines for Carcinogen Risk Assessment	EPA/630/P-03/001F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would comply. There are no unacceptable carcinogenic risks from direct exposure to contaminated groundwater under the current industrial site use and the aquifer beneath the Lower Subase has been classified as GB. Alternatives GW-1.5, GW-4.4, and GW-7.5 would include extraction that would actively remove COCs from groundwater and LUCs that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	EPA/630/R-03/003F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would comply. There are no unacceptable carcinogenic risks to children from direct exposure to contaminated groundwater under the current industrial site use and the aquifer beneath the Lower Subase has been classified as GB. Alternatives GW-1.5, GW-4.5, and GW-7.5 would include extraction that would actively remove COCs from groundwater and LUCs that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.

TABLE 4-30

ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.5, GW-4.5, AND GW-7.5
EXTRACTION, ON SITE TREATMENT, DISCHARGE TO THAMES RIVER, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT				
Remediation Standard Regulations (RSRs)	Connecticut General Statutes (CGS) §22a-133k; Regulations of Connecticut State Agencies (RCSA) §22a-133k - 1 through 3	Applicable	These regulations provide specific numerical cleanup criteria for contaminants in groundwater. Because the groundwater beneath the Lower Subase is classified as GB, only Surface Water Protection Criteria (SWPCs) apply. Section 22a-133k-3(b)(3) of these regulations establish the methodology for the development of the site-specific Alternative SWPCs that were used to establish groundwater Preliminary Remedial Goals (PRGs).	Would comply. Alternative GW-1.5 would actively remove and treat groundwater contaminated with copper from Zone 1 and Alternative GW-4.5 would actively remove and treat groundwater contaminated with lead from Zone 4 until the Standard SWPCs for these COCs are met. In addition, Alternatives GW-1.5, GW-4.5, and GW-7.5 would actively remove and treat groundwater contaminated with arsenic from Zones 1, 4, and 7 until the Alternative SWPC for this COC is met.

TABLE 4-31

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.5, GW-4.5, AND GW-7.5
EXTRACTION, ON SITE TREATMENT, DISCHARGE TO THAMES RIVER, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Coastal Zone Management Act	16 USC Parts 1451 *et. seq*.	Applicable	Requires that any actions that affect a land or water use or water resource of the coastal zone must be conducted in a manner consistent to the maximum extent practical with enforceable policies of state-approved management programs.	Would comply. The extraction, on-site treatment, discharge to Thames River, LUCs, and monitoring activities of Alternatives GW-1.5, GW-4.5, and GW-7.5 would comply with the substantive requirements of this act.
Fish and Wildlife Coordination Act	16 USC Part 661 et seq.; 40 CFR 122.49	Applicable	Requires action to be taken to protect fish and wildlife from projects affecting streams or rivers.	Contaminated groundwater or soil may migrate into the Thames River directly or indirectly. Alternatives for Thames River sediment may include dredging and filling activities. Appropriate federal and Connecticut agencies would be consulted on how to minimize impacts of any remedial activities on any wildlife that may be dependent on the Thames River.
Floodplain Management and Protection of Wetlands	44 CFR 9	Relevant and appropriate	FEMA regulations that set forth the policy, procedure and responsibilities to implement and enforce Executive Order 11988 Floodplain Management and Executive Order 11990, Protection of Wetlands.	Would comply. Alternatives GW-1.5, GW-4.5, and GW-7.5 would be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.
STATE OF CONNECTICUT				
Coastal Management Act	Regulations of Connecticut State Agencies (RCSA) §22a-90 to 112	Applicable	The sites are in a coastal zone management area; therefore, requirements for site planning approval of activities within the coastal zone to minimize project impacts to this area.	Would comply. The extraction, on-site treatment, discharge to Thames River, LUCs, and monitoring activities of Alternatives GW-1.5, GW-4.5, and GW-7.5 would comply with the substantive requirements of this act.
Connecticut Endangered Species Act	CGS 26-303 to 314	Applicable	Regulates activities affecting state-listed endangered or threatened species or their critical habitat.	The state-threatened Atlantic Sturgeon inhabits the Thames River. Actions that can impact the sturgeon would have to comply with the requirement of this act. Remedial activities for sites addressed in this FS may directly impact the Thames River and actions would need to be taken during these remedial activities to protect the Atlantic Sturgeon.
Tidal Wetlands and Watercourses	RCSA §22a-30-1 through 17	Applicable	These rules regulate all activities within or affecting tidal wetlands and watercourses.	Would comply. The treatment and monitoring activities of Alternatives GW-1.5, GW-4.5, and GW-7.5 would be managed to prevent erosion and other disturbance to tidal wetlands and the Thames River.

TABLE 4-31

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.5, GW-4.5, AND GW-7.5
EXTRACTION, ON SITE TREATMENT, DISCHARGE TO THAMES RIVER, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT (Continued)				
Flood Management Regulations	(RCSA 25-68h-1 through 25-68h-3)	Relevant and Appropriate	These regulations address activities in flood plains to minimize flood risk and prevent flood hazards. Also addresses stormwater runoff.	Would comply. The extraction, on-site treatment, discharge to Thames River, LUCs, and monitoring activities of Alternatives GW-1.5, GW-4.5, and GW-7.5 would consider the potential for disturbance of floodplains. Any work in flood plains would comply with the substantive provisions of the regulations.

TABLE 4-32

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.5, GW-4.5, AND GW-7.5
EXTRACTION, ON SITE TREATMENT, DISCHARGE TO THAMES RIVER, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Clean Water Act (CWA), National Pollution Discharge Elimination System (NPDES)	33 Unites States Code (USC) 1342 and 40 Code of Federal Regulations (CFR) Parts 122 through 125, and 131	Relevant and Appropriate	Provides requirements for point source discharges of pollutants to surface water. Includes stormwater requirements for construction projects that disturb over one acre.	Would comply. Alternatives GW-1.5, GW-4.5, and GW-7.5 would include groundwater extraction, on-site treatment, and discharge of the treated groundwater to the Thames River. These alternatives would comply with the substantive requirements of NPDES. Stormwater standards would also be met through monitoring.
STATE OF CONNECTICUT				
Hazardous Waste Management: Generator and Handler Requirements, Listing and Identification	Regulations of Connecticut State Agencies (RCSA) § 22a-449(c) 100-101	Applicable	Connecticut is delegated to administer the Federal Resource Conservation and Recovery Act (RCRA) statute through its state regulations. These sections establish standards for listing and identification of hazardous waste. The standards of 40 CFR 260-261 are incorporated by reference	Would comply. Alternatives GW-1.5, GW-4.5, and GW-7.5 would require hazardous waste determination would be performed on contaminated groundwater removed to determine that the levels of regulated constituents do not exceed applicable limits.
Hazardous Waste Management: Generator Standards	RCSA § 22a-449(c)-102	Applicable	This section establishes standards for various classes of generators. The standards of 40 CFR 262 are incorporated by reference.	Would comply. Alternatives GW-1.5, GW-4.5, and GW-7.5 would require any hazardous waste that is generated (groundwater) would be handled and disposed of in compliance with these standards.

TABLE 4-32

ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVES GW-1.5, GW-4.5, AND GW-7.5
EXTRACTION, ON SITE TREATMENT, DISCHARGE TO THAMES RIVER, LUCs (ENGINEERING AND INSTITUTIONAL), AND MONITORING
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT (continued)				
Water Quality Standards (WQSs)	Connecticut General Statutes (CGS) 22a-426	Applicable	Establishes specific numeric criteria, designated uses, and anti-degradation policies for groundwater and surface water. Includes stormwater requirements for construction projects that disturb over one acre.	Would comply. Stormwater standards would be complied with under these regulations. If necessary, it would be used for monitoring standards for groundwater beyond the compliance boundary for any waste management area and to monitor the Thames River.
Water Pollution Control	RCSA §22a-430-1 to 8	Applicable	These regulations govern the treatment and discharge of water into surface water bodies in the state. These regulations also govern the pretreatment and discharge of water to publicly owned treatment works (POTWs).	Would comply. Alternatives GW-1.5, GW-4.5, and GW-7.5 would include groundwater extraction, on site treatment, and discharge of the treated groundwater to the Thames River. These alternatives would comply with the NPDES requirements, including permitting.

TABLE 4-33

CHEMICAL-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVE SD-1: NO ACTION
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Cancer Slope Factors (CSFs)	United States Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) and others	To Be Considered (TBC)	These are guidance values used in risk assessment to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Would not comply. These standards would be used to determine that there are no unacceptable carcinogenic risks from direct exposure to contaminated sediment. The No Action alternative would not meet these standards because risks identified would not be addressed.
Reference Doses (RfDs)	EPA IRIS and others	TBC	These are guidance values used in risk assessment to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants.	Would not comply. These standards would be used to determine that there are no unacceptable non-carcinogenic risks from direct exposure to contaminated sediment. The No Action alternative would not meet these standards because risks identified would not be addressed.
Guidelines for Carcinogen Risk Assessment	EPA/630/P-03/001F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would not comply. These standards would be used to determine that there are no unacceptable carcinogenic risks from direct exposure to contaminated sediment. The No Action alternative would not meet these standards because risks identified would not be addressed.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	EPA/630/R-03/003F (March 2005)	TBC	These guidelines are used to perform human health risk assessments.	Would not comply. These standards would be used to determine that there are no unacceptable carcinogenic risks to children from direct exposure to contaminated sediment. The No Action alternatives would not meet these standards because risks identified would not be addressed.

TABLE 4-33

CHEMICAL-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVE SD-1: NO ACTION
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL (continued)				
Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil	EPA-540-R-03-001, OSWER Dir #9285.7.54 (January 2003)	TBC	EPA guidance for evaluating the risks posed by lead in sediment.	Would not comply. The No Action alternatives would not meet these standards because risks identified from lead-contaminated sediment would not be addressed.
Effect Range Median-Quotient (ERM-Q)	Long, Edward, et al, 1995. Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments, and Long and Morgan, 1991. Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program.	TBC	Provide guidance values for identifying potential risk to ecological receptors exposed to contaminated sediments. The citations provide the ERM values which were then used in conjunction with site-specific toxicity test data to develop the PRGs.	Would not comply. The document would be used to develop standards used for evaluating risk to aquatic ecological receptors exposed to contaminated sediment. Guidance was used to establish sediment PRGs. The No Action alternative would not meet these standards because risks identified would not be addressed.
STATE OF CONNECTICUT				
None				

TABLE 4-34

CHEMICAL-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVES SD-3 AND SD-4 (CAPPING) AND SD-6 AND SD-7 (DREDGING)
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Cancer Slope Factors (CSFs)	United States Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) and others	To Be Considered (TBC) for all alternatives	These are guidance values used in risk assessment to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Would comply. These standards would be used to determine that there are no unacceptable carcinogenic risks from direct exposure to contaminated sediment. Alternatives SD-3, SD-4, SD-6, and SD-7 would meet these standards because potential risk from adult exposure to contaminated sediment would be addressed through capping or dredging and off-site disposal of contaminated sediment.
Reference Doses (RfDs)	EPA IRIS and others	TBC for all alternatives	These are guidance values used in risk assessment to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants.	Would comply. These standards would be used to determine that there are no unacceptable non-carcinogenic risks from direct exposure to contaminated sediment. Alternatives SD-3, SD-4, SD-6, and SD-7 would meet these standards because potential risk from adult exposure to contaminated sediment would be addressed through capping or dredging and off-site disposal of contaminated sediment.
Guidelines for Carcinogen Risk Assessment	EPA/630/P-03/001F (March 2005)	TBC for all alternatives	These guidelines are used to perform human health risk assessments.	Would comply. These standards would be used to determine that there are no unacceptable carcinogenic risks from direct exposure to contaminated sediment. Alternatives SD-3, SD-4, SD-6, and SD-7 would meet these standards because potential risk from adult exposure to contaminated sediment would be addressed through capping or dredging and off-site disposal of contaminated sediment.

TABLE 4-34

CHEMICAL-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVES SD-3 AND SD-4 (CAPPING) AND SD-6 AND SD-7 (DREDGING)
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL (continued)				
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	EPA/630/R-03/003F (March 2005)	TBC for all alternatives	These guidelines are used to perform human health risk assessments.	Would comply. These standards would be used to determine that there are no unacceptable carcinogenic risks to children from direct exposure to contaminated sediment. Alternatives SD-3, SD-4, SD-6, and SD-7 would meet these standards because potential risk from child exposure to contaminated sediment would be addressed through capping or dredging and off-site disposal of contaminated sediment.
Effect Range Median-Quotient (ERM-Q)	Long, Edward, et al, 1995. Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments, and Long and Morgan, 1991. Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program.	TBC	Provide guidance values for identifying potential risk to ecological receptors exposed to contaminated sediments. The citations provide the ERM values which were then used in conjunction with site-specific toxicity test data to develop the PRGs.	Would comply. The document would be used to develop standards used for evaluating risk to aquatic ecological receptors exposed to contaminated sediment. Guidance was used to establish sediment PRGs. Alternatives SD-3, SD-4, SD-6, and SD-7 would meet the standards because potential risk to aquatic ecological receptors to contaminated sediment would be addressed through capping or dredging and off-site disposal of contaminated sediment.

TABLE 4-34

CHEMICAL-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVES SD-3 AND SD-4 (CAPPING) AND SD-6 AND SD-7 (DREDGING)
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL (continued)				
Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil	EPA-540-R-03-001, OSWER Dir #9285.7.54 (January 2003)	TBC for all alternatives	EPA guidance for evaluating the risks posed by lead in sediment.	Would comply Alternatives SD-3, SD-4, SD-6, and SD-7 would meet this standard because potential lead risk from adult exposure to lead in contaminated sediment would be addressed through capping or dredging and off-site disposal.
STATE OF CONNECTICUT				
None				

TABLE 4-35

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVES SD-3 AND SD-4 (CAPPING) AND SD-6 AND SD-7 (DREDGING)
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Clean Water Act (CWA) Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material	33 United States Code (USC) 1344; 40 Code of Federal Regulations (CFR) Part 230 and 320-323	Applicable to all alternatives.	These rules regulate the discharge of dredge and fill materials in wetlands and navigable waters. Such discharges are not allowed if practicable alternatives are available.	All alternatives would comply. Dredging operations including sediment dewatering would be conducted in a manner that will minimize discharges to wetlands or navigable waters. Resource agencies have indicated that mitigation would not be required for altering aquatic habitat. Any capping remedy (Alternatives SD-3 and SD-4 only) would also meet these standards
Rivers and Harbors Act, Section 10	33 USC 403; 33 CFR Parts 320-323	Applicable to all alternatives.	Sets forth criteria for obstructions or alterations of navigable waters.	The dredging, dewatering, and potentially capping (Alternatives SD-3 and SD-4 only) components of all alternatives would meet the substantive environmental requirements of these standards.
Fish and Wildlife Coordination Act	16 USC Part 661 *et seq.*,	Applicable to all alternatives.	Protects fish and wildlife when actions at the site would result in the control or structural modification of a natural stream, body of water, wetland, floodplain, or flood-prone area. The statute requires federal agencies to take into account the effects of remedial actions and prevent loss or damage to resources.	The dredging, dewatering, and potentially capping (Alternatives SD-3 and SD-4 only) components of all alternatives would be conducted so as to minimize impacts to fish and wildlife in the Thames River. Federal and State resource agencies would be consulted to prevent, mitigate, or compensate for loss of fish and wildlife.
Coastal Zone Management Act	16 USC Parts 1451 *et seq.*	Applicable to all alternatives.	Requires that any actions that affect a land or water use or natural resource of the coastal zone must be conducted in a manner consistent to the maximum extent practical with enforceable policies of state-approved management programs.	The dredging, dewatering, and potentially capping (Alternatives SD-3 and SD-4 only) components of all alternatives would be conducted so as to comply with the substantive requirements of this act.

TABLE 4-35

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVES SD-3 AND SD-4 (CAPPING) AND SD-6 AND SD-7 (DREDGING)
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
FEDERAL (Continued)				
Floodplain Management and Protection of Wetlands	44 CFR 9	Relevant and appropriate	FEMA regulations that set forth the policy, procedure and responsibilities to implement and enforce Executive Order 11988 Floodplain Management and Executive Order 11990, Protection of Wetlands.	All alternatives would comply. Remedial alternatives conducted within the 500-year floodplain of the Thames River or within federal jurisdictional wetlands will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.
STATE OF CONNECTICUT				
Coastal Management Act	Regulations of Connecticut State Agencies (RCSA) §22a-90 to 112	Applicable to all alternatives.	Requires that any actions must be conducted in a manner consistent with state-approved management programs.	The dredging, dewatering, and potentially capping (Alternatives SD-3 and SD-4 only) components of all alternatives would be conducted so as to as to comply with the substantive requirements of this act.
Regulation of Dredging and Erection of Structures and Placement of Fill in Tidal, Coastal, or Navigable Waters	CGS 22a-359 through 363f	Applicable to all alternatives.	This statute regulates dredging and the erection of structures and the placement of fill, and work incidental thereto, in the tidal, coastal or navigable waters of the state waterward of the high tide line. Work within the regulated zone must be conducted with due regard for indigenous aquatic life, fish and wildlife, the prevention or alleviation of shore erosion and coastal flooding, the use and development of adjoining uplands, the improvement of coastal and inland navigation for all vessels, including small craft for recreational purposes, the use and development of adjacent lands and properties and the interests of the state, including pollution control, water quality, recreational use of public water and management of coastal resources, with proper regard for the rights and interests of all persons concerned.	The dredging, dewatering, and potentially capping (Alternatives SD-3 and SD-4 only) components of all alternatives would be conducted so as to as to comply with the substantive requirements of this act.

TABLE 4-35

ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVES SD-3 AND SD-4 (CAPPING) AND SD-6 AND SD-7 (DREDGING)
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis of Requirement	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT (continued)				
Tidal Wetlands and Watercourses	Regulations of Connecticut State Agencies (RCSA) §22a-30-1 through 17	Applicable to all alternatives.	These rules regulate all activities within or affecting tidal wetlands and watercourses.	The dredging, dewatering, and potentially capping (Alternatives SD-3 and SD-4 only) components of all alternatives would be conducted so as to prevent erosion, sedimentation and other disturbance to tidal wetlands and watercourses
Flood Management Regulations	RCSA 25-68h-1 through 25-68h-3	Relevant and Appropriate to all alternatives.	These regulations address activities by state agencies in flood plains to minimize flood risk and prevent flood hazards.	All alternatives would comply with this standard. Any shoreline activities within the 100-year coastal flood hazard zone would comply with the substantive provisions of these regulations.
Endangered Species Act	CGS §26-303 through 314	Applicable to all alternatives.	Remedial actions may not jeopardize the continued existence of state-listed endangered or threatened species, or adversely modify or destroy their critical habitat.	The dredging, dewatering, and potentially capping (Alternatives SD-3 and SD-4 only) components of all alternatives would be conducted so as to minimize disturbance to aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon.

TABLE 4-36

ACTION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVES SD-3 AND SD-4 (CAPPING) AND SD-6 AND SD-7 (DREDGING)
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis	Evaluation of Alternative Compliance with ARAR
FEDERAL				
Clean Water Act (CWA), Section 304; National Recommended Water Quality Criteria (NRWQC)	33 United States Code (USC) 1314; 40 Code of Federal Regulations (CFR) 122.44	Relevant and Appropriate to all alternatives.	Guidelines establish National Recommended Water Quality Criteria (NRWQC) for the protection of human health and/or the aquatic organisms.	All alternatives would comply. Water quality monitoring would ensure that these criteria are not exceeded during dredging and dewatering operations. Alternatives SD-3 and SD-4 that include capping and leaving waste in place might require long-term monitoring of water quality under these standards.
CWA, Section 402, National Pollution Discharge Elimination System (NPDES)	33 USC 1342; 40 CFR 122 through 125	Applicable to Alternatives SD-3 and SD-6 (discharge to Thames River. Not applicable to Alternatives SD-4 and SD-7	These standards govern the discharge of water into surface waters.	Alternatives SD-3 and SD-6 would comply. Dewatering operations would meet these standards through active or passive treatment before dewatering fluid is discharged back to the Thames River.
CWA; General Pretreatment Regulations for Existing and New Sources of Pollution	40 CFR § 403	Potentially applicable to Alternatives SD-4 and SD-7 (off-site disposal). Not applicable to Alternatives SD-3 and SD-6 (discharge to Thames River).	Standards for direct discharge of dewatering fluid or any other discharge into a Publicly Owned Treatment Works (POTW).	Alternatives SD-4 and SD-7 would comply with these standards if off-site disposal of dewatering fluid involves discharge to a POTW.
Toxic Substance Control Act (TSCA), Polychlorinated Biphenyls (PCB) Remediation Waste Risk-Based Standards	15 USC § 2601 *et seq.*; 40 CFR 761.61(c)	Applicable to all alternatives.	Risk-based standards for the sampling, cleanup, or disposal of PCB remediation waste. Written approval for the proposed risk-based clean-up will be obtained from the Office of Site Remediation and Restoration, EPA Region 1.	Alternatives SD-3 and SD-4 would comply by capping PCB contaminated sediment in place to prevent risks to human health and the environment. Alternatives SD-6 and SD-7 would comply because sediment exceeding the unrestricted use, risk-based standard of 1 mg/kg would be excavated/dredged and disposed of off-site. The Navy will seek public comment in the Proposed Plan as to whether the finding that the proposed remedy for PCB contamination at the Site will not pose an unreasonable risk of injury to health or the environment. An EPA finding that the remedy meets these standards will be included in the Record of Decision.

TABLE 4-36

ACTION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVES SD-3 AND SD-4 (CAPPING) AND SD-6 AND SD-7 (DREDGING)
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis	Evaluation of Alternative Compliance with ARAR
FEDERAL (Continued)				
Clean Air Act (CAA), National Emissions Standards for Hazardous Air Pollutants (NESHAPs),	42 USC §12(b)(1); 40 CFR Part 61	Applicable to all alternatives.	The regulations establish emissions standards for 189 hazardous air pollutants. Standards set for dust control and other release sources.	All alternatives would comply. If removal activities, including excavation/dredging or processing of contaminated sediment, generate regulated air pollutants, measures would be implemented to meet these standards.
United States Environmental Protection Agency (U.S. EPA) Contaminated Sediment Remediation Guidance for Hazardous Waste Sites	EPA-540-R-05-012; Office of Solid Waste and Emergency Response (OSWER) 9355.0-85 December 2005	To Be Considered (TBC) for all alternatives.	Guidance on the remediation of contaminated sediments, including capping and dredging.	All Alternatives would comply. Capping and dredging alternatives would be designed and implemented utilizing this guidance.
STATE OF CONNECTICUT				
Hazardous Waste Management: Generator and Handler Requirements, Listing and Identification	Regulations of Connecticut State Agencies (RCSA) §22a-449(c) 100-101	Applicable to all alternatives.	Connecticut is delegated to administer the federal Resource Conservation and Recovery Act (RCRA) statute through its state regulations. These sections establish standards for listing and identification of hazardous waste. The standards of 40 CFR 260-261 are incorporated by reference	All alternatives would comply. Hazardous waste determinations would be performed on all contaminated sediment excavated/dredged to determine that the levels of regulated constituents do not exceed applicable limits. Any contaminated sediments which exceed hazardous waste standards would be managed in accordance with requirements of these regulations. Also, wastes produced from dewatering process would be tested to determine whether they exceed applicable limits.
Hazardous Waste Management: Generator Standards	RCSA § 22a-449(c)-102	Applicable to all alternatives.	This section establishes standards for various classes of generators. The standards of 40 CFR 262 are incorporated by reference.	All alternatives would comply. Any hazardous waste generated as a result of either excavation/dredging or dewatering operations would be handled and disposed of in compliance with these standards.
Solid Waste Management	RSCA §22a-209 -1 through 16	Applicable to solid waste managed on-site (all alternatives).	Management and siting requirements for the disposal of solid waste.	All alternatives would comply. All material that does not exceed hazardous waste threshold that would be managed on-site as solid waste and disposed off-site in an appropriate licensed solid waste facility.

TABLE 4-36

ACTION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVES SD-3 AND SD-4 (CAPPING) AND SD-6 AND SD-7 (DREDGING)
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status	Synopsis	Evaluation of Alternative Compliance with ARAR
STATE OF CONNECTICUT (Continued)				
Water Pollution Control	RCSA §22a-430-1 through 8	Not applicable to Alternatives SD-4 and SD-7 (off-site disposal). Applicable to Alternatives SD-3 and SD-6 (discharge to Thames River.	These rules regulate water discharge to surface water.	Alternatives SD-3 and SD-6 would comply. Dewatering operations would meet these standards through active or passive treatment before dewatering fluid is discharged back to the Thames River.
Air Pollution Control	RCSA §22a-174 1-20	Applicable to all alternatives.	These regulations pertain to the construction and operation of specified types of emission sources and contain emission standards that must be met. Pollutant abatement controls may be required. Specific standards pertain to fugitive dust (18b).	All alternatives would comply. If removal activities, including excavation/dredging or processing of contaminated sediment, generates regulated air pollutants, measures would be implemented to meet the substantive requirements of these regulations. However, under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), actual permits would not be required.
Connecticut Guidelines for Soil Erosion and Sediment Control	Connecticut Council on Soil and Water Conservation	TBC for all alternatives.	Technical and administrative guidance for development, adoption and implementation of erosion and sediment control program.	All alternatives would comply. Excavation/dredging operations would include an appropriate erosion and sedimentation control program that would comply with this guidance.

P:\GIS\NLON\ZONES_1TO7.APR ZONE 1 AREA TO BE EXCAVATED LAYOUT 07/02/10 JEE

TB4-1RI [2 - 4']	RESULT	PRG
Semivolatile Organics (ug/kg)		
BENZO(B)FLUORANTHENE	7400	[7000]

TB2-1RI [2 - 3.5']	RESULT	PRG
Semivolatile Organics (ug/kg)		
BENZO(A)ANTHRACENE	21000	[11000]
BENZO(A)PYRENE	17000	[16000]
BENZO(B)FLUORANTHENE	17000	[7000]
CHRYSENE	19000	[18000]
TB2-1RI [7 - 7.5']	RESULT	PRG
Semivolatile Organics (ug/kg)		
BENZO(A)ANTHRACENE	16000	[11000]
BENZO(B)FLUORANTHENE	12000 J	[7000]

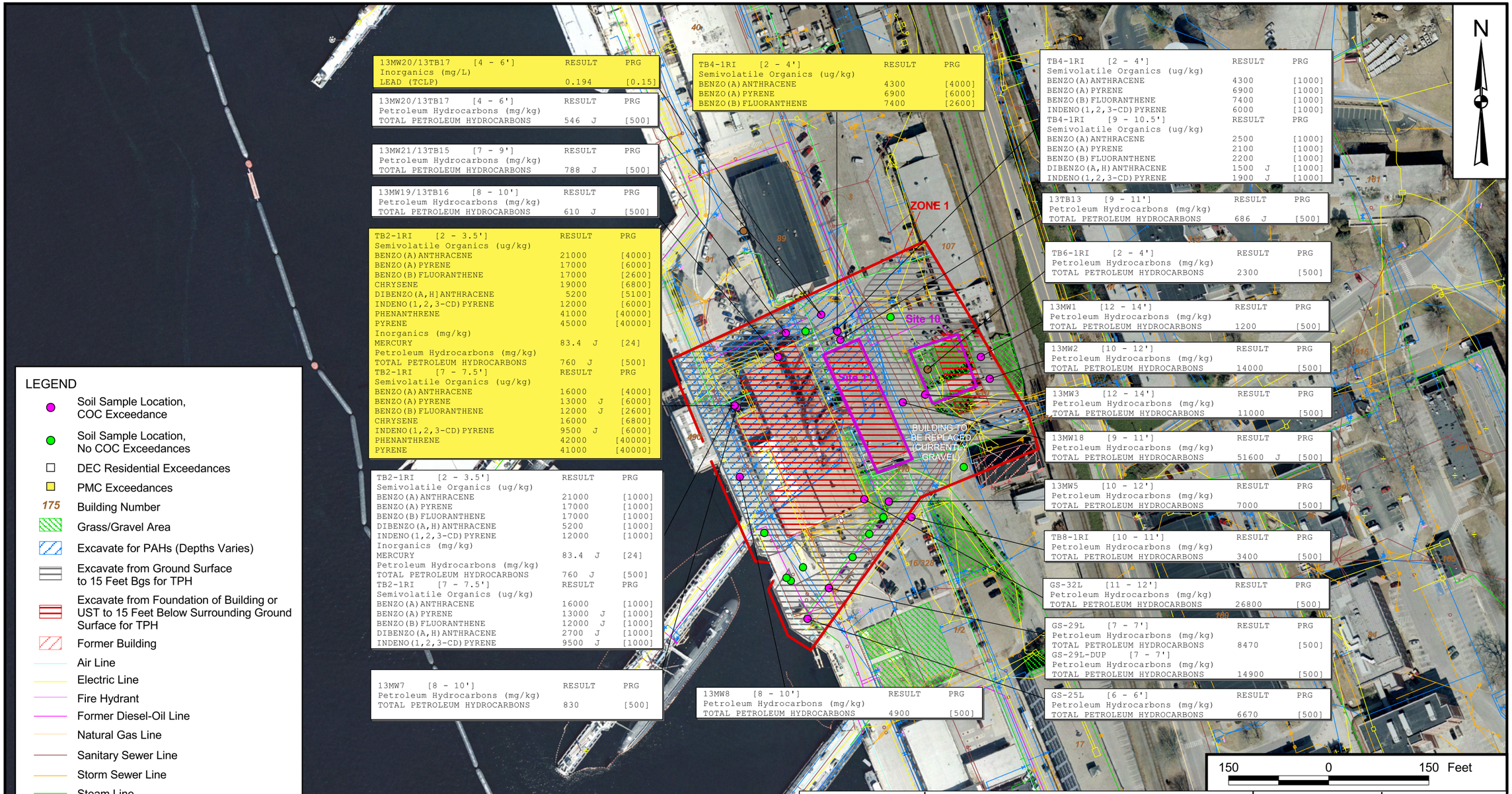
LEGEND

- Surface Soil Sample Location
- Soil Sample Location, COC Exceedance
- Soil Sample Location No COC Exceedances
- PMC Exceedances
- 175 Building Number
- Grass/Gravel Area
- Treat or Excavate to 2 Feet Bgs for PAHs
- Treat or Excavate from Ground Surface to Groundwater [Approximate Elevation 1.2 (NAVD88)] for PAHs
- Former Building
- Air Line
- Electric Line
- Fire Hydrant
- Former Diesel-Oil Line
- Natural Gas Line
- Sanitary Sewer Line
- Storm Sewer Line
- Steam Line
- Telephone Line
- Water Line

Note: * - For lead samples with no TCLP or SPLP analyses, mass results greater than 1090 mg/kg are estimated to exceed the Alternative PMC.

DRAWN BY S. STROZ	DATE 11/19/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424 / OWNER NUMBER —
CHECKED BY N. BALSAMO	DATE 07/02/10	ZONE 1 AREAS OF SOIL TO BE IN-SITU TREATED OR EXCAVATED FOR ALTERNATIVES S-1.3 AND S-1.4 LOWER SUBASE FEASIBILITY STUDY NSB-NLON, GROTON, CONNECTICUT	APPROVED BY CAR / DATE 12/14/10
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 4-1 / REV 0

P:\GIS\NLON\ZONES_1TO7.APR REV ZONE 1 AREA TO BE EXCAVATED LAYOUT 07/02/10 JEE



13MW20/13TB17 [4 - 6']	RESULT	PRG
Inorganics (mg/L)		
LEAD (TCLP)	0.194	[0.15]

13MW20/13TB17 [4 - 6']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	546 J	[500]

13MW21/13TB15 [7 - 9']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	788 J	[500]

13MW19/13TB16 [8 - 10']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	610 J	[500]

TB2-1RI [2 - 3.5']	RESULT	PRG
Semivolatile Organics (ug/kg)		
BENZO(A)ANTHRACENE	21000	[4000]
BENZO(A)PYRENE	17000	[6000]
BENZO(B)FLUORANTHENE	17000	[2600]
CHRYSENE	19000	[6800]
DIBENZO(A,H)ANTHRACENE	5200	[5100]
INDENO(1,2,3-CD)PYRENE	12000	[6000]
PHENANTHRENE	41000	[40000]
PYRENE	45000	[40000]
Inorganics (mg/kg)		
MERCURY	83.4 J	[24]
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	760 J	[500]
TB2-1RI [7 - 7.5']	RESULT	PRG
Semivolatile Organics (ug/kg)		
BENZO(A)ANTHRACENE	16000	[4000]
BENZO(A)PYRENE	13000 J	[6000]
BENZO(B)FLUORANTHENE	12000 J	[2600]
CHRYSENE	16000	[6800]
INDENO(1,2,3-CD)PYRENE	9500 J	[6000]
PHENANTHRENE	42000	[40000]
PYRENE	41000	[40000]

TB2-1RI [2 - 3.5']	RESULT	PRG
Semivolatile Organics (ug/kg)		
BENZO(A)ANTHRACENE	21000	[1000]
BENZO(A)PYRENE	17000	[1000]
BENZO(B)FLUORANTHENE	17000	[1000]
DIBENZO(A,H)ANTHRACENE	5200	[1000]
INDENO(1,2,3-CD)PYRENE	12000	[1000]
Inorganics (mg/kg)		
MERCURY	83.4 J	[24]
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	760 J	[500]
TB2-1RI [7 - 7.5']	RESULT	PRG
Semivolatile Organics (ug/kg)		
BENZO(A)ANTHRACENE	16000	[1000]
BENZO(A)PYRENE	13000 J	[1000]
BENZO(B)FLUORANTHENE	12000 J	[1000]
DIBENZO(A,H)ANTHRACENE	2700 J	[1000]
INDENO(1,2,3-CD)PYRENE	9500 J	[1000]

13MW7 [8 - 10']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	830	[500]

TB4-1RI [2 - 4']	RESULT	PRG
Semivolatile Organics (ug/kg)		
BENZO(A)ANTHRACENE	4300	[4000]
BENZO(A)PYRENE	6900	[6000]
BENZO(B)FLUORANTHENE	7400	[2600]

13MW8 [8 - 10']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	4900	[500]

TB4-1RI [2 - 4']	RESULT	PRG
Semivolatile Organics (ug/kg)		
BENZO(A)ANTHRACENE	4300	[1000]
BENZO(A)PYRENE	6900	[1000]
BENZO(B)FLUORANTHENE	7400	[1000]
INDENO(1,2,3-CD)PYRENE	6000	[1000]
TB4-1RI [9 - 10.5']	RESULT	PRG
Semivolatile Organics (ug/kg)		
BENZO(A)ANTHRACENE	2500	[1000]
BENZO(A)PYRENE	2100	[1000]
BENZO(B)FLUORANTHENE	2200	[1000]
DIBENZO(A,H)ANTHRACENE	1500 J	[1000]
INDENO(1,2,3-CD)PYRENE	1900 J	[1000]

13TB13 [9 - 11']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	686 J	[500]

TB6-1RI [2 - 4']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	2300	[500]

13MW1 [12 - 14']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	1200	[500]

13MW2 [10 - 12']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	14000	[500]

13MW3 [12 - 14']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	11000	[500]

13MW18 [9 - 11']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	51600 J	[500]

13MW5 [10 - 12']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	7000	[500]

TB8-1RI [10 - 11']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	3400	[500]

GS-32L [11 - 12']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	26800	[500]

GS-29L [7 - 7']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	8470	[500]
GS-29L-DUP [7 - 7']		
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	14900	[500]

GS-25L [6 - 6']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	6670	[500]

LEGEND

- Soil Sample Location, COC Exceedance
- Soil Sample Location, No COC Exceedances
- DEC Residential Exceedances
- PMC Exceedances
- 175 Building Number
- Grass/Gravel Area
- Excavate for PAHs (Depths Varies)
- Excavate from Ground Surface to 15 Feet Bgs for TPH
- Excavate from Foundation of Building or UST to 15 Feet Below Surrounding Ground Surface for TPH
- Former Building
- Air Line
- Electric Line
- Fire Hydrant
- Former Diesel-Oil Line
- Natural Gas Line
- Sanitary Sewer Line
- Storm Sewer Line
- Steam Line
- Telephone Line
- Water Line

Note: * - For lead samples with no TCLP or SPLP analyses, mass results greater than 1090 mg/kg are estimated to exceed the Alternative PMC.

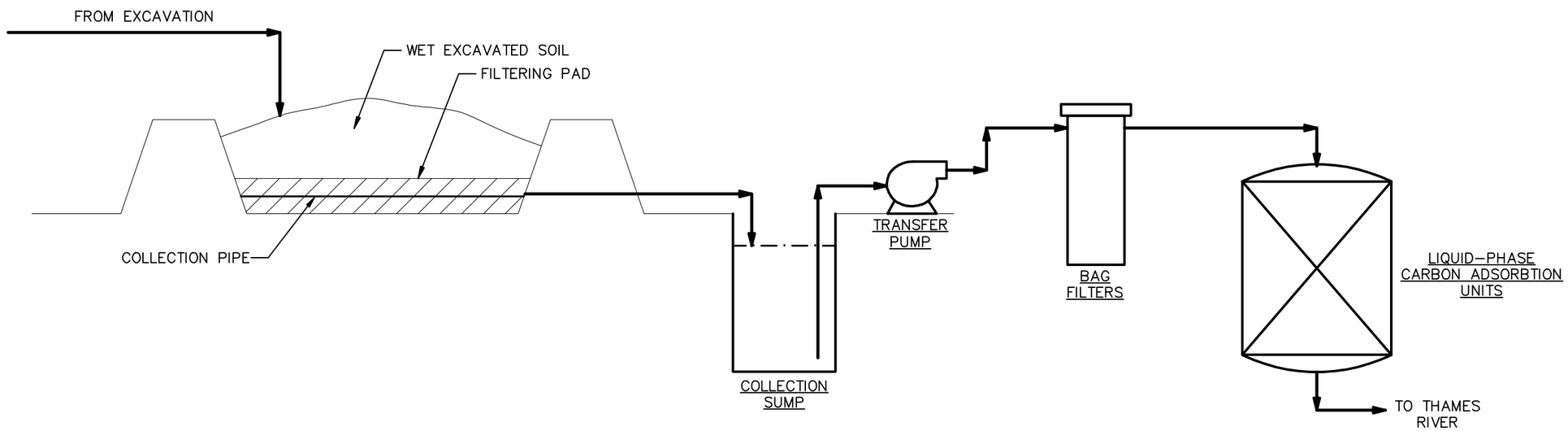
DRAWN BY	DATE
S. STROZ	11/20/09
CHECKED BY	DATE
N. BALSAMO	07/02/10
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

Tetra Tech NUS, Inc.

ZONE 1 AREAS TO BE EXCAVATED
FOR ALTERNATIVE S-1.5
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

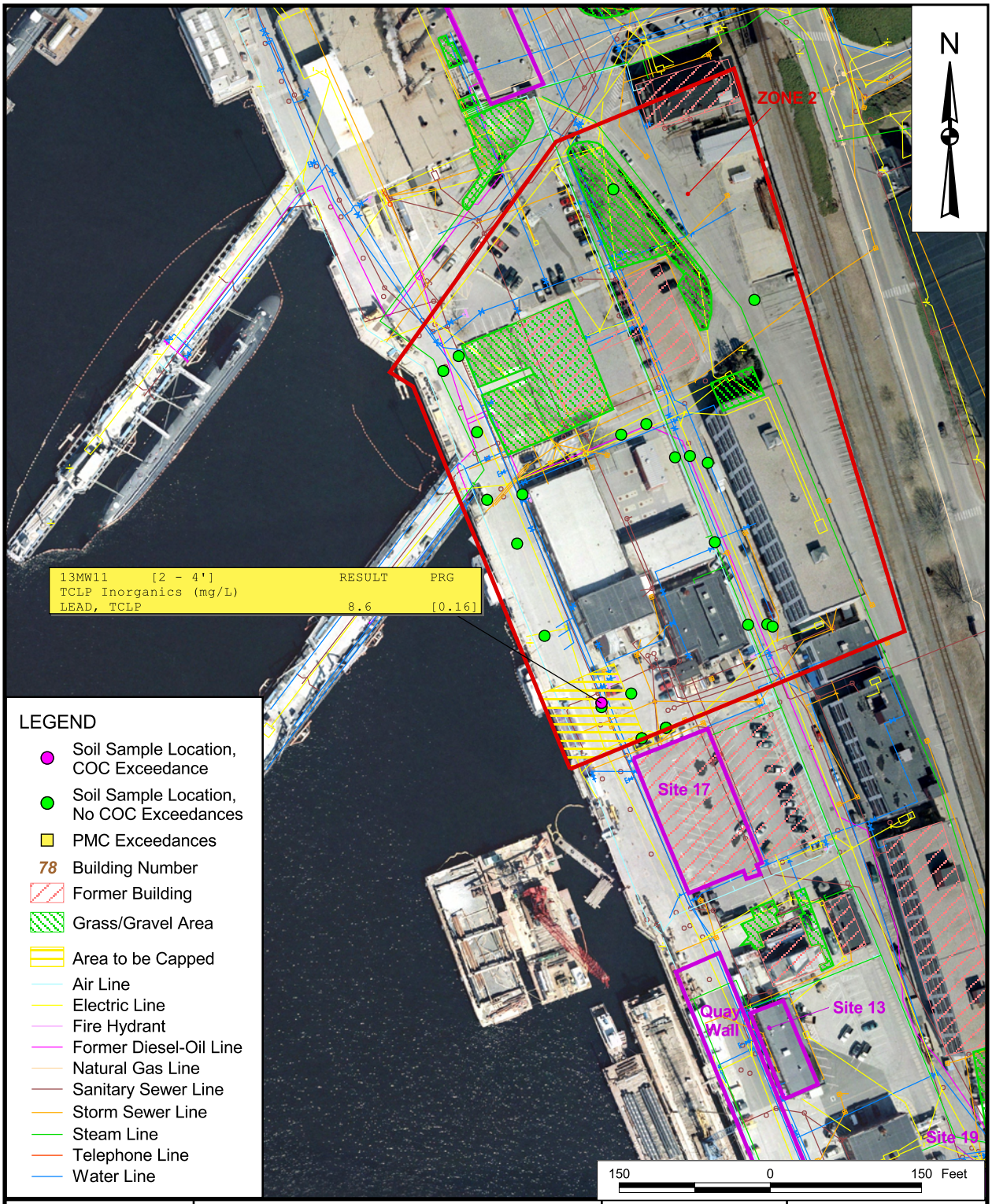
CONTRACT NUMBER	OWNER NUMBER
0424	—
APPROVED BY	DATE
CAR	12/14/10
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 4-2	0

ACAD: 0811PF01.dwg 02/12/08 MF PIT



DRAWN BY CK DATE 11/04/09	Tetra Tech NUS, Inc.	PROCESS FLOW DIAGRAM ON–SITE SOIL DEWATERING SYSTEM ALTERNATIVES S–1.5, S–2.6, S–3.6, S–4.6, S–5.5, S–6.5, AND S–7.6 LOWER SUBASE FEASIBILITY STUDY NSB–NLON GROTON, CONNECTICUT	CONTRACT NO. 0811
CHECKED BY DATE			OWNER NO.
REVISED BY DATE			APPROVED BY CAR DATE 12/14/10
SCALE AS NOTED			DRAWING NO. FIGURE 4–3 REV. 0

FORM CADD NO. TTNUS–BH.DWG – REV 1 – 9/10/98



DRAWN BY S. STROZ — DATE 11/19/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424	OWNER NO.
CHECKED BY N. BALSAMO — DATE 07/07/10	ZONE 2 AREA OF SOIL TO BE CAPPED FOR ALTERNATIVE S-2.3 LOWER SUBASE FEASIBILITY STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CONNECTICUT	APPROVED BY CAR — DATE 12/14/10	
COST/SCHEDULE-AREA		APPROVED BY — — DATE — —	
SCALE AS NOTED		DRAWING NO. FIGURE 4-4	REV 0

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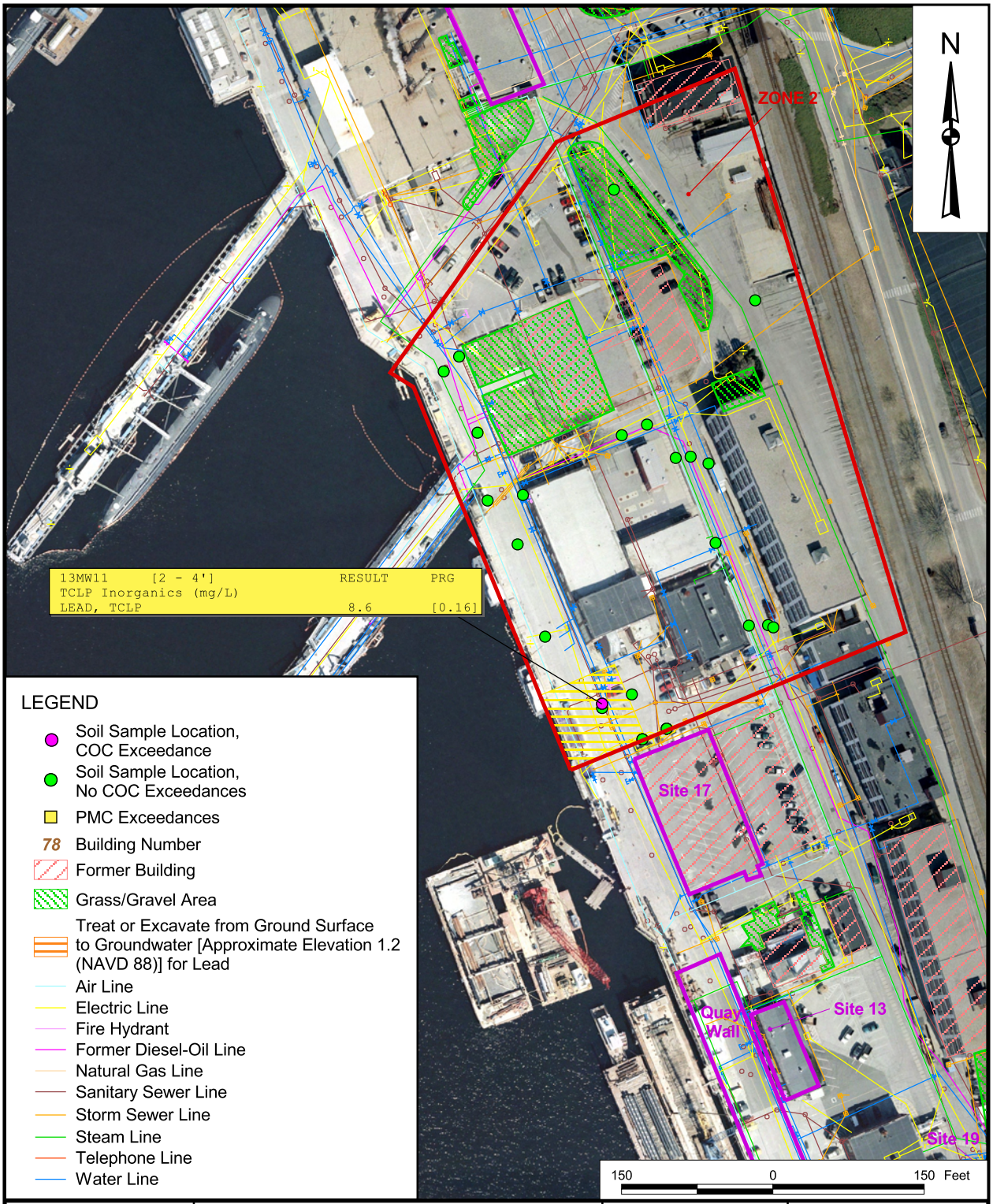

LEGEND

- Soil Sample Location, COC Exceedance
- Soil Sample Location, No COC Exceedances
- PMC Exceedances
- 78 Building Number
- Former Building
- Grass/Gravel Area
- Treat or Excavate from Ground Surface to Groundwater [Approximate Elevation 1.2 (NAVD 88)] for Lead
- Air Line
- Electric Line
- Fire Hydrant
- Former Diesel-Oil Line
- Natural Gas Line
- Sanitary Sewer Line
- Storm Sewer Line
- Steam Line
- Telephone Line
- Water Line

DRAWN BY S. STROZ	DATE 11/19/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424 / OWNER NO.
CHECKED BY N. BALSAMO	DATE 07/07/10	ZONE 2 AREA OF SOIL TO BE IN-SITU TREATED OR EXCAVATED FOR ALTERNATIVES S-2.4 AND S-2.5 LOWER SUBASE FEASIBILITY STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CONNECTICUT	APPROVED BY CAR / DATE 12/14/10
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 4-5 / REV 0

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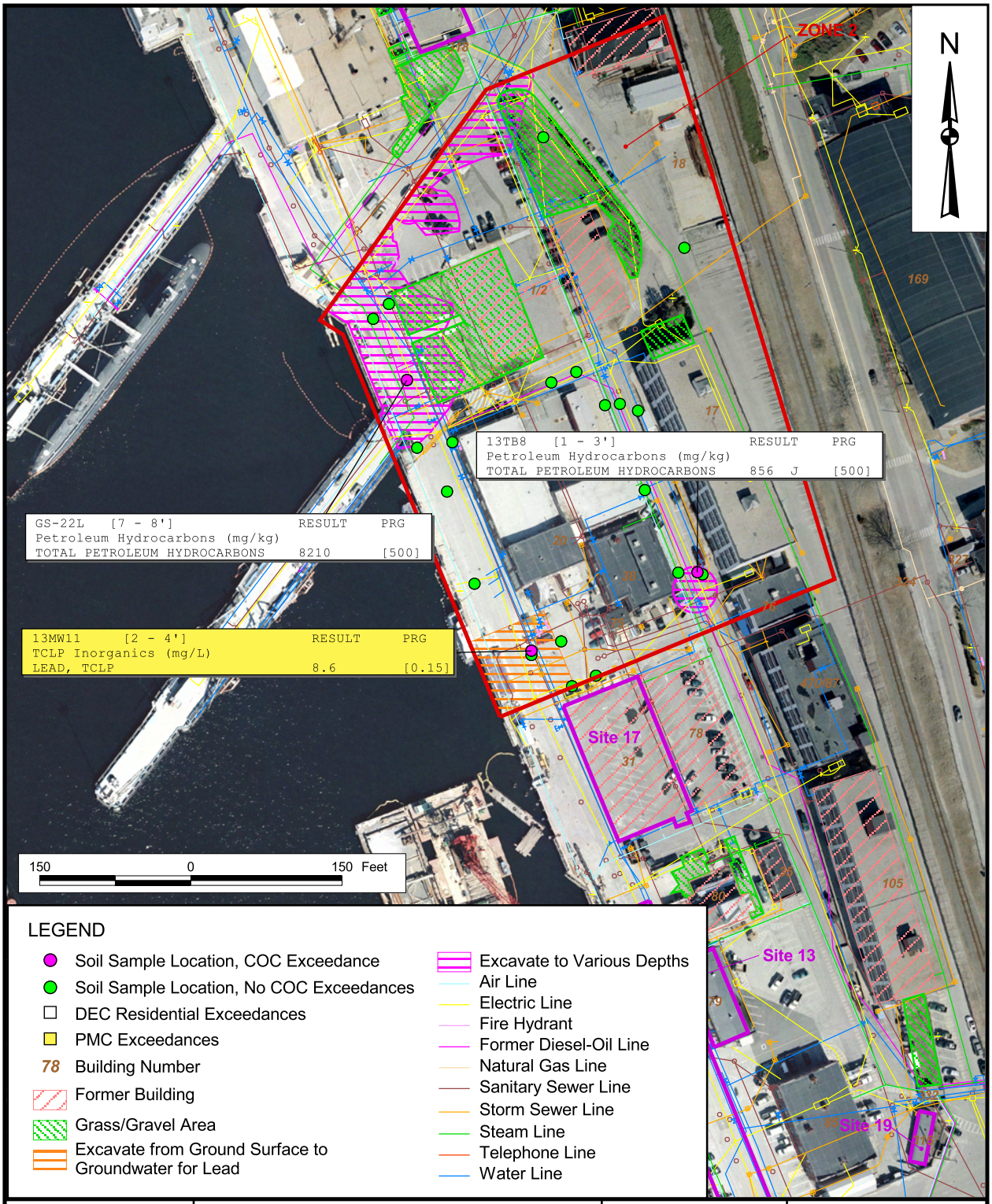

LEGEND

- Soil Sample Location, COC Exceedance
- Soil Sample Location, No COC Exceedances
- DEC Residential Exceedances
- PMC Exceedances
- 78 Building Number
- Former Building
- Grass/Gravel Area
- Excavate from Ground Surface to Groundwater for Lead
- Excavate to Various Depths
- Air Line
- Electric Line
- Fire Hydrant
- Former Diesel-Oil Line
- Natural Gas Line
- Sanitary Sewer Line
- Storm Sewer Line
- Steam Line
- Telephone Line
- Water Line

DRAWN BY S. STROZ	DATE 11/19/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424 / OWNER NO.
CHECKED BY N. BALSAMO	DATE 07/02/10	ZONE 2 AREAS TO BE EXCAVATED FOR ALTERNATIVE S-2.6 LOWER SUBASE FEASIBILITY STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CONNECTICUT	APPROVED BY CAR / DATE 12/14/10
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 4-6 / REV 0

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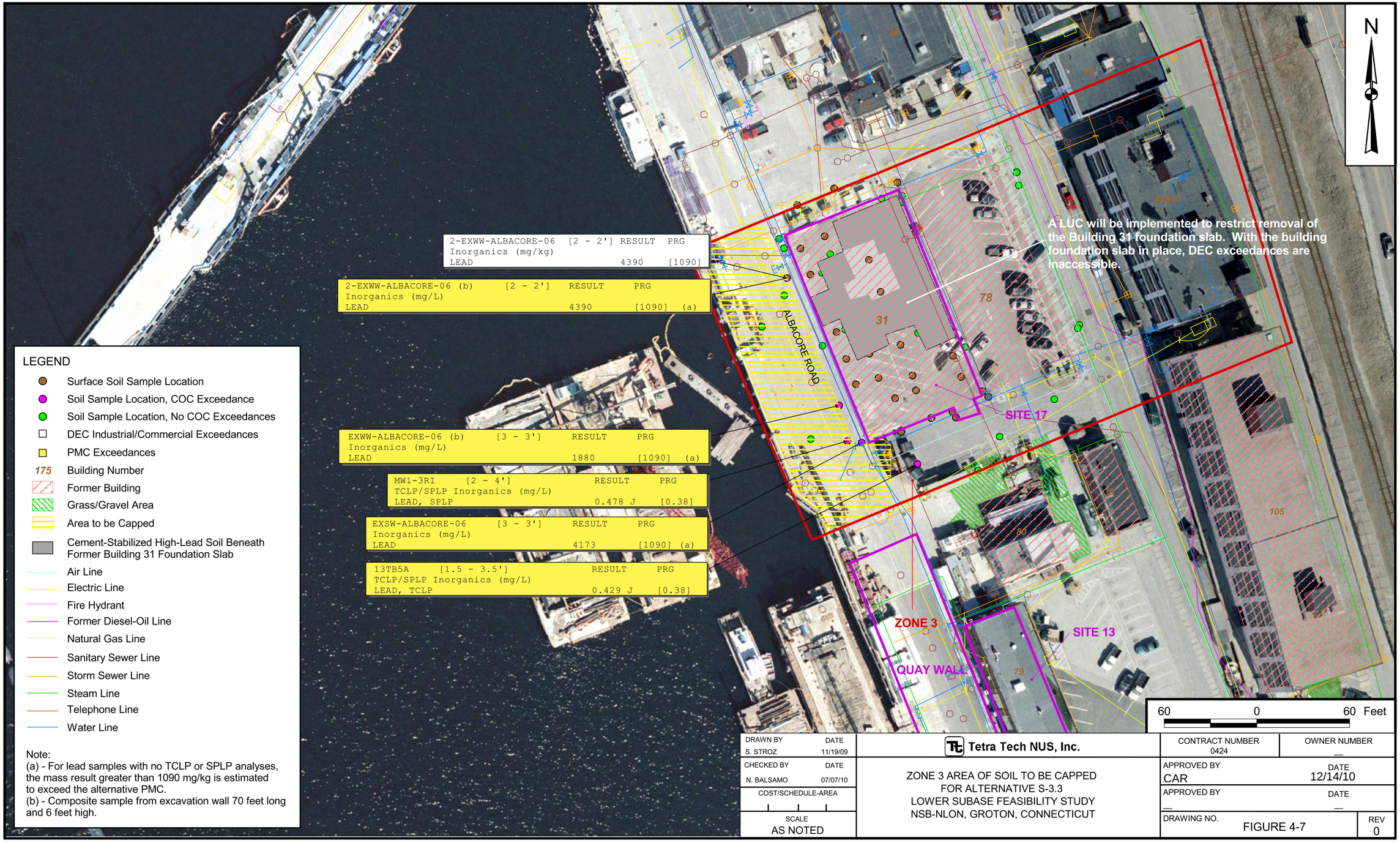
P:\GIS\NLON\ZONES_1TO7.APR ZONE 3 AREA OF SOIL TO BE EXCAVATED LAYOUT 2 07/07/10 JEE



LEGEND

- Surface Soil Sample Location
- Soil Sample Location, COC Exceedance
- Soil Sample Location, No COC Exceedances
- DEC Industrial/Commercial Exceedances
- PMC Exceedances
- 175 Building Number
- Former Building
- Grass/Gravel Area
- Area to be Capped
- Cement-Stabilized High-Lead Soil Beneath Former Building 31 Foundation Slab
- Air Line
- Electric Line
- Fire Hydrant
- Former Diesel-Oil Line
- Natural Gas Line
- Sanitary Sewer Line
- Storm Sewer Line
- Steam Line
- Telephone Line
- Water Line

Note:
(a) - For lead samples with no TCLP or SPLP analyses, the mass result greater than 1090 mg/kg is estimated to exceed the alternative PMC.
(b) - Composite sample from excavation wall 70 feet long and 6 feet high.

DRAWN BY S. STROZ	DATE 11/19/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424 / OWNER NUMBER —
CHECKED BY N. BALSAMO	DATE 07/07/10	ZONE 3 AREA OF SOIL TO BE CAPPED FOR ALTERNATIVE S-3.3 LOWER SUBASE FEASIBILITY STUDY NSB-NLON, GROTON, CONNECTICUT	APPROVED BY CAR / DATE 12/14/10
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 4-7 / REV 0

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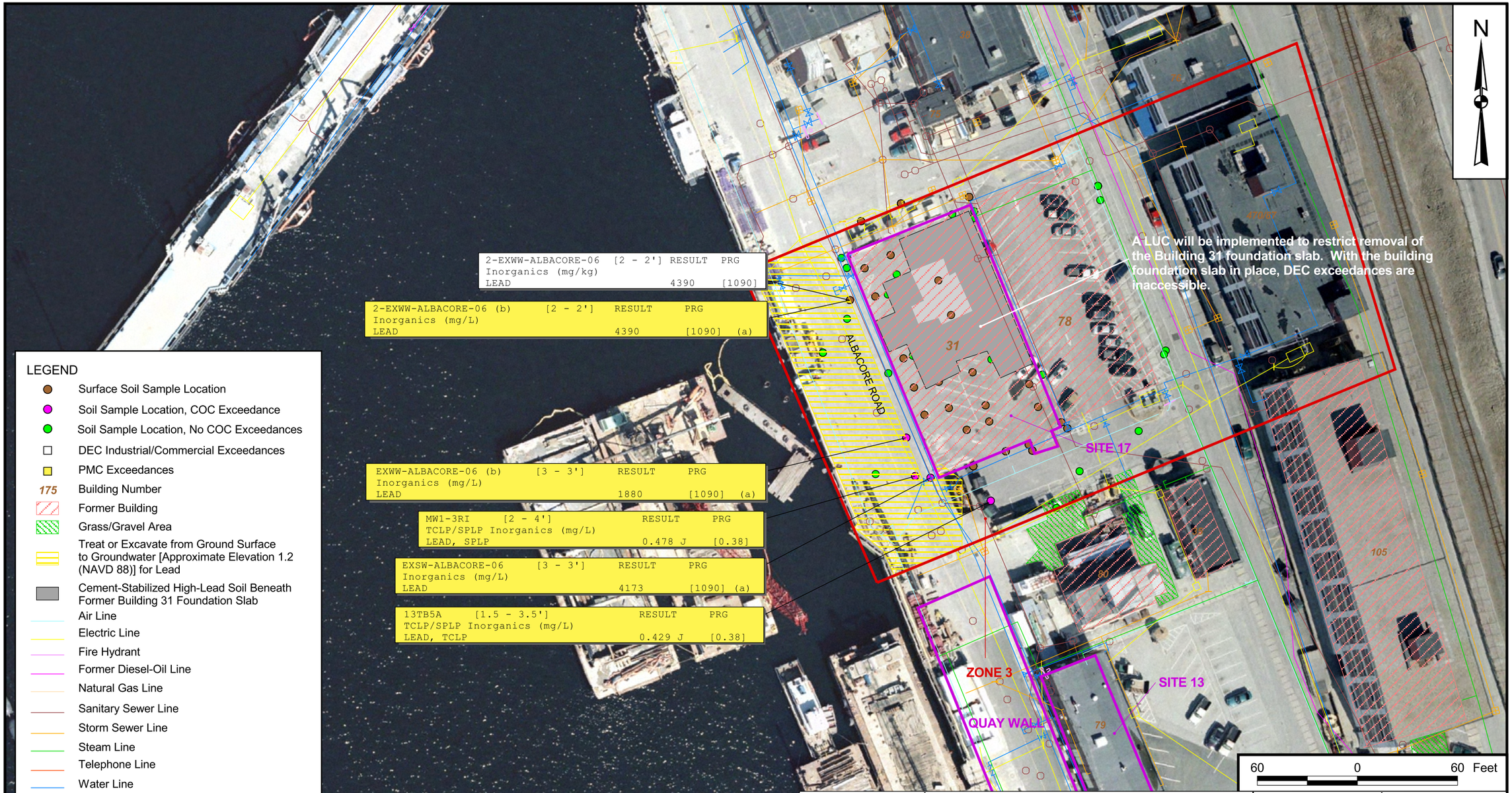

LEGEND

- Surface Soil Sample Location
- Soil Sample Location, COC Exceedance
- Soil Sample Location, No COC Exceedances
- DEC Industrial/Commercial Exceedances
- PMC Exceedances
- 175 Building Number
- Former Building
- Grass/Gravel Area
- Treat or Excavate from Ground Surface to Groundwater [Approximate Elevation 1.2 (NAVD 88)] for Lead
- Cement-Stabilized High-Lead Soil Beneath Former Building 31 Foundation Slab
- Air Line
- Electric Line
- Fire Hydrant
- Former Diesel-Oil Line
- Natural Gas Line
- Sanitary Sewer Line
- Storm Sewer Line
- Steam Line
- Telephone Line
- Water Line

Note:
(a) - For lead samples with no TCLP or SPLP analyses, the mass result greater than 1090 mg/kg is estimated to exceed the alternative PMC.
(b) - Composite sample from excavation wall 70 feet long and 6 feet high.

DRAWN BY S. STROZ	DATE 11/19/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424 / OWNER NUMBER —
CHECKED BY N. BALSAMO	DATE 07/07/10	ZONE 3 AREA OF SOIL TO BE IN-SITU TREATED OR EXCAVATED FOR ALTERNATIVES S-3.4 AND S-3.5 LOWER SUBASE FEASIBILITY STUDY NSB-NLON, GROTON, CONNECTICUT	APPROVED BY CAR / DATE 12/14/10
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 4-8 / REV 0

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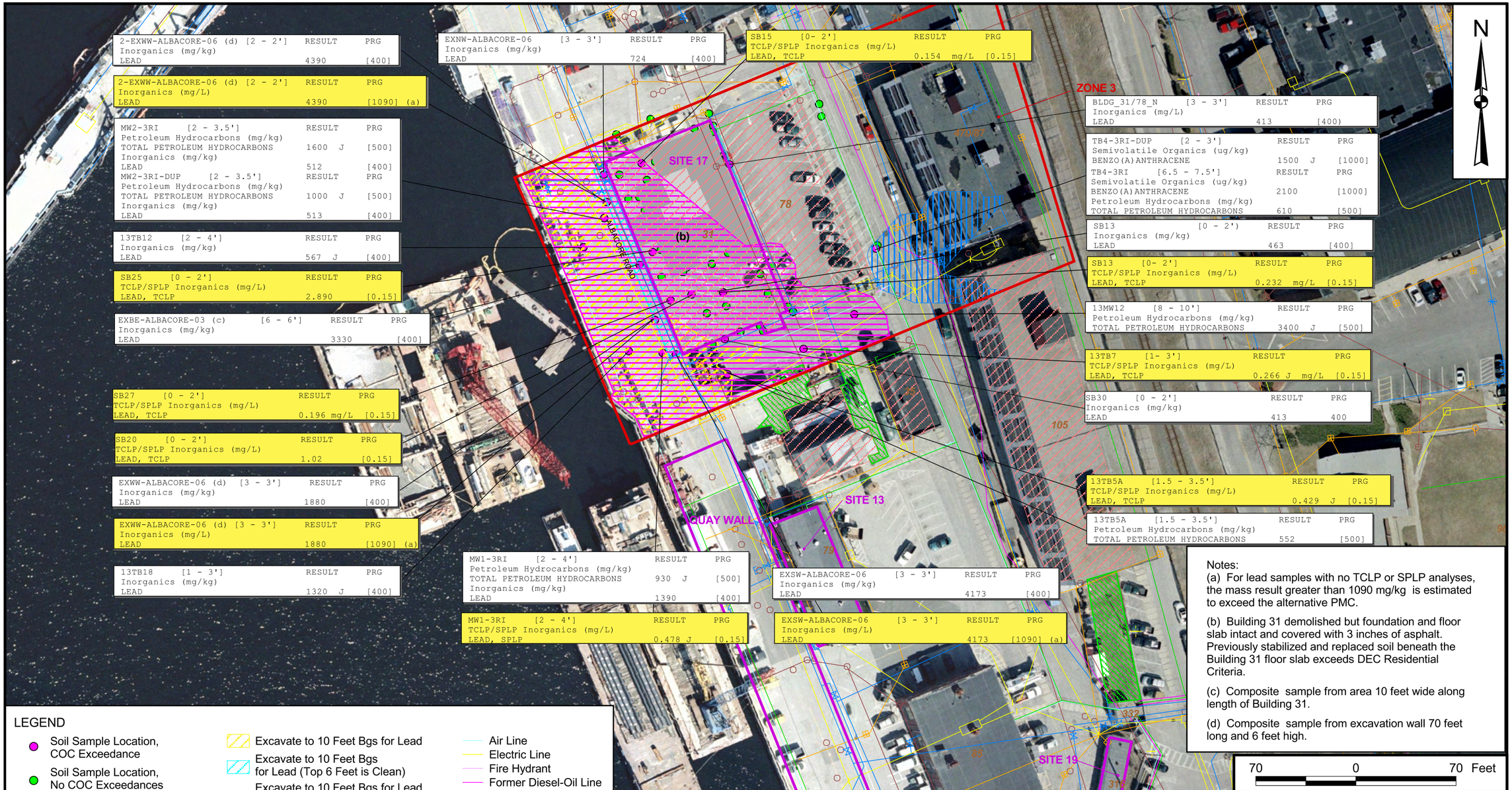

Notes:

(a) For lead samples with no TCLP or SPLP analyses, the mass result greater than 1090 mg/kg is estimated to exceed the alternative PMC.

(b) Building 31 demolished but foundation and floor slab intact and covered with 3 inches of asphalt. Previously stabilized and replaced soil beneath the Building 31 floor slab exceeds DEC Residential Criteria.

(c) Composite sample from area 10 feet wide along length of Building 31.

(d) Composite sample from excavation wall 70 feet long and 6 feet high.

LEGEND

- Soil Sample Location, COC Exceedance
- Soil Sample Location, No COC Exceedances
- DEC Residential Exceedances
- PMC Exceedances
- 105 Building Number
- Former Building
- Grass/Gravel Area
- Excavate to 10 Feet Bgs for Lead
- Excavate to 10 Feet Bgs for Lead (Top 6 Feet is Clean)
- Excavate to 10 Feet Bgs for Lead (Top 5 to 7 Feet is Cement-Stabilized High-Lead Soil)
- Excavate to 15 Feet Bgs for PAHs
- Excavate to 14 Feet Bgs for TPH Some Upper Soil TPH < 500 mg/kg
- Air Line
- Electric Line
- Fire Hydrant
- Former Diesel-Oil Line
- Natural Gas Line
- Sanitary Sewer Line
- Storm Sewer Line
- Steam Line
- Water Line

70 0 70 Feet

DRAWN BY	DATE
S. STROZ	11/20/09
CHECKED BY	DATE
N. BALSAMO	07/07/10
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

Tetra Tech NUS, Inc.

ZONE 3 AREAS OF SOIL TO BE EXCAVATED
FOR ALTERNATIVE S-3.6
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

CONTRACT NUMBER	OWNER NUMBER
0424	—
APPROVED BY	DATE
CAR	12/14/10
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 4-9	0

DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER	OWNER NO.
S. STROZ	11/19/09		0424	
CHECKED BY	DATE	ZONE 4 AREAS TO BE CAPPED FOR ALTERNATIVE S-4.3 NAVAL SUBMARINE BASE - NEW LONDON GROTON, CONNECTICUT	APPROVED BY	DATE
N. BALSAMO	07/06/10		CAR	12/14/10
COST/SCHEDULE-AREA			APPROVED BY	DATE
			—	—
SCALE			DRAWING NO.	REV
AS NOTED			FIGURE 4-10	0

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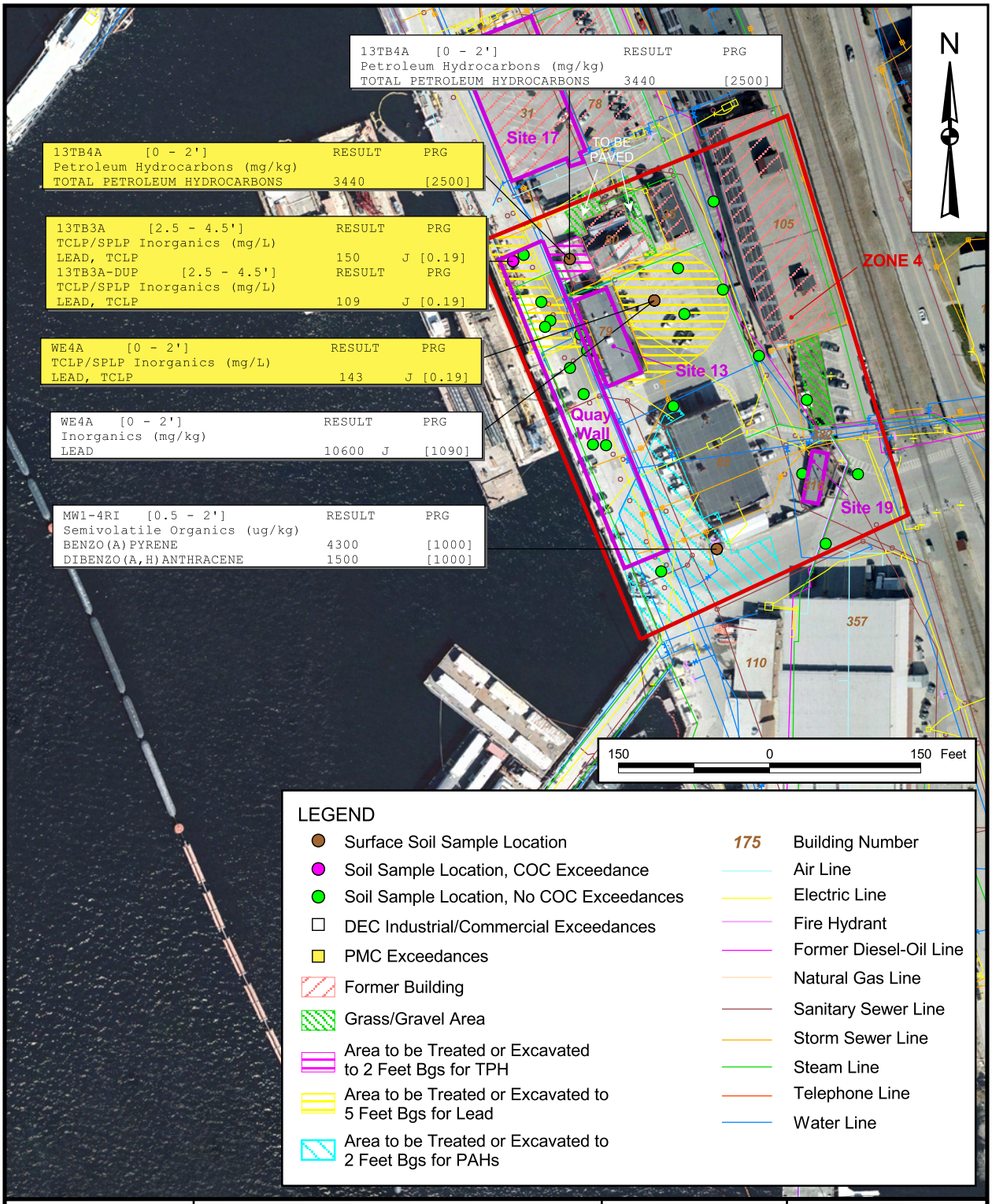

DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER	OWNER NO.
S. STROZ	11/19/09		0424	
CHECKED BY	DATE	ZONE 4 AREAS TO BE IN-SITU TREATED OR EXCAVATED FOR ALTERNATIVES S-4.4 AND S-4.5 NAVAL SUBMARINE BASE - NEW LONDON GROTON, CONNECTICUT	APPROVED BY	DATE
N. BALSAMO	07/08/10		CAR	12/14/10
COST/SCHEDULE-AREA			APPROVED BY	DATE
			—	—
SCALE			DRAWING NO.	REV
AS NOTED			FIGURE 4-11	0

P:\GIS\NLON\ZONES_1TO7.APR ZONE 4 AREAS TO BE EXCAVATED LAYOUT 07/08/10 JEE

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QW-2 [5.00 - 6.00']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	1730	[500]

13TB3A [2.50 - 4.50']	RESULT	PRG
Inorganics (mg/kg)		
LEAD	8240 J	[400]
13TB3A-DUP [2.50 - 4.50']	RESULT	PRG
Inorganics (mg/kg)		
LEAD	4770 J	[400]
13TB3A [6.00 - 8.00']	RESULT	PRG
Inorganics (mg/kg)		
LEAD	1990 J	[400]

13TB3A [2.5 - 4.5']	RESULT	PRG
TCLP/SPLP Inorganics (mg/L)		
LEAD, TCLP	150 J	[0.15]
13TB3A-DUP [2.5 - 4.5']	RESULT	PRG
TCLP/SPLP Inorganics (mg/L)		
LEAD, TCLP	109 J	[0.15]

QW-1 [5.00 - 6.00']	RESULT	PRG
Inorganics (mg/kg)		
LEAD	1470	[400]
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	2450 J	[500]

13MW16 [10.00 - 12.00']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	960	[500]

13TB2A [4.00 - 6.00']	RESULT	PRG
Inorganics (mg/kg)		
LEAD	1880 J	[400]
13TB2A [6.00 - 8.00']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	11800	[500]

QW-3 [5.00 - 6.00']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	642	[500]

13TB6 [5.00 - 7.00']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	970	[500]

13TB4A [0 - 2']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	3440	[500]

13TB4A [0 - 2']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	3440	[2500]
TCLP/SPLP Inorganics (mg/L)		
LEAD, TCLP	0.909 J	[0.15]

WE4A [0 - 2']	RESULT	PRG
Inorganics (mg/kg)		
LEAD	10600 J	[400]
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	925	[500]

WE4A [0 - 2']	RESULT	PRG
TCLP/SPLP Inorganics (mg/L)		
LEAD, TCLP	143 J	[0.15]

GS-9L [8.00 - 8.00']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	3720	[500]
GS-9L-DUP [8.00 - 8.00']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	9360	[500]

MW1-4RI [0.5 - 2']	RESULT	PRG
Semivolatile Organics (ug/kg)		
BENZO(A)ANTHRACENE	5300	[1000]
BENZO(A)PYRENE	4300	[1000]
BENZO(B)FLUORANTHENE	4300	[1000]
DIBENZO(A,H)ANTHRACENE	1500	[1000]
INDENO(1,2,3-CD)PYRENE	3400	[1000]

MW1-4RI [0.5 - 2']	RESULT	PRG
Semivolatile Organics (ug/kg)		
BENZO(A)ANTHRACENE	5300	[3400]
BENZO(B)FLUORANTHENE	4300	[2200]

QW-4 [7.00 - 7.30']	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)		
TOTAL PETROLEUM HYDROCARBONS	1360	[500]

LEGEND

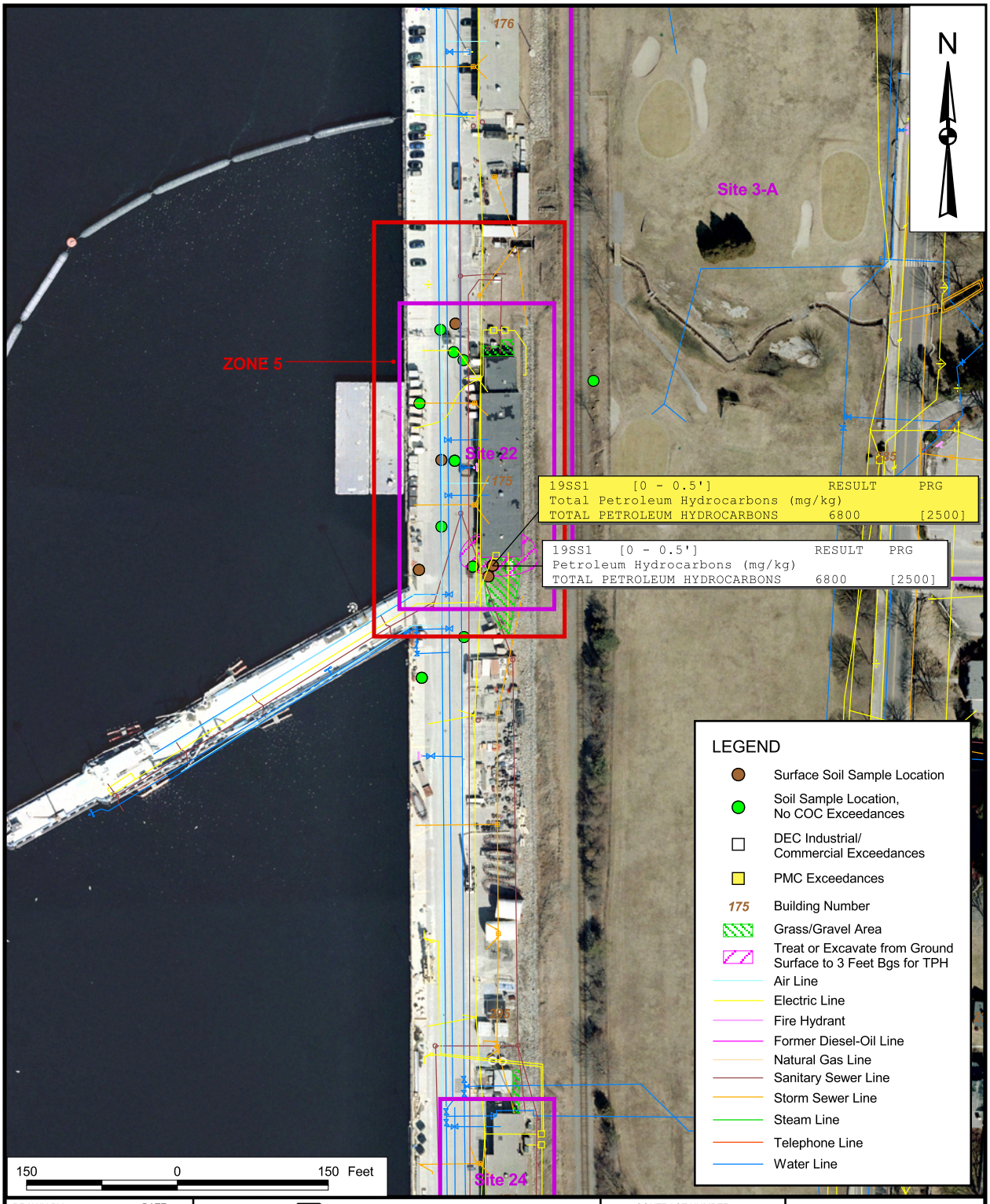
- Soil Sample Location, COC Exceedance
- Soil Sample Location, No COC Exceedances
- DEC Residential Exceedances
- PMC Exceedances
- 175 Building Number
- Grass/Gravel Area
- Former Building
- Excavate to 12 Feet Bgs for TPH
- Excavate to 12 Feet Bgs for Lead
- Excavate to 4 Feet Bgs for PAHs
- Air Line
- Electric Line
- Fire Hydrant
- Former Diesel-Oil Line
- Natural Gas Line
- Sanitary Sewer Line
- Storm Sewer Line
- Steam Line
- Telephone Line
- Water Line

DRAWN BY	DATE
S. STROZ	11/20/09
CHECKED BY	DATE
N. BALSAMO	07/20/10
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

Tetra Tech NUS, Inc.

ZONE 4 AREAS OF SOIL TO BE EXCAVATED
FOR ALTERNATIVE S-4.6
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CONNECTICUT

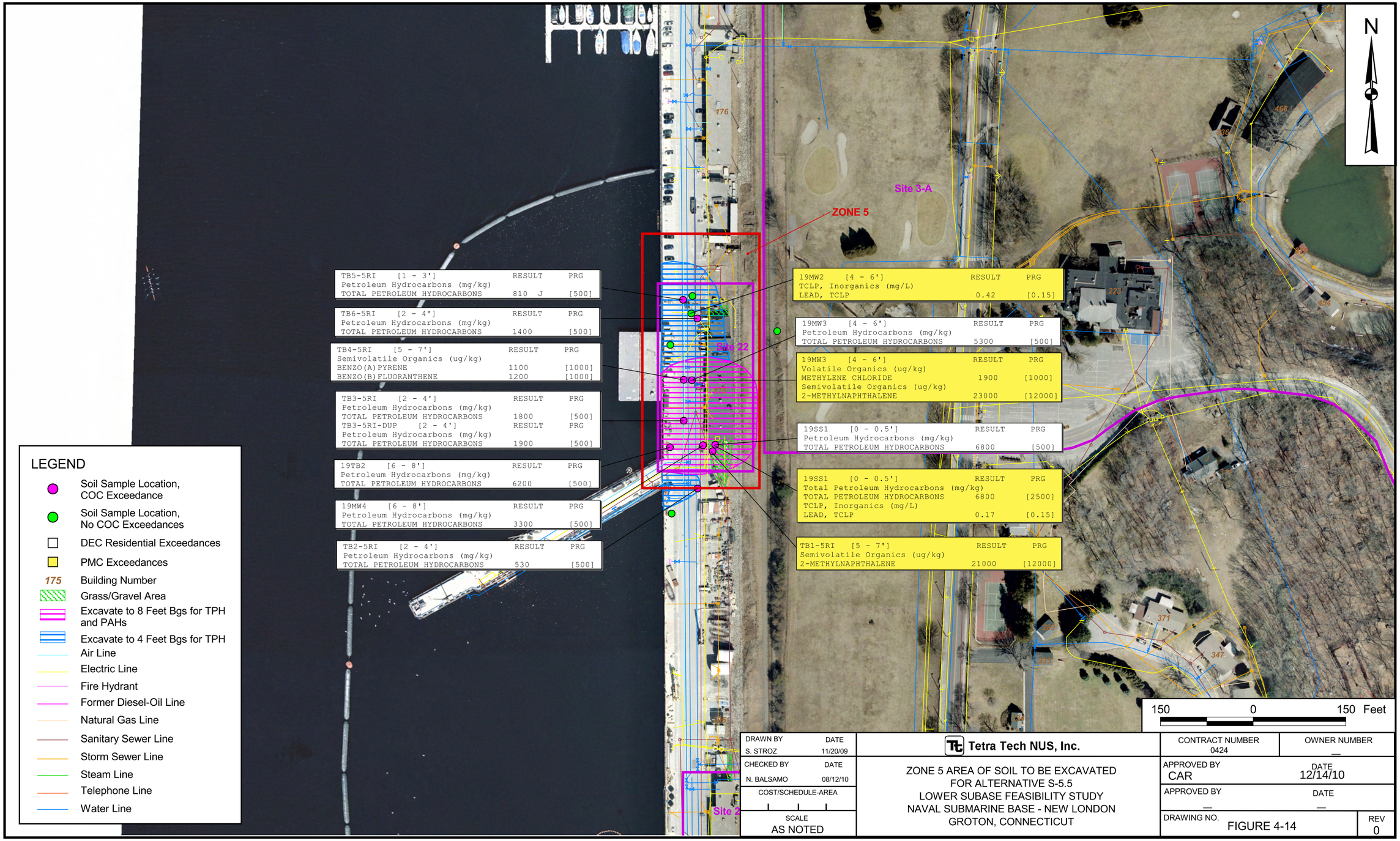
CONTRACT NUMBER	OWNER NUMBER
0424	—
APPROVED BY	DATE
CAR	12/14/10
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 4-12	0



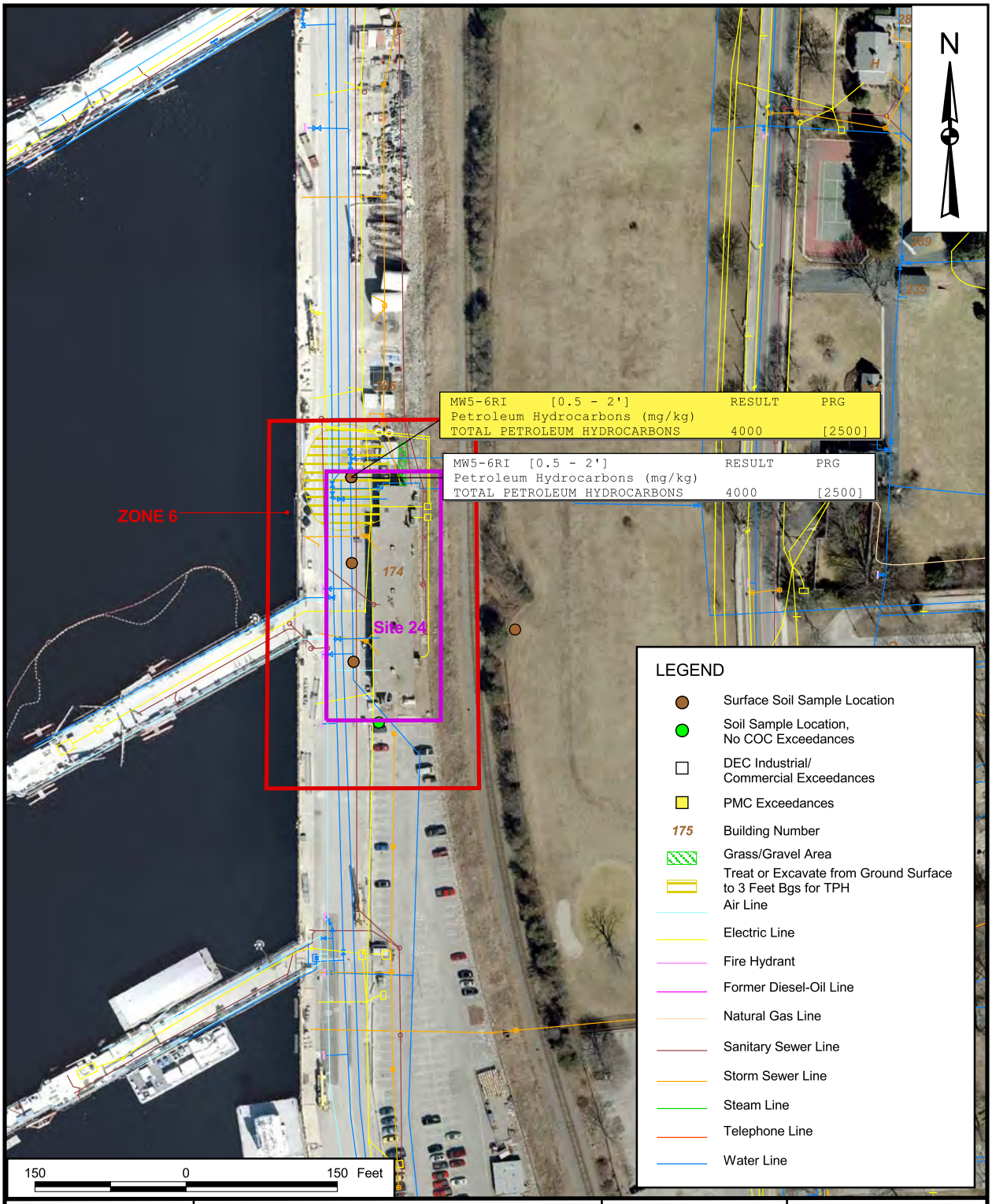
DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER	OWNER NO.
S. STROZ	11/19/09		0424	
CHECKED BY	DATE	ZONE 5 AREA OF SOIL TO BE IN-SITU TREATED OR EXCAVATED FOR ALTERNATIVES S-5.3 AND S-5.4 LOWER SUBASE FEASIBILITY STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CONNECTICUT	APPROVED BY	DATE
N. BALSAMO	07/06/10		CAR	12/14/10
COST/SCHEDULE-AREA			APPROVED BY	DATE
			—	—
SCALE			DRAWING NO.	REV
AS NOTED			FIGURE 4-13	0

P:\GIS\NLON\ZONES_1_7.APR ZONE 5 AREA OF SOIL TO BE EXCAVATED LAYOUT 07/06/10 JEE

P:\GIS\NLON\ZONES_1TO7.APR ZONE 5 AREAS TO BE EXCAVATED LAYOUT 08/12/10 JEE

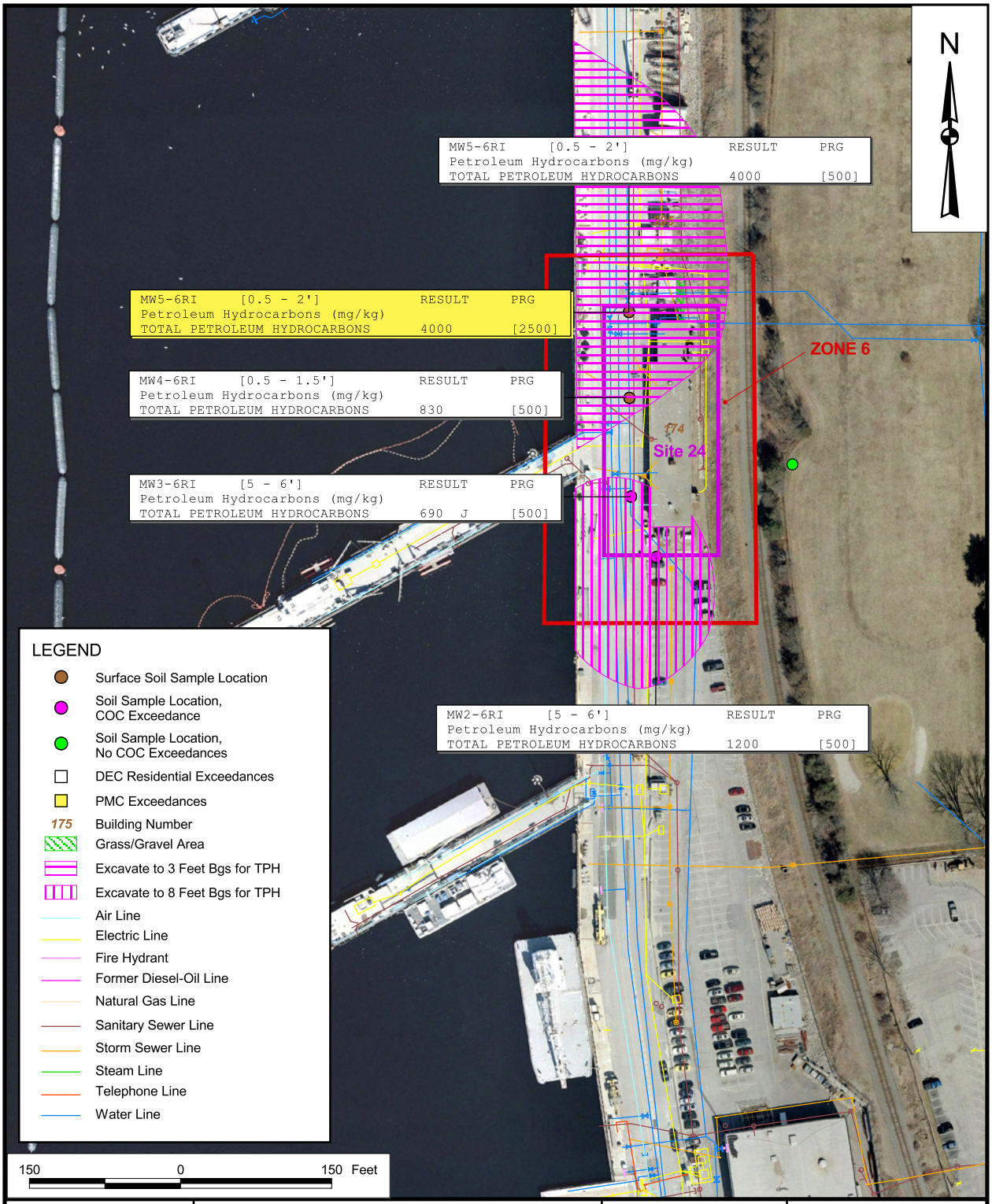


DRAWN BY S. STROZ	DATE 11/20/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424 / OWNER NUMBER —
CHECKED BY N. BALSAMO	DATE 08/12/10	ZONE 5 AREA OF SOIL TO BE EXCAVATED FOR ALTERNATIVE S-5.5 LOWER SUBASE FEASIBILITY STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CONNECTICUT	APPROVED BY CAR / DATE 12/14/10
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 4-14 / REV 0



DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER	OWNER NO.
S. STROZ	11/19/09		0424	
CHECKED BY	DATE	ZONE 6 AREA OF SOIL TO BE IN-SITU TREATED OR EXCAVATED FOR ALTERNATIVES S-6.2 AND S-6.3 LOWER SUBASE FEASIBILITY STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CONNECTICUT	APPROVED BY	DATE
N. BALSAMO	07/14/10		CAR	12/14/10
COST/SCHEDULE-AREA			APPROVED BY	DATE
			—	—
SCALE			DRAWING NO.	REV
AS NOTED			FIGURE 4-15	0

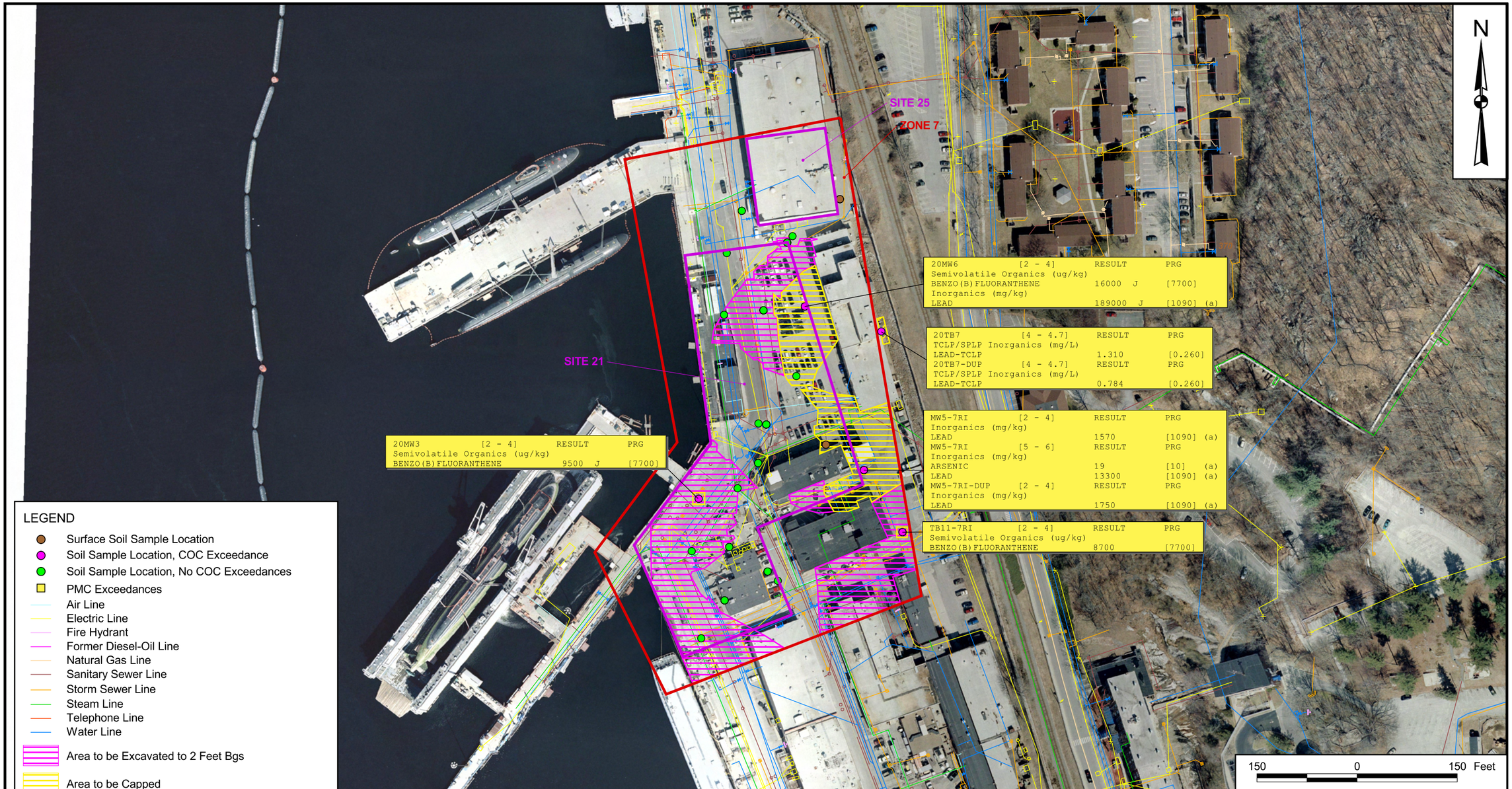
P:\GIS\NLON\ZONES_1TO7.APR ZONE 6 AREA TO BE EXCAVATED LAYOUT 07/14/10 JEE



DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER	OWNER NO.
S. STROZ	11/20/09		0424	
CHECKED BY	DATE	ZONE 6 AREA OF SOIL TO BE EXCAVATED FOR ALTERNATIVE S-6.4 LOWER SUBASE FEASIBILITY STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CONNECTICUT	APPROVED BY	DATE
N. BALSAMO	07/14/10		CAR	12/14/10
COST/SCHEDULE-AREA			APPROVED BY	DATE
			—	—
SCALE			DRAWING NO.	REV
AS NOTED			FIGURE 4-16	0

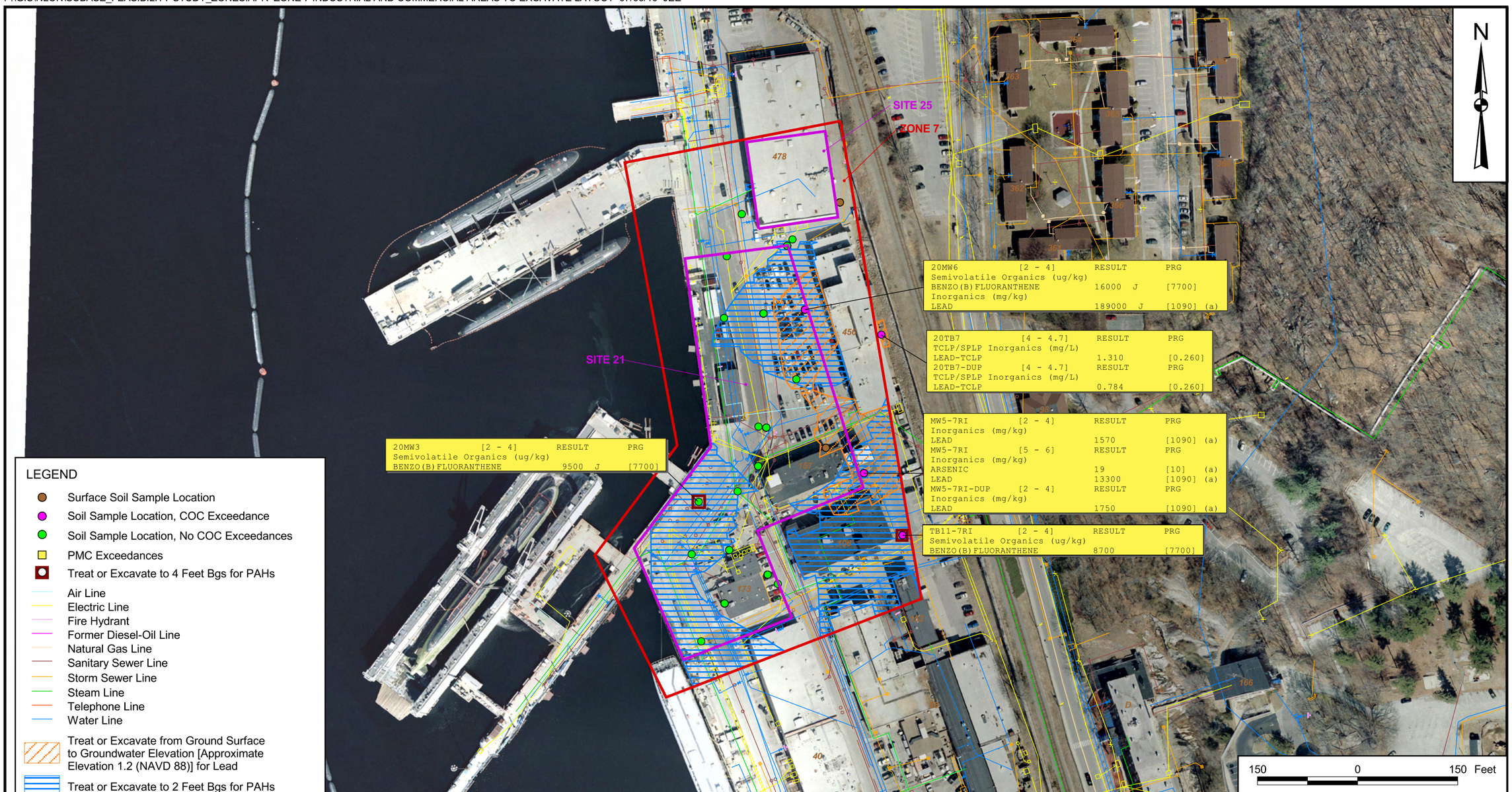
P:\GIS\NLON\ZONES_1TO7.APR REV ZONE 6 AREAS TO BE EXCAVATED LAYOUT 07/14/10 JEE

P:\GIS\NLON\SUBASE_FEASIBILITY STUDY_ZONES.APR ZONE 7 AREAS TO BE CAPPED LAYOUT 07/06/10 JEE



DRAWN BY S. STROZ	DATE 12/02/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424 / OWNER NUMBER —
CHECKED BY N. BALSAMO	DATE 07/06/10	ZONE 7 AREAS OF SOIL TO BE CAPPED FOR ALTERNATIVE S-7.3 LOWER SUBASE FEASIBILITY STUDY NSB-NLON, GROTON, CONNECTICUT	APPROVED BY CAR / DATE 12/14/10
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 4-17 / REV 0

P:\GIS\NLON\SUBASE_FEASIBILITY STUDY_ZONES.APR ZONE 7 INDUSTRIAL AND COMMERCIAL AREAS TO EXCAVATE LAYOUT 07/06/10 JEE



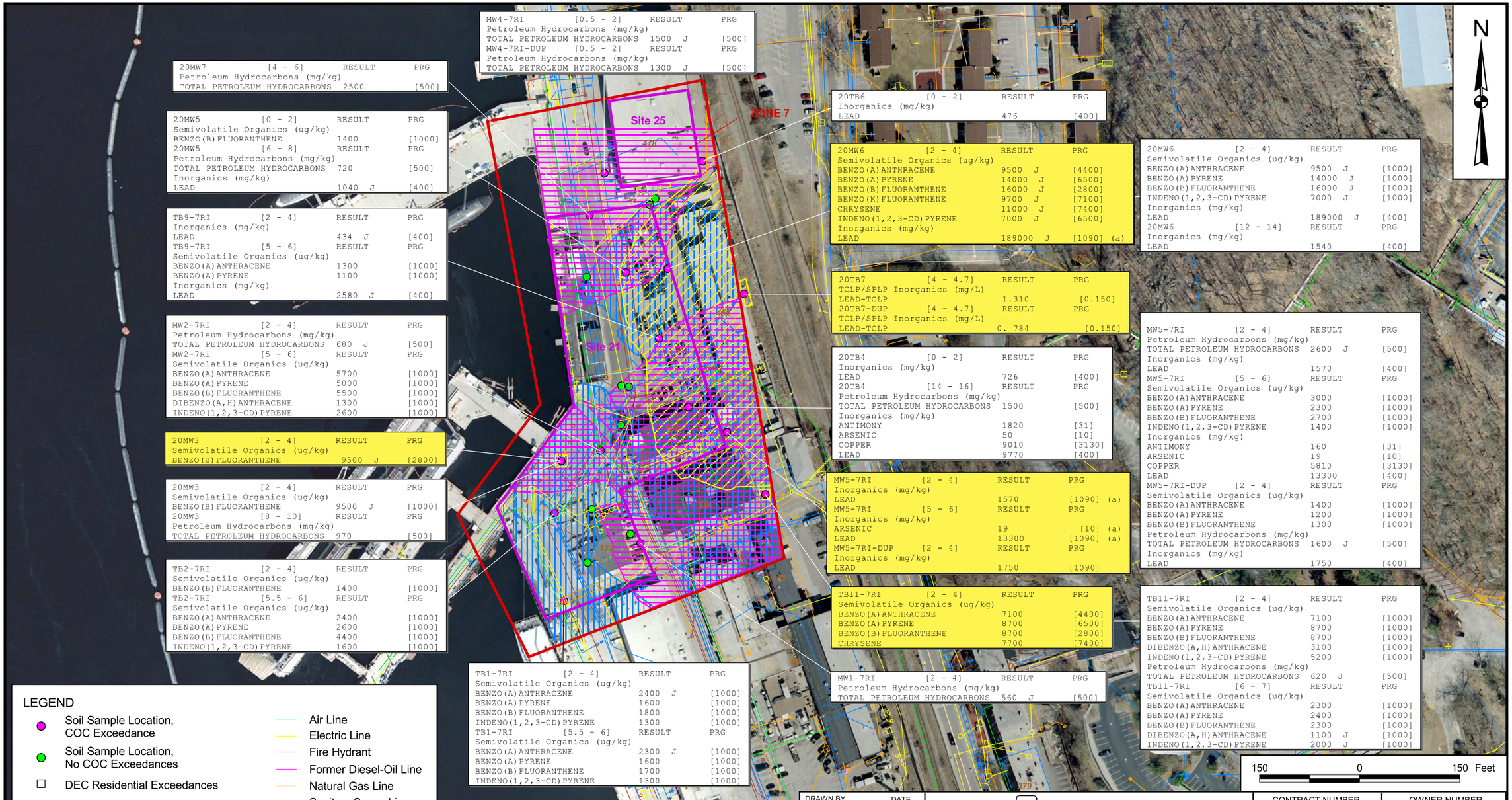
LEGEND

- Surface Soil Sample Location
- Soil Sample Location, COC Exceedance
- Soil Sample Location, No COC Exceedances
- PMC Exceedances
- Treat or Excavate to 4 Feet Bgs for PAHs
- Air Line
- Electric Line
- Fire Hydrant
- Former Diesel-Oil Line
- Natural Gas Line
- Sanitary Sewer Line
- Storm Sewer Line
- Steam Line
- Telephone Line
- Water Line
- Treat or Excavate from Ground Surface to Groundwater Elevation [Approximate Elevation 1.2 (NAVD 88)] for Lead
- Treat or Excavate to 2 Feet Bgs for PAHs

Note: (a) - For lead/arsenic samples with no TCLP or SPLP analyses, mass results greater than 1090/10 mg/kg are estimated to exceed the Alternative PMC. For antimony samples with no TCLP or SPLP analyses, the mass results greater than 410 mg/kg are estimated to exceed the Alternative PMC.

DRAWN BY S. STROZ	DATE 11/23/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424 / OWNER NUMBER —
CHECKED BY N. BALSAMO	DATE 07/06/10	ZONE 7 AREAS OF SOIL TO BE IN-SITU TREATED OR EXCAVATED FOR ALTERNATIVES S-7.4 AND S-7.5 LOWER SUBASE FEASIBILITY STUDY NSB-NLON, GROTON, CONNECTICUT	APPROVED BY CAR / DATE 12/14/10
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 4-18 / REV 0

P:\GIS\NLON\SUBASE_FEASIBILITY_STUDY_ZONES.APR ZONE 7 AREAS TO BE EXCAVATED LAYOUT 07/07/10 JEE



20MW7	[4 - 6]	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)			
TOTAL PETROLEUM HYDROCARBONS		2500	[500]

20MW5	[0 - 2]	RESULT	PRG
Semivolatile Organics (ug/kg)			
BENZO(B)FLUORANTHENE		1400	[1000]
20MW5	[6 - 8]	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)			
TOTAL PETROLEUM HYDROCARBONS		720	[500]
Inorganics (mg/kg)			
LEAD		1040 J	[400]

TB9-7RI	[2 - 4]	RESULT	PRG
Inorganics (mg/kg)			
LEAD		434 J	[400]
TB9-7RI	[5 - 6]	RESULT	PRG
Semivolatile Organics (ug/kg)			
BENZO(A)ANTHRACENE		1300	[1000]
BENZO(A)PYRENE		1100	[1000]
Inorganics (mg/kg)			
LEAD		2580 J	[400]

MW2-7RI	[2 - 4]	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)			
TOTAL PETROLEUM HYDROCARBONS		680 J	[500]
MW2-7RI	[5 - 6]	RESULT	PRG
Semivolatile Organics (ug/kg)			
BENZO(A)ANTHRACENE		5700	[1000]
BENZO(A)PYRENE		5000	[1000]
BENZO(B)FLUORANTHENE		5500	[1000]
DIBENZO(A,H)ANTHRACENE		1300	[1000]
INDENO(1,2,3-CD)PYRENE		2600	[1000]

20MW3	[2 - 4]	RESULT	PRG
Semivolatile Organics (ug/kg)			
BENZO(B)FLUORANTHENE		9500 J	[2800]

20MW3	[2 - 4]	RESULT	PRG
Semivolatile Organics (ug/kg)			
BENZO(B)FLUORANTHENE		9500 J	[1000]
20MW3	[8 - 10]	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)			
TOTAL PETROLEUM HYDROCARBONS		970	[500]

TB2-7RI	[2 - 4]	RESULT	PRG
Semivolatile Organics (ug/kg)			
BENZO(B)FLUORANTHENE		1400	[1000]
TB2-7RI	[5.5 - 6]	RESULT	PRG
Semivolatile Organics (ug/kg)			
BENZO(A)ANTHRACENE		2400	[1000]
BENZO(A)PYRENE		2600	[1000]
BENZO(B)FLUORANTHENE		4400	[1000]
INDENO(1,2,3-CD)PYRENE		1600	[1000]

MW4-7RI	[0.5 - 2]	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)			
TOTAL PETROLEUM HYDROCARBONS		1500 J	[500]
MW4-7RI-DUP	[0.5 - 2]	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)			
TOTAL PETROLEUM HYDROCARBONS		1300 J	[500]

20TB6	[0 - 2]	RESULT	PRG
Inorganics (mg/kg)			
LEAD		476	[400]

20MW6	[2 - 4]	RESULT	PRG
Semivolatile Organics (ug/kg)			
BENZO(A)ANTHRACENE		9500 J	[4400]
BENZO(A)PYRENE		14000 J	[6500]
BENZO(B)FLUORANTHENE		16000 J	[2800]
BENZO(K)FLUORANTHENE		9700 J	[7100]
CHRYSENE		11000 J	[7400]
INDENO(1,2,3-CD)PYRENE		7000 J	[6500]
Inorganics (mg/kg)			
LEAD		189000 J	[1090] (a)

20MW6	[2 - 4]	RESULT	PRG
Semivolatile Organics (ug/kg)			
BENZO(A)ANTHRACENE		9500 J	[1000]
BENZO(A)PYRENE		14000 J	[1000]
BENZO(B)FLUORANTHENE		16000 J	[1000]
INDENO(1,2,3-CD)PYRENE		7000 J	[1000]
Inorganics (mg/kg)			
LEAD		189000 J	[400]
20MW6	[12 - 14]	RESULT	PRG
Inorganics (mg/kg)			
LEAD		1540	[400]

20TB7	[4 - 4.7]	RESULT	PRG
TCLP/SPLP Inorganics (mg/L)			
LEAD-TCLP		1.310	[0.150]
20TB7-DUP	[4 - 4.7]	RESULT	PRG
TCLP/SPLP Inorganics (mg/L)			
LEAD-TCLP		0. 784	[0.150]

20TB4	[0 - 2]	RESULT	PRG
Inorganics (mg/kg)			
LEAD		726	[400]
20TB4	[14 - 16]	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)			
TOTAL PETROLEUM HYDROCARBONS		1500	[500]
Inorganics (mg/kg)			
ANTIMONY		1820	[31]
ARSENIC		50	[10]
COPPER		9010	[3130]
LEAD		9770	[400]

MW5-7RI	[2 - 4]	RESULT	PRG
Inorganics (mg/kg)			
LEAD		1570	[1090] (a)
MW5-7RI	[5 - 6]	RESULT	PRG
Inorganics (mg/kg)			
ARSENIC		19	[10] (a)
LEAD		13300	[1090] (a)
MW5-7RI-DUP	[2 - 4]	RESULT	PRG
Inorganics (mg/kg)			
LEAD		1750	[1090]

MW5-7RI	[2 - 4]	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)			
TOTAL PETROLEUM HYDROCARBONS		2600 J	[500]
Inorganics (mg/kg)			
LEAD		1570	[400]
MW5-7RI	[5 - 6]	RESULT	PRG
Semivolatile Organics (ug/kg)			
BENZO(A)ANTHRACENE		3000	[1000]
BENZO(A)PYRENE		2300	[1000]
BENZO(B)FLUORANTHENE		2700	[1000]
INDENO(1,2,3-CD)PYRENE		1400	[1000]
Inorganics (mg/kg)			
ANTIMONY		160	[31]
ARSENIC		19	[10]
COPPER		5810	[3130]
LEAD		13300	[400]
MW5-7RI-DUP	[2 - 4]	RESULT	PRG
Semivolatile Organics (ug/kg)			
BENZO(A)ANTHRACENE		1400	[1000]
BENZO(A)PYRENE		1200	[1000]
BENZO(B)FLUORANTHENE		1300	[1000]
Petroleum Hydrocarbons (mg/kg)			
TOTAL PETROLEUM HYDROCARBONS		1600 J	[500]
Inorganics (mg/kg)			
LEAD		1750	[400]

TB11-7RI	[2 - 4]	RESULT	PRG
Semivolatile Organics (ug/kg)			
BENZO(A)ANTHRACENE		7100	[4400]
BENZO(A)PYRENE		8700	[6500]
BENZO(B)FLUORANTHENE		8700	[2800]
CHRYSENE		7700	[7400]

TB11-7RI	[2 - 4]	RESULT	PRG
Semivolatile Organics (ug/kg)			
BENZO(A)ANTHRACENE		7100	[1000]
BENZO(A)PYRENE		8700	[1000]
BENZO(B)FLUORANTHENE		8700	[1000]
DIBENZO(A,H)ANTHRACENE		3100	[1000]
INDENO(1,2,3-CD)PYRENE		5200	[1000]
Petroleum Hydrocarbons (mg/kg)			
TOTAL PETROLEUM HYDROCARBONS		620 J	[500]
TB11-7RI	[6 - 7]	RESULT	PRG
Semivolatile Organics (ug/kg)			
BENZO(A)ANTHRACENE		2300	[1000]
BENZO(A)PYRENE		2400	[1000]
BENZO(B)FLUORANTHENE		2300	[1000]
DIBENZO(A,H)ANTHRACENE		1100 J	[1000]
INDENO(1,2,3-CD)PYRENE		2000 J	[1000]

TB1-7RI	[2 - 4]	RESULT	PRG
Semivolatile Organics (ug/kg)			
BENZO(A)ANTHRACENE		2400 J	[1000]
BENZO(A)PYRENE		1600	[1000]
BENZO(B)FLUORANTHENE		1800	[1000]
INDENO(1,2,3-CD)PYRENE		1300	[1000]
TB1-7RI	[5.5 - 6]	RESULT	PRG
Semivolatile Organics (ug/kg)			
BENZO(A)ANTHRACENE		2300 J	[1000]
BENZO(A)PYRENE		1600	[1000]
BENZO(B)FLUORANTHENE		1700	[1000]
INDENO(1,2,3-CD)PYRENE		1300	[1000]

MW1-7RI	[2 - 4]	RESULT	PRG
Petroleum Hydrocarbons (mg/kg)			
TOTAL PETROLEUM HYDROCARBONS		560 J	[500]

LEGEND

- Soil Sample Location, COC Exceedance
- Soil Sample Location, No COC Exceedances
- DEC Residential Exceedances
- PMC Exceedances
- Excavate to Various Depths for Lead
- Excavate to Various Depths for TPH
- Excavate to Various Depths for PAHs
- Air Line
- Electric Line
- Fire Hydrant
- Former Diesel-Oil Line
- Natural Gas Line
- Sanitary Sewer Line
- Storm Sewer Line
- Steam Line
- Telephone Line
- Water Line

Note: (a) - For lead/arsenic samples with no TCLP or SPLP analyses, mass results greater than 1090/10 mg/kg are estimated to exceed the Alternative PMC. For antimony samples with no TCLP or SPLP analyses, the mass results greater than 410 mg/kg are estimated to exceed the Alternative PMC.

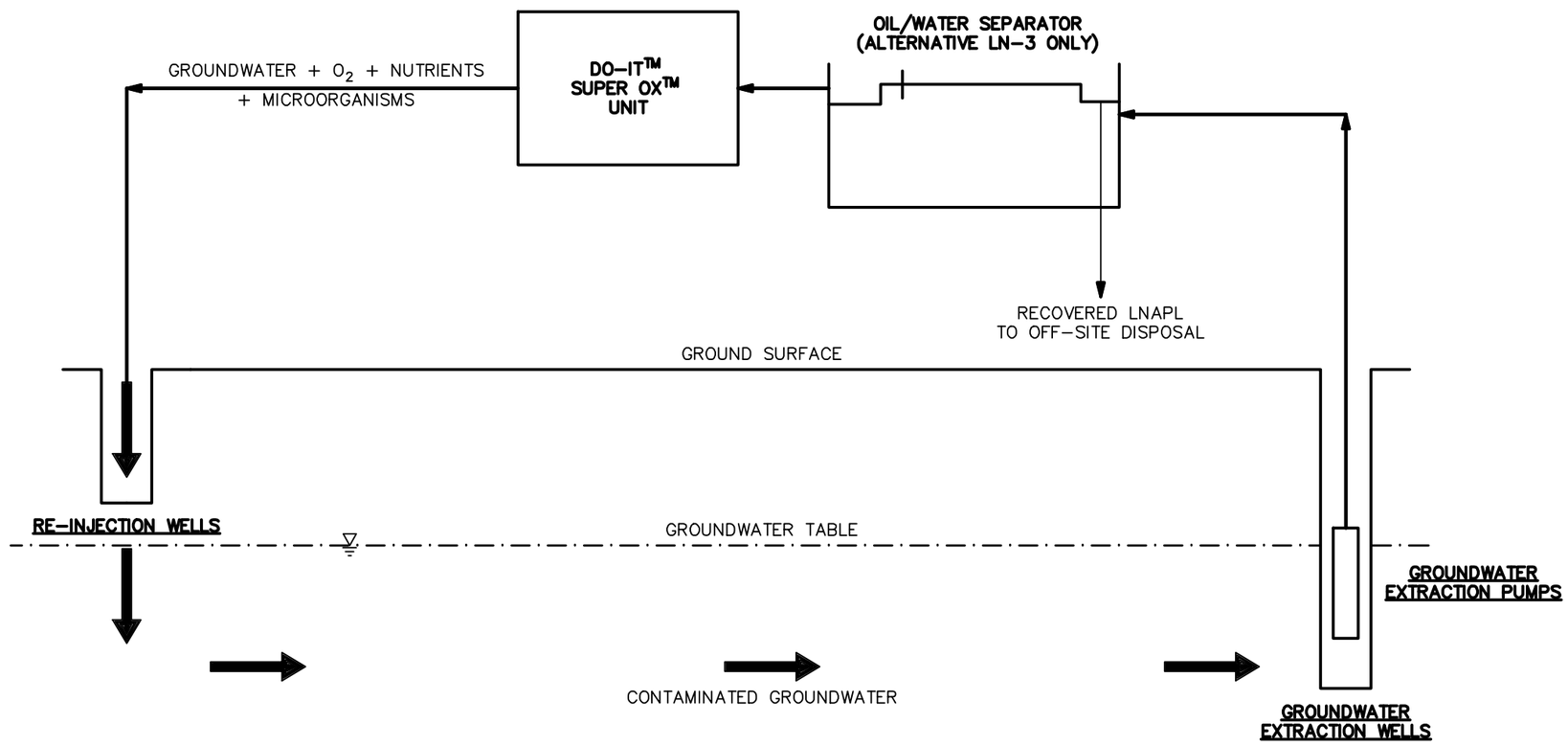
DRAWN BY	DATE
S. STROZ	11/20/09
CHECKED BY	DATE
N. BALSAMO	07/07/10
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

Tetra Tech NUS, Inc.

ZONE 7 AREAS OF SOIL TO BE EXCAVATED
FOR ALTERNATIVE S-7.6
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

CONTRACT NUMBER	OWNER NUMBER
0424	—
APPROVED BY	DATE
CAR	12/14/10
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 4-19	0

ACAD: 0811PF04.dwg 11/05/09 CK PIT



DRAWN BY CK DATE 11/05/09	Tetra Tech NUS, Inc.	PROCESS FLOW DIAGRAM IN-SITU ENHANCED BIOREMEDIATION DO-IT™ PROCESS ALTERNATIVES GW-1.3, GW-4.3, AND LN-2 LOWER SUBASE FEASIBILITY STUDY NSB-NLON GROTON, CONNECTICUT	CONTRACT NO. 0811
CHECKED BY DATE			OWNER NO.
REVISED BY DATE			APPROVED BY CAR DATE 12/14/10
SCALE AS NOTED			DRAWING NO. FIGURE 4-20 REV. 0

FORM CADD NO. TTNUS-BH.DWG – REV 1 – 9/10/98

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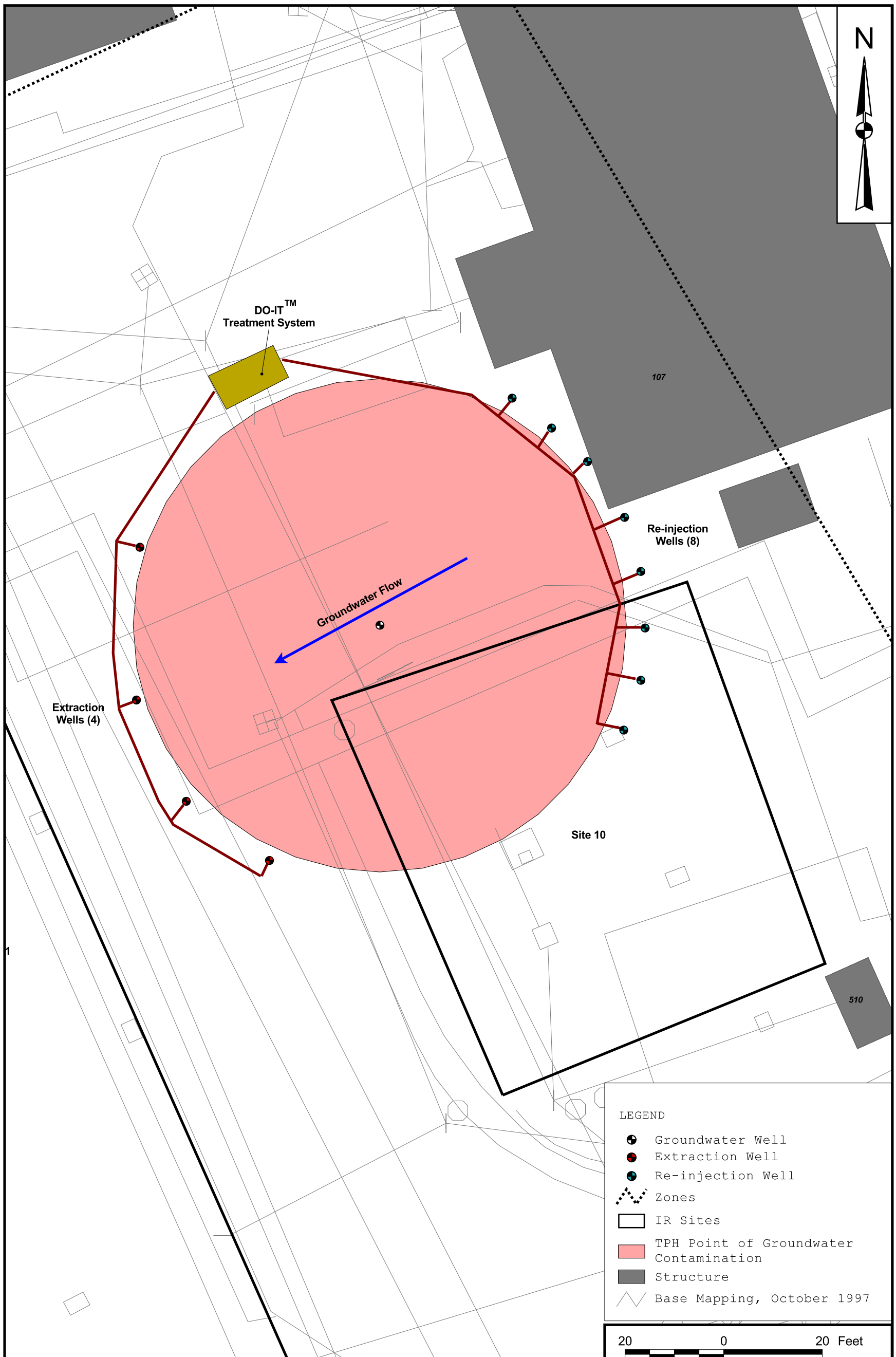

DRAWN BY S.STROZ — DATE 12/10/07	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424	OWNER NUMBER —
CHECKED BY N. BALSAMO — DATE 01/11/10	ZONE 1 COPPER/TPH POINTS OF GROUNDWATER CONTAMINATION IN-SITU ENHANCED BIOREMEDIATION ALTERNATIVE GW- 1.3 LOWER SUBASE FEASIBILITY STUDY NSB-NLON, GROTON, CONNECTICUT	APPROVED BY CAR	DATE 01/12/10
COST/SCHEDULE-AREA		APPROVED BY —	DATE —
SCALE AS NOTED		DRAWING NO. FIGURE 4-21	REV 0

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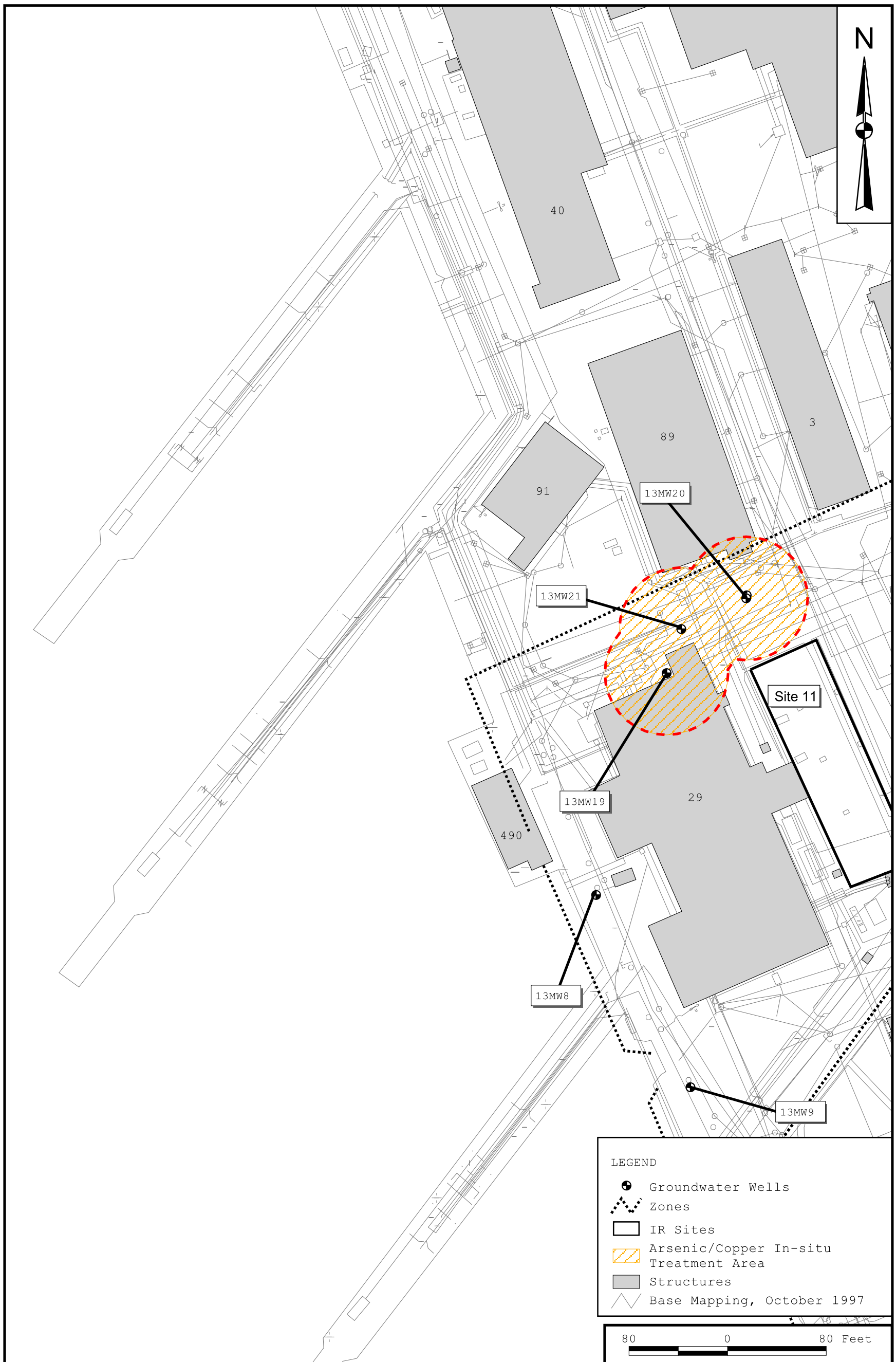
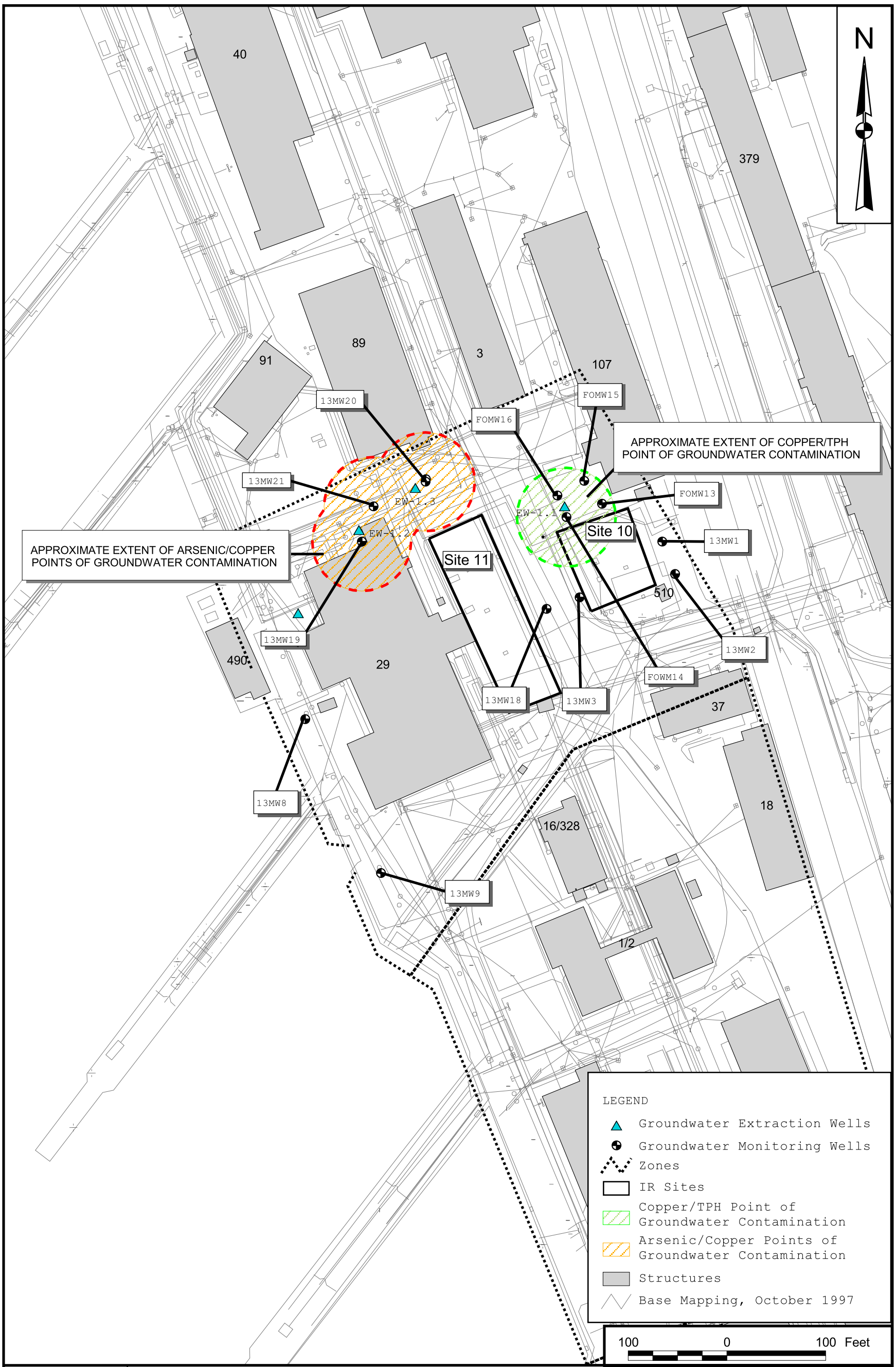


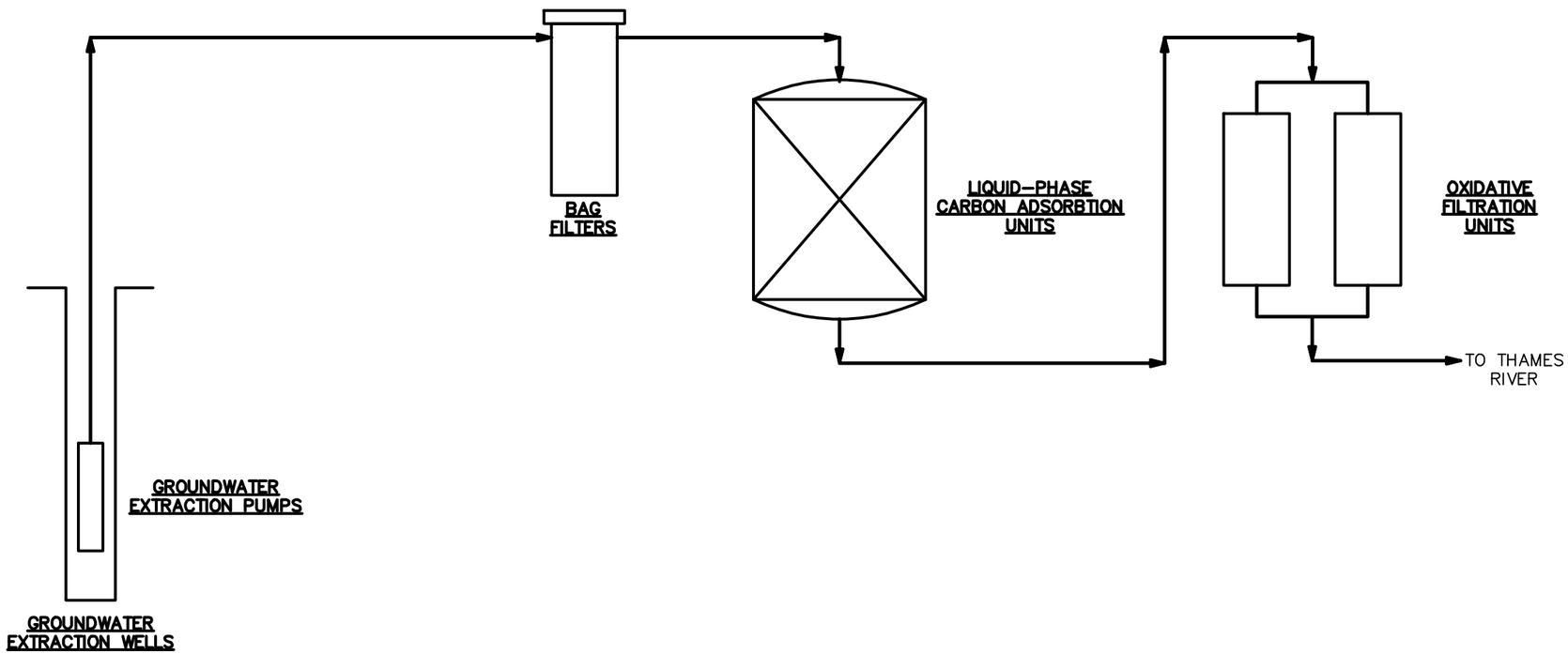
DRAWN BY S.STROZ DATE 11/16/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424	OWNER NUMBER —
CHECKED BY N. BALSAMO DATE 11/17/09	ZONE 1 ARSENIC/COPPER IN-SITU GROUNDWATER TREATMENT AREA ALTERNATIVE GW-1.3 LOWER SUBASE FEASIBILITY STUDY NSB-NLON, GROTON, CONNECTICUT	APPROVED BY CAR	DATE 01/12/10
COST/SCHEDULE-AREA		APPROVED BY —	DATE —
SCALE AS NOTED		DRAWING NO. FIGURE 4-22	REV 0

P:\GIS\NLON\MAPDOCS\APR\NLONTAGS.APR ZONE 1 PROPOSED GW EXTRACTION WELL LOCATIONS LAYOUT 01/11/10 SS



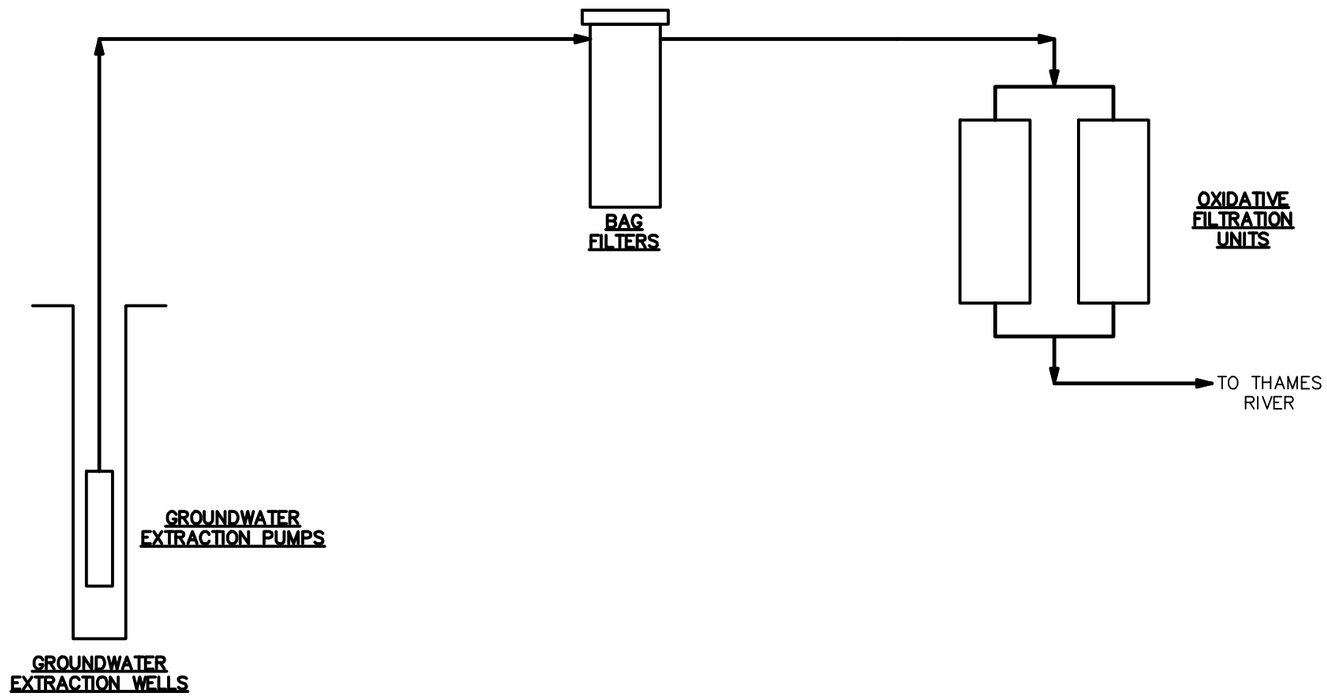
DRAWN BY S.STROZ — DATE 11/18/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424	OWNER NUMBER —
CHECKED BY N. BALSAMO — DATE 01/11/10	ZONE 1 TPH/COPPER AND ARSENIC/COPPER POINTS OF GROUNDWATER CONTAMINATION PROPOSED GROUNDWATER EXTRACTION WELL LOCATIONS ALTERNATIVES GW-1.4 AND GW-1.5 LOWER SUBASE FEASIBILITY STUDY NSB-NLON, GROTON, CONNECTICUT	APPROVED BY CAR	DATE 01/12/10
COST/SCHEDULE-AREA		APPROVED BY —	DATE —
SCALE AS NOTED		DRAWING NO. FIGURE 4-23	REV 0

ACAD:0811PF03.dwg 11/06/09 CK PIT



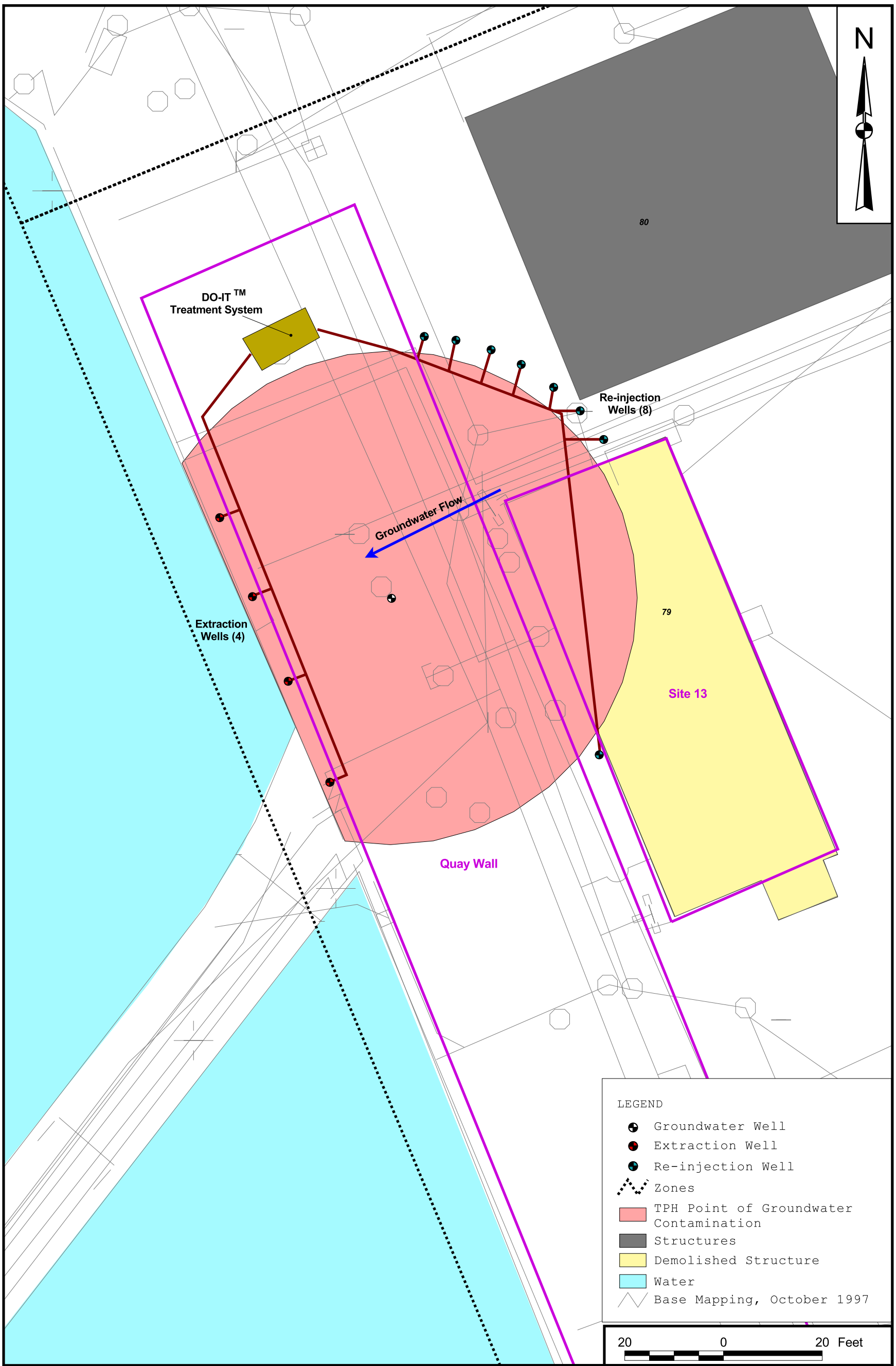
DRAWN BY CK DATE 11/06/09	Tetra Tech NUS, Inc.	PROCESS FLOW DIAGRAM ZONE 1 COPPER/TPH POINT OF GROUNDWATER CONTAMINATION ON–SITE GROUNDWATER TREATMENT SYSTEM ALTERNATIVE GW–1.5 LOWER SUBASE FEASIBILITY STUDY NSB–NLON GROTON, CONNECTICUT	CONTRACT NO. 0811
CHECKED BY DATE			OWNER NO.
REVISED BY DATE			APPROVED BY CAR DATE 01/12/10
SCALE AS NOTED			DRAWING NO. FIGURE 4–24 REV. 0

ACAD: 0811PF07.dwg 11/06/09 CK PIT



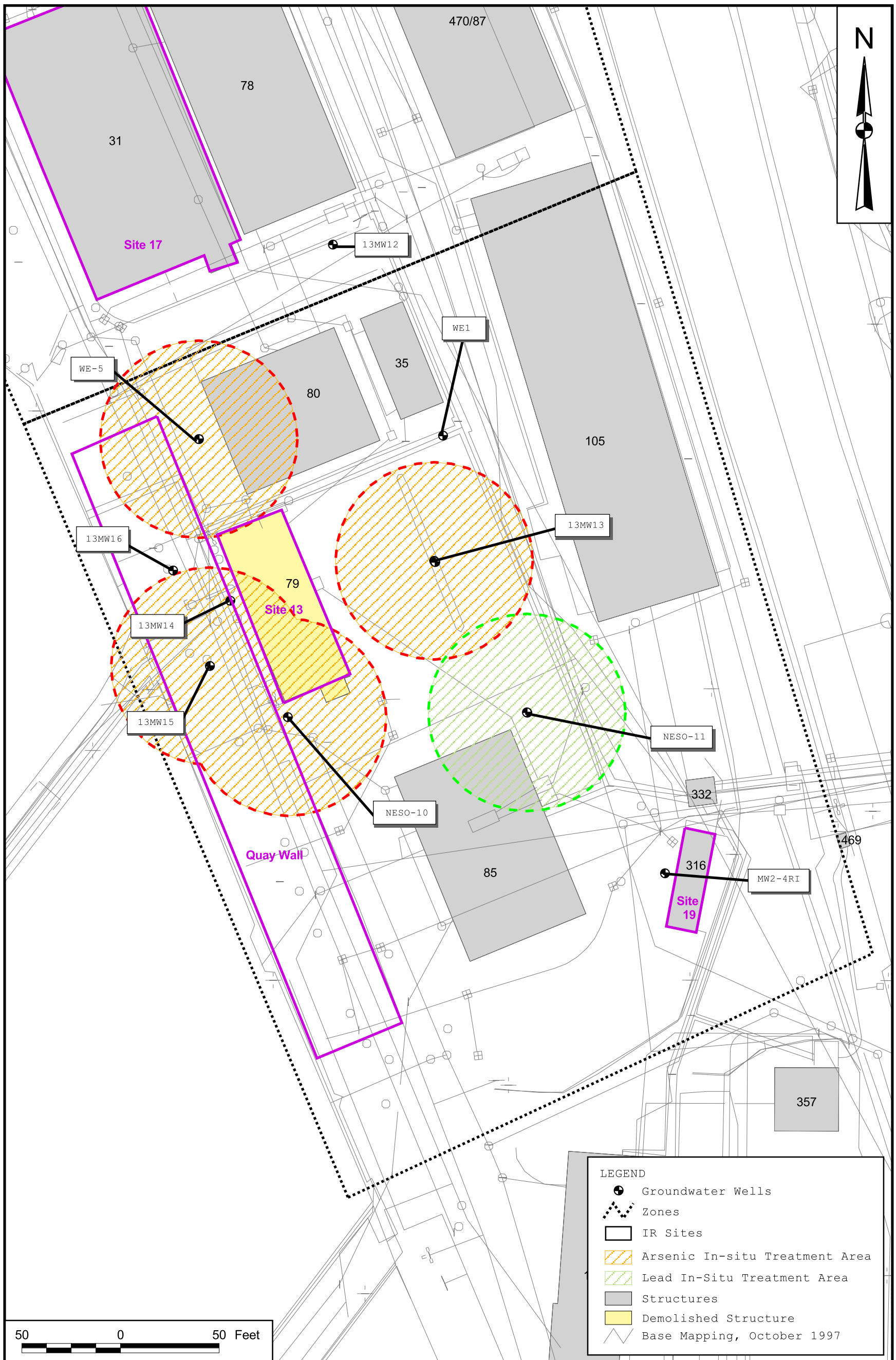
DRAWN BY CK DATE 11/06/09	Tetra Tech NUS, Inc.	PROCESS FLOW DIAGRAM ZONE 1 ARSENIC/COPPER POINTS OF GROUNDWATER CONTAMINATION ON-SITE GROUNDWATER TREATMENT SYSTEM ALTERNATIVE GW-1.5 LOWER SUBASE FEASIBILITY STUDY NSB-NLON GROTON, CONNECTICUT	CONTRACT NO. 0811
CHECKED BY DATE			OWNER NO.
REVISED BY DATE			APPROVED BY CAR DATE 01/12/10
SCALE AS NOTED			DRAWING NO. FIGURE 4-25 REV. 0

P:\GIS\NLON\MAPDOCS\APR\NLONTAGS.APR ZOOMED ZONE 4 TPH PLUME LAYOUT 01/11/10 SS



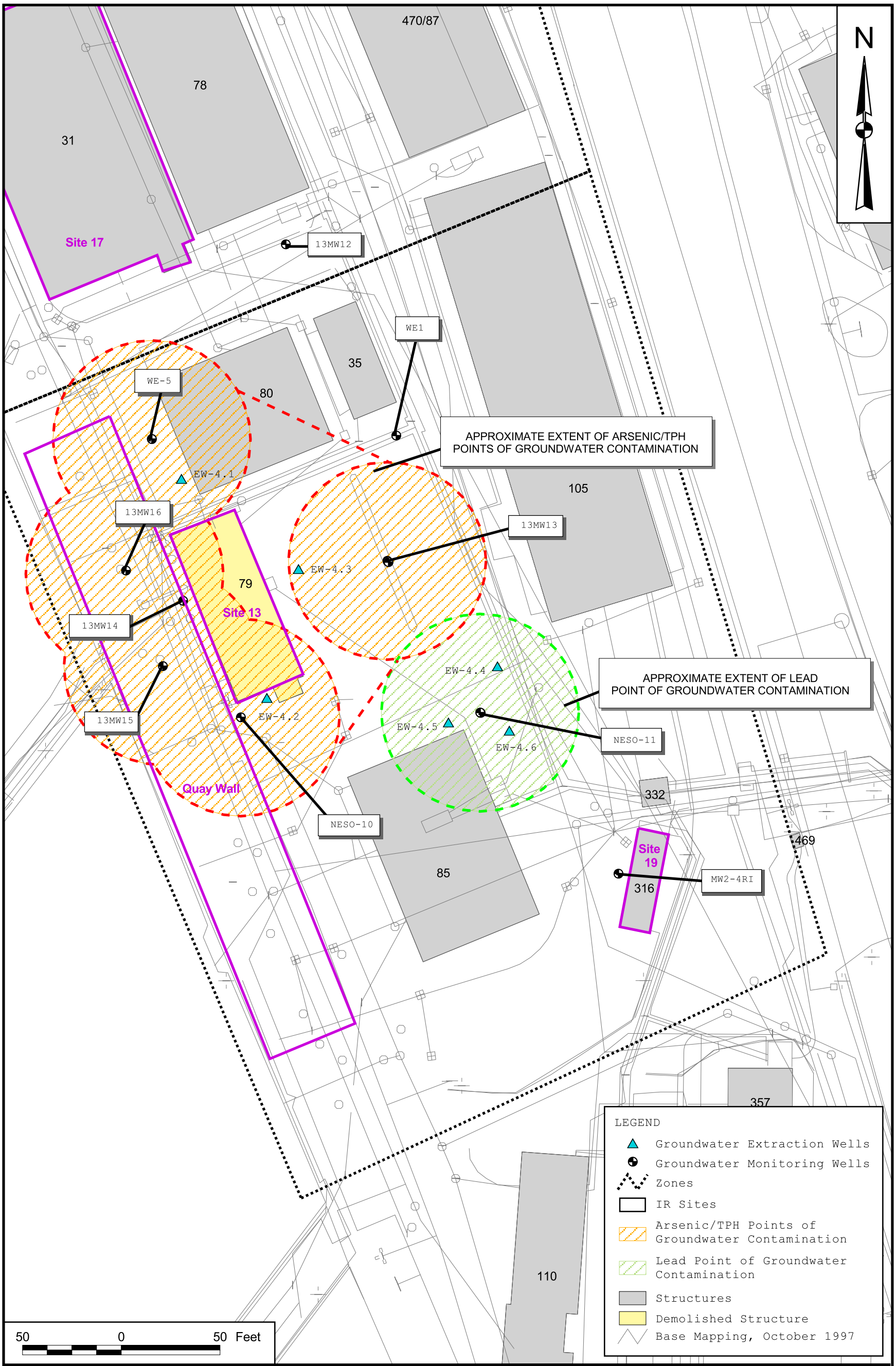
DRAWN BY S.STROZ DATE 12/10/07	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424	OWNER NUMBER —
CHECKED BY N. BALSAMO DATE 01/11/10	ZONE 4 ARSENIC/TPH POINTS OF GROUNDWATER CONTAMINATION IN-SITU ENHANCED BIOREMEDIATION ALTERNATIVE GW - 4.3 LOWER SUBASE FEASIBILITY STUDY NSB-NLON, GROTON, CONNECTICUT	APPROVED BY CAR	DATE 01/12/10
COST/SCHEDULE-AREA		APPROVED BY —	DATE —
SCALE AS NOTED		DRAWING NO. FIGURE 4-26	REV 0

P:\GIS\NLON\MAPDOCS\APR\NLONTAGS.APR ZONE 4 ARSENIC AND LEAD IN-SITU AREA LAYOUT 07/07/10 JEE



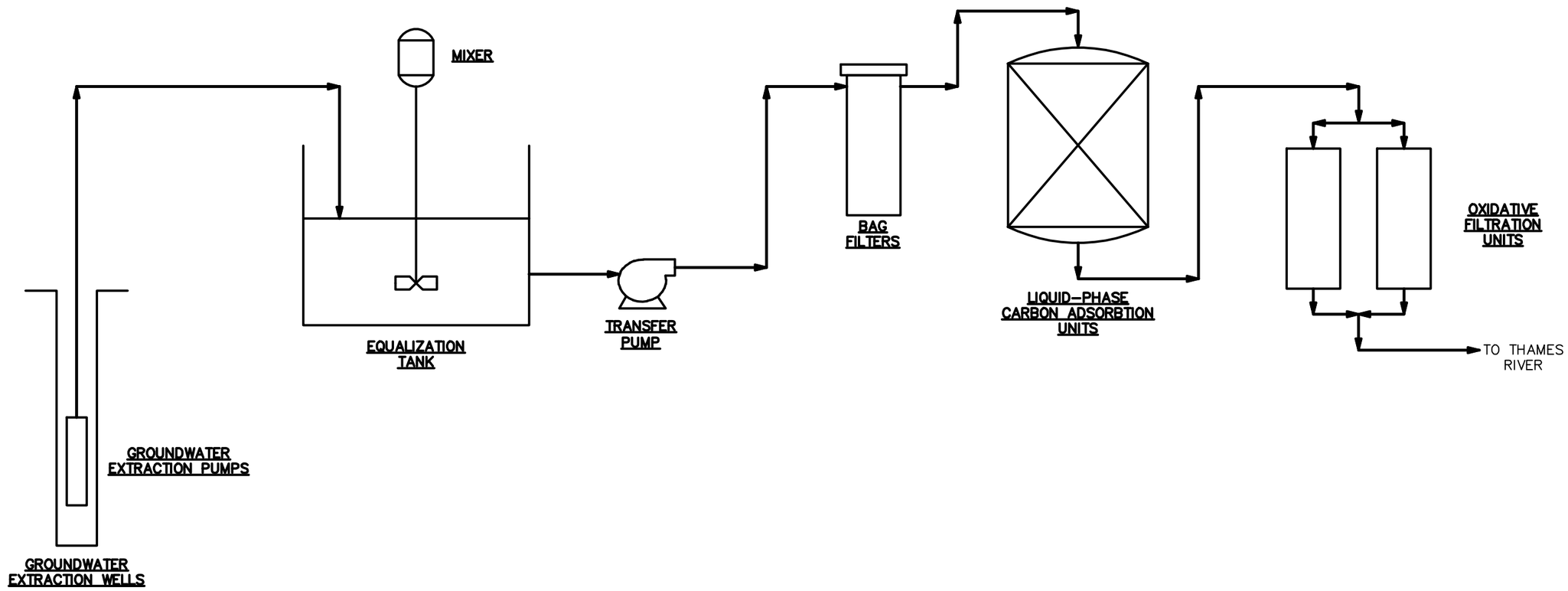
DRAWN BY S.STROZ — DATE 11/16/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424	OWNER NUMBER —
CHECKED BY N. BALSAMO — DATE 07/07/10	ZONE 4 ARSENIC AND LEAD IN-SITU GROUNDWATER TREATMENT AREAS ALTERNATIVE GW-4.3 LOWER SUBASE FEASIBILITY STUDY NSB-NLON, GROTON, CONNECTICUT	APPROVED BY CAR	DATE 12/14/10
COST/SCHEDULE-AREA		APPROVED BY —	DATE —
SCALE AS NOTED		DRAWING NO. FIGURE 4-27	REV 0

P:\GIS\NLON\MAPDOCS\APR\NLONTAGS.APR ZONE 4 PROPOSED GW EXTRACTION WELL LOCATIONS LAYOUT 07/07/10 JEE



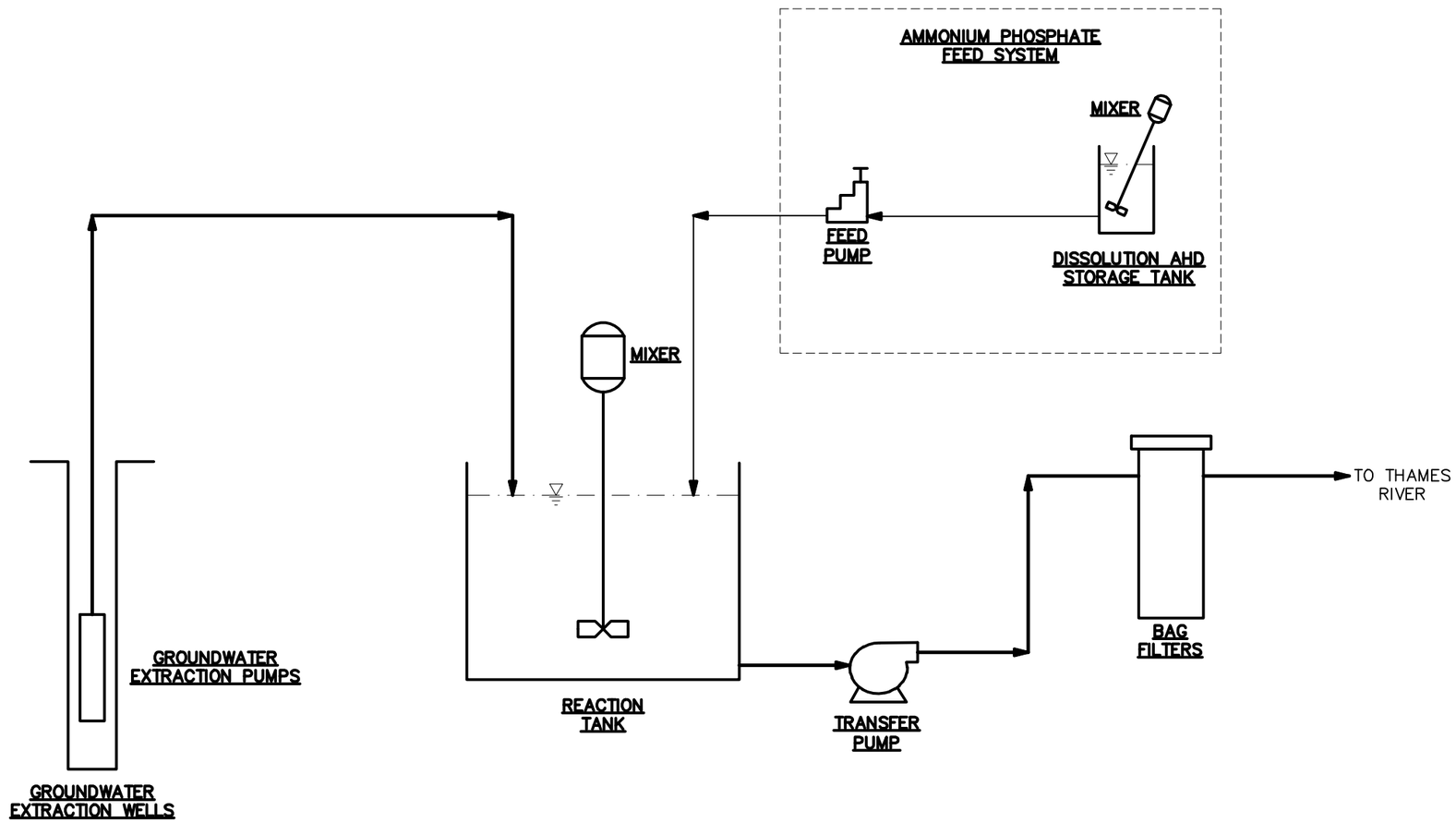
DRAWN BY S.STROZ — DATE 11/18/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424	OWNER NUMBER —
CHECKED BY N. BALSAMO — DATE 07/07/10	ZONE 4 ARSENIC/TPH AND LEAD POINTS OF GROUNDWATER CONTAMINATION PROPOSED GROUNDWATER EXTRACTION WELLS LOCATION ALTERNATIVES GW-4.4 AND GW-4.5 LOWER SUBASE FEASIBILITY STUDY NSB-NLON, GROTON, CONNECTICUT	APPROVED BY CAR	DATE 12/14/10
COST/SCHEDULE-AREA		APPROVED BY —	DATE —
SCALE AS NOTED		DRAWING NO. FIGURE 4-28	REV 0

ACAD:0811PF09.dwg 11/06/09 CK PIT



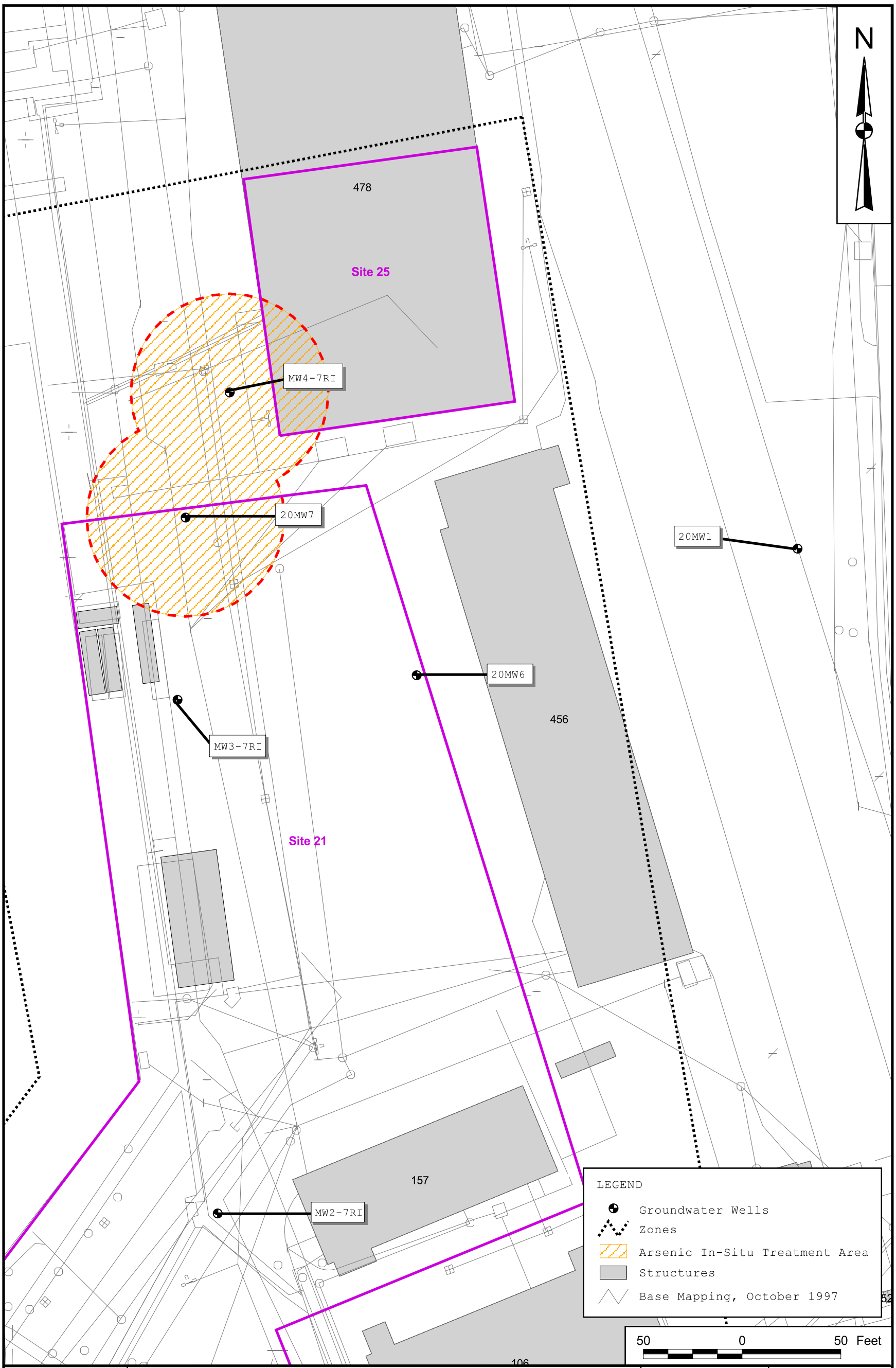
DRAWN BY CK DATE 11/06/09	Tetra Tech NUS, Inc.	PROCESS FLOW DIAGRAM ZONE 4 ARSENIC/TPH POINTS OF GROUNDWATER CONTAMINATION ON-SITE GROUNDWATER TREATMENT SYSTEM ALTERNATIVE GW-4.5 LOWER SUBASE FEASIBILITY STUDY NSB-NLON GROTON, CONNECTICUT	CONTRACT NO. 0811
CHECKED BY DATE			OWNER NO.
REVISED BY DATE			APPROVED BY CAR DATE 01/12/10
SCALE AS NOTED			DRAWING NO. FIGURE 4-29 REV. 0

ACAD:0811PF10.dwg 11/06/09 CK PIT



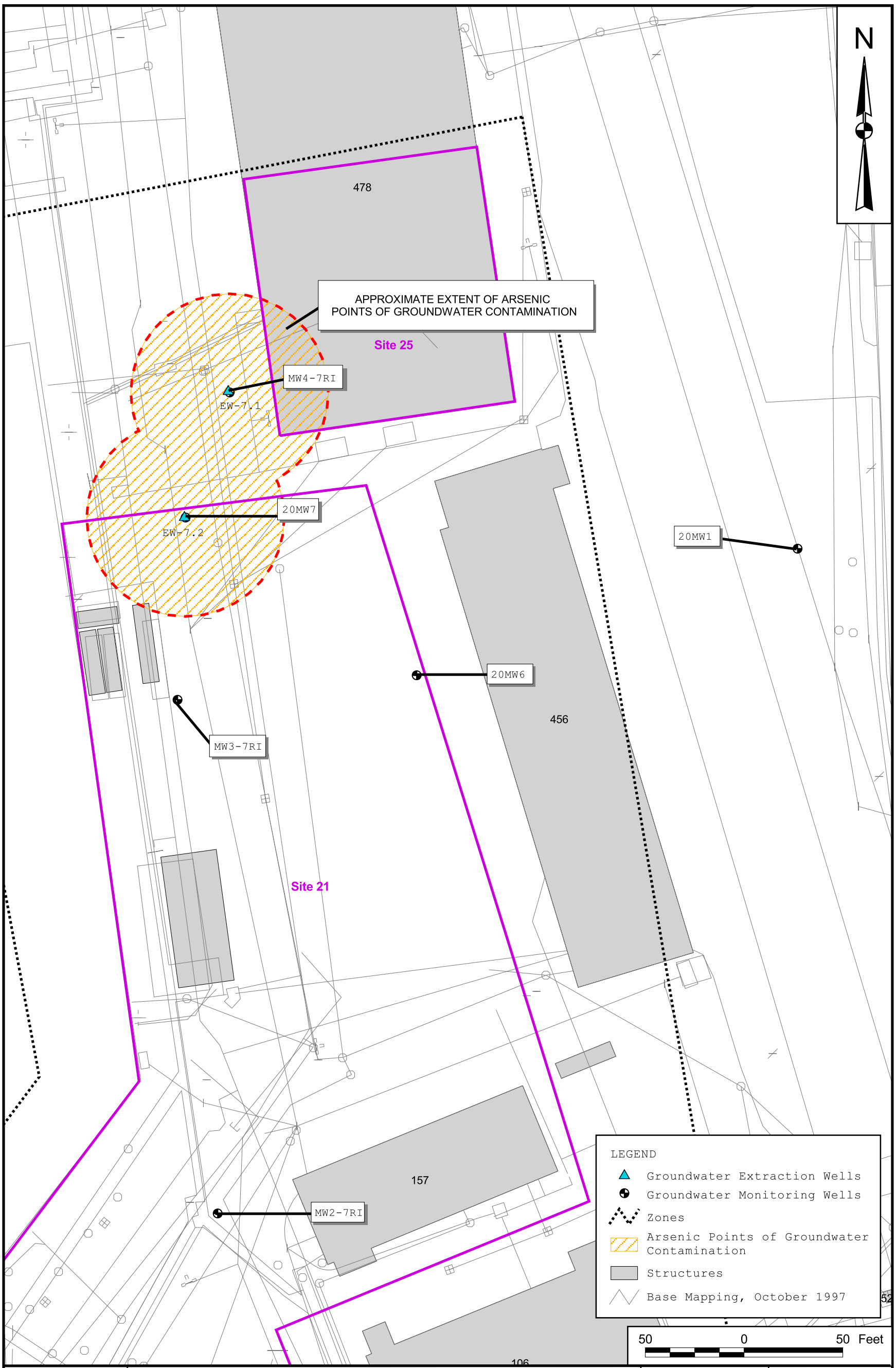
DRAWN BY CK DATE 11/06/09	Tetra Tech NUS, Inc.	PROCESS FLOW DIAGRAM ZONE 4 LEAD POINT OF GROUNDWATER CONTAMINATION ON-SITE GROUNDWATER TREATMENT SYSTEM ALTERNATIVE GW-4.5 LOWER SUBASE FEASIBILITY STUDY NSB-NLON GROTON, CONNECTICUT	CONTRACT NO. 0811
CHECKED BY DATE			OWNER NO.
REVISED BY DATE			APPROVED BY CAR DATE 01/12/10
SCALE AS NOTED			DRAWING NO. FIGURE 4-30 REV. 0

P:\GIS\NLON\MAPDOCS\APR\NLONTAGS.APR ZONE 7 ARSENIC IN-SITU TREATMENT AREA LAYOUT 07/07/10 JEE



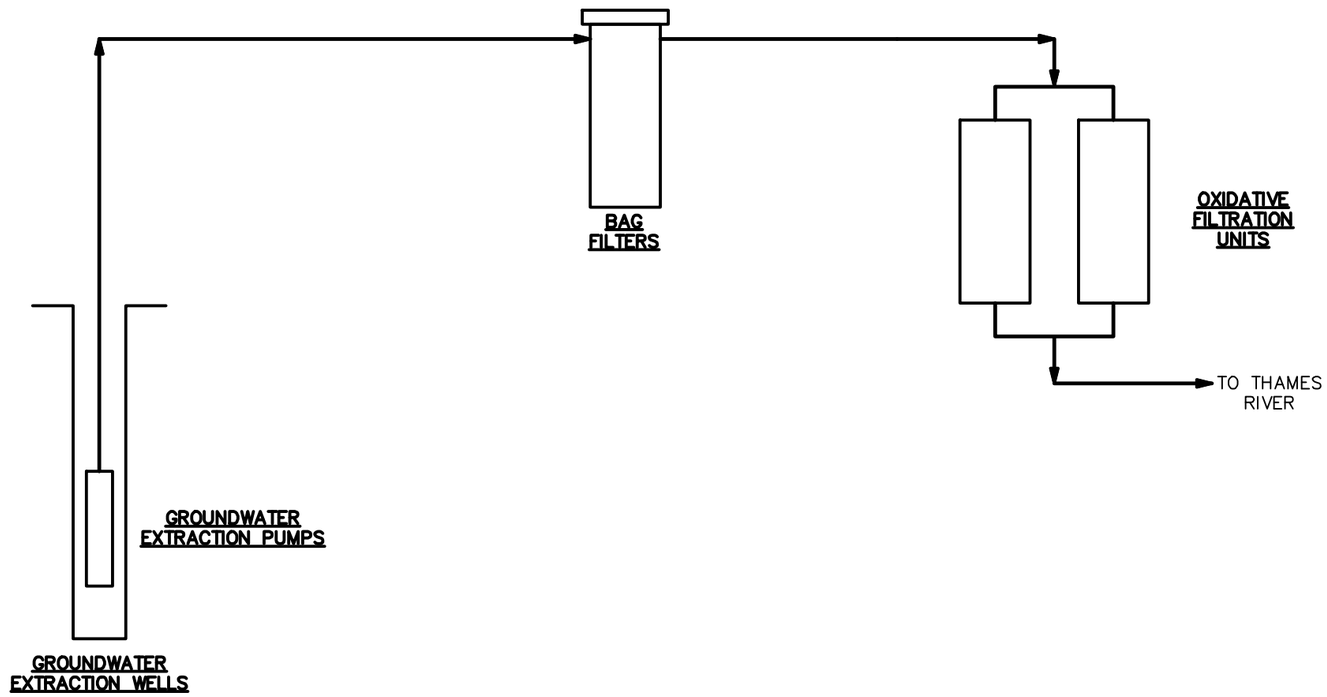
DRAWN BY S.STROZ — DATE 11/16/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424	OWNER NUMBER —
CHECKED BY N. BALSAMO — DATE 07/07/10	ZONE 7 ARSENIC IN-SITU GROUNDWATER TREATMENT AREA ALTERNATIVE GW - 7.3 LOWER SUBASE FEASIBILITY STUDY NSB-NLON, GROTON, CONNECTICUT	APPROVED BY CAR — DATE 12/14/10	
COST/SCHEDULE-AREA		APPROVED BY — DATE —	
SCALE AS NOTED		DRAWING NO. FIGURE 4-31	REV 0

P:\GIS\NLON\MAPDOCS\APR\NLONTAGS.APR ZONE 7 PROPOSED GW EXTRACTION WELL LOCATIONS LAYOUT 07/07/10 JEE



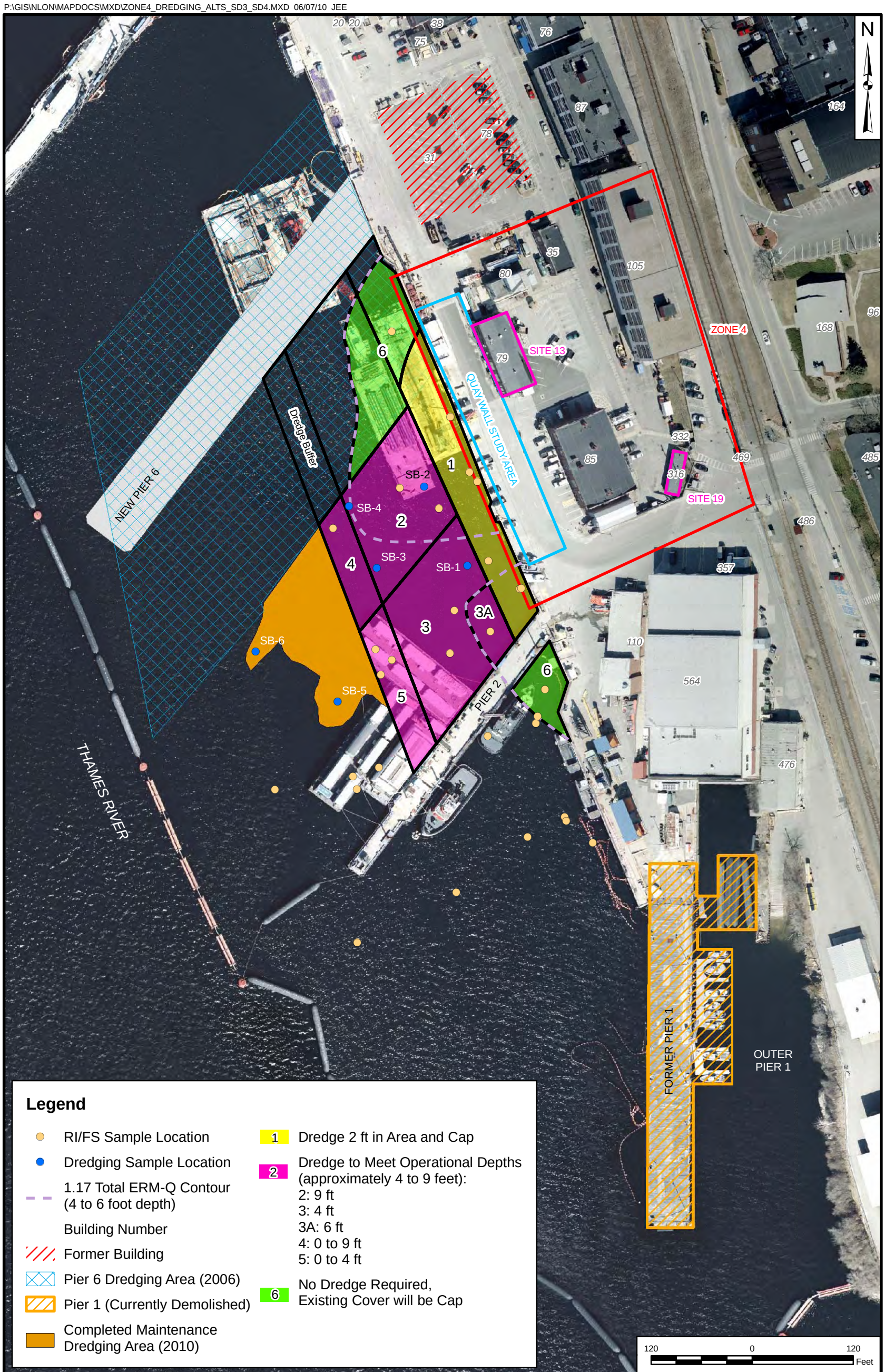
DRAWN BY S.STROZ	DATE 11/18/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424 / OWNER NUMBER —
CHECKED BY N. BALSAMO	DATE 07/07/10	ZONE 7 ARSENIC POINTS OF GROUNDWATER CONTAMINATION PROPOSED GROUNDWATER EXTRACTION WELL LOCATIONS ALTERNATIVES GW-7.4 AND GW-7.5 LOWER SUBASE FEASIBILITY STUDY NSB-NLON, GROTON, CONNECTICUT	APPROVED BY CAR / DATE 12/14/10
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 4-32 / REV 0

ACAD: 0811PF08.dwg 11/06/09 CK PIT



DRAWN BY CK DATE 11/06/09	Tetra Tech NUS, Inc.	PROCESS FLOW DIAGRAM ZONE 7 ARSENIC POINTS OF GROUNDWATER CONTAMINATION ON-SITE GROUNDWATER TREATMENT SYSTEM ALTERNATIVE GW-7.5 LOWER SUBASE FEASIBILITY STUDY NSB-NLON GROTON, CONNECTICUT	CONTRACT NO. 0811
CHECKED BY DATE			OWNER NO.
REVISED BY DATE			APPROVED BY CAR DATE 01/12/10
SCALE AS NOTED			DRAWING NO. FIGURE 4-33 REV. 0

P:\GIS\NLON\MAPDOCS\MXD\ZONE4_DREDGING_ALTS_SD3_SD4.MXD 06/07/10 JEE

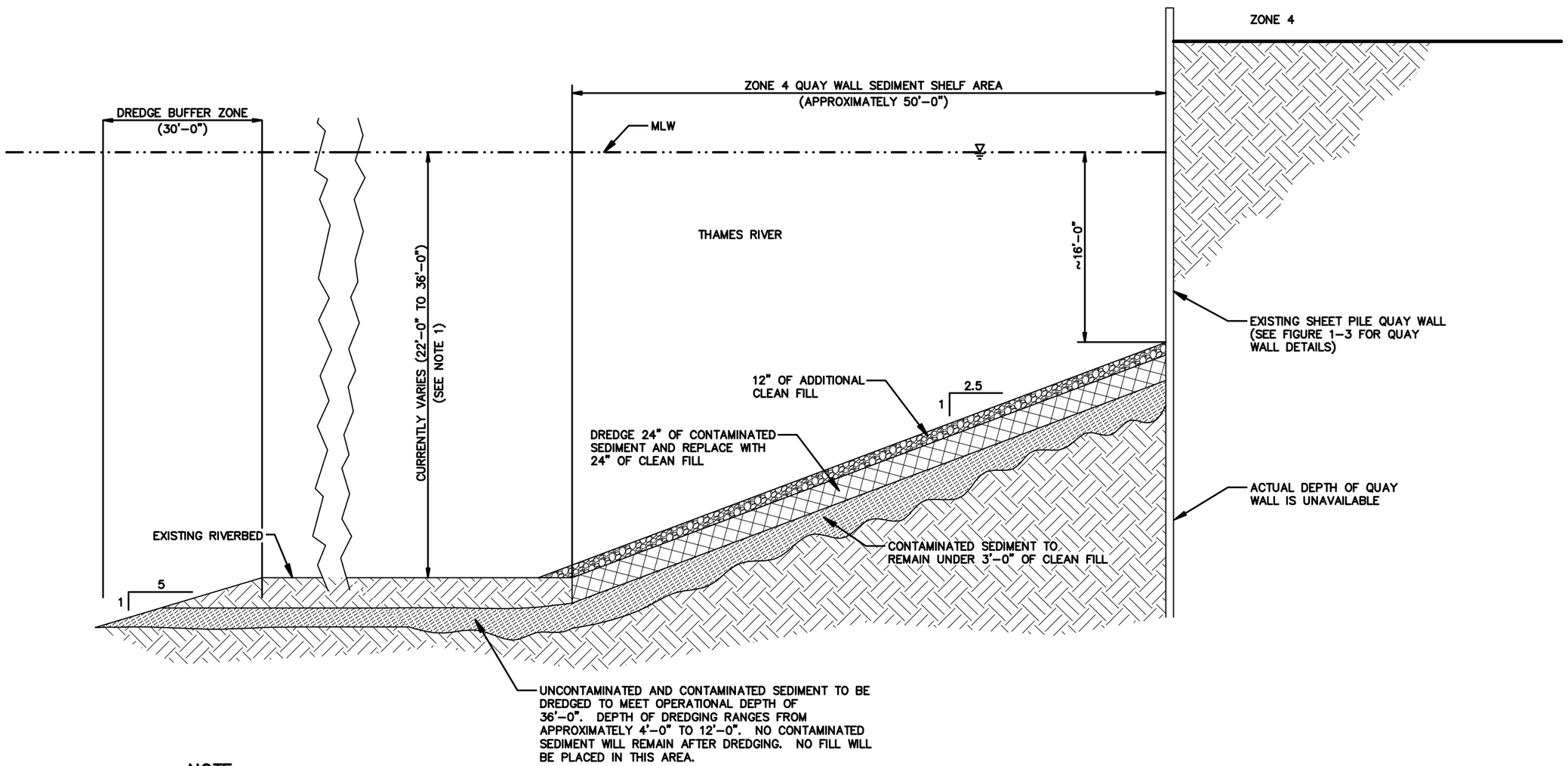


Legend

- RI/FS Sample Location
- Dredging Sample Location
- 1.17 Total ERM-Q Contour (4 to 6 foot depth)
- Building Number
- Former Building
- Pier 6 Dredging Area (2006)
- Pier 1 (Currently Demolished)
- Completed Maintenance Dredging Area (2010)
- 1 Dredge 2 ft in Area and Cap
- 2 Dredge to Meet Operational Depths (approximately 4 to 9 feet):
  2: 9 ft
  3: 4 ft
  3A: 6 ft
  4: 0 to 9 ft
  5: 0 to 4 ft
- 6 No Dredge Required, Existing Cover will be Cap

DRAWN BY J. ENGLISH	DATE 06/04/10	Tetra Tech NUS, Inc.	CONTRACT NUMBER CTO WE57 / OWNER NUMBER 2630
CHECKED BY C. RICH	DATE 06/04/10	ZONE 4 AREAS OF SEDIMENT TO BE DREDGED AND CAPPED ALTERNATIVES SD-3 AND SD-4 LOWER SUBASE NSB - NLON, GROTON, CONNECTICUT	APPROVED BY CAR / DATE 06/05/10
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 4-34 / REV 0

ACAD: 0811CD05.dwg 5/26/10 CK PIT

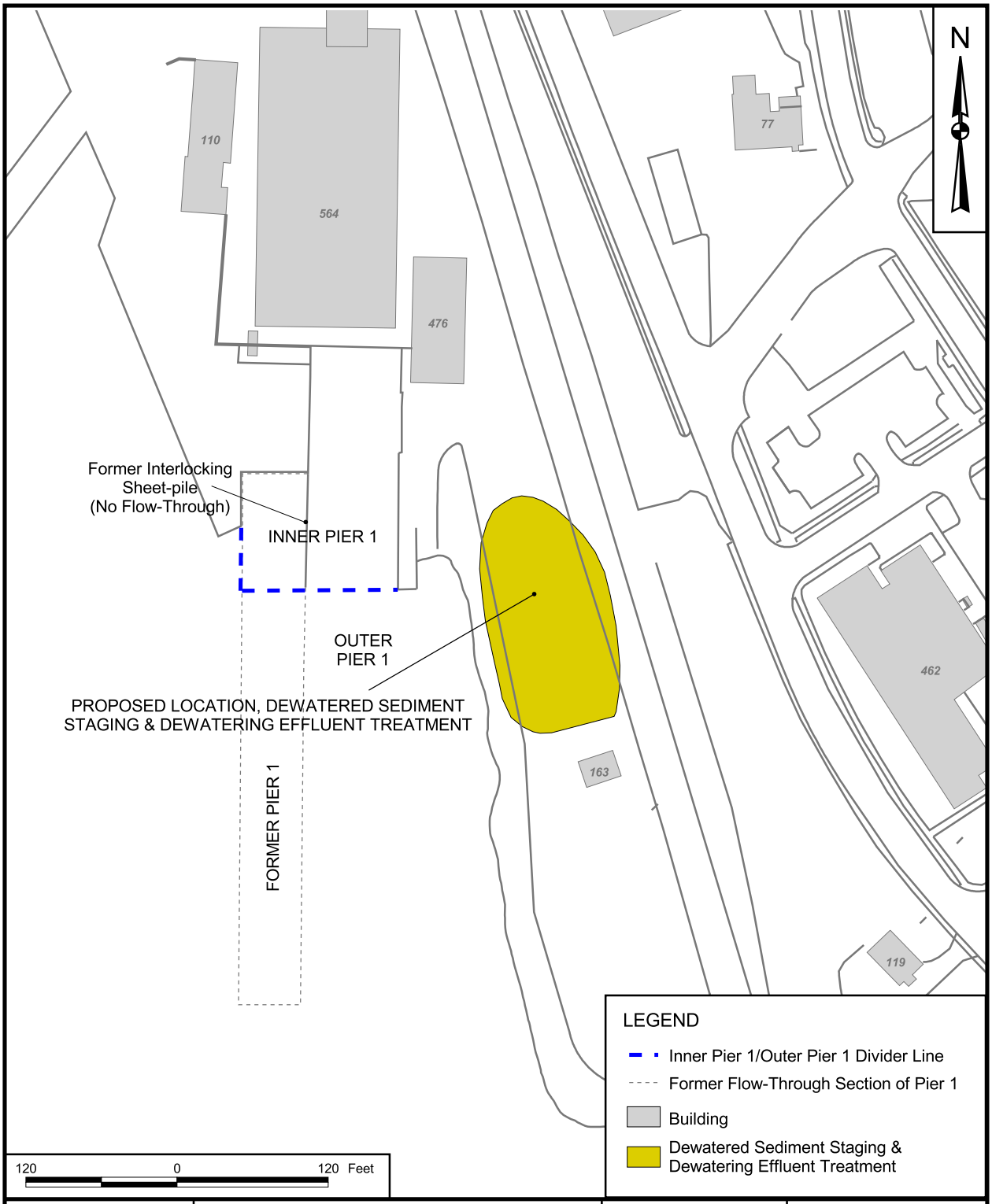


NOTE:

1.) DEPTH OF WATER AT THE END OF THE QUAY WALL SEDIMENT SHELF IS IDEALLY 36'-0" TO ALLOW FOR OPERATIONS; HOWEVER, THE CURRENT DEPTH WITHIN ZONE 4 VARIES AND DREDGING WILL BE REQUIRED TO MEET BOTH OPERATIONAL CONCERNS AND TO REMOVE CONTAMINATED SEDIMENT PRIOR TO CAPPING.

DRAWN BY CK	DATE 11/09/08	Tetra Tech NUS, Inc.	TYPICAL CROSS-SECTION OF ZONE 4 SEDIMENT CAP ALTERNATIVES SD-3 AND SD-4 LOWER SUBASE FEASIBILITY STUDY NSB-NLON GROTON, CONNECTICUT
CHECKED BY	DATE		
REVISED BY	DATE		
SCALE NOT-TO-SCALE			

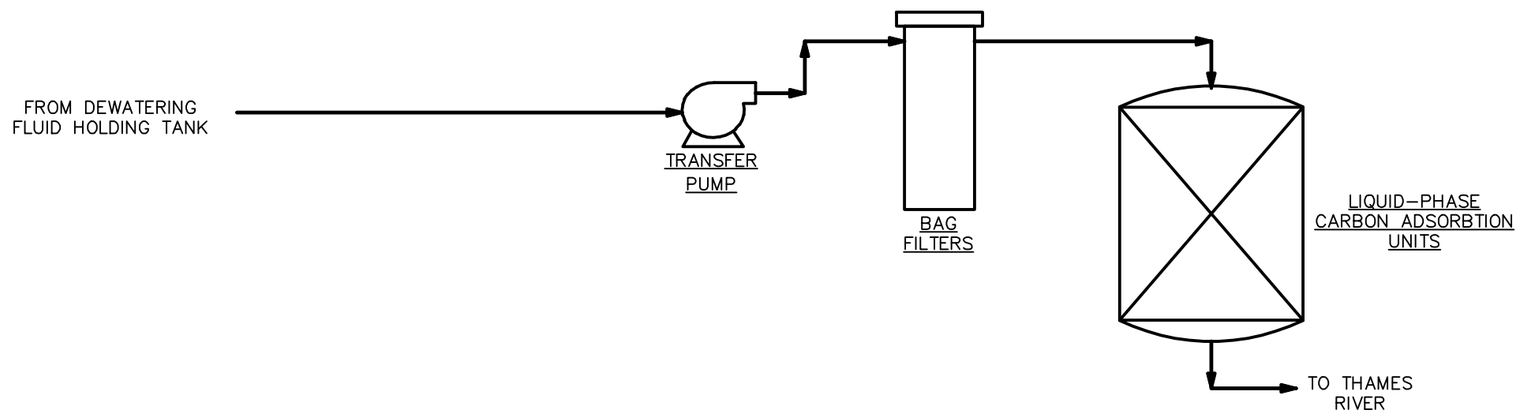
CONTRACT NO. 0811	
OWNER NO. 0424	
APPROVED BY CAR	DATE 5/25/10
DRAWING NO. FIGURE 4-35	REV. 0



DRAWN BY S. STROZ	DATE 09/30/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424 / OWNER NO. 0811
CHECKED BY N. BALSAMO	DATE 11/06/09	LOCATION OF ON-SITE DEWATERED SEDIMENT STAGING & DEWATERING EFFLUENT TREATMENT SYSTEM LOWER SUBASE FEASIBILITY STUDY NSB-NLON GROTON, CONNECTICUT	APPROVED BY CAR / DATE 01/12/10
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 4-36 / REV 0

P:\GIS\NLON\SUBASE FEASIBILITY STUDY.APR DEWATERING AND TREATMENT AREA LAYOUT 11/06/09 SS

ACAD: 0B11PF06.dwg 11/06/09 CK PIT



DRAWN BY CK DATE 11/06/09	Tetra Tech NUS, Inc.	PROCESS FLOW DIAGRAM TYPICAL ON–SITE DEWATERING FLUID TREATMENT SYSTEM ALTERNATIVES SD–3 AND SD–6 LOWER SUBASE FEASIBILITY STUDY NSB–NON, GROTON, CONNECTICUT	CONTRACT NO. 0424
CHECKED BY DATE			OWNER NO.
REVISED BY DATE			APPROVED BY CAR DATE 01/12/10
SCALE NOT TO SCALE			DRAWING NO. FIGURE 4–37 REV. 0

FORM CADD NO. TTNUS–BH.DWG – REV 1 – 9/10/98

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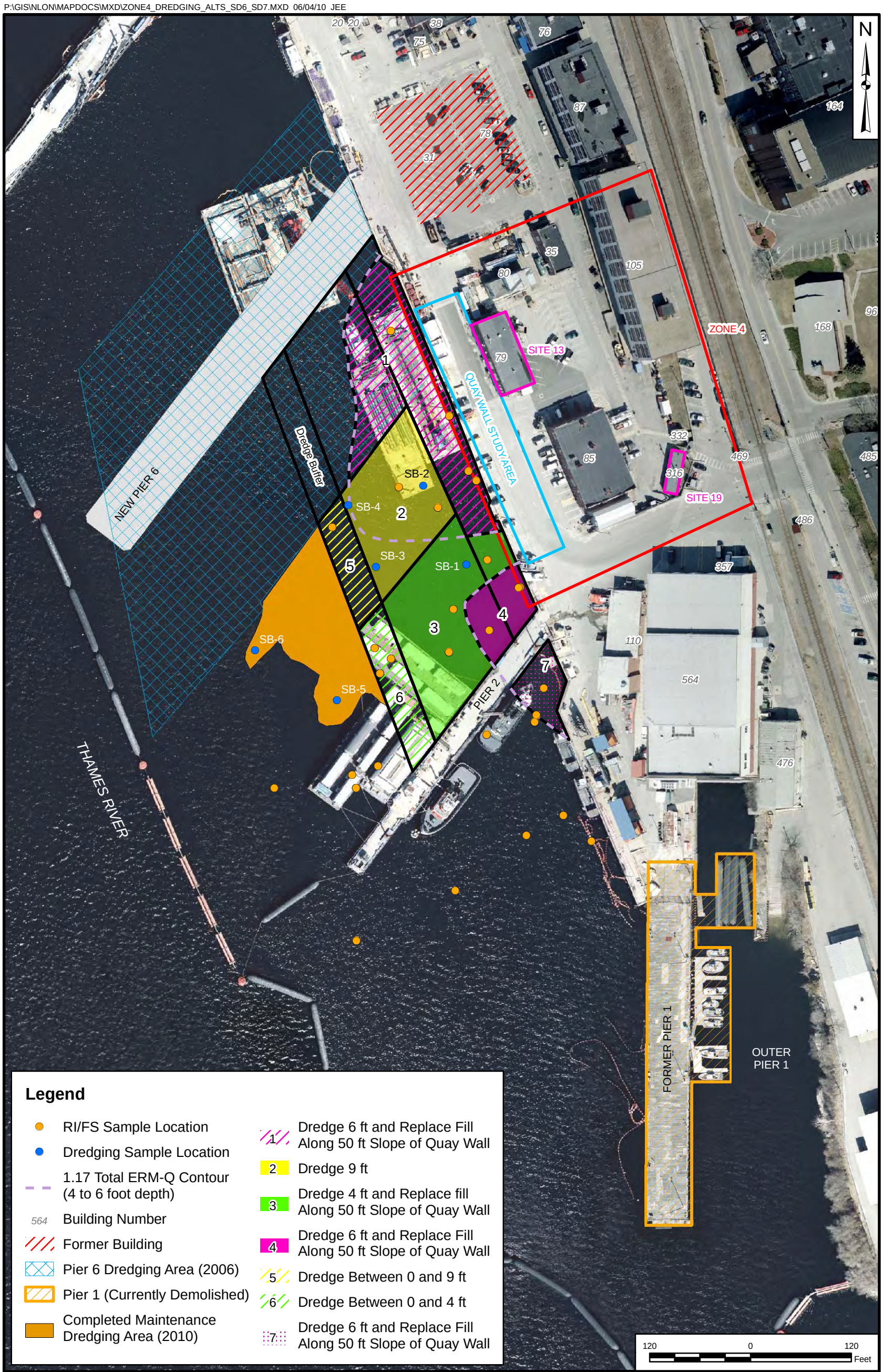
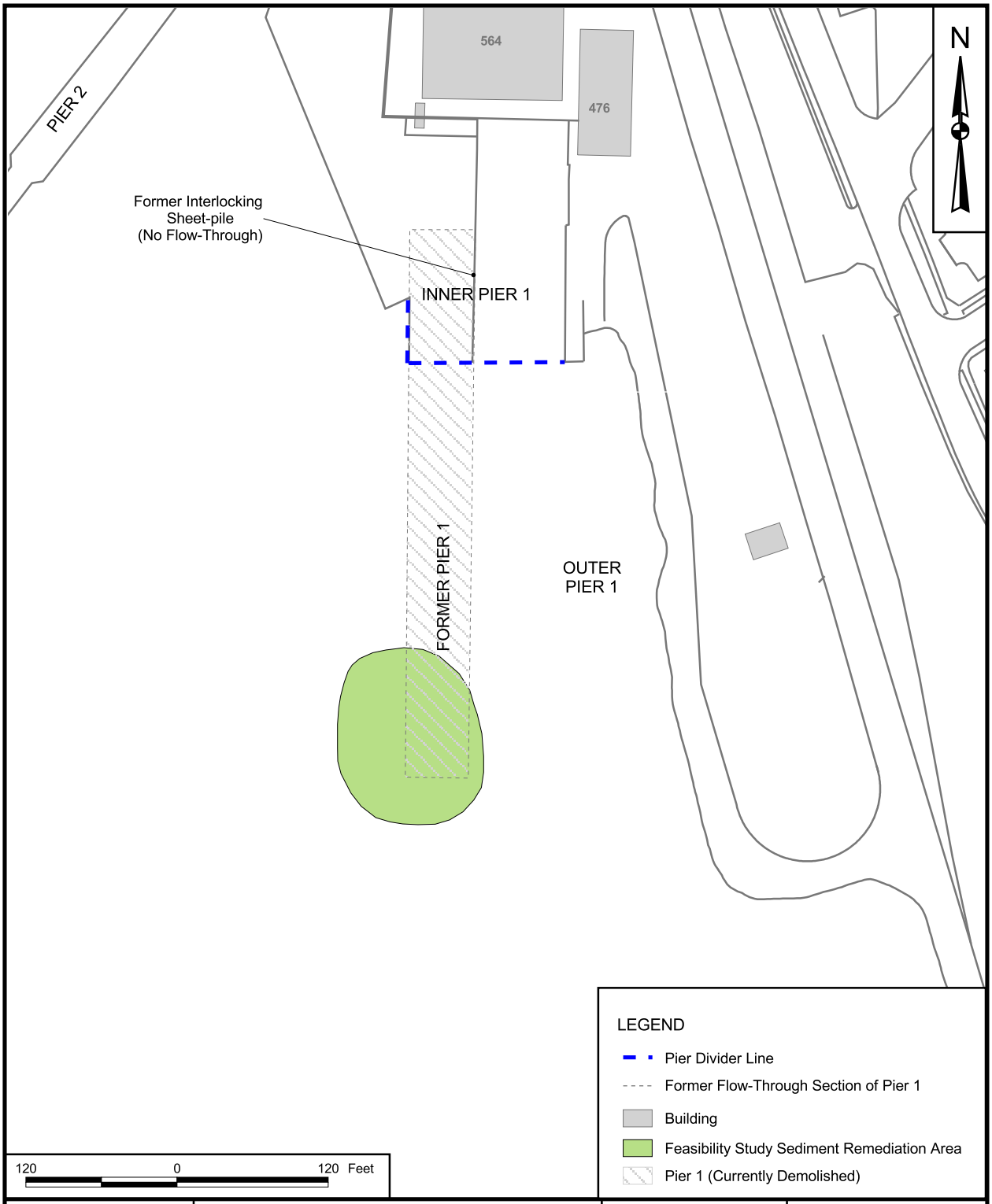


DRAWN BY J. ENGLISH — DATE 06/04/10	Tetra Tech NUS, Inc.	CONTRACT NUMBER CTO WE57	OWNER NUMBER 2630
CHECKED BY C. RICH — DATE 06/07/10	ZONE 4 AREAS OF SEDIMENT TO BE DREDGED ALTERNATIVES SD-6 AND SD-7 LOWER SUBASE NSB - NLON, GROTON, CONNECTICUT	APPROVED BY CAR	DATE 06/05/10
COST/SCHEDULE-AREA		APPROVED BY —	DATE —
SCALE AS NOTED		DRAWING NO. FIGURE 4-38	REV 0



DRAWN BY S. STROZ — DATE 04/22/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424	OWNER NO. 0811
CHECKED BY N. BALSAMO — DATE 12/06/10	OUTER PIER 1 AREA OF SEDIMENT TO BE DREDGED ALTERNATIVES SD-6 AND SD-7 LOWER SUBASE FEASIBILITY STUDY NSB - NLON GROTON, CONNECTICUT	APPROVED BY CAR — DATE 12/06/10	
COST/SCHEDULE-AREA		APPROVED BY — — DATE —	
SCALE AS NOTED		DRAWING NO. FIGURE 4-39	REV 0

P:\GIS\NLON\SUBASE FEASIBILITY STUDY.APR OUTER PIER 1 AREA OF SD TO BE CAPPED LAYOUT 12/08/09 SS

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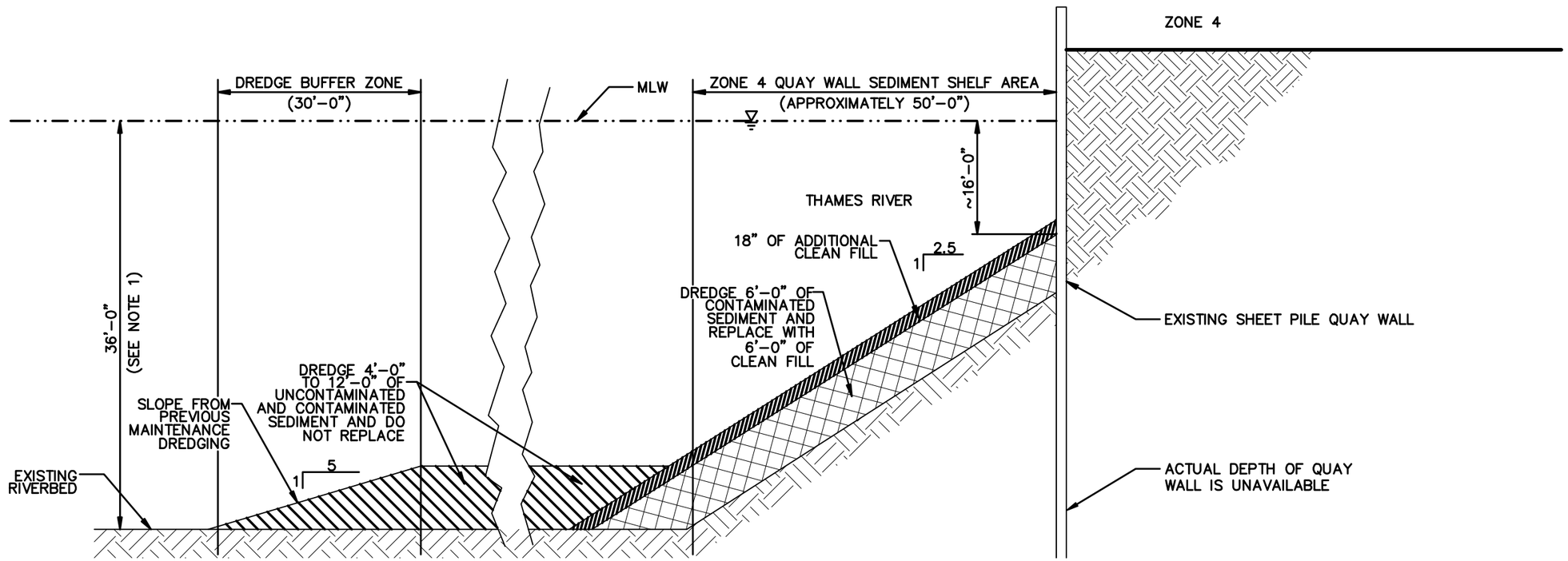

NOTE:

1.) DEPTH OF WATER AT THE END OF THE QUAY WALL SEDIMENT SHELF IS IDEALLY 36'–0" TO ALLOW FOR OPERATIONS; HOWEVER, THE CURRENT DEPTH WITHIN ZONE 4 VARIES AND DREDGING WILL BE REQUIRED TO MEET BOTH OPERATIONAL CONCERNS AND TO REMOVE CONTAMINATED SEDIMENT.

DRAWN BY CK DATE 11/09/08	Tetra Tech NUS, Inc.	TYPICAL CROSS–SECTION OF ZONE 4 SEDIMENT DREDGING AREA ALTERNATIVES SD–6 AND SD–7 LOWER SUBASE FEASIBILITY STUDY NSB–NLON GROTON, CONNECTICUT	CONTRACT NO. 0811
CHECKED BY DATE			OWNER NO. 0424
REVISED BY DATE			APPROVED BY CAR DATE 5/25/10
SCALE NOT–TO–SCALE			DRAWING NO. FIGURE 4–40 REV. 0

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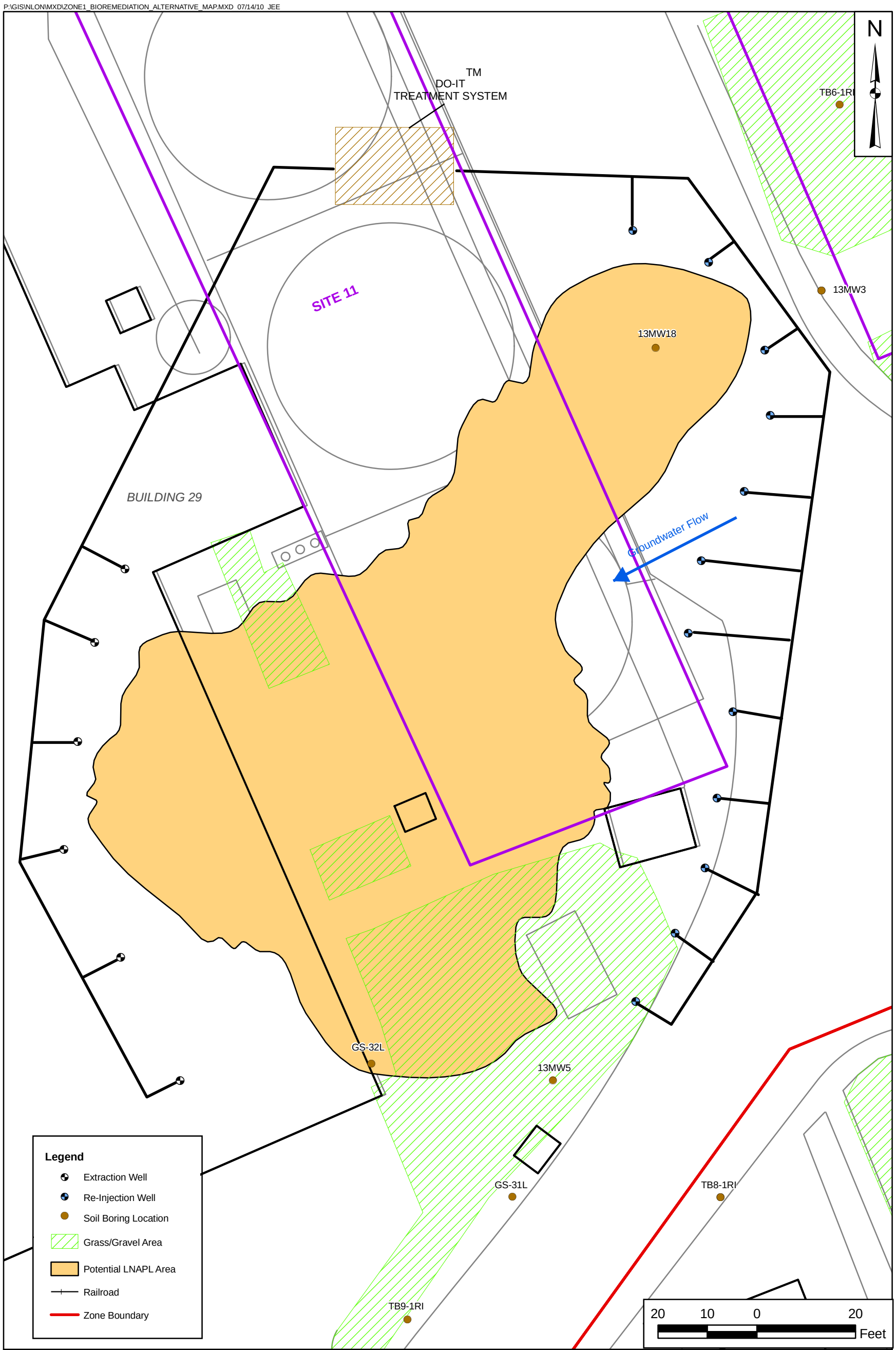
DRAWN BY S. STROZ	DATE 11/12/09	Tetra Tech NUS, Inc.	CONTRACT NO. 2195
CHECKED BY N. BALSAMO	DATE 07/14/10	ZONE 1 AREA OF LNAPL ACCUMULATION AND SKIMMING WELL LOCATIONS ALTERNATIVE LN-1 NAVAL SUBMARINE BASE - NEW LONDON GROTON, CONNECTICUT	APPROVED BY CAR / DATE 12/14/10
COST/SCHED-AREA			APPROVED BY -- / DATE --
SCALE AS NOTED			FIGURE NO. FIGURE 4-41 / REV.

P:\GIS\NLON\MXD\ZONE1_BIOREMEDIATION_ALTERNATIVE_MAP.MXD 07/14/10 JEE



DRAWN BY S. STROZ	DATE 11/13/09	Tetra Tech NUS, Inc.	CONTRACT NO. 2195
CHECKED BY N. BALSAMO	DATE 07/14/10	ZONE 1 AREA OF LNAPL ACCUMULATION IN-SITU ENHANCED BIOREMEDIATION ALTERNATIVE LN-2 NAVAL SUBMARINE BASE - NEW LONDON GROTON, CONNECTICUT	APPROVED BY CAR / DATE 12/14/10
COST/SCHED-AREA			APPROVED BY -- / DATE --
SCALE AS NOTED			FIGURE NO. FIGURE 4-42 / REV.

5.0 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

This section compares the analyses presented for each of the remedial alternatives in Section 4.0 of this FS. The criteria for comparison are identical to those used for the detailed analysis of individual alternatives.

5.1 COMPARISON OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 1

The following Zone 1 soil remedial alternatives are compared in this section:

Alternative S-1.1: No Action.

Alternative S-1.2: LUCs (Engineering and Institutional Controls) and Monitoring.

Alternative S-1.3: In-Situ Treatment (Enhanced Bioremediation) to Meet I/C DECs and PMCs, LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-1.4: Excavation to Meet I/C DECs and PMCs, Off-Site Disposal (LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-1.5: Excavation to Meet PMCs and Residential DECs, On-Site Dewatering, and Off-Site Disposal (LTTD, Landfilling, and Incineration).

5.1.1 Overall Protection of Health and Environment

Alternative S-1.1 would not be protective of human health and the environment. Unacceptable human health risks from direct exposure to PAHs in soil could develop because building foundations and pavement that cover most of this soil would not be maintained, because the disturbance of areas of contaminated soil would not be regulated, and because nothing would prevent residential development. In addition, Alternative S-1.1 would not be protective because it would provide no warning of the potential migration of PAHs from soil to groundwater. Alternative S-1.1 would not achieve the soil RAOs.

Alternatives S-1.2, S-1.3, S-1.4, and S-1.5 would be protective of human health and the environment and would achieve the soil RAOs.

Alternative S-1.2 would be protective because it would prevent unacceptable human health and environmental risks through LUCs that would ensure regular maintenance of building foundations and paved areas, regulate disturbance of contaminated soil, and prevent residential development of Zone 1. Alternative S-1.2 would also be protective because monitoring would warn of potential migration of PAHs from soil to groundwater. Alternatives S-1.3 and S-1.4 would be more protective than Alternative S-1.2 because, in addition to including the same protective elements, these two alternatives would actively

reduce the risk of exposure to PAHs and potential for migration of these COCs from soil to groundwater though in-situ enhanced bioremediation or excavation and off-site treatment and disposal, respectively. Alternative S-1.4 would be slightly more protective than Alternative S-1.3 because it would achieve protection somewhat faster. Alternative S-1.5 would be most protective because it would eliminate any unacceptable human health risks under current industrial site use and hypothetical future residential site use, and it would prevent potential migration of PAHs and TPH from soil to groundwater.

Alternatives S-1.2, S-1.3, and S-1.4 would achieve Soil RAOs Nos. 1 to 3 directly and Soil RAO No. 4 indirectly through implementation of LUCs that would prevent residential development. Alternative S-1.5 would achieve Soil RAOs Nos. 1 to 4.

5.1.2 Compliance with ARARs and TBCs

Alternative S-1.1 would not comply with chemical-specific ARARs and TBCs. No location- or action-specific ARARs or TBCs apply to this alternative.

Alternatives S-1.2, S-1.3, and S-1.4 would comply with all location- and action-specific ARARs and TBCs and would also comply with federal chemical-specific TBCs (there are no federal chemical-specific ARARs). Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of these alternatives would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil. See Appendix D.1.3 for engineering control calculations.

AlternativeS-1.5 would comply with chemical-, location-, and action-specific ARARs and TBCs.

A summary of the compliance of Alternatives S-1.2, S-1.3, S-1.4, and S-1.5 with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 5-1, 5-2, and 5-3, respectively.

5.1.3 Long-Term Effectiveness and Permanence

Alternative S-1.1 would not be long-term effective and permanent because it would involve no action.

Alternatives S-1.2 to S-1.5 would be long-term effective and permanent.

The LUCs of Alternative S-1.2 that would ensure regular maintenance of building foundations and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 1 would effectively and permanently prevent unacceptable risk from direct exposure to

contaminated soil. The monitoring of Alternative S-1.2 would effectively detect potential migration of PAHs from soil to groundwater.

Alternatives S-1.3 and S-1.4 would be more effective and permanent than Alternative S-1.2 because, in addition to LUCs and monitoring, these alternatives would both effectively and permanently remove PAHs from the site. Alternative S-1.4 would be slightly more effective than Alternative S-1.3 because it would achieve removal somewhat faster.

Alternative S-1.5 would be most effective and permanent because it would permanently remove from the site any soil that could constitute an unacceptable human health risk under either current or hypothetical future site uses or that could contribute to migration of PAHs or TPH from soil to groundwater.

5.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives S-1.1 and S-1.2 would not reduce the toxicity, mobility, or volume of PAHs through treatment because no treatment would occur.

Alternative S-1.3 would reduce the toxicity and mobility of PAHs through treatment. An estimated 2,800 cubic yards of “high PAH” soil would be permanently and irreversibly treated by in-situ enhanced bioremediation

Alternative S-1.4 would not reduce the toxicity, mobility, or volume of PAHs through treatment. Alternative S-1.5 would not reduce the toxicity, mobility, and volume of PAHs, TPH, and mercury in soil through treatment.

5.1.5 Short-Term Effectiveness

Implementation of Alternatives S-1.1 would not result in any short-term risks to on-site workers or adversely impact the local community or the environment because no action would be taken.

Implementation of Alternatives S-1.2, S-1.3, S-1.4, and S-1.5 could result in short-term risks to on-site workers as a result of exposure to contamination. The potential for exposure would be minimal for Alternative S-1.2, moderate for Alternatives S-1.3 and S-1.4, and significant for Alternative S-1.5 because of the increasing level of activities. However, these risks would be adequately mitigated for all alternatives by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures.

Alternatives S-1.4 and S-1.5 could also have a moderate adverse impact on the surrounding community and the environment as a result of on-site activities and off-site transportation of contaminated soil. However, this impact would be adequately mitigated by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-1.1 would not attain the soil RAOs or meet the Zone 1 soil PRGs. Alternatives S-1.2, S-1.3, and S-1.4 could be completed within approximately 3 months, 9 months, and 9 months, respectively, and would achieve Soil RAOs Nos. 1 to 3 at completion. In addition, because they include LUCs that prohibit residential development of Zone 1, Alternatives S-1.2, S-1.3, and S-1.4 would also indirectly attain Soil RAO No. 4 at completion. Alternatives S-1.3 and S-1.4 would meet the Zone 1 soil PAH PRGs for I/C direct exposure and pollutant mobility within approximately 9 months and approximately 3 to 5 years, respectively. In addition, the cleanup criteria would not apply to leftover areas of inaccessible and/or environmentally isolated contaminated soil that could not be treated or excavated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternatives S-1.2, S-1.3 and S-1.4 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Alternative S-1.5 could be completed in approximately 18 months and would achieve all four soil RAOs and meet the Zone 1 soil PRGs for residential direct exposure and pollutant mobility at completion. Contaminated soil in inaccessible areas would be removed in this alternative.

5.1.6 Implementability

Technically, Alternative S-1.1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Alternatives S-1.2, S-1.3, S-1.4, and S-1.5 would be technically implementable, and resources, equipment, and materials would be readily available for this purpose. From the technical point of view, Alternative S-1.2 would be easiest to implement because it would only require maintenance of building foundations, paved areas, and existing monitoring wells and long-term monitoring of groundwater. Alternatives S-1.3, S-1.4, and S-1.5 would be much harder to implement than Alternative S-1.2. Alternatives S-1.3 and S-1.4 would be similar in complexity, with Alternative S-1.3 requiring in-situ LDA soil mixing at numerous locations and Alternative S-1.4 requiring excavation, off-site transportation, and treatment and disposal. The implementability of both of these alternatives would be severely restricted by ongoing base activities and multiple underground obstacles. Although it has been assumed for the purpose of this FS that neither of these two restrictive factors would actually prevent implementation of

Alternatives S-1.3 and S-1.4, this assumption might not prove to be correct. Even though it would not be restricted by base activities and underground obstacles, Alternative S-1.5 would be hardest to implement because it would deal with much larger volumes of contaminated soil and would require such complex operations as excavation below the water table and on-site dewatering of excavated soil.

The administrative aspects of Alternatives S-1.2, S-1.3, S-1.4, and S-1.5 would be simple to implement. The administrative aspects of Alternatives S-1.2 and S-1.5 would be easiest to implement. Alternative S-1.2 would only require preparation of a LUC RD and the long-term enforcement of LUCs, and Alternative S-1.5 would require a construction permit issued by NSB-NLON DPW, documentation of off-site transportation and disposal of excavated soil, and compliance with the substantive requirements of federal and state water discharge regulations for the discharge of the on-site dewatering operation drainage water to the Thames River. The administrative aspects of Alternative S-1.3 would be slightly harder to implement because, in addition to the preparation of a LUC RD and long-term enforcement of LUCs, this alternative would require a construction permit issued by NSB-NLON DPW. The administrative aspects of Alternative S-1.4 would be hardest to implement because it would require preparation of a LUC RD, long-term enforcement of LUCs, securing of a construction permit, and documentation of off-site transportation and disposal of excavated soil.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

5.1.7 Cost

The capital and O&M costs and NPW of the Zone 1 soil alternatives are as follows. Costs have been rounded to the nearest $1,000 to reflect the preliminary nature of the estimates. Detailed cost estimates are provided in Appendix E.

Alternative	Capital ($)	NPW of O&M ($)	NPW ($)
S-1.1	0	55,000 (30 years)	55,000 (30 years)
S-1.2	70,000	415,000 (30 years)	485,000 (30 years)
S-1.3	1,186,000	421,000 (30 years)	1,607,000 (30 years)

Alternative	Capital ($)	NPW of O&M ($)	NPW ($)
S-1.4	1,412,000	416,000 (30 years)	1,828,000 (30 years)
S-1.5	20,195,000	0	20,195,000 (1 year)

5.2 SUMMARY OF COMPARISON OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 1

Table 5-4 summarizes the comparative analysis of soil remedial alternatives for Zone 1.

5.3 COMPARISON OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 2

The following Zone 2 soil remedial alternatives are compared in this section:

Alternative S-2.1: No Action.

Alternative S-2.2: LUCs (Engineering and Institutional Controls) and Monitoring.

Alternative S-2.3: Capping to Prevent Leaching, LUCs, and Monitoring.

Alternative S-2.4: In-Situ Treatment (Stabilization/Solidification) to Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-2.5: Excavation to Meet I/C PMCs, Off-Site Disposal (Stabilization/Solidification and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-2.6: Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/Solidification, LTTD, and Landfilling).

5.3.1 Overall Protection of Health and Environment

Alternative S-2.1 would not be protective of human health and the environment. Unacceptable human health risks from direct exposure to contaminated soil could develop because building foundations and pavement that cover most of this soil would not be maintained, because disturbance of contaminated soil would be unregulated, and because nothing would prevent residential development. In addition, Alternative S-2.1 would not be protective because it would provide no warning of the potential migration of lead from soil to groundwater. Alternative S-2.1 would not achieve the soil RAOs.

Alternatives S-2.2, S-2.3, S-2.4, S-2.5, and S-2.6 would be protective of human health and the environment and would achieve the soil RAOs.

Alternative S-2.2 would be protective because it would prevent unacceptable human health and environmental risks through LUCs that would ensure regular maintenance of building foundations and paved areas, regulate disturbance of contaminated soil, and prevent residential development of Zone 2. Alternative S-2.2 would also be protective because monitoring would warn of potential migration of lead from soil to groundwater. Alternatives S-2.3, S-2.4, and S-2.5 would be more protective than

Alternative S-2.2 because, in addition to including the same protective elements, these alternatives would actively minimize the potential for migration of lead from soil to groundwater through capping, in-situ chemical stabilization/solidification, or excavation and off-site treatment and disposal, respectively. Alternatives S-2.3 and S-2.4 would provide approximately the same level of protection. The capping of Alternative S-2.3 would result in the actual removal and off-site treatment and/or disposal of a significant volume of lead-contaminated surface soil and would meet the Zone 2 Alternative GB PMC for I/C use for lead. The in-situ chemical stabilization/solidification of Alternative S-2.4 would also meet the Zone 2 Alternative GB PMC for I/C use for lead. Alternative S-2.5 would be more protective than Alternatives S-2.3 and S-2.4 because it would result in the removal and off-site treatment and/or disposal of all soil that could result in migration of lead from soil to groundwater. Alternative S-2.6 would be most protective because it would eliminate any unacceptable human health risks under current industrial site use and hypothetical future residential site use and prevent potential migration of TPH or lead from soil to groundwater.

Alternatives S-2.2, S-2.3, S-2.4, and S-2.5 would achieve Soil RAOs Nos. 1 to 3 directly and Soil RAO No. 4 indirectly through implementation of LUCs that would prevent residential development. Alternative S-2.6 would achieve Soil RAOs Nos. 1 to 4.

5.3.2 Compliance with ARARs and TBCs

Alternative S-2.1 would not comply with chemical-specific ARARs and TBCs. No location- or action-specific ARARs or TBCs apply to this alternative.

Alternatives S-2.2, S-2.3, S-2.4, and S-2.5 would comply with all location- and action-specific ARARs and TBCs and would also comply with federal chemical-specific TBCs (there are no federal chemical-specific ARARs). Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of these alternatives would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of environmentally isolated contaminated soil. See Appendix D.1.3 for engineering control calculations.

AlternativeS-2-6 would comply with chemical-, location-, and action-specific ARARs and TBCs.

A summary of the compliance of Alternatives S-2.2, S-2.3, S-2.4, S-2.5, and S-2.6 with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 5-5, 5-6, and 5-7, respectively.

5.3.3 Long-Term Effectiveness and Permanence

Alternative S-2.1 would not be long-term effective and permanent because it would involve no action.

Alternatives S-2.2, S-2.3, S-2.4, S-2.5, and S-2.6 would be long-term effective and permanent.

The LUCs of Alternative S-2.2 that ensure regular maintenance of building foundations and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 2 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. The monitoring of Alternative S-2.2 would effectively warn of the potential migration of lead from soil to groundwater. Alternatives S-2.3 and S-2.4 would be more effective and permanent than Alternative S-2.2 because they would supplement LUCs and monitoring with more active means of controlling exposure to contaminated soil and migration of soil COCs to groundwater (capping and in-situ chemical stabilization/fixation). The long-term effectiveness and permanence of these two alternatives would be similar. The capping of Alternative S-2.3 and in-situ chemical stabilization/solidification of Alternative S-2.4 are both well-established and well-proven technologies, and although capping would more effectively prevent direct exposure to contaminated soil and would result in the excavation and off-site treatment and disposal of a significant quantity of that soil, the in-situ chemical stabilization/solidification of Alternative S-2.4 would more effectively prevent the potential migration of lead from soil to groundwater.

Alternative S-2.5 would be more effective and permanent than Alternative S-2.3 because it would replace capping or in-situ treatment of contaminated soil with excavation and off-site treatment and disposal, which are the most effective and permanent means of removing this soil from the site.

Alternative S-2.6 would be most effective and permanent because it would permanently remove from the site any soil that could constitute an unacceptable human health risk under either current or hypothetical future site uses or that could contribute to migration of TPH or lead from soil to groundwater.

5.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives S-2.1 and S-2.2 would not reduce the toxicity, mobility, or volume of lead in soil through treatment because no treatment would occur.

Alternative S-2.3 would not address CERCLA risks by reducing the toxicity, mobility, and volume of lead in soil through treatment.

Alternative S-2.4 would reduce the toxicity and mobility of lead in soil by treatment through in-situ chemical stabilization/solidification. An estimated 1,130 cubic yards of “high lead” soil would be permanently and irreversibly treated by this technology.

Alternative S-2.5 would not reduce the toxicity, mobility, and volume of lead in soil through treatment. Alternative S-2.6 would not reduce the toxicity, mobility, and volume of TPH and lead in soil through treatment.

5.3.5 Short-Term Effectiveness

Because no action would occur, implementation of Alternative S-2.1 would not result in any short-term risks to on-site workers or adversely impact the local community or the environment.

Implementation of Alternatives S-2.2, S-2.3, S-2.4, S-2.5, and S-2.6 could result in short-term risks to on-site workers as a result of exposure to contamination. The potential for exposure would be minimal for Alternative S-2.2; moderate for Alternatives S-2.3, S-2.4, and S-2.5; and significant for Alternative S-2.6 because of the increasing level of activities. However, these risks would be adequately mitigated for all alternatives by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures.

Alternatives S-2.3, S-2.5, and S-2.6 could also have an adverse impact on the surrounding community and the environment as a result of on-site activities and off-site transportation of contaminated soil. The potential for adverse impact would be moderate for Alternatives S-2.3 and S-2.5 and significant for Alternative S-2.6 because of the increasing level of activities and the larger volume of contaminated soil being handled. However, this impact would also be adequately mitigated for all alternatives by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-2.1 would not attain the Soil RAOs or meet the Zone 2 soil PRGs. Alternatives S-2.2, S-2.3, S-2.4, and S-2.5 could be completed within approximately 3 months, 6 months, 6 months, and 6 months, respectively, and would achieve Soil RAOs Nos. 1 to 3 at completion. In addition, because they include LUCs that prohibit residential development of Zone 2, Alternatives S-2.2, S-2.3, S-2.4, and S-2.5 would also indirectly attain Soil RAO No. 4 at completion. The pavement in Alternative S-2.2 and capping in Alternative S-2.3 would meet the Zone 2 Alternative GB PMC for I/C use. Alternatives S-2.4 and S-2.5 would also meet the Alternative GB PMC for I/C use. In addition, these cleanup criteria would not apply to leftover areas of environmentally isolated contaminated soil that could not be capped, treated, or excavated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternatives S-2.2, S-2.3, S-2.4, and S-2.5 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Alternative S-2.6 could be completed in approximately 9 months and would attain all four soil RAOs and meet the Zone 2 soil PRGs for residential direct exposure and pollutant mobility at completion. Contaminated soil in inaccessible areas would be removed in this alternative.

5.3.6 Implementability

Technically, Alternative S-2.1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Alternatives S-2.2, S-2.3, S-2.4, S-2.5, and S-2.6 would be technically implementable, and resources, equipment, and materials would be readily available for this purpose. From the technical point of view, Alternative S-2.2 would be easiest to implement because it would only require maintenance of building foundations, paved areas, and existing monitoring wells and long-term monitoring of groundwater. Alternatives S-2.3, S-2.4, S-2.5, and S-2.6 would be much harder to implement than Alternative S-2.2. Alternative S-2.3 would be slightly easier to implement than Alternatives S-2.4 and S-2.5 because it would require capping with shallow pre-excavation and off-site treatment and disposal of relatively small volumes of contaminated soil. Alternatives S-2.4 and S-2.5 would be similar to each other in complexity, with Alternative S-2.4 requiring in-situ chemical stabilization/solidification and Alternative S-2.5 requiring excavation and off-site treatment and disposal of significantly larger volumes of contaminated soil. The implementability of these three alternatives, particularly Alternatives S-2.4 and S-2.5, would be severely restricted by ongoing base activities and multiple underground obstacles. Although it has been assumed for the purpose of this FS that neither of these two restrictive factors would actually prevent implementation of Alternatives S-2.3, S-2.4, and S-2.5, this assumption might not prove to be correct. Even though it would not be restricted by base activities and underground obstacles, Alternative S-2.6 would be hardest to implement because it would deal with much larger volumes of contaminated soil and would require such complex operations as excavation below the water table and on-site dewatering of excavated soil.

The administrative aspects of Alternatives S-2.2, S-2.3, S-2.4, S-2.5, and S-2.6 would be simple to implement. The administrative aspects of Alternatives S-2.2 and S-2.6 would be easiest to implement. Alternative S-3.2 would require preparation of a LUC RD and long-term enforcement of LUCs, and Alternative S-2.6 would require a construction permit, documentation of off-site transportation and treatment and disposal of excavated soil, and compliance with the substantive requirements of federal and State water discharge regulations for the discharge of the on-site dewatering operation drainage water to the Thames River. The administrative aspects of Alternative S-2.4 would be slightly harder to implement because, in addition to the preparation of a LUC RD and long-term enforcement of LUCs, this alternative would require a construction permit. The administrative aspects of Alternatives S-2.3 and

S-2.5 would be hardest to implement because they would require preparation of a LUC RD, long-term enforcement of LUCs, securing of a construction permit issued by NSB-NLON DPW, and documentation of off-site transportation and disposal of excavated soil.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

5.3.7 Cost

The capital and O&M costs and NPW of the Zone 2 soil alternatives are as follows. Detailed cost estimates are provided in Appendix E.

Alternative	Capital ($)	NPW of O&M ($)	NPW ($)
S-2.1	0	55,000 (30 years)	55,000 (30 years)
S-2.2	27,000	287,000 (30 years)	314,000 (30 years)
S-2.3	359,000	287,000 (30 years)	646,000 (30 years)
S-2.4	544,000	287,000 (30 years)	831,000 (30 years)
S-2.5	652,000	287,000 (30 years)	939,000 (30 years)
S-2.6	3,881,000	0	3,881,000 (1 Year)

5.4 SUMMARY OF COMPARISON OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 2

Table 5-8 summarizes the comparative analysis of soil remedial alternatives for Zone 2.

5.5 COMPARISON OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 3

The following Zone 3 soil remedial alternatives are compared in this section:

Alternative S-3.1: No Action.

Alternative S-3.2: LUCs (Engineering and Institutional Controls) and Monitoring.

Alternative S-3.3: Capping to Allow I/C Site Use and Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-3.4: In-Situ Treatment (Stabilization/Solidification) to Allow I/C Site Use and Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-3.5: Excavation to Meet I/C DECs and PMCs, Off-Site Disposal (Stabilization/Solidification and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-3.6: Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/Solidification, LTTD, and Landfilling).

5.5.1 Overall Protection of Health and Environment

Alternative S-3.1 would not be protective of human health and the environment. Unacceptable human health risks from direct exposure to lead in surface soil could develop because building foundations and pavement that cover most of this soil would not be maintained, because disturbance of contaminated soil would be unregulated, and because nothing would prevent residential development. In addition, Alternative S-3.1 would not be protective because it would provide no warning of the potential migration of lead from soil to groundwater. Alternative S-3.1 would not achieve the soil RAOs.

Alternatives S-3.2, S-3.3, S-3.4, S-3.5, and S-3.6 would be protective of human health and the environment and would achieve the soil RAOs.

Alternative S-3.2 would be protective because it would prevent unacceptable human health and environmental risks through LUCs that would ensure regular maintenance of building foundations and paved areas, regulate disturbance of contaminated soil, and prevent residential development of Zone 3. Alternative S-3.2 would also be protective because monitoring would warn of potential migration of lead from soil to groundwater. Alternatives S-3.3, S-3.4, and S-3.5 would be more protective than Alternative S-3.2 because, in addition to including the same protective elements, these alternatives would actively reduce risk from exposure to lead-contaminated soil and minimize the potential for migration of lead from soil to groundwater through capping, in-situ chemical stabilization/solidification, or excavation and disposal, respectively. Alternatives S-3.3 and S-3.4 would provide approximately the same level of protection. The capping of Alternative S-3.3 would provide better protection against direct exposure to contaminated soil than in-situ chemical stabilization/solidification and would result in the actual removal and off-site treatment and/or disposal of a significant volume of lead-contaminated surface soil and would meet the Zone 2 Alternative GB PMC for I/C use for lead. The in-situ chemical stabilization/solidification of Alternative S-3.4 would also meet the Zone 3 Alternative GB PMC for I/C use for lead. Alternative S-3.5 would be more protective than Alternatives S-3.3 and S-3.4 because it would result in the removal and off-site treatment and/or disposal of all soil to which current industrial site users should not be exposed and/or that could result in migration of lead from soil to groundwater. Alternative S-3.6 would be most protective because it would eliminate any unacceptable human health risks under current

industrial site use and hypothetical future residential site use and prevent potential migration of TPH or lead from soil to groundwater.

Alternatives S-3.2, S-3.3, S-3.4, and S-3.5 would achieve Soil RAOs Nos. 1 to 3 directly and Soil RAO No. 4 indirectly through implementation of LUCs that would prevent residential development. Alternative S-3.6 would achieve Soil RAOs Nos. 1 to 4.

5.5.2 Compliance with ARARs and TBCs

Alternative S-3.1 would not comply with chemical-specific ARARs and TBCs. No location- or action-specific ARARs or TBCs apply to this alternative.

Alternatives S-3.2, S-3.3, S-3.4, and S-3.5 would comply with all location- and action-specific ARARs and TBCs and would also comply with federal chemical-specific TBCs (there are no federal chemical-specific ARARs). Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of these alternatives would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil. See Appendix D.1.3 for engineering control calculations.

Alternative S-3.6 would comply with chemical-, location-, and action-specific ARARs and TBCs.

A summary of the compliance of Alternatives S-3.2, S-3.3, S-3.4, S-3.5, and S-3.6 with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 5-5, 5-6, and 5-7, respectively.

5.5.3 Long-Term Effectiveness and Permanence

Alternative S-3.1 would not be long-term effective and permanent because it would involve no action.

Alternatives S-3.2, S-3.3, S-3.4, S-3.5, and S-3.6 would be long-term effective and permanent.

The LUCs of Alternative S-3.2 that ensure regular maintenance of building foundations and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 3 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. The monitoring of Alternative S-3.2 would effectively warn of the potential migration of lead from soil to groundwater. Alternatives S-3.3 and S-3.4 would be more effective and permanent than Alternative S-3.2 because they would supplement LUCs and monitoring with more active means of controlling exposure to contaminated soil and migration of soil COCs to groundwater (capping and in-situ chemical stabilization/fixation). The long-term effectiveness and permanence of these two alternatives

would be similar. The capping of Alternative S-3.3 and in-situ chemical stabilization/solidification of Alternative S-3.4 are both well-established and well-proven technologies, and although capping would better prevent direct exposure to contaminated soil and would result in the excavation and off-site treatment and disposal of a significant quantity of that soil, the in-situ chemical stabilization/solidification of Alternative S-3.4 would more effectively prevent potential lead migration.

Alternative S-3.5 would be more effective and permanent than Alternatives S-3.3 and S-3.4 because it would replace capping or in-situ chemical stabilization/solidification with excavation and off-site disposal, which are the most well-proven and most effective and permanent means of removing contaminated soil from the site.

Alternative S-3.6 would be most effective and permanent because it would permanently remove from the site any soil that could constitute an unacceptable human health risk under either current or hypothetical future site uses or that could contribute to migration of TPH or lead from soil to groundwater.

5.5.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives S-3.1 and S-3.2 would not reduce the toxicity, mobility, or volume of lead in soil through treatment because no treatment would occur.

Alternative S-3.3 would not address CERCLA risks by reducing the toxicity, mobility, and volume of lead in soil through treatment.

Alternative S-3.4 would reduce the toxicity and mobility of lead in soil by treatment through in-situ chemical stabilization/solidification. An estimated 1,540 cubic yards of “high lead” soil would be permanently and irreversibly treated by this technology.

Alternative S-3.5 would not reduce the toxicity, mobility, and volume of lead in soil through treatment.

Alternative S-3.6 would not reduce the toxicity, mobility, and volume of PAHs, TPH, and lead in soil through treatment.

5.5.5 Short-Term Effectiveness

Because no action would occur, implementation of Alternative S-3.1 would not result in any short-term risks to on-site workers or adversely impact the local community or the environment.

Implementation of Alternatives S-3.2, S-3.3, S-3.4, S-3.5, and S-3.6 could result in short-term risks to on-site workers as a result of exposure to contamination. The potential for exposure would be minimal for Alternative S-3.2; moderate for Alternatives S-3.3, S-3.4, and S-3.5; and significant for Alternative S-3.6 because of the increasing level of activities. However, these risks would be adequately mitigated for all alternatives by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures.

Alternatives S-3.3, S-3.5, and S-3.6 could also have an adverse impact on the surrounding community and the environment as a result of on-site activities and off-site transportation of contaminated soil. The potential for adverse impact would be moderate for Alternatives S-3.3 and S-3.5 and significant for Alternative S-3.6 because of the increasing level of activities and the larger volume of contaminated soil being handled. However, this impact would also be adequately mitigated for these alternatives by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-3.1 would not achieve the soil RAOs or meet the Zone 3 soil PRGs. Alternatives S-3.2, S-3.3, S-3.4, and S-3.5 could be completed within approximately 3 months, 6 months, 6 months, and 6 months, respectively and would achieve Soil RAOs Nos. 1 to 3 at completion. In addition, because they include LUCs that prohibit residential development of Zone 3, Alternatives S-3.2, S-3.3, S-3.4, and S-3.5 would also indirectly achieve Soil RAO No. 4 at completion. The pavement in Alternative S-3.2 and capping in Alternative S-3.3 would meet the Zone 3 Alternative GB PMC for I/C use and PRG for I/C direct exposure. Alternative S-3.4 would only meet the Zone 3 soil lead PRG for I/C pollutant mobility, and Alternative S-3.5 would meet both the Zone 3 soil lead PRGs for I/C direct exposure and pollutant mobility. In addition, these cleanup criteria would not apply to leftover areas of inaccessible and/or environmentally isolated contaminated soil that could not be capped, treated, or excavated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternatives S-3.2, S-3.3, S-3.4, and S-3.5 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Alternative S-3.6 could be completed in approximately 9 months and would achieve all four soil RAOs and meet the Zone 3 soil PRGs for residential direct exposure and pollutant mobility at completion. Contaminated soil in inaccessible areas would be removed in this alternative.

5.5.6 Implementability

Technically, Alternative S-3.1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Alternatives S-3.2, S-3.3, S-3.4, S-3.5, and S-3.6 would be technically implementable and resources, equipment, and materials would be readily available for this purpose. From the technical point of view, Alternative S-3.2 would be easiest to implement because it would only require maintenance of building foundations, paved areas, and existing monitoring wells and long-term monitoring of groundwater. Alternatives S-3.3, S-3.4, S-3.5, and S-3.6 would be much harder to implement than Alternative S-3.2. Alternative S-3.3 would be slightly easier to implement than Alternatives S-3.4 and S-3.5 because it would require capping with shallow pre-excavation and off-site treatment and disposal of relatively small volumes of contaminated soil.. Alternatives S-3.4 and S-3.5 would be similar to each other in complexity, with Alternative S-3.4 requiring in-situ chemical stabilization/solidification and Alternative S-3.5 requiring excavation and off-site treatment and disposal of significantly larger volumes of contaminated soil. The implementability of these three alternatives, particularly Alternatives S-3.4 and S-3.5, would be severely restricted by ongoing base activities and multiple underground obstacles. Although it has been assumed for the purpose of this FS that neither of these two restrictive factors would actually prevent implementation of Alternatives S-3.3, S-3.4, and S-3.5, this assumption might not prove to be correct. Even though it would not be restricted by base activities and underground obstacles, Alternative S-3.6 would be hardest to implement because it would deal with much larger volumes of contaminated soil and would require such complex operations as excavation below the water table and on-site dewatering of excavated soil.

The administrative aspects of Alternatives S-3.2, S-3.3, S-3.4, S-3.5, and S-3.6 would be simple to implement. The administrative aspects of Alternatives S-3.2 and S-3.6 would be easiest to implement. Alternative S-3.2 would require preparation of a LUC RD and long-term enforcement of LUCs, and Alternative S-3.6 would require a construction permit issued by NSB-NLON DPW, documentation of off-site transportation and treatment and disposal of excavated soil, and compliance with the substantive requirements of federal and State water discharge regulations for the discharge of the on-site dewatering operation drainage water to the Thames River. The administrative aspects of Alternative S-3.4 would be slightly harder to implement because, in addition to the preparation of a LUC RD and long-term enforcement of LUCs, this alternative would require a construction permit issued by NSB-NLON DPW. The administrative aspects of Alternatives S-3.3 and S-3.5 would be hardest to implement because these would require preparation of a LUC RD, long-term enforcement of LUCs, securing of a construction permit issued by NSB-NLON DPW, and documentation of off-site transportation and disposal of excavated soil.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be

recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

5.5.7 Cost

The capital and O&M costs and NPW of the Zone 3 soil alternatives are as follows. Detailed cost estimates are provided in Appendix E.

Alternative	Capital ($)	NPW of O&M ($)	NPW ($)
S-3.1	0	55,000 (30 years)	55,000 (30 years)
S-3.2	34,000	297,000 (30 years)	331,000 (30 years)
S-3.3	461,000	297,000 (30 years)	758,000 (30 years)
S-3.4	698,000	296,000,(30 years)	994,000 (30 years)
S-3.5	817,000	297,000 (30 years)	1,114,000 (30 years)
S-3.6	5,704,000	0	5,704,000 (1 year)

5.6 SUMMARY OF COMPARISON OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 3

Table 5-9 summarizes the comparative analysis of soil remedial alternatives for Zone 3.

5.7 COMPARISON OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 4

The following Zone 4 soil remedial alternatives are compared in this section:

Alternative S-4.1: No Action.

Alternative S-4.2: LUCs (Engineering and Institutional Controls) and Monitoring.

Alternative S-4.3: Capping to Allow I/C Site Use and Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-4.4: In-Situ Treatment (Enhanced Bioremediation or Stabilization/Solidification) to Allow I/C Site Use and Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-4.5: Excavation to Meet I/C DECs, and PMCs Off-Site Disposal (Stabilization/Solidification, LTTD, and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-4.6: Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/Solidification, LTTD, and Landfilling).

5.7.1 Overall Protection of Health and Environment

Alternative S-4.1 would not be protective of human health and the environment. Unacceptable human health risks from direct exposure to PAHs, TPH, or lead in surface soil could develop because the building foundations and pavement that cover most of this soil would not be maintained, because disturbance of contaminated soil would be unregulated, and because nothing would prevent residential development. In addition, In addition, Alternative S-4.1 would not be protective because it would provide no warning of the potential migration of TPH or lead from soil to groundwater. Alternative S-3.1 would not achieve the soil RAOs.

Alternatives S-4.2, S-4.3, S-4.4, S-4.5, and S-4.6 would be protective of human health and the environment and would achieve the soil RAOs.

Alternative S-4.2 would be protective because it would prevent unacceptable human health and environmental risks through LUCs that would ensure regular maintenance of building foundations and paved areas, regulate disturbance of contaminated soil, and prevent residential development of Zone 4. Alternative S-4.2 would also be protective because monitoring would warn of potential migration of TPH or lead from soil to groundwater. Alternatives S-4.3, S-4.4, and S-4.5 would be more protective than Alternative S-4.2 because, in addition to including the same protective elements, these alternatives would actively reduce risk from exposure to PAHs, TPH, or lead in surface soil and minimize the potential for migration of TPH and lead from soil to groundwater through capping, in-situ treatment, or excavation and treatment and disposal, respectively. Alternatives S-4.3 and S-4.4 would provide approximately the same level of protection. Both alternatives would result in removal of PAHs and TPH, although the pre-excavation of Alternative S-4.3 would achieve this faster than the in-situ enhanced bioremediation of Alternative S-4.4. The capping of Alternative S-4.3 would provide better protection against direct exposure to lead-contaminated soil than in-situ chemical stabilization/solidification and would result in the actual removal and off-site treatment and/or disposal of a significant volume of contaminated surface soil and would meet the Zone 2 Alternative GB PMC for I/C use for lead. The in-situ chemical stabilization/solidification of Alternative S-4.4 would also meet the Zone 4 Alternative GB PMC for I/C use for lead. Alternative S-4.5 would be more protective than Alternatives S-4.3 and S-4.4 because it would result in the removal and off-site treatment and/or disposal of all soil to which current industrial site users should not be exposed and/or that could result in migration of TPH or lead from soil to groundwater. Alternative S-4.6 would be most protective because it would eliminate any unacceptable human health risks under current industrial site use and hypothetical future residential site use and prevent potential migration of PAHs, TPH, or lead from soil to groundwater.

Alternatives S-4.2, S-4.3, S-4.4, and S-4.5 would achieve Soil RAOs Nos. 1 to 3 directly and Soil RAO No. 4 indirectly through implementation of LUCs that would prevent residential development. Alternative S-4.6 would achieve Soil RAOs Nos. 1 to 4.

5.7.2 Compliance with ARARs and TBCs

Alternative S-4.1 would not comply with chemical-specific ARARs and TBCs. No location- or action-specific ARARs or TBCs apply to this alternative.

Alternative S-4.2, S-4.3, S-4.4, and S-4.5 would comply with all location- and action-specific ARARs and TBCs and would also comply with federal chemical-specific TBCs (there are no federal chemical-specific ARARs). Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of these alternatives would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil. See Appendix D.1.3 for engineering control calculations.

Alternative S-4.6 would comply with chemical-, location-, and action-specific ARARs and TBCs.

A summary of the compliance of Alternatives S-4.2, S-4.3, S-4.4, S-4.5, and S-4.6 with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 5-5, 5-6, and 5-7, respectively.

5.7.3 Long-Term Effectiveness and Permanence

Alternative S-4.1 would not be long-term effective and permanent because it would involve no action.

Alternatives S-4.2, S-4.3, S-4.4, S-4.5, and S-4.6 would be long-term effective and permanent.

The LUCs of Alternative S-4.2 that ensure regular maintenance of building foundations and paved areas, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 4 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. The monitoring of Alternative S-4.2 would effectively warn of the potential migration of TPH or lead from soil to groundwater. Alternatives S-4.3 and S-4.4 would be more effective and permanent than Alternative S-4.2 because they would supplement LUCs and monitoring with more active means of controlling exposure to contaminated soil and migration of soil COCs to groundwater (via capping and in-situ treatment, respectively). The long-term effectiveness and permanence of these two alternatives would be similar. The capping of Alternative S-3.3 and the in-situ enhanced bioremediation or chemical stabilization/solidification of Alternative S-3.4 are well-established and well-proven technologies. Both alternatives would effectively remove PAHs and TPH either through excavation and

off-site treatment and disposal (Alternative S-4.3) or through in-situ enhanced bioremediation (Alternative S-4.4). Although the capping of Alternative S-4.3 would better prevent direct exposure to lead-contaminated soil and would result in the excavation and off-site treatment and disposal of a significant quantity of that soil, in-situ chemical stabilization/solidification of Alternative S-4.4 would more effectively prevent potential lead migration.

Alternative S-4.5 would be more effective and permanent than Alternatives S-4.3 and S-4.4 because it would replace capping or in-situ treatment of contaminated soil with excavation and off-site treatment and disposal, which is the most effective and permanent means of removing this soil from the site.

Alternative S-4.6 would be most effective and permanent because it would permanently remove from the site any soil that could constitute an unacceptable human health risk under either current or hypothetical future site uses or that could contribute to migration of PAHs, TPH, or lead from soil to groundwater.

5.7.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives S-4.1 and S-4.2 would not reduce the toxicity, mobility, or volume of the PAHs, TPH, and lead in soil through treatment because no treatment would occur.

Alternative S-4.3 would not address CERCLA risks by reducing the toxicity, mobility, and volume of lead in soil through treatment.

Alternative S-4.4 would reduce the toxicity, mobility, and volume of PAHs, TPH, and lead in soil through in-situ treatment. An estimated 960 cubic yards of “high PAH” and 80 cubic yards of “high TPH” soil would be permanently and irreversibly treated by in-situ enhanced bioremediation. An estimated 3,060 cubic yards of “high lead” soil would be permanently and irreversibly treated by in-situ chemical stabilization/solidification.

Alternative S-4.5 would not reduce the toxicity, mobility, and volume of PAHs, TPH, and lead in soil through treatment.

Alternative S-4.6 would not reduce the toxicity, mobility, and volume of PAHs, TPH, and lead in soil through treatment.

5.7.5 Short-Term Effectiveness

Because no action would occur, implementation of Alternative S-4.1 would not result in any short-term risks to on-site workers or adversely impact the local community or the environment.

Implementation of Alternatives S-4.2, S-4.3, S-4.4, S-4.5, and S-4.6 could result in short-term risks to on-site workers as a result of exposure to contamination. The potential for exposure would be minimal for Alternative S-4.2; moderate for Alternatives S-4.3, S-4.4, and S-4.5; and significant for Alternative S-4.6 because of the increasing level of activities. However, these risks would be adequately mitigated for all alternatives by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures.

Alternatives S-4.3, S-4.5, and S-4.6 could also have an adverse impact on the surrounding community and the environment as a result of on-site activities and off-site transportation of contaminated soil. The potential for adverse impact would be moderate for Alternatives S-4.3 and S-4.5 and significant for Alternative S-4.6 because of the increasing level of activities and the larger volume of contaminated soil being handled. However, this impact would also be adequately mitigated for all alternatives by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-4.1 would not attain the soil RAOs or meet the Zone 4 soil PRGs. Alternatives S-4.2, S-4.3, and S-4.4 could be completed within approximately 3 months, 9 months, and 9 months, respectively and would achieve Soil RAOs Nos. 1 to 3 at completion. In addition, because they include LUCs that prohibit residential development of Zone 4, Alternatives S-4.2, S-4.3, and S-4.4 would also indirectly attain Soil RAO No. 4 at completion.

The pavement in Alternative S-4.2 would meet the Zone 4 Alternative GB PMC for I/C use and PRG for I/C direct exposure for lead.

Alternative S-4.3 would meet the Zone 4 soil PAHs and TPH PRGs for I/C direct exposure and the Zone 4 soil TPH PRG for I/C pollutant mobility at completion. The capping in Alternative S-4.3 would meet the Zone 4 Alternative GB PMC for I/C use and PRG for I/C direct exposure for lead.

Alternative S-4.4 would meet the Zone 4 soil lead PRG for I/C pollutant mobility at completion and the Zone 4 soil PAHs and TPH PRGs for I/C direct exposure and Zone 4 soil TPH PRG for pollutant mobility within 3 to 5 years. However, Alternative S-4.4 would not meet the Zone 4 soil lead PRG for I/C direct exposure.

Alternative S-4.5 would meet the Zone 4 soil PRGs for I/C direct exposure and pollutant mobility at completion.

In addition, these cleanup criteria would not apply to leftover areas of inaccessible and/or environmentally isolated contaminated soil that could not be capped, treated, or excavated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternatives S-4.2, S-4.3, S-4.4, and S-4.5 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Alternative S-4.6 could be completed in approximately 1 year and would attain all four soil RAOs and meet the Zone 4 soil PRGs for residential direct exposure and pollutant mobility at completion. Contaminated soil in inaccessible areas would be removed in this alternative.

5.7.6 Implementability

Technically, Alternative S-4.1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Alternatives S-4.2, S-4.3, S-4.4, S-4.5, and S-4.6 would be technically implementable and resources, equipment, and materials would be readily available for this purpose. From the technical point of view, Alternative S-4.2 would be easiest to implement because it would only require maintenance of building foundations, paved areas, and existing monitoring wells and long-term monitoring of groundwater. Alternatives S-4.3, S-4.4, S-4.5, and S-4.6 would be much harder to implement than Alternative S-4.2. Alternative S-4.3 would be slightly easier to implement than Alternatives S-4.4 and S-4.5 because it would require capping with shallow pre-excavation and off-site treatment and disposal of relatively small volumes of contaminated soil. Alternatives S-4.4 and S-4.5 would be similar to each other in complexity, with Alternative S-4.3 requiring in-situ treatment and Alternative S-4.5 requiring excavation and off-site treatment and disposal of significantly larger volumes of contaminated soil. The implementability of these three alternatives, particularly Alternatives S-4.4 and S-4.5, would be severely restricted by ongoing base activities and multiple underground obstacles. Although it has been assumed for the purpose of this FS that neither of these two restrictive factors would actually prevent implementation of Alternatives S-4.3, S-4.4, and S-4.5, this assumption might not prove to be correct. Even though it would not be restricted by base activities and underground obstacles, Alternative S-4.6 would be hardest to implement because it would deal with much larger volumes of contaminated soil and would require such complex operations as excavation below the water table and on-site dewatering of excavated soil.

The administrative aspects of Alternatives S-4.2, S-4.3, S-4.4, S-4.5, and S-4.6 would be simple to implement. The administrative aspects of Alternatives S-4.2 and S-4.6 would be easiest to implement. Alternative S-4.2 would require preparation of a LUC RD and the long-term enforcement of LUCs, and Alternative S-4.6 would require a construction permit issued by NSB-NLON DPW, documentation of off-site transportation and treatment and disposal of excavated soil, and compliance with the substantive

requirements of federal and State water discharge regulations for the discharge of the on-site dewatering operation drainage water to the Thames River. The administrative aspects of Alternative S-4.4 would be slightly harder to implement because, in addition to the preparation of a LUC RD and long-term enforcement of LUCs, this alternative would require a construction permit issued by NSB-NLON DPW. The administrative aspects of Alternatives S-4.3 and S-4.5 would be hardest to implement because these would require preparation of a LUC RD, long-term enforcement of LUCs, securing of a construction permit issued by NSB-NLON DPW, and documentation of off-site transportation and disposal of excavated soil.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

5.7.7 Cost

The capital and O&M costs and NPW of the Zone 4 soil alternatives are as follows. Detailed cost estimates are provided in Appendix E.

Alternative	Capital ($)	NPW of O&M ($)	NPW ($)
S-4.1	0	55,000 (30 years)	55,000 (30 years)
S-4.2	47,000	413,000 (30 years)	460,000 (30 years)
S-4.3	1,265,000	414,000 (30 years)	1,679,000 (30 years)
S-4.4	1,389,000	417,000 (30 years)	1,806,000 (30 years)
S-4.5	1,984,000	414,000 (30 years)	2,398,000 (30years)
S-4.6	7,737,000	0	7,737,000 (1 year)

5.8 SUMMARY OF COMPARISON OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 4

Table 5-10 summarizes the comparative analysis of soil remedial alternatives for Zone 4.

5.9 COMPARISON OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 5

The following Zone 5 soil remedial alternatives are compared in this section:

Alternative S-5.1: No Action.

Alternative S-5.2: LUCs (Engineering and Institutional Controls) and Monitoring.

Alternative S-5.3: In-Situ Treatment (Enhanced Bioremediation) to Meet I/C DECs and PMCs, LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-5.4: Excavation to Meet I/C DECs and PMCs, Off-Site Disposal (LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-5.5: Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (LTTD and Landfilling).

5.9.1 Overall Protection of Health and Environment

Alternative S-5.1 would not be protective of human health and the environment. Unacceptable human health risks from direct exposure to COCs and TPH in surface soil could develop because building foundations and pavement that cover most of this soil would not be maintained, because the disturbance of areas of contaminated soil would not be regulated, and because nothing would prevent residential development. In addition, Alternative S-5.1 would not be protective because it would provide no warning of the potential migration of TPH from soil to groundwater. Alternative S-5.1 would not achieve the soil RAOs.

Alternatives S-5.2, S-5.3, and S-5.4 would be protective of human health and the environment under the Connecticut RSRs. Alternative S-5.5 would be protective of human health and the environment and would achieve the soil RAOs.

Alternative S-5.2 would be protective because it would prevent unacceptable human health and environmental risks through LUCs that would ensure regular maintenance of building foundations and pavement, regulate disturbance of contaminated soil, and prevent residential development of Zone 5. Alternative S-5.2 would also be protective because monitoring would warn of potential migration of TPH from soil to groundwater. Alternatives S-5.3 and S-5.4 would be more protective than Alternative S-5.2 because, in addition to including the same protective elements, these two alternatives would actively reduce the risk of exposure to TPH and potential for migration of TPH from soil to groundwater though in-situ enhanced bioremediation or excavation and off-site treatment and disposal, respectively. Alternative S-5.4 would be slightly more protective than Alternative S-5.3 because it would achieve protection somewhat faster. Alternative S-5.5 would be most protective because it would eliminate any

unacceptable human health risks under current industrial site use and hypothetical future residential site use and it would prevent potential migration of soil COCs and TPH to groundwater.

Alternatives S-5.2, S-5.3, and S-5.4 would achieve Soil RAO No. 4 indirectly through implementation of LUCs that would prevent residential development. Alternative S-5.5 would achieve Soil RAOs Nos. 1 to 4.

5.9.2 Compliance with ARARs and TBCs

Alternative S-5.1 would not comply with chemical-specific ARARs and TBCs. No location- or action-specific ARARs or TBCs apply to this alternative.

Alternatives S-5.2, S-5.3, and S-5.4 would comply with federal chemical-specific TBCs (there are no federal chemical-specific ARARs) for residential exposure. Because TPH is the only contaminant, there are no location- and action-specific ARARs and TBCs.

Alternative S-5.5 would comply with chemical-, location-, and action-specific ARARs and TBCs.

A summary of the compliance of Alternatives S-5.2, S-5.3, S-5.4, and S-5.5 with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 5-1, 5-2, and 5-3, respectively.

5.9.3 Long-Term Effectiveness and Permanence

Alternative S-5.1 would not be long-term effective and permanent because it would involve no action.

Alternatives S-5.2, S-5.3, S-5.4, and S-5.5 would be long-term effective and permanent.

The LUCs of Alternative S-5.2 that ensure regular maintenance of paved surfaces, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 5 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. The monitoring of Alternative S-5.2 would effectively warn of the potential migration of TPH from soil to groundwater. Alternative S-5.3 would be more effective and permanent than Alternative S-5.2 because, in addition to LUCs and monitoring, it would actively reduce concentrations of TPH in soil through in-situ enhanced bioremediation.

Alternative S-5.4 would be more effective and permanent than Alternative S-5.3 because it would replace in-situ treatment of contaminated soil with excavation and off-site treatment disposal, which is the most effective and permanent means of removing this soil from the site.

Alternative S-5.5 would be most effective and permanent because it would permanently remove from the site any soil that could constitute an unacceptable human health risk under either current or hypothetical future site uses or that could contribute to migration of soil COCs and TPH to groundwater.

5.9.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives S-5.1 and S-5.2 would not reduce the toxicity, mobility, or volume of TPH in soil through treatment because no treatment would occur.

Alternative S-5.3 would reduce the toxicity, mobility and volume of TPH in soil by treatment through in-situ enhanced bioremediation. An estimated 230 cubic yards of “high TPH” soil would be permanently and irreversibly treated by this technology.

Alternative S-5.4 would not reduce the toxicity, mobility, and volume of TPH in soil through treatment.

Alternative S-5.5 would not reduce the toxicity, mobility, and volume of PAHs and TPH in soil through treatment.

5.9.5 Short-Term Effectiveness

Because no action would occur, implementation of Alternative S-5.1 would not result in any short-term risks to on-site workers or adversely impact the local community or the environment.

Implementation of Alternatives S-5.2, S-5.3, S-5.4, and S-5.5 could result in short-term risks to on-site workers as a result of exposure to contamination. The potential for exposure would be minimal for Alternative S-5.2, moderate for Alternatives S-5.3 and S-5.4, and significant for Alternative S-5.5 because of the increasing level of activities. However, these risks would be adequately mitigated for all alternatives by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures.

Alternatives S-5.4 and S-5.5 could also have an adverse impact on the surrounding community and the environment as a result of on-site activities and off-site transportation of contaminated soil. The potential for adverse impact would be moderate for Alternative S-5.4 and significant for Alternative S-5.5 because of the increasing level of activities and the larger volume of contaminated soil being handled. However, this impact would also be adequately mitigated for both alternatives by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-5.1 would not attain the soil RAOs or meet the Zone 5 soil PRGs. Alternatives S-5.2, S-5.3, and S-5.4 could be completed within approximately 3 months, 6 months, and 6 months, respectively, and would achieve CTDEP RSRs at completion. Alternatives S-5.3 and S-5.4 would meet the Zone 5 soil TPH PRGs for I/C direct exposure and pollutant mobility within approximately 9 months and approximately 3 to 5 years, respectively. In addition, these cleanup criteria would not apply to leftover areas of inaccessible and/or environmentally isolated contaminated soil that could not be capped, treated, or excavated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternatives S-5.2, S-5.3, and S-5.4 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs. See Appendix D.1.3 for engineering control calculations.

Alternative S-5.5 could be completed in approximately 9 months and would achieve all four soil RAOs and meet the Zone 5 soil PRGs for residential direct exposure and pollutant mobility at completion. Contaminated soil in inaccessible areas would be removed in this alternative.

5.9.6 Implementability

Technically, Alternative S-5.1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Alternatives S-5.2, S-5.3, S-5.4, and S-5.5 would be technically implementable, and resources, equipment, and materials would be readily available for this purpose. From the technical point of view, Alternative S-5.2 would be easiest to implement because it would only require maintenance of building foundations, paved areas, and existing monitoring wells and long-term monitoring of groundwater. Alternatives S-5.3, S-5.4, and S-5.5 would be much harder to implement than Alternative S-5.2. Alternatives S-5.3 and S-5.4 would be similar in complexity, with Alternative S-5.3 requiring in-situ LDA soil mixing at numerous locations and Alternative S-5.4 requiring excavation, off-site transportation, and treatment and disposal. The implementability of both of these alternatives would be restricted by ongoing base activities and multiple underground obstacles, but not as severely as in Zones 1, 2, 3, 4, and 7. Even though it would not be restricted by base activities and underground obstacles, Alternative S-5.5 would be hardest to implement because it would deal with much larger volumes of contaminated soil and would require such complex operations as excavation below the water table and on-site dewatering of excavated soil.

The administrative aspects of Alternatives S-5.2, S-5.3, S-5.4, and S-5.5 would be simple to implement. The administrative aspects of Alternatives S-5.2 and S-5.5 would be easiest to implement. Alternative S-5.2 would only require preparation of a LUC RD and long-term enforcement of LUCs, and

Alternative S-5.5 would require a construction permit issued by NSB-NLON DPW, documentation of off-site transportation and treatment and disposal of excavated soil, and compliance with the substantive requirements of federal and State water discharge regulations for the discharge of the on-site dewatering operation drainage water to the Thames River. The administrative aspects of Alternative S-5.3 would be slightly harder to implement because, in addition to the preparation of a LUC RD and long-term enforcement of LUCs, this alternative would require a construction permit issued by NSB-NLON DPW. The administrative aspects of Alternative S-5.4 would be hardest to implement because it would require preparation of a LUC RD, long-term enforcement of LUCs, securing of a construction permit issued by NSB-NLON DPW, and documentation of off-site transportation and disposal of excavated soil.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

5.9.7 Cost

The capital and O&M costs and NPW of the Zone 5 soil alternatives are as follows. Detailed cost estimates are provided in Appendix E.

Alternative	Capital ($)	NPW of O&M ($)	NPW ($)
S-5.1	0	55,000 (30 years)	55,000 (30 years)
S-5.2	27,000	276,000 (30 years)	303,000 (30 years)
S-5.3	1,175,000	279,000 (30 years)	1,454,000 (30 years)
S-5.4	220,000	276,000 (30 years)	496,000 (30 years)
S-5.5	2,930,000	0	2,930,000 (1 year)

5.10 SUMMARY OF COMPARISON OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 5

Table 5-11 summarizes the comparative analysis of soil remedial alternatives for Zone 5.

5.11 COMPARISON OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 6

The following Zone 6 soil remedial alternatives are compared in this section:

Alternative S-6.1: LUCs (Engineering and Institutional Controls) and Monitoring.

Alternative S-6.2: In-Situ Treatment (Enhanced Bioremediation) to Meet TPH PMC and I/C DEC, LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-6.3: Excavation to Meet TPH PMC and I/C DECs, Off-Site Disposal (LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-6.4: Excavation to Meet TPH PMC and Residential DEC, On-Site Dewatering, and Off-Site Disposal (LTTD and Landfilling).

5.11.1 Overall Protection of Health and Environment

Alternatives S-6.1, S-6.2, S-6.3, and S-6.4 would be protective of human health and the environment under the Connecticut RSRs.

Alternative S-6.2 would be protective because it would prevent unacceptable human health and environmental risks through LUCs that would ensure regular maintenance of building foundations and pavement, regulate disturbance of contaminated soil, and prevent residential development of Zone 6. Alternative S-6.2 would also be protective because monitoring would warn of potential migration of TPH from soil to groundwater. Alternatives S-6.3 and S-6.4 would be more protective than Alternative S-6.2 because, in addition to including the same protective elements, these two alternatives would actively reduce the risk of exposure to TPH and potential for migration of TPH from soil to groundwater though in-situ enhanced bioremediation or excavation and off-site treatment and disposal, respectively. Alternative S-6.4 would be slightly more protective than Alternative S-6.3 because it would achieve protection somewhat faster. Alternative S-6.5 would be most protective because it would eliminate any unacceptable human health risks under current industrial site use and hypothetical future residential site use and it would prevent potential migration of soil TPH to groundwater.

5.11.2 Long-Term Effectiveness and Permanence

Alternatives S-6.1, S-6.2, S-6.3, and S-6.4 would be long-term effective and permanent.

The LUCs of Alternative S-6.1 that ensure regular maintenance of paved surfaces, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 6 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. The monitoring of Alternative S-6.1 would effectively warn of the potential migration of TPH from soil to groundwater.

Alternative S-6.2 would be more effective and permanent than Alternative S-6.1 because, in addition to LUCs and monitoring, it would actively reduce concentrations of TPH in soil through in-situ enhanced bioremediation.

Alternative S-6.3 would be more effective and permanent than Alternative S-6.2 because it would replace in-situ treatment of contaminated soil with excavation and off-site treatment disposal, which is the most effective and permanent means of removing this soil from the site.

Alternative S-6.4 would be most effective and permanent because it would permanently remove from the site any soil that could constitute an unacceptable human health risk under either current or hypothetical future site uses or that could contribute to migration of TPH from soil to groundwater.

5.11.3 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-6.1 would not reduce the toxicity, mobility, or volume of TPH in soil through treatment because no treatment would occur.

Alternative S-6.2 would reduce the toxicity, mobility and volume of TPH in soil by treatment through in-situ enhanced bioremediation. An estimated 730 cubic yards of “high TPH” soil would be permanently and irreversibly treated by this technology.

Alternative S-6.3 would not reduce the toxicity, mobility, and volume of TPH in soil through treatment.

Alternative S-6.4 would not reduce the toxicity, mobility, and volume of TPH in soil through treatment.

5.11.4 Short-Term Effectiveness

Implementation of Alternatives S-6.1, S-6.2, S-6.3, and S-6.4 could result in short-term risks to on-site workers as a result of exposure to contamination. The potential for exposure would be minimal for Alternative S-6.1, moderate for Alternatives S-6.2 and S-6.3, and significant for Alternative S-6.4 because of the increasing level of activities. However, these risks would be adequately mitigated for all alternatives by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures.

Alternatives S-6.3 and S-6.4 could also have an adverse impact on the surrounding community and the environment as a result of on-site activities and off-site transportation of contaminated soil. The potential for adverse impact would be moderate for Alternative S-6.3 and significant for Alternative S-6.4 because of the increasing level of activities and the larger volume of contaminated soil being handled. However,

this impact would be adequately mitigated for both alternatives by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternatives S-6.2, S-6.3, and S-6.4 could be completed within approximately 3 months, 6 months, and 6 months, respectively, and would achieve CTDEP RSRs at completion. Alternatives S-6.2 and S-6.3 would meet the Zone 6 soil TPH PRGs for I/C direct exposure and pollutant mobility within approximately 9 months and approximately 3 to 5 years, respectively. Alternative S-6.4 could be completed in approximately 9 months. In addition, these cleanup criteria would not apply to leftover areas of inaccessible and/or environmentally isolated contaminated soil that could not be capped, treated, or excavated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternatives S-6.1, S-6.2, S-6.3, and S-6.4 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs. See Appendix D.1.3 for engineering control calculations.

5.11.5 Implementability

Alternatives S-6.1, S-6.2, S-6.3, and S-6.4 would be technically implementable, and resources, equipment, and materials would be readily available for this purpose. From the technical point of view, Alternative S-6.1 would be easiest to implement because it would only require maintenance of building foundations, paved areas, and existing monitoring wells and long-term monitoring of groundwater. Alternatives S-6.2, S-6.3, and S-6.4 would be much harder to implement than Alternative S-6.1. Alternatives S-6.2 and S-6.3 would be similar in complexity, with Alternative S-6.2 requiring in-situ LDA soil mixing at numerous locations and Alternative S-6.3 requiring excavation, off-site transportation, and treatment and disposal. The implementability of both of these alternatives would be restricted by ongoing base activities and multiple underground obstacles, but not as severely as in Zones 1, 2, 3, 4, and 7. Even though it would not be restricted by base activities and underground obstacles, Alternative S-6.4 would be hardest to implement because it would deal with much larger volumes of contaminated soil and would require such complex operations as excavation below the water table and on-site dewatering of excavated soil.

The administrative aspects of Alternatives S-6.1, S-6.2, S-6.3, and S-6.4 would be simple to implement. The administrative aspects of Alternatives S-6.1 and S-6.4 would be easiest to implement. Alternative S-6.1 would only require preparation of a LUC RD and long-term enforcement of LUCs, and Alternative S-6.4 would require a construction permit issued by NSB-NLON DPW, documentation of off-site transportation and treatment and disposal of excavated soil, and compliance with the substantive requirements of federal and State water discharge regulations for the discharge of the on-site dewatering operation drainage water to the Thames River. The administrative aspects of Alternative S-6.2 would be slightly harder to implement because, in addition to the preparation of a LUC RD and long-term

enforcement of LUCs, this alternative would require a construction permit issued by NSB-NLON DPW. The administrative aspects of Alternative S-6.3 would be hardest to implement because it would require preparation of a LUC RD, long-term enforcement of LUCs, securing of a construction permit issued by NSB-NLON DPW, and documentation of off-site transportation and disposal of excavated soil.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

5.11.6 Cost

The capital and O&M costs and NPW of the Zone 6 soil alternatives are as follows. Detailed cost estimates are provided in Appendix E.

Alternative	Capital ($)	NPW of O&M ($)	NPW ($)
S-6.1	27,000	297,000 (30 years)	324,000 (30 years)
S-6.2	2,192,000	300,000 (30 years)	2,492,000 (30 years)
S-6.3	427,000	297,000 (30 years)	724,000 (30 years)
S-6.4	2,812,000	0	2,812,000 (1 year)

5.12 SUMMARY OF COMPARISON OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 6

Table 5-12 summarizes the comparative analysis of soil remedial alternatives for Zone 6.

5.13 COMPARISON OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 7

The following Zone 7 soil remedial alternatives are compared in this section:

Alternative S-7.1: No Action.
Alternative S-7.2: LUCs (Engineering and Institutional Controls) and Monitoring.
Alternative S-7.3: Capping to Allow I/C Site Use and Prevent Leaching, LUCs, and Monitoring.
Alternative S-7.4: In-Situ Treatment (Stabilization/Solidification) to Allow I/C Site Use and Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-7.5: Excavation to Meet I/C DECs and PMCs, Off-Site Disposal (Stabilization/Solidification and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring.

Alternative S-7.6: Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/Solidification, LTTD, and Landfilling).

5.13.1 Overall Protection of Health and Environment

Alternative S-7.1 would not be protective of human health and the environment. Unacceptable human health risks from direct exposure to PAHs, antimony and lead in surface soil could develop because building foundations and pavement that cover most of this soil would not be maintained, because disturbance of contaminated soil would be unregulated, and because nothing would prevent residential development. In addition, In addition, Alternative S-7.1 would not be protective because it would provide no warning of the potential migration of benzo(b)fluoranthene, antimony, or lead from soil to groundwater. Alternative S-7.1 would not achieve the soil RAOs.

Alternatives S-7.2, S-7.3, S-7.4, S-7.5, and S-7.6 would be protective of human health and the environment and would achieve the soil RAOs.

Alternative S-7.2 would be protective because it would prevent unacceptable human health and environmental risks through LUCs that would ensure regular maintenance of building foundations and paved areas, regulate disturbance of contaminated soil, and prevent residential development of Zone 7. Alternative S-7.2 would also be protective because monitoring would warn of potential migration of benzo(b)fluoranthene, antimony, and lead from soil to groundwater. Alternatives S-7.3, S-7.4, and S-7.5 would be more protective than Alternative S-7.2 because, in addition to including the same protective elements, these alternatives would actively reduce risk from exposure to PAHs, antimony, and lead in surface soil and minimize the potential for migration of benzo(b)fluoranthene, antimony, or lead from soil to groundwater through capping, in-situ treatment, or excavation and treatment and disposal, respectively. Alternatives S-7.3 and S-7.4 would provide approximately the same level of protection. Both alternatives would remove PAHs, and although removal by the pre-excavation of Alternative S-7.3 would be more rapid than that achieved by the in-situ enhanced bioremediation of Alternative S-7.4, it would not be quite as complete. The capping of Alternative S-7.3 would provide better protection against direct exposure to lead-contaminated soil than in-situ chemical stabilization/solidification and would result in the actual removal and off-site treatment and/or disposal of a significant volume of contaminated surface soil and would meet the Zone 2 Alternative GB PMC for I/C use for lead. The in-situ chemical stabilization/solidification of Alternative S-7.4 would also meet the Zone 4 Alternative GB PMC for I/C use for lead. Alternative S-7.5 would be more protective than Alternatives S-7.3 and S-7.4 because it would result in the removal and off-site treatment and/or disposal of all soil to which current industrial site users

should not be exposed and/or that could result in migration of benzo(b)fluoranthene, antimony, or lead from soil to groundwater. Alternative S-7.6 would be most protective because it would eliminate any unacceptable human health risks under current industrial site use and hypothetical future residential site use and prevent potential migration of PAHs, antimony, and lead from soil to groundwater.

Alternatives S-7.2, S-7.3, S-7.4, and S-7.5 would achieve Soil RAOs Nos. 1 to 3 directly and Soil RAO No. 4 indirectly through implementation of LUCs that would prevent residential development. Alternative S-7.6 would achieve Soil RAOs Nos. 1 to 4.

5.13.2 Compliance with ARARs and TBCs

Alternative S-7.1 would not comply with chemical-specific ARARs and TBCs. No location- or action-specific ARARs or TBCs apply to this alternative.

Alternatives S-7.2, S-7.3, S-7.4, and S-7.5 would comply with all location- and action-specific ARARs and TBCs and would also comply with federal chemical-specific TBCs (there are no federal chemical-specific ARARs). Because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of these alternatives would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs, DECs and PMCs would not apply to those areas of inaccessible and/or environmentally isolated contaminated soil. See Appendix D.1.3 for engineering control calculations.

Alternative S-7.6 would comply with chemical-, location-, and action-specific ARARs and TBCs.

A summary of the compliance of Alternatives S-7.2, S-7.3, S-7.4, S-7.5, and S-7.6 with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 5-5, 5-6, and 5-7, respectively.

5.13.3 Long-Term Effectiveness and Permanence

Alternative S-7.1 would not be long-term effective and permanent because it would involve no action.

Alternatives S-7.2, S-7.3, S-7.4, S-7.5, and S-7.6 would be long-term effective and permanent.

The LUCs of Alternative S-7.2 that ensure regular maintenance of paved surfaces, restrict disturbance of contaminated soil, and prevent hypothetical future residential development of Zone 7 would effectively and permanently prevent unacceptable risk from direct exposure to contaminated soil. The monitoring of Alternative S-7.2 would effectively warn of the potential migration of benzo(b)fluoranthene, antimony, or lead from soil to groundwater. Alternatives S-7.3 and S-7.4 would be more effective and permanent than Alternative S-7.2 because they would supplement LUCs and monitoring with more active means of

controlling exposure to contaminated soil and migration of soil COCs to groundwater (via capping and in-situ treatment, respectively). The long-term effectiveness and permanence of these two alternatives would be similar. The capping of Alternative S-7.3 and in-situ enhanced bioremediation or chemical stabilization/solidification of Alternative S-7.4 are well-established and well-proven technologies. Both alternatives would effectively remove PAHs either through pre-excavation and off-site treatment and disposal (Alternative S-7.3) or through in-situ enhanced bioremediation (Alternative S-7.4), but the removal achieved by Alternative S-7.4, although slower, would be more complete. The capping of Alternative S-7.3 would better prevent direct exposure to lead-contaminated soil and would result in the excavation and off-site treatment and disposal of a significant quantity of that soil, but the in-situ chemical stabilization/solidification of Alternative S-7.4 would more effectively prevent potential antimony and lead migration.

Alternative S-7.5 would be more effective and permanent than Alternatives S-7.3 and S-7.4 because it would replace capping or in-situ chemical stabilization/solidification with excavation and off-site disposal, which are the best proven and most effective and permanent means of removing contaminated soil from the site.

Alternative S-7.6 would be most effective and permanent because it would permanently remove from the site any soil that could constitute an unacceptable human health risk under either current or hypothetical future site uses or that could contribute to migration of PAHs, antimony and lead from soil to groundwater.

5.13.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives S-7.1 and S-7.2 would not reduce the toxicity, mobility, or volume of PAHs, antimony, or lead in soil through treatment because no treatment would occur.

Alternative S-7.3 would not address CERCLA risks by reducing the toxicity, mobility, and volume of benzo(b)fluoranthene, antimony, and lead in soil through treatment.

Alternative S-7.4 would reduce the toxicity, mobility and volume of PAHs, antimony, and lead in soil through in-situ treatment. An estimated 3,900 cubic yards of “high PAH” soil would be permanently and irreversibly treated by in-situ enhanced bioremediation. An estimated 5,600 cubic yards of “high lead” soil would be permanently and irreversibly treated by in-situ chemical stabilization/solidification.

Alternative S-7.5 would not reduce the toxicity, mobility, and volume of PAHs, antimony, and lead in soil through treatment.

Alternative S-7.6 would not reduce the toxicity, mobility, and volume of PAHs, TPH, antimony, arsenic, copper, and lead in soil through treatment.

5.13.5 Short-Term Effectiveness

Because no action would occur, implementation of Alternative S-7.1 would not result in any short-term risks to on-site workers or adversely impact the local community or the environment.

Implementation of Alternatives S-7.2, S-7.3, S-7.4, S-7.5, and S-7.6 could result in short-term risks to on-site workers as a result of exposure to contamination. The potential for exposure would be minimal for Alternative S-7.2, moderate for Alternatives S-7.3, S-7.4, and S-7.5, and significant for Alternative S-7.6 because of the increasing level of activities. However, these risks would be adequately mitigated for all alternatives by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures.

Alternatives S-7.3, S-7.5, and S-7.6 could also have an adverse impact on the surrounding community and the environment as a result of on-site activities and off-site transportation of contaminated soil. The potential for adverse impact would be moderate for Alternatives S-7.3 and S-7.5 and significant for Alternative S-7.6 because of the increasing level of activities and the larger volume of contaminated soil being handled. However, this impact would be adequately mitigated for these alternatives by the implementation of engineering controls such as dust suppression and air quality monitoring, by adherence to spill prevention procedures, and by compliance with DOT regulations.

Alternative S-7.1 would not achieve the soil RAOs or meet the Zone 7 soil PRGs. Alternatives S-7.2, S-7.3, S-7.4, and S-7.5 could be completed within approximately 3 months, 1 year, 1 year, and 1 year, respectively, and would achieve Soil RAOs Nos. 1 to 3 at completion. In addition, because they include LUCs that prohibit residential development of Zone 7, Alternatives S-7.2, S-7.3, S-7.4, and S-7.5 would also indirectly achieve Soil RAO No. 4 at completion.

The pavement in Alternative S-7.2 and capping in Alternative S-7.3 would meet the Zone 7 Alternative GB PMCs for I/C use PRGs for I/C direct exposure for antimony and lead.

Alternative S-7.4 would meet the Zone 7 soil antimony and lead PRGs for I/C pollutant mobility at completion and the Zone 7 soil PAH PRG for I/C direct exposure and Zone 7 soil benzo(b)fluoranthene PRG for I/C pollutant mobility within 3 to 5 years. However, Alternative S-7.4 would not meet the Zone 7 soil antimony or lead PRG for I/C direct exposure.

Alternative S-7.5 would meet all Zone 7 soil PRGs for I/C direct exposure and pollutant mobility at completion.

In addition, these cleanup criteria would not apply to leftover areas of inaccessible and/or environmentally isolated contaminated soil that could not be capped, treated, or excavated because the engineering controls (pending CTDEP concurrence of the adequacy of the engineering controls) of Alternatives S-7.2, S-7.3, S-7.4, and S-7.5 would satisfy the conditions set forth in Section 22a-133k-2(f)(2) of the CT RSRs.

Alternative S-7.6 could be completed within approximately 18 months and would achieve all four soil RAOs and meet the Zone 7 soil PRGs for residential direct exposure and pollutant mobility at completion. Contaminated soil in inaccessible areas would be removed in this alternative.

5.13.6 Implementability

Technically, Alternative S-7.1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Alternatives S-7.2, S-7.3, S-7.4, S-7.5, and S-7.6 would be technically implementable; and resources, equipment, and materials would be readily available for this purpose. From the technical point of view, Alternative S-7.2 would be easiest to implement because it would only require maintenance of building foundations, paved areas, and existing monitoring wells and long-term monitoring of groundwater. Alternatives S-7.3, S-7.4, S-7.5, and S-7.6 would be much harder to implement than Alternative S-7.2. Alternative S-7.3 would be slightly easier to implement than Alternatives S-7.4 and S-7.5because it would require capping with shallow pre-excavation and off-site treatment and disposal of relatively small volumes of contaminated soil. Alternatives S-7.4 and S-7.5 would be similar in complexity, with Alternative S-7.3 requiring in-situ treatment and Alternative S-7.5 requiring excavation and off-site treatment and disposal of significantly larger volumes of contaminated soil. The implementability of these three alternatives, particularly Alternatives S-7.4 and S-7.5, would be severely restricted by ongoing base activities and multiple underground obstacles. Although it has been assumed for the purpose of this FS that neither of these two restrictive factors would actually prevent implementation of Alternatives S-7.3, S-7.4, and S-7.5, this assumption might not prove to be correct. Even though it would not be restricted by base activities and underground obstacles, Alternative S-7.6 would be hardest to implement because it would deal with much larger volumes of contaminated soil and would require such complex operations as excavation below the water table and on-site dewatering of excavated soil.

The administrative aspects of Alternatives S-7.2, S-7.3, S-7.4, S-7.5, and S-7.6 would be simple to implement. The administrative aspects of Alternatives S-7.2 and S-7.5 would be easiest to implement,

the first requiring preparation of a LUC RD and long-term enforcement of LUCs, and the second requiring a construction permit issued by NSB-NLON DPW and documentation of off-site transportation and disposal of excavated soil. The administrative aspects of Alternative S-7.4 would be slightly harder to implement because, in addition to the preparation of a LUC RD and long-term enforcement of LUCs, this alternative would require a construction permit issued by NSB-NLON DPW. The administrative aspects of Alternatives S-7.3 and S-7.5 would be hardest to implement because they would require preparation of a LUC RD, long-term enforcement of LUCs, securing of a construction permit issued by NSB-NLON DPW, and documentation of off-site transportation and disposal of excavated soil.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

5.13.7 Cost

The capital and O&M costs and NPW of the Zone 7 soil alternatives are as follows. Detailed cost estimates are provided in Appendix E.

Alternative	Capital ($)	NPW of O&M ($)	NPW ($)
S-7.1	0	55,000 (30 years)	55,000 (30 years)
S-7.2	79,000	648,000 (30 years)	727,000 (30 years)
S-7.3	2,745,000	648,000 (30 years)	3,393,000 (30 years)
S-7.4	2,388,000	660,000 (30 years)	3,048,000 (30 years)
S-7.5	4,488,000	648,000 (30 years)	5,136,000 (30 years)
S-7.6	22,979,000	0	22,979,000 (1 year)

5.14 SUMMARY OF COMPARISON OF SOIL REMEDIAL ALTERNATIVES FOR ZONE 7

Table 5-13 summarizes the comparative analysis of soil remedial alternatives for Zone 7.

5.15 COMPARISON OF GROUNDWATER REMEDIAL ALTERNATIVES FOR ZONE 1

The following Zone 1 groundwater remedial alternatives are compared in this section:

Alternative GW-1.1: No Action.

Alternative GW-1.2: Natural Attenuation, LUCs (Institutional Controls), and Monitoring.

Alternative GW-1.3: In-Situ Treatment (Enhanced Bioremediation and Chemical Precipitation and Oxidation), LUCs (Institutional Controls), and Monitoring.

Alternative GW-1.4: Extraction, Discharge and Disposal to Off-Base POTW, LUCs (Institutional Controls), and Monitoring.

Alternative GW-1.5: Extraction, On-Site Treatment (Filtration, Oxidative Filtration, and Liquid-Phase GAC Adsorption), Discharge to Thames River, LUCs (Institutional Controls), and Monitoring.

5.15.1 Overall Protection of Human Health and the Environment

Alternative GW-1.1 would not be protective of human health and the environment. Although the groundwater beneath the Lower Subase is classified as GB and unfit for human consumption and there are no unacceptable human health risks from exposure to contaminated groundwater under the current I/C site use, Alternative GW-1.1 would not prevent unacceptable human health risks that could result from uncontrolled groundwater access and use. In addition, in the absence of monitoring, the progress of natural attenuation of groundwater COCs and TPH would remain unknown, and potential future migration of the COCs and TPH to the nearby Thames River would remain undetected, which could cause additional human health and environmental risks. Alternative GW-1.1 would not meet the groundwater RAOs.

Alternative GW-1.2 would not be protective of human health and the environment since groundwater RAOs would not be met within an acceptable period of time. Alternatives GW-1.3, GW-1.4, and GW-1.5 would be protective of human health and the environment and would meet the groundwater RAOs.

The LUC component of these alternatives would be protective because it would formally restrict access to and use of surficial groundwater. The monitoring component of these alternatives would be protective because it would evaluate the progress of natural attenuation or active remediation and detect potential migration of groundwater COCs and TPH to the Thames River so that appropriate contingency measures could be taken.

Alternatives GW-1.3, GW-1.4, and GW-1.5 would be more protective than Alternative GW-1.2 because, in addition to LUCs and monitoring, these alternatives include one or more active remedial components that

would significantly accelerate the natural attenuation of the Zone 1 points of groundwater contamination. These active components would be in-situ enhanced bioremediation and chemical precipitation and oxidation for Alternative GW-1.3 and groundwater extraction for Alternatives GW-1.4 and GW-1.5. Although Alternative GW-1.3 is expected to be more protective than Alternatives GW-1.4 and GW-1.5 because it would actively remove both metals COCs and TPH within the shortest time, the in-situ treatment technologies of this alternative are subject to site-specific limitations (e.g., weathered TPH, saline groundwater) that prevent it from being definitively ranked as most protective.

5.15.2 Compliance with ARARs and TBCs

Alternative GW-1.1 would not comply with chemical-specific ARARs and TBCs. There are no location-specific ARARs and TBC for groundwater. Action-specific ARARs and TBCs would not apply.

Alternative GW-1.2 would not comply with chemical-specific ARARs nor with Action-specific standards for Monitored Natural Attenuation remedies. Alternatives GW-1.3, GW-1.4, and GW-1.5 would comply with all ARARs and TBCs through remediation. For these alternatives once CERCLA cleanup standards are met State standards for TPH would be achieved through natural attenuation. Compliance would be achieved first by Alternative GW-1.3, then by Alternatives GW-1.4 and GW-1.5, and last by Alternative GW-1.2. Alternatives GW-1.2, GW-1.3, GW-1.4, and GW-1.5 would also comply with action-specific ARARs and TBCs.

A summary of the compliance of Alternatives GW-1.1, GW-1.2, GW-1.3, GW-1.4, and GW-1.5 with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 5-14, 5-15, and 5-16, respectively.

5.15.3 Long-Term Effectiveness and Permanence

Alternative GW-1.1 would not be long-term effective and permanent because it would not involve any action and because it would leave Zone 1 of the Lower Subase open to unrestricted use, which would result in unacceptable human health risks. In addition, because there would be no monitoring, the progress of natural attenuation would remain unknown and potential migration of groundwater COCs to the Thames River would not be detected.

Alternative GW-1.2 would not be considered to be effective because of the long timeframe to meet COC criteria, although the CTDEP TPH criteria would be met in a reasonable time. Alternatives GW-1.3, GW-1.4, and GW-1.5 would be long-term effective and permanent.

The LUC component of these alternatives would effectively restrict access to and use of surficial groundwater. The monitoring component of these alternatives would provide an effective means of evaluating the progress of remediation and detecting the potential migration of groundwater COCs and TPH to the Thames River so that appropriate action could be taken.

Alternatives GW-1.4 and GW-1.5 would be more effective than Alternative GW-1.2 because, based on modeling results, their groundwater extraction component would significantly accelerate the removal of arsenic and copper from the Zone 1 points of groundwater contamination, but not that of TPH. The effectiveness of the treatment component of these two alternatives (Town of Groton POTW or on-site filtration, oxidative filtration, and liquid-phase GAC adsorption, respectively) would be similar. Alternative GW-1.3 would potentially be most effective because in-situ enhanced bioremediation and chemical precipitation and oxidation could result in the fastest removal of groundwater COCs and TPH. In-situ enhanced bioremediation also has the potential to be much more effective than groundwater extraction for the removal of the soil-bound TPH that could be an ongoing source of groundwater contamination. However, site-specific conditions (e.g., weathered TPH, highly saline groundwater) are such that the effectiveness of the Alternative GW-1.3 in-situ treatment technologies must be verified through treatability testing. In addition, there would be a slight possibility that the metals COCs that had been immobilized by in-situ chemical oxidation and precipitation could be redissolved over the long term as a result of naturally occurring changes in groundwater chemistry. Therefore, at this time, Alternative GW-1.3 cannot be ranked as clearly more effective than Alternatives GW-1.4 and GW-1.5.

5.15.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW-1.1 would not reduce the toxicity, mobility, or volume of groundwater COCs through treatment because no treatment would occur.

Alternative GW-1.2 would not reduce the toxicity, mobility, and volume of arsenic, copper, and TPH through treatment.

Alternative GW-1.3 would reduce the toxicity, mobility, and volume of arsenic, copper, and TPH through in-situ treatment. An estimated total 5,300 pounds of TPH would be permanently and irreversibly removed by in-situ enhanced bioremediation. In addition, an estimated 0.04 pound of arsenic and 0.4 pound of copper would be removed from groundwater and immobilized through in-situ chemical precipitation and oxidation. However, as noted earlier, there is a slight possibility that this immobilization might not be completely permanent and irreversible. Reductions in toxicity, mobility, and volume would be quantified by monitoring.

Alternative GW-1.4 would not reduce the toxicity and volume of arsenic and copper through treatment.

Alternative GW-1.5 would reduce the toxicity and volume of arsenic and copper through removal and on-site treatment. An estimated total of 0.04 pound of arsenic and 0.4 pound of copper would be permanently and irreversibly removed through groundwater extraction and treated on site by filtration, oxidative filtration, and liquid-phase GAC adsorption.

In addition, Alternative GW-1.5 would generate significant quantities of residuals associated with on-site groundwater treatment, including clogged filter bag elements and spent oxidative filter medium and GAC.

5.15.5 Short-Term Effectiveness

Because no action would occur, implementation of Alternative GW-1.1 would not pose any short-term risks to on-site workers or result in adverse impact to the local community or the environment.

Implementation of Alternatives GW-1.2, GW-1.3, GW-1.4, and GW-1.5 could result in short-term risks to on-site workers as a result of exposure to contamination. The potential for exposure would be minimal for Alternative GW-1.2, moderate for Alternatives GW-1.3 and GW-1.4, and significant for Alternative GW-1.5 because of the increasing level of activities. However, these risks would be adequately mitigated for all alternatives by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures.

Alternatives GW-1.2 and GW-1.3 would have no adverse impact on the surrounding community or the environment. Alternative GW-1.4 and GW-1.5 could have a minimal impact on the surrounding community and the environment as a result of the disposal of extracted groundwater to the Town of Groton POTW and because of the off-site transportation and disposal of treatment residuals, respectively. However, risks associated with Alternative GW-1.4 would be adequately mitigated by adherence to established sewage handling and treatment procedures, and those associated with Alternative GW-1.5 would be mitigated by adherence to spill prevention procedures and compliance with DOT regulations.

Alternative GW-1.1 would not achieve the groundwater RAOs or meet the groundwater PRGs or the TPH cleanup criterion. Alternatives GW-1.2, GW-1.3, GW-1.4, and GW-1.5 could be implemented within approximately 3 months, 1 year, 1 year, and 18 months, respectively, and would achieve the groundwater RAOs and the TPH cleanup criterion at completion. Based on natural attenuation modeling results (see Appendix D), Alternative GW-1.2 would meet the groundwater PRGs and the TPH cleanup criterion within an estimated 42 years in the Zone 1 copper/TPH point of groundwater contamination (42 years for arsenic and 27 years for TPH) and within an estimated 219 years in the Zone 1 arsenic/copper points of groundwater contamination (80 years for arsenic and 219 years for copper). Alternative GW-1.3 would meet the groundwater PRGs and the TPH cleanup criterion in the Zone 1 copper/TPH and arsenic/copper

points of groundwater contamination within approximately 1 year. Based on groundwater extraction modeling results, Alternatives GW-1.4 and GW-1.5 would meet the groundwater PRGs and the TPH cleanup criterion within an estimated 27 years in the Zone 1 copper/TPH point of groundwater contamination (11 years for copper and 27 years for TPH) and within an estimated 26 years in the Zone 1 arsenic/copper point of groundwater contamination (9 years for arsenic and 26 years for copper). As discussed earlier, the remediation time frames for Alternatives GW-1.2, GW-1.4, and GW-1.5 are very conservative because of the nature of the input data and type of model used.

5.15.6 Implementability

Technically, Alternative GW-1.1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Alternatives GW-1.2, GW-1.3, GW-1.4, and GW-1.5 would be technically implementable, and resources, equipment, and materials would be readily available for this purpose. From the technical point of view, Alternative GW-1.2 would be easiest to implement, requiring only monitoring. Alternative GW-1.4 would be more difficult to implement than Alternative GW-1.2 because, in addition to monitoring, it would require the installation and O&M of two Groundwater Extraction Systems (one with a single well and one with two wells). Alternative GW-1.5 would be more difficult to implement than Alternative GW-1.4 because, in addition to monitoring and the same two Groundwater Extraction Systems, it would also require the performance of treatability testing and installation and O&M of two On-Site Treatment Systems. Alternative GW-1.3 would be the most difficult to implement because it would require the installation and O&M of groundwater recirculation systems, each with multiple extraction and reinjection wells for in-situ enhanced bioremediation and the installation and operation of a significant number (92) of DPT injection points for in-situ chemical precipitation and oxidation, both of which would impact ongoing site activities and interfere with existing site structures (particularly Building 29). In addition, Alternative GW-1.3 would require treatability testing.

The administrative aspects of Alternatives GW-1.2, GW-1.3, GW-1.4, and GW-1.5 would be relatively simple to implement. The administrative aspects of Alternative GW-1.2 would be easiest to implement, requiring only preparation of a LUC RD and long-term enforcement of LUCs. The administrative aspects of Alternative GW-1.3 would be slightly harder to implement than those of Alternative GW-1.2 because, in addition to the preparation of a LUC RD and long-term enforcement of LUCs, this alternative would require a construction permit issued by NSB-NLON DPW. The administrative aspects of Alternatives GW-1.4 and GW-1.5 would be hardest to implement because, in addition to the preparation of a LUC RD, long-term enforcement of LUCs, and securing of a construction permit issued by NSB-NLON DPW, the first of these two alternatives would require negotiations with the Town of Groton for the discharge of the

extracted groundwater to their POTW, and the second would have to meet the substantive requirements of federal and State water discharge regulations for discharge of the treated groundwater to the Thames River.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

5.15.7 Cost

The capital and O&M costs and NPW of the Zone 1 groundwater alternatives are as follows.

Alternative	Capital ($)	NPW of O&M ($)	NPW ($)
GW-1.1	0	55,000 (30 years)	55,000 (30 years)
GW-1.2	38,000	338,000 (30 years)	376,000 (30 years)
GW-1.3	482,000	619,000 (5 years)	1,101,000 (5 years)
GW-1.4	329,000	3,561,000 (30 years)	3,890,000 (30 years)
GW-1.5	942,000	2,011,000 (30 years)	2,953,000 (30 years)

Detailed cost estimates are provided in Appendix E.

5.16 SUMMARY OF COMPARISON OF GROUNDWATER REMEDIAL ALTERNATIVES FOR ZONE 1

Table 5-17 summarizes the comparative analysis of the Zone 1 groundwater remedial alternatives.

5.17 COMPARISON OF GROUNDWATER REMEDIAL ALTERNATIVES FOR ZONE 4

The following Zone 4 groundwater remedial alternatives are compared in this section:

Alternative GW-4.1: No Action.
Alternative GW-4.2: Natural Attenuation, LUCs (Institutional Controls), and Monitoring.

Alternative GW-4.3: In-Situ Treatment (Enhanced Bioremediation and Chemical Precipitation and Oxidation), LUCs (Institutional Controls), and Monitoring.

Alternative GW-4.4: Extraction, Discharge and Disposal to Off-Base POTW, LUCs (Institutional Controls), and Monitoring.

Alternative GW-4.5: Extraction, On-Site Treatment (Filtration, Oxidative Filtration, Chemical Precipitation, and Liquid-Phase GAC Adsorption), Discharge to Thames River, LUCs (Institutional Controls), and Monitoring.

5.17.1 Overall Protection of Human Health and the Environment

Alternative GW-4.1 would not be protective of human health and the environment. Although the groundwater beneath the Lower Subase is classified as GB and unfit for human consumption and there are no unacceptable human health risks from exposure to contaminated groundwater under the current industrial site use, Alternative GW-4.1 would not prevent unacceptable human health risks that could result from uncontrolled groundwater access and use. In addition, in the absence of monitoring, the progress of the natural attenuation of groundwater COCs and TPH would remain unknown, and potential future migration of the COCs and TPH to the nearby Thames River would remain undetected, which could cause additional human health and environmental risks. Alternative GW-4.1 would not meet the groundwater RAOs.

Alternative GW-4.2 would not be protective of human health since groundwater RAOs would not be met within an acceptable period of time. Alternatives GW-4.3, GW-4.4, and GW-4.5 would be protective of human health and the environment and would meet the groundwater RAOs.

The LUC component of these alternatives would be protective because it would formally restrict access to and use of surficial groundwater. The monitoring component of these alternatives would be protective because it would evaluate the progress of natural attenuation or active remediation and detect potential migration of groundwater COCs and TPH to the Thames River so that appropriate contingency measures could be taken.

Alternatives GW-4.3, GW-4.4, and GW-4.5 would be more protective than Alternative GW-4.2 because, in addition to LUCs and monitoring, these alternatives include one or more active remedial components that would significantly accelerate the natural attenuation of the Zone 4 points of groundwater contamination. These active components would be in-situ enhanced bioremediation and chemical precipitation and oxidation for Alternative GW-4.3, and groundwater extraction for Alternatives GW-4.4 and GW-4.5. Although Alternative GW-4.3 should be more protective than Alternatives GW-4.4 and GW-4.5 because it would actively remove both metals COCs and TPH within the shortest time, the in-situ treatment

technologies of this alternative are subject to site-specific limitations (e.g., weathered TPH, saline groundwater) that prevent it from being definitively ranked as most protective.

5.17.2 Compliance with ARARs and TBCs

Alternative GW-4.1 would not comply with chemical-specific ARARs and TBCs. There are no location-specific ARARs and TBC for groundwater. Action-specific ARARs and TBCs would not apply.

Alternative GW-4.2 would not comply with chemical-specific ARARs nor with Action-specific standards for Monitored Natural Attenuation remedies. Alternatives GW-4.3, GW-4.4, and GW-4.5 would comply with all ARARs and TBCs through remediation. For these alternatives once CERCLA cleanup standards are met State standards for TPH would be achieved through natural attenuation. Compliance would be achieved first by Alternative GW-4.3, then by Alternatives GW-4.4 and GW-4.5, and last by Alternative GW-4.2. Alternatives GW-4.2, GW-4.3, GW-4.4, and GW-4.5 would also comply with action-specific ARARs and TBCs.

A summary of the compliance of Alternatives GW-4.1, GW-4.2, GW-4.3, GW-4.4, and GW-4.5 with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 5-14, 5-15, and 5-16, respectively.

5.17.3 Long-Term Effectiveness and Permanence

Alternative GW-4.1 would not be long-term effective and permanent because it would not involve any action and because it would leave Zone 4 of the Lower Subase open to unrestricted use, which would result in unacceptable human health risks. In addition, because there would be no monitoring, the progress of natural attenuation would remain unknown and potential migration of groundwater COCs to the Thames River would not be detected.

Alternative GW-4.2 would not be considered to be effective because of the long timeframe to meet COC criteria, although the CTDEP TPH criteria would be met in a reasonable time. Alternatives GW-4.3, GW-4.4, and GW-4.5 would be long-term effective and permanent.

The LUC component of these alternatives would effectively restrict access to and use of surficial groundwater. The monitoring component of these alternatives would provide an effective means of evaluating the progress of remediation and detecting the potential migration of groundwater COCs and TPH to the Thames River so that appropriate action could be taken.

Alternatives GW-4.4 and GW-4.5 would be more effective than Alternative GW-4.2 because, based on modeling results, their groundwater extraction component would significantly accelerate the removal of arsenic and lead from the Zone 4 points of groundwater contamination, but not that of TPH. The effectiveness of the treatment component of these two alternatives (Town of Groton POTW or on-site oxidative filtration and chemical precipitation and filtration, respectively) would be similar. Alternative GW-4.3 would potentially be most effective because in-situ enhanced bioremediation and chemical precipitation and oxidation could result in the fastest removal of groundwater COCs and TPH. In-situ enhanced bioremediation also has the potential to be much more effective than groundwater extraction for the removal of the soil-bound TPH that could be an ongoing source of groundwater contamination. However, site-specific conditions (e.g., weathered TPH, highly saline groundwater) are such that the effectiveness of the Alternative GW-4.3 in-situ treatment technologies must be verified through treatability testing. In addition, there would be a slight possibility that the arsenic and lead that had been immobilized by in-situ chemical precipitation and oxidation could be redissolved over the long term as a result of naturally occurring changes in groundwater chemistry. Therefore, at this time, Alternative GW-4.3 cannot be ranked as clearly more effective than Alternatives GW-4.4 and GW-4.5.

5.17.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW-4.1 would not reduce the toxicity, mobility, or volume of groundwater arsenic, lead, and TPH through treatment because no treatment would occur.

Alternative GW-4.2 would not reduce the toxicity, mobility, and volume of arsenic, lead, and TPH through treatment.

Alternative GW-4.3 would reduce the toxicity, mobility, and volume of arsenic, lead, and TPH through in-situ treatment. An estimated total 1,030 pounds of TPH would be permanently and irreversibly removed by in-situ enhanced bioremediation. In addition, an estimated 0.08 pound of arsenic and 4.06 pounds of lead would be removed from groundwater and immobilized through in-situ chemical precipitation and oxidation. However, as noted earlier, there is a slight possibility that this immobilization might not be completely permanent and irreversible. Reductions in toxicity, mobility, and volume would be quantified by monitoring.

Alternative GW-4.4 would not reduce the toxicity, mobility, and volume of arsenic and lead through treatment.

Alternative GW-4.5 would reduce the toxicity, mobility, and volume of arsenic and lead through removal and on-site treatment. An estimated total of 0.08 pound of arsenic and 4.06 pounds of lead would be

permanently and irreversibly removed through groundwater extraction and treated on site with oxidative filtration, chemical precipitation, and filtration.

Alternative GW-4.5 would generate significant quantities of residuals associated with on-site groundwater treatment, including clogged filter bag elements and spent oxidative filter medium and GAC.

5.17.5 Short-Term Effectiveness

Because no action would occur, implementation of Alternative GW-4.1 would not pose any short-term risks to on-site workers or result in adverse impact to the local community or the environment.

Implementation of Alternatives GW-4.2, GW-4.3, GW-4.4, and GW-4.5 could result in short-term risks to on-site workers as a result of exposure to contamination. The potential for exposure would be minimal for Alternative GW-4.2, moderate for Alternatives GW-4.3 and GW-4.4, and significant for Alternative GW-4.5 because of the increasing level of activities. However, these risks would be adequately mitigated for all alternatives by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures.

Alternatives GW-4.2 and GW-4.3 would have no adverse impact on the surrounding community or the environment. Alternative GW-4.4 and GW-4.5 could have a minimal impact on the surrounding community and the environment as a result of the disposal of extracted groundwater to the Town of Groton POTW and because of the off-site transportation and disposal of treatment residuals, respectively. However, risks associated with Alternative GW-4.4 would be adequately mitigated by adherence to established sewage handling and treatment procedures, and those associated with Alternative GW-4.5 would be mitigated by adherence to spill prevention procedures and compliance with DOT regulations.

Alternative GW-4.1 would not achieve the groundwater RAOs or meet the groundwater PRGs or the TPH cleanup criterion. Alternatives GW-4.2, GW-4.3, GW-4.4, and GW-4.5 could be implemented within approximately 3 months, 1 year, 1 year, and 18 months, respectively, and would achieve the groundwater RAOs and the TPH cleanup criterion at completion. Based on natural attenuation modeling results (see Appendix D), Alternative GW-4.2 would meet the groundwater PRGs and the TPH cleanup criterion within an estimated 22 years in the Zone 4 arsenic/TPH points of groundwater contamination (22 years for arsenic and 11 years for TPH) and within an estimated 548 years in the Zone 4 lead point of groundwater contamination. Alternative GW-4.3 would meet the groundwater PRGs and the TPH cleanup criterion in the Zone 4 arsenic/TPH and lead points of groundwater contamination within approximately 1 year. Based on groundwater extraction modeling results, Alternatives GW-4.4 and GW-4.5 would meet the groundwater PRGs and the TPH cleanup criterion within an estimated 11 years in the Zone 4 arsenic/TPH points of groundwater contamination (11 years for both arsenic and TPH) and within an

estimated 27 years in the Zone 4 lead point of groundwater contamination. As discussed earlier, the remediation time frames for Alternatives GW-4.2, GW-4.4, and GW-4.5 are very conservative because of the nature of the input data and type of model used.

5.17.6 Implementability

Technically, Alternative GW-4.1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Alternatives GW-4.2, GW-4.3, GW-4.4, and GW-4.5 would be technically implementable, and resources, equipment, and materials would be readily available for this purpose. From the technical point of view, Alternative GW-4.2 would be easiest to implement, requiring only monitoring. Alternative GW-4.4 would be more difficult to implement than Alternative GW-4.2 because, in addition to monitoring, it would require the installation and O&M of two Groundwater Extraction Systems (each with three wells). Alternative GW-4.5 would be more difficult to implement than Alternative GW-4.4 because, in addition to monitoring and the same two Groundwater Extraction Systems, it would also require the performance of treatability testing and the installation and O&M of two On-Site Treatment Systems. Alternative GW-4.3 would be the most difficult to implement because it would require the installation and O&M of groundwater recirculation systems, each with multiple extraction and reinjection wells for in-situ enhanced bioremediation, and the installation and operation of a significant number (162) of DPT injection points for in-situ chemical precipitation and oxidation, both of which would impact ongoing site activities and interfere with existing site structures. In addition, Alternative GW-4.3 would require treatability testing.

The administrative aspects of Alternatives GW-4.2, GW-4.3, GW-4.4, and GW-4.5 would be relatively simple to implement. The administrative aspects of Alternative GW-4.2 would be easiest to implement, requiring only preparation of a LUC RD and long-term enforcement of LUCs. The administrative aspects of Alternative GW-4.3 would be slightly harder to implement than those of Alternative GW-4.2 because, in addition to the preparation of a LUC RD and long-term enforcement of LUCs, this alternative would require a construction permit issued by NSB-NLON DPW. The administrative aspects of Alternatives GW-4.4 and GW-4.5 would be hardest to implement because, in addition to the preparation of a LUC RD, the long-term enforcement of LUCs, and securing of a construction permit issued by NSB-NLON DPW, the first of these two alternatives would require negotiations with the Town of Groton for discharge of extracted groundwater to their POTW and the second would have to meet the substantive requirements of federal and State water discharge regulations for discharge of the treated groundwater to the Thames River.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

5.17.7 Cost

The capital and O&M costs and NPW of the Zone 4 groundwater alternatives are as follows.

Alternative	Capital ($)	NPW of O&M ($)	NPW ($)
GW-4.1	0	55,000 (30 years)	55,000 (30 years)
GW-4.2	33,000	338,000 (30 years)	371,000 (30 years)
GW-4.3	548,000	445,000 (5 years)	993,000 (5 years)
GW-4.4	518,000	7,777,000 (30 years)	8,295,000 (30 years)
GW-4.5	1,535,000	2,641,000 (30 years)	4,176,000 (30 years)

Detailed cost estimates are provided in Appendix E.

5.18 SUMMARY OF COMPARISON OF GROUNDWATER REMEDIAL ALTERNATIVES FOR ZONE 4

Table 5-18 summarizes the comparative analysis of the Zone 4 groundwater remedial alternatives.

5.19 COMPARISON OF GROUNDWATER REMEDIAL ALTERNATIVES FOR ZONE 7

The following Zone 7 groundwater remedial alternatives are compared in this section:

Alternative GW-7.1: No Action.

Alternative GW-7.2: Natural Attenuation, LUCs (Institutional Controls), and Monitoring.

Alternative GW-7.3: In-Situ Treatment (Chemical Precipitation and Oxidation), LUCs (Institutional Controls), and Monitoring.

Alternative GW-7.4: Extraction, Discharge and Disposal to Off-Base POTW, LUCs (Institutional Controls), and Monitoring.

Alternative GW-7.5: Extraction, On-Site Treatment (Filtration and Oxidative Filtration), Discharge to Thames River, LUCs (Institutional Controls), and Monitoring.

5.19.1 Overall Protection of Human Health and the Environment

Alternative GW-7.1 would not be protective of human health and the environment. Although the groundwater beneath the Lower Subase is classified as GB and unfit for human consumption and there are no unacceptable human health risks from exposure to contaminated groundwater under the current industrial site use, Alternative GW-7.1 would not prevent unacceptable human health risks that could result from uncontrolled groundwater access and use. In addition, in the absence of monitoring, the progress of the natural attenuation of arsenic would remain unknown, and potential future migration of this COC to the nearby Thames River would remain undetected, which could cause additional human health and environmental risks. Alternative GW-7.1 would not meet the groundwater RAOs.

Alternative GW-7.2 would be protective of human health and the environment since groundwater RAOs would be met within an acceptable period of time. Alternatives GW-7.3, GW-7.4, and GW-7.5 would be protective of human health and the environment and would meet the groundwater RAOs.

The LUC component of these alternatives would be protective because it would formally restrict access to and use of surficial groundwater. The monitoring component of these alternatives would be protective because it would evaluate the progress of natural attenuation or active remediation and detect potential migration of arsenic to the Thames River so that appropriate contingency measures could be taken.

Alternatives GW-7.3, GW-7.4, and GW-7.5 would be more protective than Alternative GW-7.2 because, in addition to LUCs and monitoring, these alternatives include one or more active remedial components that would significantly accelerate natural attenuation in the Zone 7 arsenic points of groundwater contamination. These active components would be in-situ chemical precipitation and oxidation for Alternative GW-7.3 and groundwater extraction for Alternatives GW-7.4 and GW-7.5. Although Alternative GW-7.3 is expected to be more protective than Alternatives GW-7.4 and GW-7.5 because it would actively remove arsenic within the shortest time, the in-situ treatment technology of this alternative is subject to site-specific limitations (e.g., saline groundwater) that prevent it from being definitively ranked as most protective.

5.19.2 Compliance with ARARs and TBCs

Alternative GW-7.1 would not comply with chemical-specific ARARs and TBCs. There are no location-specific ARARs and TBC for groundwater. Action-specific ARARs and TBCs would not apply.

Alternative GW-7.2 would not comply with chemical-specific ARARs nor with Action-specific standards for Monitored Natural Attenuation remedies. Alternatives GW-7.3, GW-7.4, and GW-7.5 would comply with all ARARs and TBCs through remediation. Compliance would be achieved first by Alternative GW-7.3, then by Alternatives GW-7.4 and GW-7.5, and last by Alternative GW-7.2. Alternatives GW-7.2, GW-7.3, GW-7.4, and GW-7.5 would also comply with action-specific ARARs and TBCs.

A summary of the compliance of Alternatives GW-7.1, GW-7.2, GW-7.3, GW-7.4, and GW-7.5 with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 5-14, 5-15, and 5-16, respectively.

5.19.3 Long-Term Effectiveness and Permanence

Alternative GW-7.1 would not be long-term effective and permanent because it would not involve any action and because it would leave Zone 7 of the Lower Subase open to unrestricted use, which could result in unacceptable human health risks. In addition, because there would be no monitoring, the progress of natural attenuation would remain unknown, and potential migration of arsenic to the Thames River would not be detected.

Alternatives GW-7.2, GW-7.3, GW-7.4, and GW-7.5 would be long-term effective and permanent.

The LUC component of these alternatives would effectively restrict access to and use of surficial groundwater. The monitoring component of these alternatives would provide an effective means of evaluating the progress of remediation and detecting the potential migration of arsenic to the Thames River so that appropriate action could be taken.

Alternatives GW-7.4 and GW-7.5 would be more effective than Alternative GW-7.2 because, based on modeling results, their groundwater extraction component would significantly accelerate the removal of arsenic from the Zone 7 groundwater. The effectiveness of the treatment component of these two alternatives (Town of Groton POTW or on-site oxidative filtration) would be similar. Alternative GW-7.3 would potentially be most effective because in-situ chemical precipitation and oxidation could result in the fastest removal of arsenic, but site-specific conditions (e.g., highly saline groundwater) are such that the effectiveness of the Alternative GW-7.3 in-situ treatment technology must be verified through treatability testing. In addition, there would be a slight possibility that the arsenic that had been immobilized by in-

situ chemical precipitation and oxidation could be redissolved over the long term as a result of naturally occurring changes in groundwater chemistry. Therefore, at this time, Alternative GW-7.3 cannot be ranked as clearly more effective than Alternatives GW-7.4 and GW-7.5.

5.19.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW-7.1 would not reduce the toxicity, mobility, or volume of groundwater arsenic through treatment because no treatment would occur.

Alternative GW-7.2 would not reduce the toxicity and volume of arsenic through treatment.

Alternative GW-7.3 would reduce the toxicity, mobility, and volume of arsenic through in-situ treatment. An estimated 0.04 pound of arsenic would be removed from groundwater and immobilized through in-situ chemical precipitation and oxidation. However, as noted earlier, there is a slight possibility that this immobilization might not be completely permanent and irreversible. Reductions in toxicity, mobility, and volume would be quantified by monitoring.

Alternative GW-7.4 would not reduce the toxicity, mobility, and volume of arsenic through treatment.

Alternative GW-7.5 would reduce the toxicity, mobility, and volume of arsenic through removal and on-site treatment. An estimated total of 0.04 pound of arsenic would be permanently and irreversibly removed through groundwater extraction and treated on-site with oxidative filtration.

Alternative GW-7.5 would generate significant quantities of residuals associated with on-site groundwater treatment, including clogged filter bag elements and spent oxidative filter medium.

5.19.5 Short-Term Effectiveness

Because no action would occur, implementation of Alternative GW-7.1 would not pose any short-term risks to on-site workers or result in adverse impact to the local community or the environment.

Implementation of Alternatives GW-7.2, GW-7.3, GW-7.4, and GW-7.5 could result in short-term risks to on-site workers as a result of exposure to contamination. The potential for exposure would be minimal for Alternative GW-7.2, moderate for Alternatives GW-7.3 and GW-7.4, and significant for Alternative GW-7.5 because of the increasing level of activities. However, these risks would be adequately mitigated for all alternatives by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures.

Alternatives GW-7.2 and GW-7.3 would have no adverse impact on the surrounding community or the environment. Alternative GW-7.4 and GW-7.5 could have a minimal impact on the surrounding community and the environment as a result of disposal of extracted groundwater to the Town of Groton POTW and because of the off-site transportation and disposal of treatment residuals, respectively. However, risks associated with Alternative GW-7.4 would be adequately mitigated by adherence to established sewage handling and treatment procedures, and those associated with Alternative GW-7.5 would be mitigated by adherence to spill prevention procedures and compliance with DOT regulations.

Alternative GW-7.1 would not achieve the groundwater RAOs or meet the groundwater arsenic PRG. Alternatives GW-7.2, GW-7.3, GW-7.4, and GW-7.5 could be implemented within approximately 3 months, 1 year, 1 year, and 18 months, respectively, and would achieve the groundwater RAOs at completion. Based on natural attenuation modeling results (see Appendix D), Alternative GW-7.2 would meet the groundwater arsenic PRG within an estimated 34 years. Alternative GW-7.3 would meet the groundwater arsenic PRG within approximately 1 year. Based on groundwater extraction modeling results, Alternatives GW-7.4 and GW-7.5 would meet the groundwater arsenic PRG within an estimated 18 years. As discussed earlier, the remediation time frames for Alternatives GW-7.2, GW-7.4, and GW-7.5 are very conservative because of the nature of the input data and type of model used.

5.19.6 Implementability

Technically, Alternative GW-7.1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Alternatives GW-7.2, GW-7.3, GW-7.4, and GW-7.5 would be technically implementable, and resources, equipment, and materials would be readily available for this purpose. From the technical point of view, Alternative GW-7.2 would be easiest to implement, requiring only monitoring. Alternative GW-7.4 would be more difficult to implement than Alternative GW-7.2 because, in addition to monitoring, it would require the installation and O&M of a Groundwater Extraction System (with two wells). Alternative GW-7.5 would be more difficult to implement than Alternative GW-7.4 because, in addition to monitoring and the same Groundwater Extraction System, it would also require the performance of treatability testing and installation and O&M of an On-Site Treatment System. Alternative GW-7.3 would be the most difficult to implement because it would require the installation and operation of a significant number (74) of DPT injection points for in-situ chemical precipitation and oxidation, both of which would impact ongoing site activities and interfere with existing site structures. In addition, Alternative GW-7.3 would require treatability testing.

The administrative aspects of Alternatives GW-7.2, GW-7.3, GW-7.4, and GW-7.5 would be relatively simple to implement. The administrative aspects of Alternative GW-7.2 would be easiest to implement, requiring only preparation of a LUC RD and long-term enforcement of LUCs. The administrative aspects of Alternative GW-4.3 would be slightly harder to implement than those of Alternative GW-7.2 because, in addition to the preparation of a LUC RD and long-term enforcement of LUCs, this alternative would require a construction permit issued by NSB-NLON DPW. The administrative aspects of Alternatives GW-7.4 and GW-7.5 would be hardest to implement because, in addition to the preparation of a LUC RD, long-term enforcement of LUCs, and securing of a construction permit issued by NSB-NLON DPW, the first of these two alternatives would require negotiations with the Town of Groton for discharge of the extracted groundwater to their POTW, and the second would have to meet the substantive requirements of federal and State water discharge regulations for discharge of the treated groundwater to the Thames River.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

5.19.7 Cost

The capital and O&M costs and NPW of the Zone 7 groundwater alternatives are as follows.

Alternative	Capital ($)	NPW of O&M ($)	NPW ($)
GW-7.1	0	55,000 (30 years)	55,000 (30 years)
GW-7.2	24,000	318,000 (30 years)	342,000 (30 years)
GW-7.3	282,000	149,000 (5 years)	431,000 (5 years)
GW-7.4	265,000	1,938,000 (30 years)	2,203,000 (30 years)
GW-7.5	499,000	929,000 (30 years)	1,428,000 (30 years)

Detailed cost estimates are provided in Appendix E.

5.20 SUMMARY OF COMPARISON OF GROUNDWATER REMEDIAL ALTERNATIVES FOR ZONE 7

Table 5-19 summarizes the comparative analysis of the Zone 7 groundwater remedial alternatives.

5.21 COMPARISON OF SEDIMENT REMEDIAL ALTERNATIVES FOR ZONE 4 AND OUTER PIER 1

The following remedial alternatives for sediment are compared in this section:

Alternative SD-1: No Action.

Alternative SD-3: Capping with Pre-Dredging to Meet RAOs, Dewatering, On-Site Treatment and Discharge of Dewatering Fluid, Off-Site Disposal of Dewatered Sediment, LUCs (Institutional Controls), and Monitoring.

Alternative SD-4: Capping with Pre-Dredging to Meet RAOs, Dewatering, Off-Site Disposal of Dewatered Sediment and Dewatering Fluid, LUCs (Institutional Controls), and Monitoring.

Alternative SD-6: Dredging to Meet PRGs, Dewatering, On-Site Treatment and Discharge of Dewatering Fluid, and Off-Site Disposal of Dewatered Sediment.

Alternative SD-7: Dredging to Meet PRGs, Dewatering, and Off-Site Disposal of Dewatered Sediment and Dewatering Fluid.

As noted in Section 4, Alternatives SD-2 and SD-5 which were evaluated in the previous version of this FS have now been eliminated because their distinctive technology component was disposal of contaminated sediment in an existing CAD which proved unacceptable to CTDEP.

5.21.1 Overall Protection of Health and Environment

There are no unacceptable human health risks from direct exposure to contaminated sediment at the Lower Subase under the current site use scenario.

Alternative SD-1 would not be protective of the environment because it would allow sediment COCs (PAHs, PCBs, pesticides, and metals) to remain on site at concentrations that would result in unacceptable risks to ecological receptors such as benthic macroinvertebrates and piscivorous birds. Alternative SD-1 would also not be protective of the environment because it would allow the migration of contaminated sediment to previously uncontaminated areas as a result of maintenance dredging and disposal. Alternative SD-1 would not achieve the sediment RAOs.

Alternatives SD-3, SD-4, SD-6, and SD-7 would be protective of the environment and would achieve the sediment RAOs.

Alternatives SD-3 and SD-4 would be protective because they would prevent unacceptable environmental risks through capping that would isolate contaminated sediment, through LUCs that would prevent cap disturbance, and through monitoring that would verify long-term cap integrity. Cap installation would also include removal and off-site disposal of a significant portion of the contaminated sediment.

Alternatives SD-6 and SD-7 would be more protective than Alternatives SD-3 and SD-4 because they would remove all of the contaminated sediment instead of removing part of it and isolating the rest.

5.21.2 Compliance with ARARs and TBCs

Alternative SD-1 would not comply with chemical-specific ARARs and TBCs. No location- or action-specific ARARs or TBCs apply to this alternative.

Alternatives SD-3, SD-4, SD-6, and SD-7 would comply with chemical-, location-, and action-specific ARARs and TBCs.

A summary of the compliance of Alternatives SD-3, SD-4, SD-6, and SD-7 with chemical-, location-, and action-specific ARARs and TBCs is provided in Tables 5-20, 5-21, and 5-22, respectively.

5.21.3 Long-Term Effectiveness and Permanence

Alternative SD-1 would not be long-term effective and permanent because it would involve no action.

Alternatives SD-3, SD-4, SD-6, and SD-7 would be long-term effective and permanent.

The capping, LUCs, and monitoring of Alternatives SD-3 and SD-4 would constitute effective and permanent means of isolating contaminated sediment to prevent unacceptable ecological risks. Alternative SD-3 would be slightly more effective than Alternative SD-4 because on-site treatment and discharge of dewatering fluid would be preferable to its off-site disposal.

Alternatives SD-6 and SD-7 would be more effective and permanent than Alternatives SD-3 and SD-4 and because removal and off-site disposal of all of the contaminated sediment is more effective and permanent than removal of part of this sediment and isolating of the rest through capping. Alternative SD-6 would be slightly more effective than Alternative SD-7 because on-site treatment and discharge of dewatering fluid would be preferable to its off-site disposal.

5.21.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative SD-1 would not reduce the toxicity, mobility, or volume of sediment COCs through treatment because no action would occur.

Alternative SD-3 would partly address CERCLA risks by reducing the toxicity, mobility, and volume of COCs through treatment. An estimated 246,000 gallons of contaminated sediment dewatering fluid would be permanently and irreversibly removed from Zone 4 and treated and disposed on-site with Alternative SD-3. Alternative SD-4 would not address CERCLA risks by reducing the toxicity, mobility, and volume of sediment COCs through treatment.

Alternative SD-6 would partly address CERCLA risks by reducing the toxicity, mobility, and volume of sediment COCs but through treatment. An estimated 471,000 gallons of contaminated sediment dewatering fluid would be permanently and irreversibly removed from Zone 4 and Outer Pier 1 and treated and disposed on site with Alternative SD-6. Alternative SD-7 would not address CERCLA risks by reducing the toxicity, mobility, and volume of sediment COCs but through treatment.

Alternatives SD-3 and SD-6 would generate residuals as a result of on-site treatment of dewatering fluid (clogged filter bags and spent GAC).

5.21.5 Short-Term Effectiveness

Because no action would occur, implementation of Alternative SD-1 would not result in any short-term risks to on-site workers or adversely impact the local community or the environment.

Implementation of Alternatives SD-3, SD-4, SD-6, and SD-7 could result in short-term risks to on-site workers as a result of exposure to contaminated sediment. The potential for exposure would be somewhat greater for Alternatives SD-3 and SD-6 than for Alternatives SD-4 and SD-7 because of the on-site treatment of dewatering effluent. However, these risks would be adequately mitigated for these alternatives by the wearing of appropriate PPE and by compliance with OSHA regulations and site-specific health and safety procedures.

Alternatives SD-3, SD-4, SD-6, and SD-7 could impact the surrounding community because of aquatic migration of contaminated sediment as a result of dredging. This impact could be somewhat greater for Alternatives SD-6 and SD-7 than for Alternatives SD-3 and SD-4 because of the far greater areas and volumes of dredged sediment. However, impacts of all these alternatives on the surrounding community

would be adequately mitigated by the implementation of engineering controls (silt curtains) and performance of perimeter water monitoring.

Alternatives SD-3, SD-4, SD-6, and SD-7 could also have an adverse effect on the surrounding community as a result of off-site transportation of contaminated sediment. The potential for adverse impact would be least for Alternative SD-4 because of the relatively small volume of transported sediment, greater for Alternative SD-3 because of the added volume of transported dewatering fluid, even greater for Alternative SD-7 because of the much greater volume of sediment being transported, and greatest for Alternative SD-6 because of the very large additional volume of transported dewatering fluid. However, these impacts would be adequately mitigated for these alternatives by the implementation of engineering controls, by adherence to spill prevention procedures, and by compliance with applicable regulations.

The short-term impact of the dredging and capping or backfilling of Alternatives SD-3, SD-4, SD-6, and SD-7 would be destructive of ecological receptors in the immediate area of remedial activities (i.e., benthic macroinvertebrates). However, capping or replacement of contaminated sediment with clean backfill material would also create conditions favorable for the re-colonization of expanded populations of these same receptors. Impact to the surrounding environment and ecological receptors would be minimized by engineering controls such as silt curtains that would minimize contaminant migration and by administrative controls such as the restriction of dredging operations to the period from October 1 to January 31 that corresponds to minimal ecological activity.

Alternative SD-1 would not attain the sediment RAOs or meet the sediment PRGs. Alternatives SD-3, and SD-4 could both be completed within approximately 3 months and would achieve the sediment RAOs and meet the sediment PRGs at completion. Alternatives SD-6 and SD-7 could both be completed in approximately 6 months and would achieve the sediment RAOs and meet the sediment PRGs at completion.

5.21.6 Implementability

Technically, Alternative SD-1 would be very easy to implement because there would be nothing to implement. Administrative implementability would also be easy because it would only involve the performance of five-year reviews.

Alternatives SD-3, SD-4, SD-6, and SD-7 would be technically implementable, and resources, equipment, and materials would be readily available for this purpose. However, all of these alternatives would be fairly difficult to implement because dredging and capping and, to a lesser extent, barge dewatering or on-shore treatment of dewatering fluid would be technically challenging in the congested and restrictive

environment of the Lower Subase. Alternative SD-4 would be somewhat less difficult to implement than the other alternatives because it would only require a relatively small amount and dredging and capping. Alternative SD-3 would be slightly more difficult to implement than Alternative SD-4 because it would include the same dredging and capping in addition to on-shore treatment of dewatering fluid. Alternative SD-7 would be slightly more difficult to implement than Alternative SD-3 because it would include dredging of much greater areas and volumes of sediment. Alternative SD-6 would be the most difficult to implement because it would include dredging of a large volume of sediment and on-shore treatment of a large volume of dewatering effluent.

The administrative aspects of Alternatives SD-3, SD-4, SD-6, and SD-7 would be simple to implement. All four alternatives would require construction permits issued by NSB-NLON DPW and documentation of off-site transportation and disposal of sediment. Alternatives SD-4 and SD-7 would also require documentation of the transportation and disposal of dewatering fluid, and Alternatives SD-3 and SD-6 would have to meet the substantive requirements of federal and State water discharge regulations to discharge treated dewatering fluid to the Thames River. The long-term administrative implementation of Alternatives SD-6 and SD-7 would be slightly easier than that of Alternatives SD-3 and SD-4 because they would not require preparation of a LUC RD and long-term enforcement of LUCs.

For Alternatives SD-3 and SD-4, as long as access to the capped area is controlled by the Navy, these LUCs would be implemented in accordance with a post-ROD LUC RD that will be prepared by the Navy as the LUC component of the remedy, in coordination with the State, which owns the subtidal area. If the property is transferred out of federal ownership, the LUCs would be converted into deed restrictions, which would comply with State recording standards. If the property is transferred to another federal agency, the Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement imposed in the ROD and described in the LUC RD to keep such LUCs in place until such time as they are no longer required. Monitoring of compliance with LUCs will occur at least yearly.

5.21.7 Cost

The capital and O&M costs and NPW of the sediment alternatives are as follows. Detailed cost estimates are provided in Appendix E.

Alternative	Capital ($)	NPW of O&M ($)	NPW ($)
SD-1	0	55,000 (30 years)	55,000 (30 years)
SD-3	5,716,000	398,000 (30 years)	6,114,000 (30 years)
SD-4	5,289,000	396,000 (30 years)	5,685,000 (30 years)

Alternative	Capital ($)	NPW of O&M ($)	NPW ($)
SD-6	8,165,000	0	8,165,000 (1 year)
SD-7	7,359,000	0	7,359,000 (1 year)

5.22 SUMMARY OF COMPARISON OF SEDIMENT REMEDIAL ALTERNATIVES FOR ZONE 4 AND OUTER PIER 1

Table 5-23 summarizes the comparative analysis of sediment remedial alternatives for Zone 4 and Outer Pier 1.

5.23 COMPARISON OF LNAPL REMEDIAL ALTERNATIVES FOR ZONE 1

The following LNAPL remedial alternatives are compared in this section:

Alternative LN-1: Skimming, Off-Site Disposal (Incineration or Recycling), LUCs (Institutional Controls), and Monitoring.

Alternative LN-2: In-Situ Treatment (Enhanced Bioremediation), LUCs (Institutional Controls), and Monitoring.

5.23.1 Overall Protection of Health and Environment

Alternatives LN-1 and LN-2 would be protective of human health and the environment.

Alternative LN-1 would be protective because it would actively remove LNAPL through skimming, prevent accidental exposure to LNAPL through LUCs regulating excavation, and warn of potential off-site migration of LNAPL through monitoring. Alternative LN-2 would be more protective than Alternative LN-1 because in-situ enhanced bioremediation would not only remove LNAPL faster than skimming, but it would also remediate the TPH-impregnated soil that could act as a source of additional LNAPL release.

Alternatives LN-1 and LN-2 would achieve LNAPL Remedial Goals Nos. 1 and 3 at completion and LNAPL Remedial Goal No. 2 in the longer term.

5.23.2 Long-Term Effectiveness and Permanence

Alternatives LN-1 and LN-2 would be long-term effective and permanent.

The skimming, LUCs, and monitoring of Alternative LN-2 would constitute effective and permanent means of removing LNAPL at a reasonable rate while preventing accidental exposure to remaining LNAPL and verifying that remaining LNAPL is not migrating off site.

Alternative LN-2 would be more effective than Alternative LN-2 because its in-situ enhanced bioremediation would not only remove LNAPL faster than skimming, but it would also remove the associated TPH-impregnated soil that could constitute a source of additional LNAPL release.

5.23.3 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative LN-1 would not reduce the toxicity, mobility, and volume of LNAPL through treatment.

Alternatives LN-2 would reduce the toxicity, mobility, and volume of LNAPL through enhanced bioremediation. An estimated 29,600 pounds (or 3,900 gallons) of LNAPL and an estimated 91,700 pounds of associated soil-bound TPH would be permanently and irreversibly removed from Zone 1 by this alternative.

5.23.4 Short-Term Effectiveness

Implementation of Alternatives LN-1 and LN-2 could result in short-term risks to on-site workers as a result of exposure to contamination. The potential for exposure would be moderate for Alternative LN-1 and significant for Alternative LN-2 because of the increasing level of activities. However, these risks would be adequately mitigated for both alternatives by the wearing of appropriate PPE and by compliance with OSHA regulations and with site-specific health and safety procedures.

Alternative LN-1 could have an adverse impact on the surrounding community and the environment as a result of off-site transportation of removed LNAPL. However, this impact would be adequately mitigated by adherence to spill prevention procedures and by compliance with DOT regulations.

Alternatives LN-1 could be implemented within approximately 6 months and would meet LNAPL Remedial Goals Nos. 1 and 3 upon implementation. Alternative LN-1 would also remove LNAPL and achieve LNAPL Remedial Goal No. 2 within an estimated 10 to 11 years. However, additional LNAPL could be released beyond that time frame by the soil-bound TPH. LNAPL removal would be verified through monitoring. Alternative LN-2 could be implemented within approximately 6 months and would achieve LNAPL Remedial Goals Nos. 1 and 3 upon implementation and LNAPL Remedial Goal No. 2 within 8 to 10 years.

5.23.5 Implementability

Alternatives LN-1 and LN-2 would be technically implementable, and resources, equipment, and materials would be readily available for this purpose. From the technical point of view, Alternative LN-1 would be

easiest to implement, requiring only the installation of a moderate amount of skimming wells, periodic collection and off-site disposal of LNAPL, and performance of long-term monitoring. Alternative LN-2 would be somewhat harder to implement, requiring the installation and operation of a groundwater recirculation system to inject large quantities of oxygen, nutrients, and bacterial culture and performance of long-term monitoring.

The administrative aspects of Alternatives LN-1 and LN-2 would be simple to implement. The administrative aspects of Alternative LN-1 would be easiest to implement, requiring preparation of a LUC RD and long-term enforcement of LUCs. The administrative aspects of Alternative LN-2 would be slightly harder to implement because, in addition to the preparation of a LUC RD and long-term enforcement of LUCs, this alternative would require a construction permit issued by NSB-NLON DPW.

Transfer of SUBASENLON to private, non-federal ownership is not anticipated in the near term or in future years. However, imposing a deed restriction to maintain LUCs if the property were transferred from federal ownership would not be difficult. As part of the property transfer process, a deed would be drawn up to include all necessary land control restrictions to be imposed on the new owner, and would be recorded in accordance with state laws. If the property is transferred to another federal agency, Navy would ensure the federal agency taking over the property was formally made aware of the (1) environmental status of the installation, to include all LUCs, and (2) the requirement described in the LUC RD to keep such LUCs in place until such time as they are no longer required.

5.23.6 Cost

The capital and O&M costs and NPW of the LNAPL alternatives are as follows. Detailed cost estimates are provided in Appendix E.

Alternative	Capital ($)	NPW of O&M ($)	NPW ($)
LN-1	337,000	1,543,000 (30 years)	1,880,000 (30 years)
LN-2	713,000	1,565,000 (10 years)	2,278,000 (10 years)

5.24 SUMMARY OF COMPARISON OF LNAPL REMEDIAL ALTERNATIVES FOR ZONE 1

Table 5-24 summarizes the comparative analysis of LNAPL remedial alternatives for Zone 1.

TABLE 5-1

COMPARATIVE ASSESSMENT OF SOIL ALTERNATIVES COMPLIANCE WITH CHEMICAL-SPECIFIC ARARs AND TBCs
ZONES 1 AND 5
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR				
		Alternatives S-1.1, S-5.1, and S-6.1 No Action	**Alternatives S-1.2 and S-5.2 LUCs (Engineering and Institutional) and Monitoring**	**Alternatives S-1.3 and S-5.3 In-Situ Treatment (Enhanced Bioremediation) to Meet I/C PRGs, LUCs (Engineering and Institutional), and Monitoring**	**Alternatives S-1.4 and S-5.4 Excavation to Meet I/C PRGs, LUCs (Engineering and Institutional) and Monitoring**	**Alternatives S-1.5 and S-5.5 Excavation to Meet Residential PRGs**
FEDERAL						
Cancer Slope Factors (CSFs)	United States Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) and others	To be considered (TBC). Would not comply. The No Action alternatives would not maintain building foundations and paved areas, or regulate the disturbance of contaminated soil, or prevent hypothetical future residential development, either one of which could result in unacceptable risks. In addition, No Action would not warn of potential migration of soil chemicals of concern (COCs) to groundwater which could also result in unacceptable risk from exposure.	TBC. Would comply. The land use controls (LUCs) of Alternatives S-1.2 and S-5.2 would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable I/C carcinogenic risks. In addition, the monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-1.3 and S-5.3 would include in-situ enhanced bioremediation that would remove COCs that could contribute to unacceptable I/C carcinogenic risks and migrate to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-1.4 and S-5.4 would include excavation and off-site treatment and disposal of soil that could result in unacceptable I/C carcinogenic risks and contribute to the migration of COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-1.5 and S-5.5 would include excavation and off-site treatment and disposal of soil which could result in unacceptable residential carcinogenic risks and contribute to the migration of COCs to groundwater.
Reference Doses (RfDs)	EPA IRIS and others	TBC. Would not comply. The No Action alternatives would not maintain building foundations and paved areas, or regulate the disturbance of contaminated soil, or prevent hypothetical future residential development, either one of which could result in unacceptable risks. In addition, No Action would not warn of potential migration of soil COCs to groundwater which could also result in unacceptable risk from exposure.	TBC. Would comply. The LUCs of Alternatives S-1.2 and S-5.2 would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable I/C non-carcinogenic risks. In addition, the monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-1.3 and S-5.3 would include in-situ enhanced bioremediation which would remove COCs that could contribute in unacceptable I/C non-carcinogenic risks and migrate to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-1.4 and S-5.4 would include excavation and off-site treatment and disposal of soil that could result in unacceptable I/C non-carcinogenic risks and contribute to the migration of COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-1.5 and S-5.5 would include excavation and off-site treatment and disposal of soil which could result in unacceptable residential non-carcinogenic risks and contribute to the migration of COCs to groundwater.

TABLE 5-1

COMPARATIVE ASSESSMENT OF SOIL ALTERNATIVES COMPLIANCE WITH CHEMICAL-SPECIFIC ARARs AND TBCs
ZONES 1 AND 5
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR				
		Alternatives S-1.1, S-5.1, and S-6.1 No Action	**Alternatives S-1.2 and S-5.2 LUCs (Engineering and Institutional) and Monitoring**	**Alternatives S-1.3 and S-5.3 In-Situ Treatment (Enhanced Bioremediation) to Meet I/C PRGs, LUCs (Engineering and Institutional), and Monitoring**	**Alternatives S-1.4 and S-5.4 Excavation to Meet I/C PRGs, LUCs (Engineering and Institutional) and Monitoring**	**Alternatives S-1.5 and S-5.5 Excavation to Meet Residential PRGs**
FEDERAL (continued)						
Guidelines for Carcinogen Risk Assessment	EPA/630/P-03/001F (March 2005)	TBC. Would not comply. The No Action alternatives would not maintain building foundations and paved areas, or regulate the disturbance of contaminated soil, or prevent hypothetical future residential development, either one of which could result in unacceptable risks. In addition, No Action would not warn of potential migration of soil COCs to groundwater which could also result in unacceptable risk from exposure.	TBC. Would comply. The LUCs of Alternatives S-1.2 and S-5.2 would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable I/C carcinogenic risks. In addition, the monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-1.3 and S-5.3 would include in-situ enhanced bioremediation which would remove COCs that could contribute to unacceptable I/C carcinogenic risks and migrate to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-1.4 and S-5.4 would include excavation and off-site treatment and disposal of soil that could result in unacceptable I/C carcinogenic risks and contribute to the migration of COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-1.5 and S-5.5 would include excavation and off-site treatment and disposal of soil which could result in unacceptable residential carcinogenic risks and contribute to the migration of COCs to groundwater.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	EPA/630/R-03/003F (March 2005)	TBC. Would not comply. The No Action alternatives would not maintain building foundations and paved areas, or regulate the disturbance of contaminated soil, or prevent hypothetical future residential development, either one of which could result in unacceptable risks. In addition, No Action would not warn of potential migration of soil COCs to groundwater which could also result in unacceptable risk from exposure.	TBC. Would comply. The LUCs of Alternatives S-1.2 and S-5.2 would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable I/C carcinogenic risks. In addition, the monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-1.3 and S-5.3 would include in-situ enhanced bioremediation which would remove COCs that could contribute to unacceptable I/C carcinogenic risks and migrate to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-1.4 and S-5.4 would include excavation and off-site treatment and disposal of soil that could result in unacceptable I/C carcinogenic risks and contribute to the migration of COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-1.5 and S-5.5 would include excavation and off-site treatment and disposal of soil which could result in unacceptable residential carcinogenic risks and contribute to the migration of COCs to groundwater.

TABLE 5-1

COMPARATIVE ASSESSMENT OF SOIL ALTERNATIVES COMPLIANCE WITH CHEMICAL-SPECIFIC ARARs AND TBCs
ZONES 1 AND 5
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR				
		Alternatives S-1.1, S-5.1, and S-6.1 No Action	**Alternatives S-1.2 and S-5.2 LUCs (Engineering and Institutional) and Monitoring**	**Alternatives S-1.3 and S-5.3 In-Situ Treatment (Enhanced Bioremediation) to Meet I/C PRGs, LUCs (Engineering and Institutional), and Monitoring**	**Alternatives S-1.4 and S-5.4 Excavation to Meet I/C PRGs, LUCs (Engineering and Institutional) and Monitoring**	**Alternatives S-1.5 and S-5.5 Excavation to Meet Residential PRGs**
FEDERAL (continued)						
Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil	EPA-540-R-03-001, OSWER Dir #9285.7-54 (January 2003)	TBC. Would not comply. The No Action alternatives would not meet this standard because potential lead risk would not be addressed.	TBC. Would comply. The LUCs of Alternatives S-1.2 and S-5.2 would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risk from exposure to lead contaminated soil. In addition, the monitoring of these same alternatives would warn of potential migration of lead from soil to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-1.3 and S-5.3 would include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks from exposure to lead contaminated soil. The monitoring of these same alternatives would also warn of potential migration of lead from soil to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-1.4 and S-5.4 would meet this standard because potential lead risk from adult exposure would be addressed through excavation and off-site treatment and disposal of all lead-contaminated media exceeding risk levels. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks from exposure to lead contaminated soil. The monitoring of these same alternatives would also warn of potential migration of lead from soil to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-1.5 and S-5.5 would meet this standard because potential lead risk from adult exposure would be addressed through excavation and off-site treatment and disposal of all lead-contaminated media exceeding risk levels.
STATE OF CONNECTICUT						
Remediation Standard Regulations (RSRs)	Connecticut General Statutes (CGS) §22a-133k; Regulations of Connecticut State Agencies (RCSA) §22a-133k - 1 through 3	Applicable. The No Action alternatives would not remedy current exceedances of industrial/commercial (I/C) Direct Exposure Criteria (DECs) and Pollutant Mobility Criteria (PMCs). In addition, the No Action alternatives would not prevent hypothetical future residential development which would result in exceedances of Residential DECs.	Applicable. Alternatives S-1.2 and S-5.2 would not fully comply with the DECs and PMCs of these regulations because some of the soil with concentrations than the PRGs cannot be classified as inaccessible or environmentally isolated. However, the LUCs of these alternatives would minimize risks from these exceedances and prevent even greater risks from residential development. In addition, the groundwater monitoring from these alternatives would warn of potential migration of soil COCs to groundwater. A variance might have to be negotiated with the Connecticut Department of Environmental Protection (CTDEP).	Applicable. Would comply. Alternatives S-1.3 and S-5.3 would include in-situ enhanced bioremediation which would remedy current exceedances of I/C DECs and PMCs. These alternatives would also include LUCs which would prevent risk from exposure under residential site use and monitoring which would warn of the potential migration of soil COCs to groundwater.	Applicable. Would comply. Alternatives S-1.4 and S-5.4 would include excavation and off-site treatment and disposal which would remedy current exceedances of I/C DECs and PMCs. These alternatives would also include LUCs which would prevent risk from exposure under residential site use and monitoring which would warn of the potential migration of soil COCs to groundwater.	Applicable. Would comply. Alternatives S-1.5 and S-5.5 would include excavation and off-site treatment and disposal of contaminated soil which would remedy current exceedances of I/C DECs and PMCs and hypothetical future exceedances of Residential DECs and PMCs.

TABLE 5-2

COMPARATIVE ASSESSMENT OF SOIL ALTERNATIVES COMPLIANCE WITH LOCATION-SPECIFIC ARARs AND TBCs
ZONES 1 AND 5
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR			
		Alternative 1.2 LUCs (Engineering and Institutional) and Monitoring	**Alternative S-1.3 In-Situ Treatment (Enhanced Bioremediation) to Meet I/C PRGs, LUCs (Engineering and Institutional), and Monitoring**	**Alternative S-1.4 Excavation to Meet I/C PRGs, LUCs (Engineering and Institutional) and Monitoring**	**Alternative S-1.5 Excavation to Meet Residential PRGs**
FEDERAL					
Fish and Wildlife Coordination Act	16 USC Part 661 *et. seq.*, 40 CFR 122	Applicable. Would comply. The groundwater monitoring of Alternative S-1.2 would provide adequate warning of the potential migration of soil chemicals of concern (COCs) to groundwater and surface water. Federal resource agencies would be consulted to prevent, mitigate, or compensate for loss of fish and wildlife.	Applicable. Would comply. The in-situ enhanced bioremediation of Alternative S-1.3 would remove soil COCs and prevent their potential migration to groundwater or surface water which could eventually impact fish and wildlife in the Thames River. In addition, the monitoring of these alternatives would provide warning of the potential migration of COCs from soil to groundwater and surface water. Federal resource agencies would be consulted to prevent, mitigate, or compensate for loss of fish and wildlife.	Applicable. Would comply. The excavation and off-site treatment and disposal of Alternative S-1.4 would remove soil COCs and prevent their potential migration to groundwater or surface water which could eventually impact fish and wildlife in the Thames River. In addition, the monitoring of these alternatives would provide warning of the potential migration of COCs from soil to groundwater and surface water. Federal resource agencies would be consulted to prevent, mitigate, or compensate for loss of fish and wildlife.	Applicable. Would comply. The excavation and off-site treatment and disposal of Alternative S-1.5 would remove soil COCs and prevent their potential migration to groundwater or surface water which could eventually impact fish and wildlife in the Thames River. Federal resource agencies would be consulted to prevent, mitigate, or compensate for loss of fish and wildlife.
Coastal Zone Management Act	16 USC Parts 1451 *et. seq.*	Applicable. Would comply. The monitoring activities and establishment and long-term maintenance of the cover system of Alternative S-1.2 would comply with the substantive requirements of this act.	Applicable. Would comply. The in-situ enhanced bioremediation and monitoring activities of Alternative S-1.3 would comply with the substantive requirements of this act.	Applicable. Would comply. The excavation, off-site treatment and disposal, and monitoring activities of Alternative S-1.4 would comply with the substantive requirements of this act.	Applicable. Would comply. The excavation and off-site treatment and disposal of Alternative S-1.5 would comply with the substantive requirements of this act.
Floodplain Management and Protection of Wetlands	44 CFR 9	Relevant and appropriate. The monitoring activities and establishment and long-term maintenance of the cover system of Alternative S-1.2 conducted within the 500-year floodplain of the Thames River or within federal jurisdictional wetlands will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.	Relevant and appropriate. The in-situ enhanced bioremediation and monitoring activities of Alternative S-1.3 conducted within the 500-year floodplain of the Thames River or within federal jurisdictional wetlands will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.	Relevant and appropriate. The excavation and monitoring activities of Alternative S-1.4 conducted within the 500-year floodplain of the Thames River or within federal jurisdictional wetlands will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.	Relevant and appropriate The excavation of Alternative S-1.5 conducted within the 500-year floodplain of the Thames River or within federal jurisdictional wetlands will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.
STATE OF CONNECTICUT					
Connecticut Coastal Management Act	Regulations of Connecticut State Agencies (RCSA) §22a-90 to 112	Applicable. Would comply. The monitoring activities and establishment and long-term maintenance of the cover system of Alternative S-1.2 would comply with the substantive requirements of this act.	Applicable. Would comply. The in-situ enhanced bioremediation and monitoring activities of Alternative S-1.3 would comply with the substantive requirements of this act.	Applicable. Would comply. The excavation, off-site treatment and disposal, and monitoring activities of Alternative S-1.4 would comply with the substantive requirements of this act.	Applicable. Would comply. The excavation and off-site treatment and disposal of Alternative S-1.5 would comply with the substantive requirements of this act.

TABLE 5-2

COMPARATIVE ASSESSMENT OF SOIL ALTERNATIVES COMPLIANCE WITH LOCATION-SPECIFIC ARARs AND TBCs
ZONES 1 AND 5
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR			
		Alternative 1.2 LUCs (Engineering and Institutional) and Monitoring	**Alternative S-1.3 In-Situ Treatment (Enhanced Bioremediation) to Meet I/C PRGs, LUCs (Engineering and Institutional), and Monitoring**	**Alternative S-1.4 Excavation to Meet I/C PRGs, LUCs (Engineering and Institutional) and Monitoring**	**Alternative S-1.5 Excavation to Meet Residential PRGs**
STATE OF CONNECTICUT (Continued)					
Tidal Wetlands and Watercourses	RCSA §22a-30-1 through 17	Applicable. Would comply. The monitoring activities and establishment and long-term maintenance of the cover system of Alternative S-1.2 would be managed to prevent erosion and other disturbance to tidal wetlands and the Thames River.	Applicable. Would comply. The in-situ enhanced bioremediation and monitoring activities of Alternative S-1.3 would be managed to prevent erosion and other disturbance to tidal wetlands.	Applicable. Would comply. The excavation, off-site treatment and disposal, and monitoring activities of Alternative S-1.4 would be managed to prevent erosion and other disturbance to tidal wetlands.	Applicable. Would comply. The excavation and off-site treatment and disposal of Alternative S-1.5 would be managed to prevent erosion and other disturbance to tidal wetlands.
Flood Management Regulations	(RCSA 25-68h-1 through 25-68h-3)	Relevant and appropriate. Would comply. The monitoring activities and establishment and long-term maintenance of the cover system of Alternative S-1.2 would consider the potential for disturbance of floodplains. Any work in flood plains would comply with the substantive provisions of the regulations.	Relevant and appropriate. Would comply. The in-situ enhanced bioremediation and monitoring activities of Alternative S-1.3 would consider the potential for disturbance of floodplains. Any work in flood plains would comply with the substantive provisions of the regulations.	Relevant and appropriate. Would comply. The excavation, off-site treatment and disposal, and monitoring activities of Alternative S-1.4 would consider the potential for disturbance of floodplains. Any work in flood plains would comply with the substantive provisions of the regulations.	Relevant and appropriate. Would comply. The excavation and dewatering activities of Alternative S-1.5 would consider the potential for disturbance of floodplains. Any work in flood plains would comply with the substantive provisions of the regulations.
Connecticut Endangered Species Act	CGS §26-303 through 314	Applicable. Would comply. The monitoring activities and establishment and long-term maintenance of the cover system of Alternative S-1.2 would not disturb aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon and would address risks posed by potential migration of soil COCs to the Thames River.	Applicable. Would comply. The in-situ enhanced bioremediation and monitoring activities of Alternatives Alternative S-1.3 would not disturb aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon and would address risks posed by potential migration of soil COCs to the Thames River.	Applicable. Would comply. The excavation, off-site treatment and disposal, and monitoring activities of Alternative S-1.4 would not disturb aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon and would address risks posed by potential migration of soil COCs to the Thames River.	Applicable. Would comply. The excavation, discharge of treated water, and off site treatment and disposal activities associated with Alternative S-1.5 would not cause disturbance to aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon.

TABLE 5-3

COMPARATIVE ASSESSMENT OF SOIL ALTERNATIVES COMPLIANCE WITH ACTION-SPECIFIC ARARs AND TBCs
ZONES 1 AND 5
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR			
		Alternative S-1.2 LUCs (Engineering and Institutional) and Monitoring	**Alternative S-1.3 In-Situ Treatment (Bioremediation) to Meet I/C PRGs, LUCs (Engineering and Institutional), and Monitoring**	**Alternative S-1.4 Excavation to Meet I/C PRGs, LUCs (Engineering and Institutional) and Monitoring**	**Alternative S-1.5 and S-5.5 Excavation to Meet Residential PRGs**
FEDERAL					
Clean Water Act, Section 402, National Pollution Discharge Elimination System (NPDES)	33 USC 1342; 40 CFR 122 through 125	Applicable. Would comply. The establishment or maintenance of the cover system of Alternative S-1.2 would be performed in accordance with the stormwater requirements of these standards.	Applicable. Would comply. Any construction activities during implementation of Alternative S-1.3 would be performed in accordance with the stormwater requirements of these standards.	Applicable. Would comply. Any construction activities during implementation of Alternative S-1.4 would be performed in accordance with the stormwater requirements of these standards.	Applicable. Would comply. Alternatives S-1.5 and S-5.5 would include on-site dewatering of soil excavated below the water table before transportation of that soil for off-site treatment and disposal. The water generated by this soil dewatering would be treated to meet the standards of this act prior to discharge to the Thames River.
Clean Air Act (CAA), National Emissions Standards for Hazardous Air Pollutants (NESHAPs)	42 USC §12(b)(1); 40 C.F.R. Part 61	Applicable. Would comply. Activities during the establishment or maintenance of the cover system that would generate dust and air pollutants would comply with the substantive requirements of these regulations.	Not applicable.	Applicable. Would comply. The soil excavated as part of Alternative S-1.4 be performed so as to minimize fugitive emissions and would comply with the substantive requirements of these regulations.	Applicable. Would comply. Alternatives S-1.5 and S-5.5 would be performed so as to minimize fugitive emissions and would comply with the substantive requirements of these regulations.
RCRA, Interim Status TSDF Standards, Chemical, Physical and Biological Treatment	40 C.F.R. § 265.401(b)	Not applicable.	Relevant and Appropriate, Would comply. No reagents would be used in the in-situ bioremediation treatment of Alternative S-1.3 that could adversely affect the integrity of the system. In addition, inspections would be performed to ensure the treatment system is operating correctly.	Not applicable.	Not applicable.
STATE OF CONNECTICUT					
Hazardous Waste Management: Generator and Handler Requirements, Listing and Identification	Regulations of Connecticut State Agencies (RCSA) § 22a-449(c) 100-101	Applicable. Would comply. No significant excavation would be part of the monitoring of Alternative S-1.2. However, excavated soil would be tested and any soil identified as hazardous would be managed in accordance with these regulations.	Applicable. Would comply. Soil excavated as part of the in-situ bioremediation and monitoring of Alternative S-1.3 would be tested. Any soil identified as hazardous would be managed in accordance with these regulations. Confirmatory sampling would determine whether any soil with hazardous characteristic is left in place following treatment.	Applicable. Would comply. The soil excavated as part of Alternative S-1.4 would be tested and any soil identified as hazardous would be managed in accordance with these regulations. Confirmatory sampling would determine whether any soil with hazardous characteristic is left in place following excavation.	Applicable. Would comply. Would comply. Excavated soil and dewatering waste generated by Alternatives S-1.5 and S-5.5 would be tested for hazardous characteristics. Any soil or waste identified as hazardous would be handled and disposed in compliance with these standards.
Hazardous Waste Management: Generator Standards	RCSA § 22a-449(c)-102	Applicable. Would comply. Any hazardous waste that would be generated from the monitoring activities and establishment and long-term maintenance of the cover system of Alternative S-1.2 would be handled and disposed in compliance with these standards.	Applicable. Would comply. Any hazardous waste that would be generated from the in-situ bioremediation and monitoring activities of Alternative S-1.3 would be handled and disposed in compliance with these standards.	Applicable. Would comply. Soil excavated as part of Alternative S-1.4 would be tested for hazardous characteristics. Any excavated soil identified as hazardous would be handled and disposed in compliance with these standards.	Applicable. Would comply. Would comply. Excavated soil and dewatering waste generated by Alternatives S-1.5 and S-5.5 would be tested for hazardous characteristics. Any soil or waste identified as hazardous would be handled and disposed in compliance with these standards.

TABLE 5-3

COMPARATIVE ASSESSMENT OF SOIL ALTERNATIVES COMPLIANCE WITH ACTION-SPECIFIC ARARs AND TBCs
ZONES 1 AND 5
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR			
		Alternative S-1.2 LUCs (Engineering and Institutional) and Monitoring	**Alternative S-1.3 In-Situ Treatment (Bioremediation) to Meet I/C PRGs, LUCs (Engineering and Institutional), and Monitoring**	**Alternative S-1.4 Excavation to Meet I/C PRGs, LUCs (Engineering and Institutional) and Monitoring**	**Alternative S-1.5 and S-5.5 Excavation to Meet Residential PRGs**
STATE OF CONNECTICUT (continued)					
Water Pollution Control	RCSA §22a-430-3 and 4	Not applicable.	Applicable. Would comply. The in-situ bioremediation and monitoring activities of Alternative S-1.3 would be performed in a manner that would meet the substantive environmental criteria contained in these regulations.	Not applicable.	Applicable. Would comply. The water generated by soil dewatering operations of Alternatives S-1.5 and S-5.5 would be treated to comply with these rules prior to discharge to the Thames River.
Water Quality Standards	Regulations Promulgated under Connecticut General Statutes (CGS) §22a-426	Applicable. Would comply. The long-term groundwater monitoring of Alternative S-1.2 would ensure that groundwater quality standards for GB groundwater would be maintained. Monitoring would ensure that stormwater and groundwater standards were being met.	Applicable. Would comply. The in-situ bioremediation and long-term groundwater monitoring of Alternative S-1.3 would ensure that groundwater quality standards for GB groundwater would be maintained. Monitoring would ensure that stormwater and groundwater standards were being met.	Applicable. Would comply. The excavation, off-site treatment and disposal, and long-term groundwater monitoring of Alternative S-1.4 would ensure that groundwater quality standards for GB groundwater would be maintained. Monitoring would ensure that stormwater and groundwater standards were being met.	Applicable. Would comply. The water generated by the soil dewatering operations of Alternatives S-1.5 and S-5.5 would be treated to comply with these rules prior to discharge to the Thames River. Monitoring would ensure that stormwater and groundwater standards were being met.
Air Pollution Control	RCSA §22a-174 1-20	Applicable. Would comply. The monitoring activities and establishment and long-term maintenance of the cover system of Alternative S-1.2 would be performed so as to minimize fugitive emissions and would comply with these regulations.	Applicable. Would comply. The in-situ bioremediation and monitoring activities of Alternative S-1.3 would be performed so as to minimize fugitive emissions and would comply with these regulations.	Applicable. Would comply. The excavation, off-site treatment and disposal, and long-term groundwater monitoring of Alternative S-1.4 would be performed so as to minimize fugitive emissions and would comply with these regulations.	Applicable. The excavation activities associated with Alternatives S-1.5 and S-5.5 would be performed so as to minimize fugitive emissions and would comply with these regulations.
Connecticut Guidelines for Soil Erosion and Sediment Control	Connecticut Council on Soil and Water Conservation	To Be Considered (TBC). Would comply. No significant excavation would be part of the monitoring of Alternative S-1.2. Erosion and sedimentation control measures would be implemented as required.	TBC. Would comply. Any excavation activities associated with the in-situ bioremediation and monitoring of Alternative S-1.3 would include an appropriate erosion and sedimentation control program that would comply with this guidance.	TBC. Would comply. Excavation activities associated with Alternative S-1.4 would include an appropriate erosion and sedimentation control program that would comply with this guidance.	TBC. The excavation activities associated with Alternatives S-1.5 and S-5.5 would include an appropriate erosion and sedimentation control program that would comply with this guidance.
Underground Injection Control	RCSA § 22a-430-3, 4, and 8	Not applicable.	Applicable. The subsurface injection of chemical substances of Alternative S-1.3 would comply with these regulations.	Not applicable.	Not applicable.

TABLE 5-4

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 1 SOIL REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-1.1 No Action	Alternative S-1.2 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-1.3 In-Situ Treatment (Enhanced Bioremediation) to Meet I/C DECs and PMCs, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-1.4 Excavation to Meet I/C DECs and PMCs, Off-Site (LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-1.5 Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (LTTD, Landfilling, and Incineration)
Overall Protection of Human Health and Environment	Not protective.	Protective.	More protective than Alternative S-1.2.	More protective than Alternative S-1.3.	Most protective.
Compliance with ARARs and TBCs					
Chemical-Specific	Would not comply.	Would comply.	Would comply.	Would comply.	Would comply.
Location-Specific	No location-specific ARARs.	Would comply.	Would comply.	Would comply.	Would comply.
Action-Specific	Not applicable.	Would comply.	Would comply.	Would comply.	Would comply.
Long-Term Effectiveness and Permanence	Not effective.	Effective.	More effective than Alternative S-1.2.	More effective than Alternative S-1.3.	Most effective.
Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment	There is no treatment.	There is no treatment.	Would reduce toxicity, mobility, and volume of PAHs by in-situ enhanced bioremediation. Total of 2,800 cy treated.	There is no treatment.	There is no treatment.

TABLE 5-4

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 1 SOIL REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-1.1 No Action	Alternative S-1.2 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-1.3 In-Situ Treatment (Enhanced Bioremediation) to Meet I/C DECs and PMCs, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-1.4 Excavation to Meet I/C DECs and PMCs, Off-Site (LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-1.5 Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (LTTD, Landfilling, and Incineration)
Short-Term Effectiveness	No short-term risks. Would not achieve soil RAOs.	Short-term risks to address: Worker exposure during GW sampling; No impacts to environment or community. Three months to implement and achieve soil RAOs. Minimum potential for short-term risks. Three months to implement and achieve soil RAOs.	Short-term risks to address: Worker exposure during treatment and GW sampling; No impacts to environment or community. Six months to implement and achieve soil RAOs. Would meet Zone 1 soil PRGs for I/C direct exposure and pollutant mobility within 3 to 5 years.	Short-term risks to address: Worker exposure during excavation; Transport of contaminated soil through community; Dust from excavation. Six months to implement and achieve soil RAOs. Would meet Zone 1 soil PRGs for I/C direct exposure and pollutant mobility at completion.	Short-term risks to address: Worker exposure during excavation; Transport of contaminated soil through community; Dust from excavation. Nine months to implement and achieve soil RAOs. Would meet Zone 1 soil PRGs for residential direct exposure and pollutant mobility at completion.

TABLE 5-4

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 1 SOIL REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-1.1 No Action	Alternative S-1.2 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-1.3 In-Situ Treatment (Enhanced Bioremediation) to Meet I/C DECs and PMCs, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-1.4 Excavation to Meet I/C DECs and PMCs, Off-Site (LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-1.5 Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (LTTD, Landfilling, and Incineration)
Implementability	Needs only 5-year reviews.	Issues include: Maintaining paved areas and MWs; No base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Treatment may interfere with base activities; Underground utilities may interfere with treatment; Treatability tests needed; Maintaining paved areas and MWs; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Excavation may interfere with base activities; Underground utilities may interfere with excavation; Maintaining paved areas and MWs; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Shoring required to protect buildings; Dewatering system required; water treatment and disposal system required; Base construction permit needed; Resources are readily available.
Costs:					
Capital	$0	$70,000	$1,186,000	$1,412,000	$20,195,000
O&M NPW (Years)	$55,000 (30)	$415,000 (30)	$421,000 (30)	$416,000(30)	$0
NPW (Years)	$55,000 (30)	$485,000 (30)	$1,607,000 (30)	$1,828,000 (30)	$20,195,000 (1)

TABLE 5-4

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 1 SOIL REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

NOTES:

ARARs	Applicable or Relevant and Appropriate Requirements
cy	Cubic yards
DECs	Direct Exposure Criteria (Connecticut)
I/C	Industrial/commercial
LTTD	Low-temperature thermal desorption
LUCs	Land use controls
NPW	Net present worth
O&M	Operation and maintenance
PAHs	Polycyclic aromatic hydrocarbons
PMCs	Pollutant Mobility Criteria (Connecticut)
PRGs	Preliminary Remedial Goals
RAOs	Remedial Action Objectives
TBCs	To be considered (criteria)

TABLE 5-5

COMPARATIVE ASSESSMENT OF SOIL ALTERNATIVES COMPLIANCE WITH CHEMICAL-SPECIFIC ARARs AND TBCs
ZONES 2, 3, 4, AND 7
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR					
		Alternatives S-2.1, S-3-1, S-4-1, and S-7.1 No Action	**Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 LUCs and Monitoring**	**Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 Capping to Meet I/C PRGs, LUCs, and Monitoring**	**Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 In-Situ Treatment to Meet I/C PRGs, LUCs, and Monitoring**	**Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 Excavation to Meet I/C PRGs, Off-Site Treatment and Disposal, LUCs, and Monitoring**	**Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 Excavation to Meet Residential PRGs and Off-Site Treatment and Disposal**
FEDERAL							
Cancer Slope Factors (CSFs)	United States Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) and others	To be considered (TBC). Would not comply. The No Action alternatives would not maintain building foundations and paved areas, or regulate the disturbance of contaminated soil, or prevent hypothetical future residential development, either one of which could result in unacceptable risks. In addition, No Action would not warn of potential migration of soil chemicals of concern (COCs) to groundwater which could also result in unacceptable risk from exposure.	TBC. Would comply. The land use controls (LUCs) of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable I/C carcinogenic risks. In addition, the monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would include capping or removal of soil that could result in unacceptable I/C carcinogenic risks and contribute to the migration of soil COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would include in-situ chemical stabilization/ solidification of soil that could result in unacceptable I/C carcinogenic risks and contribute to the migration of soil COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would include excavation and off-site treatment and disposal of soil that could result in unacceptable I/C carcinogenic risks and contribute to the migration of COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would include excavation and off-site treatment and disposal of soil which could result in unacceptable residential carcinogenic risks and contribute to the migration of COCs to groundwater.
Reference Doses (RfDs)	EPA IRIS and others	TBC. Would not comply. The No Action alternatives would not maintain building foundations and paved areas, or regulate the disturbance of contaminated soil, or prevent hypothetical future residential development, either one of which could result in unacceptable risks. In addition, No Action would not warn of potential migration of soil COCs to groundwater which could also result in unacceptable risk from exposure.	TBC. Would comply. The LUCs of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable I/C non-carcinogenic risks. In addition, the monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would include capping or removal of soil that could result in unacceptable I/C non-carcinogenic risks and contribute to the migration of soil COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would include in-situ chemical stabilization/ solidification of soil that could result in unacceptable I/C non-carcinogenic risks and contribute to the migration of soil COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would include excavation and off-site treatment and disposal of soil that could result in unacceptable I/C non-carcinogenic risks and contribute to the migration of COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would include excavation and off-site treatment and disposal of soil which could result in unacceptable residential non-carcinogenic risks and contribute to the migration of COCs to groundwater.

TABLE 5-5

COMPARATIVE ASSESSMENT OF SOIL ALTERNATIVES COMPLIANCE WITH CHEMICAL-SPECIFIC ARARs AND TBCs
ZONES 2, 3, 4, AND 7
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR					
		Alternatives S-2.1, S-3-1, S-4-1, and S-7.1 No Action	**Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 LUCs and Monitoring**	**Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 Capping to Meet I/C PRGs, LUCs, and Monitoring**	**Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 In-Situ Treatment to Meet I/C PRGs, LUCs, and Monitoring**	**Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 Excavation to Meet I/C PRGs, Off-Site Treatment and Disposal, LUCs, and Monitoring**	**Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 Excavation to Meet Residential PRGs and Off-Site Treatment and Disposal**
FEDERAL (continued)							
Guidelines for Carcinogen Risk Assessment	EPA/630/P-03/001F (March 2005)	TBC. Would not comply. The No Action alternatives would not maintain building foundations and paved areas, or regulate the disturbance of contaminated soil, or prevent hypothetical future residential development, either one of which could result in unacceptable risks. In addition, No Action would not warn of potential migration of soil COCs to groundwater which could also result in unacceptable risk from exposure.	TBC. Would comply. The LUCs of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable I/C carcinogenic risks. In addition, the monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would include capping or removal of soil that could result in unacceptable I/C carcinogenic risks and contribute to the migration of soil COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would include in-situ chemical stabilization/ solidification of soil that could result in unacceptable I/C carcinogenic risks and contribute to the migration of soil COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would include excavation and off-site treatment and disposal of soil that could result in unacceptable I/C carcinogenic risks and contribute to the migration of COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would include excavation and off-site treatment and disposal of soil which could result in unacceptable residential carcinogenic risks and contribute to the migration of COCs to groundwater.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	EPA/630/R-03/003F (March 2005)	TBC. Would not comply. The No Action alternatives would not maintain building foundations and paved areas, or regulate the disturbance of contaminated soil, or prevent hypothetical future residential development, either one of which could result in unacceptable risks. In addition, No Action would not warn of potential migration of soil COCs to groundwater which could also result in unacceptable risk from exposure.	TBC. Would comply. The LUCs of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable I/C carcinogenic risks. In addition, the monitoring of these same alternatives would warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would include capping or removal of soil that could result in unacceptable I/C carcinogenic risks and contribute to the migration of soil COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would include in-situ chemical stabilization/ solidification of soil that could result in unacceptable I/C carcinogenic risks and contribute to the migration of soil COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would include excavation and off-site treatment and disposal of soil that could result in unacceptable I/C carcinogenic risks and contribute to the migration of COCs to groundwater. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks. The monitoring of these same alternatives would also warn of potential migration of soil COCs to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would include excavation and off-site treatment and disposal of soil which could result in unacceptable residential carcinogenic risks and contribute to the migration of COCs to groundwater.

TABLE 5-5

COMPARATIVE ASSESSMENT OF SOIL ALTERNATIVES COMPLIANCE WITH CHEMICAL-SPECIFIC ARARs AND TBCs
ZONES 2, 3, 4, AND 7
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR					
		Alternatives S-2.1, S-3-1, S-4-1, and S-7.1 No Action	**Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 LUCs and Monitoring**	**Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 Capping to Meet I/C PRGs, LUCs, and Monitoring**	**Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 In-Situ Treatment to Meet I/C PRGs, LUCs, and Monitoring**	**Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 Excavation to Meet I/C PRGs, Off-Site Treatment and Disposal, LUCs, and Monitoring**	**Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 Excavation to Meet Residential PRGs and Off-Site Treatment and Disposal**
FEDERAL (continued)							
Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil	EPA-540-R-03-001, OSWER Dir #9285.7-54 (January 2003)	TBC. Would not comply. The No Action alternatives would not meet this standard because potential lead risk would not be addressed.	TBC. Would comply. The LUCs of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risk from exposure to lead contaminated soil. In addition, the monitoring of these same alternatives would warn of potential migration of lead from soil to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would meet this standard because potential risk from adult exposure to lead would be addressed through in-situ chemical stabilization/ solidification of soil that could contribute to unacceptable I/C risks. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks from exposure to lead contaminated soil. The monitoring of these same alternatives would also warn of potential migration of lead from soil to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would meet this standard because potential risk from adult exposure to lead would be addressed through capping or removal of soil that could contribute to unacceptable I/C risks. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks from exposure to lead contaminated soil. The monitoring of these same alternatives would also warn of potential migration of lead from soil to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would meet this standard because potential lead risk from adult exposure would be addressed through excavation and off-site treatment and disposal of all lead-contaminated media exceeding risk levels. These alternatives would also include LUCs that would ensure maintenance of building foundations and paved areas, regulate the disturbance of contaminated soil, and prohibit hypothetical future residential development, all of which would minimize unacceptable risks from exposure to lead contaminated soil. The monitoring of these same alternatives would also warn of potential migration of lead from soil to groundwater, which would also minimize unacceptable risks.	TBC. Would comply. Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would meet this standard because potential lead risk from adult exposure would be addressed through excavation and off-site treatment and disposal of all lead-contaminated media exceeding risk levels.

TABLE 5-5

COMPARATIVE ASSESSMENT OF SOIL ALTERNATIVES COMPLIANCE WITH CHEMICAL-SPECIFIC ARARs AND TBCs
ZONES 2, 3, 4, AND 7
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR					
		Alternatives S-2.1, S-3-1, S-4-1, and S-7.1 No Action	**Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 LUCs and Monitoring**	**Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 Capping to Meet I/C PRGs, LUCs, and Monitoring**	**Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 In-Situ Treatment to Meet I/C PRGs, LUCs, and Monitoring**	**Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 Excavation to Meet I/C PRGs, Off-Site Treatment and Disposal, LUCs, and Monitoring**	**Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 Excavation to Meet Residential PRGs and Off-Site Treatment and Disposal**
STATE OF CONNECTICUT							
Remediation Standard Regulations (RSRs)	Connecticut General Statutes (CGS) §22a-133k; Regulations of Connecticut State Agencies (RCSA) §22a-133k - 1 through 3	Applicable. Would not comply. The No Action alternatives would not remedy current exceedances of industrial/commercial (I/C) Direct Exposure Criteria (DECs) and Pollutant Mobility Criteria (PMCs). In addition, the No Action alternatives would not prevent hypothetical future residential development which would result in exceedances of Residential DECs.	Applicable. Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 would not fully comply with the DECs and PMCs of these regulations because some of the soil with concentrations than the PRGs cannot be classified as inaccessible or environmentally isolated. However, the LUCs of these alternatives would minimize risks from these exceedances and prevent even greater risks from residential development. In addition, the groundwater monitoring from these alternatives would warn of potential migration of soil COCs to groundwater. A variance might have to be negotiated with the Connecticut Department of Environmental Protection (CTDEP).	Applicable. Would comply. Although Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would leave in place soil that exceed I/C DECs and PMCs, areas of exceedance would either be capped with an impervious soil cover or excavated and disposed off site, thus minimizing risks and potential migration of soil COCs to groundwater. In addition, these alternatives would include groundwater monitoring to provide a warning of the potential migration of soil COCs to groundwater. The cap will be constructed, monitored and maintained in compliance with these standards. LUC compliance will also meet these standards.	Applicable. Would comply. The in-situ chemical stabilization/ solidification of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would remedy current exceedances of I/C PMCs. Although exceedances of I/C DECs would remain, the LUCs of these alternatives would minimize resulting risks and prevent even greater risks by prohibiting residential development. In addition, the groundwater monitoring from these alternatives would warn of potential migration of soil COCs to groundwater.	Applicable. Would comply. Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would include excavation and off-site treatment and disposal which would remedy current exceedances of I/C DECs and PMCs. These alternatives would also include LUCs which would prevent risk from exposure under residential site use and monitoring which would warn of the potential migration of soil COCs to groundwater.	Applicable. Would comply. Alternatives S-1.5, S-2.6, S-3.6, S-4.6, S-5.5, S-6.5, and S-7.6 would include excavation and off-site treatment and disposal of contaminated soil which would remedy current exceedances of I/C DECs and PMCs and hypothetical future exceedances of Residential DECs and PMCs.

TABLE 5-6

COMPARATIVE ASSESSMENT OF SOIL ALTERNATIVES COMPLIANCE WITH LOCATION-SPECIFIC ARARs AND TBCs
ZONES 2, 3, 4, AND 7
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR				
		Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 LUCs and Monitoring	**Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 Capping to Meet I/C PRGs, LUCs, and Monitoring**	**Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 In-Situ Treatment to Meet I/C PRGs, LUCs, and Monitoring**	**Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 Excavation to Meet I/C PRGs, LUCs and Monitoring**	**Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 Excavation to Meet Residential PRGs**
FEDERAL						
Fish and Wildlife Coordination Act	16 USC Part 661 *et. seq.*, 40 CFR 122	Applicable. Would comply. The groundwater monitoring of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 would provide adequate warning of the potential migration of soil chemicals of concern (COCs) to groundwater and surface water. Federal resource agencies would be consulted to prevent, mitigate, or compensate for loss of fish and wildlife.	Applicable. Would comply. The capping, excavation, and off-site disposal of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would minimize the potential migration of soil chemicals of concern (COCs) to groundwater or to surface water that could eventually impact fish and wildlife in the Thames River. Federal resource agencies would be consulted to prevent, mitigate, or compensate for loss to fish and wildlife.	Applicable. Would comply. The in-situ chemical stabilization/ solidification of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would prevent the potential migration of COCs from soil to groundwater or to surface water that could eventually impact fish and wildlife in the Thames River. In addition, the groundwater monitoring associated with these alternatives would provide a warning of potential migration of COCs. Federal resource agencies would be consulted to prevent, mitigate, or compensate for loss of fish and wildlife.	Applicable. Would comply. The excavation and off-site treatment and disposal of Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would remove soil chemical of concern (COCs) and prevent their potential migration to groundwater or surface water which could eventually impact fish and wildlife in the Thames River. In addition, the monitoring of these alternatives would provide warning of the potential migration of COCs from soil to groundwater and surface water. Federal resource agencies would be consulted to prevent, mitigate, or compensate for loss of fish and wildlife.	Applicable. Would comply. The excavation and off-site treatment and disposal of Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would remove soil COCs and prevent their potential migration to groundwater or surface water which could eventually impact fish and wildlife in the Thames River. Federal resource agencies would be consulted to prevent, mitigate, or compensate for loss of fish and wildlife.
Coastal Zone Management Act	16 USC Parts 1451 *et. seq.*	Applicable. Would comply. The monitoring activities and establishment and long-term maintenance of the cover system of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 would comply with the substantive requirements of this act.	Applicable. Would comply. The capping, excavation, and off-site disposal of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would comply with the substantive requirements of this act.	Applicable. Would comply. The in-situ treatment and monitoring activities of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would comply with the substantive requirements of this act.	Applicable. Would comply. The excavation, off-site treatment and disposal, and monitoring activities of Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would comply with the substantive requirements of this act.	Applicable. Would comply. The excavation and off-site treatment and disposal of Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would comply with the substantive requirements of this act.
Floodplain Management and Protection of Wetlands	44 CFR 9	Relevant and appropriate. The monitoring activities and establishment and long-term maintenance of the cover system of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 conducted within the 500-year floodplain of the Thames River or within federal jurisdictional wetlands will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.	Relevant and appropriate. The capping, and excavation of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 conducted within the 500-year floodplain of the Thames River or within federal jurisdictional wetlands will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.	Relevant and appropriate. The in-situ treatment and monitoring activities of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 conducted within the 500-year floodplain of the Thames River or within federal jurisdictional wetlands will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.	Relevant and appropriate. The excavation and monitoring activities of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 conducted within the 500-year floodplain of the Thames River or within federal jurisdictional wetlands will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.	Relevant and appropriate. The excavation and off-site treatment and disposal of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 conducted within the 500-year floodplain of the Thames River or within federal jurisdictional wetlands will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.
STATE OF CONNECTICUT						
Coastal Management Act	Regulations of Connecticut State Agencies (RCSA) §22a-90 to 112	Applicable. Would comply. The monitoring activities and establishment and long-term maintenance of the cover system of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 would comply with the substantive requirements of this act.	Applicable. Would comply. The capping, excavation, and off-site disposal of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would comply with the substantive requirements of this act.	Applicable. Would comply. The in-situ treatment and monitoring activities of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would comply with the substantive requirements of this act.	Applicable. Would comply. The excavation, off-site treatment and disposal, and monitoring activities of Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would comply with the substantive requirements of this act.	Applicable. Would comply. The excavation and off-site treatment and disposal of Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would comply with the substantive requirements of this act.

TABLE 5-6

COMPARATIVE ASSESSMENT OF SOIL ALTERNATIVES COMPLIANCE WITH LOCATION-SPECIFIC ARARs AND TBCs
ZONES 2, 3, 4, AND 7
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR				
		Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 LUCs and Monitoring	**Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 Capping to Meet I/C PRGs, LUCs, and Monitoring**	**Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 In-Situ Treatment to Meet I/C PRGs, LUCs, and Monitoring**	**Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 Excavation to Meet I/C PRGs, LUCs and Monitoring**	**Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 Excavation to Meet Residential PRGs**
STATE OF CONNECTICUT (Continued)						
Tidal Wetlands and Watercourses	RCSA §22a-30-1 through 17	Applicable. Would comply. The monitoring activities and establishment and long-term maintenance of the cover system of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 would be managed to prevent erosion and other disturbance to tidal wetlands and the Thames River.	Applicable. Would comply. The capping, excavation, and off-site disposal of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would be managed to prevent erosion and other disturbance to tidal wetlands and the Thames River.	Applicable. Would comply. The in-situ treatment and monitoring activities of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would be managed to prevent erosion and other disturbance to tidal wetlands and the Thames River.	Applicable. Would comply. The excavation, off-site treatment and disposal, and monitoring activities of Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would be managed to prevent erosion and other disturbance to tidal wetlands.	Applicable. Would comply. The excavation and off-site treatment and disposal of Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would be managed to prevent erosion and other disturbance to tidal wetlands.
Flood Management Regulations	(RCSA 25-68h-1 through 25-68h-3)	Relevant and appropriate. Would comply. The monitoring activities and establishment and long-term maintenance of the cover system of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 would consider the potential for disturbance of floodplains. Any work in flood plains would comply with the substantive provisions of the regulations.	Relevant and appropriate. Would comply. The capping, excavation, and off-site disposal of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would not adversely impact the floodplain resources. The cap would be designed, constructed, and maintained to be protective in the event of a 100-year storm event. The monitoring associated with these alternatives would be performed to minimize impact to floodplain resources.	Relevant and appropriate. Would comply. The in-situ treatment and monitoring activities of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would consider the potential for disturbance of floodplains. Any work in flood plains would comply with the substantive provisions of the regulations.	Relevant and appropriate. Would comply. The excavation, off-site treatment and disposal, and monitoring activities of Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would consider the potential for disturbance of floodplains. Any work in flood plains would comply with the substantive provisions of the regulations.	Relevant and appropriate. Would comply. The excavation and dewatering activities of Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would consider the potential for disturbance of floodplains. Any work in flood plains would comply with the substantive provisions of the regulations.
Connecticut Endangered Species Act	CGS §26-303 through 314	Applicable. Would comply. The monitoring activities and establishment and long-term maintenance of the cover system of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 would not disturb aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon and would address risks posed by potential migration of soil COCs to the Thames River.	Applicable. Would comply. The capping, excavation, and off-site disposal of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would not cause disturbance to aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon and would address risks posed by potential migration of soil COCs to the Thames River.	Applicable. Would comply. The in-situ treatment and monitoring activities of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would not cause disturbance to aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon and would address risks posed by potential migration of soil COCs to the Thames River.	Applicable. Would comply. The excavation, off-site treatment and disposal, and monitoring activities of Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would not disturb aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon and would address risks posed by potential migration of soil COCs to the Thames River.	Applicable. Would comply. The excavation, discharge of treated water, and off site treatment and disposal activities associated with Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would not cause disturbance to aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon.

TABLE 5-7

COMPARATIVE ASSESSMENT OF SOIL ALTERNATIVES COMPLIANCE WITH ACTION-SPECIFIC ARARs AND TBCs
ZONES 2, 3, 4, AND 7
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Evaluation of Alternatives Compliance with ARAR				
		Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 LUCs and Monitoring	**Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 Capping to Meet I/C PRGs, LUCs, and Monitoring**	**Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 In-Situ Treatment to Meet I/C PRGs, LUCs, and Monitoring**	**Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 Excavation to Meet I/C PRGs, LUCs and Monitoring**	**Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 Excavation to Meet Residential PRGs**
FEDERAL						
Clean Water Act, Section 402, National Pollution Discharge Elimination System (NPDES)	33 USC 1342; 40 CFR 122 through 125	Applicable. Would comply. The establishment or maintenance of the cover system of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 would be performed in accordance with the stormwater requirements of these standards.	Applicable. Would comply. Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would include soil disturbance activities during the installation of the cap. If any soil disturbance activities are greater than one acre, they would be performed in accordance with this standard.	Applicable. Would comply. Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would include soil disturbance activities during the implementation of the in-situ treatment. If any soil disturbance activities are greater than one acre, they would be performed in accordance with this standard.	Applicable. Would comply. Any construction activities during implementation of Alternative S-1.4 would be performed in accordance with the stormwater requirements of these standards.	Applicable. Would comply. Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would include on-site dewatering of soil excavated below the water table before transportation of that soil for off-site treatment and disposal. The water generated by this soil dewatering would be treated to meet the standards of this act prior to discharge to the Thames River.
Clean Air Act (CAA), National Emissions Standards for Hazardous Air Pollutants (NESHAPs)	42 USC §12(b)(1); 40 C.F.R. Part 61	Applicable. Would comply. Activities during the establishment or maintenance of the cover system of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 that would generate dust and air pollutants would comply with the substantive requirements of these regulations.	Applicable. Would comply. The soil excavated during the installation of a cap during implementation of Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would be performed in compliance with these standards. Engineering controls could be used, if necessary, to meet this standard.	Not applicable.	Applicable. Would comply. The soil excavated as part of Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would be performed in compliance with these standards. Engineering controls could be used, if necessary, to meet this standard.	Applicable. Would comply. The soil excavated as part of Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would be performed in compliance with these standards. Engineering controls could be used, if necessary, to meeting this standard.
RCRA, Interim Status TSDF Standards, Chemical, Physical and Biological Treatment	40 C.F.R. § 265.401(b)	Not applicable.	Not applicable.	Relevant and Appropriate. Would comply. Any reagents use in the in-situ treatment for Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would not be used if they adversely affected the treatment process. Inspections would be performed to ensure this.	Not applicable.	Not applicable.
STATE OF CONNECTICUT						
Hazardous Waste Management: Generator and Handler Requirements, Listing and Identification	Regulations of Connecticut State Agencies (RCSA) §22a-449(c) 100-101	Applicable. Would comply. No significant excavation would be part of the monitoring of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2. However, excavated soil would be tested and any soil identified as hazardous would be managed in accordance with these regulations.	Applicable. Would comply. The soil excavated as part of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would be tested and any soil identified as hazardous would be managed in accordance with these regulations.	Applicable. Would comply. Soil excavated as part of the in-situ treatment and monitoring of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would be tested. Any soil identified as hazardous would be managed in accordance with these regulations. Confirmatory sampling would determine whether any soil with hazardous characteristic is left in place following treatment.	Applicable. Would comply. The soil excavated as part of Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would be tested and any soil identified as hazardous would be managed in accordance with these regulations. Confirmatory sampling would determine whether any soil with hazardous characteristic is left in place following excavation.	Applicable. Would comply. Would comply. Excavated soil and dewatering waste generated by Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would be tested for hazardous characteristics. Any soil or waste identified as hazardous would be handled and disposed in compliance with these standards.
Hazardous Waste Management: Generator Standards	RCSA § 22a-449(c)-102	Applicable. Would comply. Any hazardous waste that would be generated from the monitoring activities and establishment and long-term maintenance of the cover system of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 would be handled and disposed in compliance with these standards.	Applicable. Would comply. The soil excavated as part of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would be tested and any soil identified as hazardous would handled and disposed of in compliance with these standards.	Applicable. Would comply. Any hazardous waste that would be generated from the in-situ treatment and monitoring activities of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would be handled and disposed in compliance with these standards.	Applicable. Would comply. Soil excavated as part of Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would be tested for hazardous characteristics. Any excavated soil identified as hazardous would be handled and disposed in compliance with these standards.	Applicable. Would comply. Would comply. Excavated soil and dewatering waste generated by Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would be tested for hazardous characteristics. Any soil or waste identified as hazardous would be handled and disposed in compliance with these standards.

TABLE 5-7

COMPARATIVE ASSESSMENT OF SOIL ALTERNATIVES COMPLIANCE WITH ACTION-SPECIFIC ARARs AND TBCs
ZONES 2, 3, 4, AND 7
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Evaluation of Alternatives Compliance with ARAR				
		Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 LUCs and Monitoring	**Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 Capping to Meet I/C PRGs, LUCs, and Monitoring**	**Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 In-Situ Treatment to Meet I/C PRGs, LUCs, and Monitoring**	**Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 Excavation to Meet I/C PRGs, LUCs and Monitoring**	**Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 Excavation to Meet Residential PRGs**
STATE OF CONNECTICUT (continued)						
Water Pollution Control	RCSA §22a-430-3 and 4	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Applicable. Would comply. The water generated by soil dewatering operations of Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would be treated to comply with these rules prior to discharge to the Thames River.
Water Quality Standards	Regulations Promulgated under Connecticut General Statutes (CGS) §22a-426	Applicable. Would comply. The long-term groundwater monitoring of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 would ensure that groundwater quality standards for GB groundwater would be maintained. Monitoring would ensure that stormwater and groundwater standards were being met.	Applicable. Would comply. The capping and long-term groundwater monitoring of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would ensure that groundwater quality standards for GB groundwater would be maintained. Monitoring would ensure that stormwater and groundwater standards were being met.	Applicable. Would comply. The in-situ treatment and long-term groundwater monitoring of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would ensure that groundwater quality standards for GB groundwater would be maintained. Monitoring would ensure that stormwater and groundwater standards were being met.	Applicable. Would comply. The excavation, off-site treatment and disposal, and long-term groundwater monitoring of Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would ensure that groundwater quality standards for GB groundwater would be maintained. Monitoring would ensure that stormwater and groundwater standards were being met.	Applicable. Would comply. The water generated by the soil dewatering operations of Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would be treated to comply with these rules prior to discharge to the Thames River. Monitoring would ensure that stormwater and groundwater standards were being met.
Air Pollution Control	RCSA§22a-174 1-20	Applicable. Would comply. The monitoring activities and establishment and long-term maintenance of the cover system of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2 would be performed so as to minimize fugitive emissions and would comply with these regulations.	Applicable. Would comply. The capping and excavation of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would be performed so as to minimize fugitive emissions and would comply with these regulations.	Applicable. Would comply. The in-situ treatment and monitoring activities of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would be performed so as to minimize fugitive emissions and would comply with these regulations.	Applicable. Would comply. The excavation, off-site treatment and disposal, and long-term groundwater monitoring of Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would be performed so as to minimize fugitive emissions and would comply with these regulations.	Applicable. The excavation activities associated with Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would be performed so as to minimize fugitive emissions and would comply with these regulations.
Connecticut Guidelines for Soil Erosion and Sediment Control	Connecticut Council on Soil and Water Conservation	To Be Considered (TBC). Would comply. No significant excavation would be part of the monitoring of Alternatives S-2.2, S-3.2, S-4.2, and S-7.2. Erosion and sedimentation control measures would be implemented as required.	TBC. Would comply. The capping and excavation of Alternatives S-2.3, S-3.3, S-4.3, and S-7.3 would include an appropriate erosion and sedimentation control program that would comply with this guidance.	TBC. Would comply. Any excavation activities associated with the in-situ treatment and monitoring of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would include an appropriate erosion and sedimentation control program that would comply with this guidance.	TBC. Would comply. Excavation activities associated with Alternatives S-2.5, S-3.5, S-4.5, and S-7.5 would include an appropriate erosion and sedimentation control program that would comply with this guidance.	TBC. The excavation activities associated with Alternatives S-2.6, S-3.6, S-4.6, and S-7.6 would include an appropriate erosion and sedimentation control program that would comply with this guidance.
Underground Injection Control	RCSA § 22a-430-3, 4, and 8	Not applicable.	Not applicable.	Applicable. The subsurface injection of chemical substances of Alternatives S-2.4, S-3.4, S-4.4, and S-7.4 would comply with these regulations.	Not applicable.	Not applicable.

TABLE 5-8

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 2 SOIL REMEDIAL ALTERNATIVES
LOWER SUBSASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-2.1 No Action	Alternative S-2.2 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-2.3 Capping to Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-2.4 In-Situ Treatment (Stabilization/ Solidification) to Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-2.5 Excavation to Meet I/C PMCs, Off-Site Disposal (Stabilization/ Solidification and Landfilling), and LUCs (Engineering and Institutional Controls)	Alternative S-2.6 Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/ Solidification, LTTD, and Landfilling)
Overall Protection of Human Health and Environment	Not protective.	Protective.	More protective than Alternative S-2.2.	Approximately as protective as Alternative S-2.3.	More protective than Alternatives S-2.3 and S-2.4.	Most protective.
Compliance with ARARs and TBCs						
Chemical-Specific	Would not comply.	Would comply.	Would comply.	Would comply.	Would comply.	Would comply.
Location-Specific	No location-specific ARARs.	Would comply.	Would comply.	Would comply.	Would comply.	Would comply.
Action-Specific	Not applicable.	Would comply.	Would comply	Would comply.	Would comply.	Would comply.
Long-Term Effectiveness and Permanence	Not effective.	Effective.	More effective than Alternative S-2.2.	Approximately as effective as Alternative S-2.3.	More effective than Alternatives S-2.3 and S-2.4.	Most effective.
Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment	There is no treatment.	There is no treatment.	There is no treatment.	Would reduce lead toxicity and mobility by in-situ chemical stabilization/ solidification. Total of 1,130 cy treated.	There is no treatment.	There is no treatment.

TABLE 5-8

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 2 SOIL REMEDIAL ALTERNATIVES
LOWER SUBSASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-2.1 No Action	Alternative S-2.2 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-2.3 Capping to Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-2.4 In-Situ Treatment (Stabilization/ Solidification) to Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-2.5 Excavation to Meet I/C PMCs, Off-Site Disposal (Stabilization/ Solidification and Landfilling), and LUCs (Engineering and Institutional Controls)	Alternative S-2.6 Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/ Solidification, LTTD, and Landfilling)
Short-Term Effectiveness	No short-term risks. Would not achieve soil RAOs or meet Zone 2 soil PRGs.	Short-term risks to address: Worker exposure during GW sampling; No impacts to environment or community. Three months to implement and achieve soil RAOs. Zone 2 soil PRGs for I/C direct exposure or pollutant mobility would be met through engineering controls.	Short-term risks to address: Worker exposure during cap installation and GW sampling; Transport of contaminated soil through community; Dust from excavation. Six months to implement and achieve soil RAOs. Zone 2 soil PRGs for I/C direct exposure or pollutant mobility would be met through engineering controls and capping.	Short-term risks to address: Worker exposure during treatment and GW sampling; No impacts to environment or community. Six months to implement and achieve soil RAOs. Would meet Zone 2 soil PRGs for I/C pollutant mobility at completion.	Short-term risks to address: Worker exposure during excavation; Transport of contaminated soil through community; Dust from excavation. Six months to implement and achieve soil RAOs. Would meet Zone 2 soil PRGs for I/C direct exposure and pollutant mobility at completion.	Short-term risks to address: Worker exposure during excavation; Transport of contaminated soil through community; Dust from excavation. Nine months to implement and achieve soil RAOs. Would meet Zone 2 soil PRGs for residential direct exposure and pollutant mobility at completion.

TABLE 5-8

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 2 SOIL REMEDIAL ALTERNATIVES
LOWER SUBSASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-2.1 No Action	Alternative S-2.2 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-2.3 Capping to Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-2.4 In-Situ Treatment (Stabilization/ Solidification) to Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-2.5 Excavation to Meet I/C PMCs, Off-Site Disposal (Stabilization/ Solidification and Landfilling), and LUCs (Engineering and Institutional Controls)	Alternative S-2.6 Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/ Solidification, LTTD, and Landfilling)
Implementability	Needs only 5-year reviews.	Issues include: Maintaining paved areas and MWs; No base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Construction may interfere with base activities; Underground utilities may interfere with construction; Maintaining paved areas and MWs; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Treatment may interfere with base activities; Underground utilities may interfere with treatment; Treatability tests needed; Maintaining paved areas and MWs; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Excavation may interfere with base activities; Underground utilities may interfere with excavation; Maintaining paved areas and MWs; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Shoring required to protect buildings; Dewatering system required; water treatment and disposal system required; Base construction permit needed; Resources are readily available.
Costs:						
Capital	$0	$27,000	$359,000	$544,000	$652,000	$3,881,000
O&M NPW (Years)	$55,000 (30)	$287,000 (30)	$287,000 (30)	$287,000 (30)	$287,000 (30)	$0
NPW (Years)	$55,000 (30)	$314,000 (30)	$646,000 (30)	$831,000 (30)	$939,000 (30)	$3,881,000 (1)

TABLE 5-8

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 2 SOIL REMEDIAL ALTERNATIVES
LOWER SUBSASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

NOTES:

ARARs	Applicable or Relevant and Appropriate Requirements
cy	Cubic yards
DECs	Direct Exposure Criteria (Connecticut)
I/C	Industrial/commercial
LTTD	Low-temperature thermal desorption
LUCs	Land use controls
NPW	Net present worth
O&M	Operation and maintenance
PMCs	Pollutant Mobility Criteria (Connecticut)
PRGs	Preliminary Remedial Goals
RAOs	Remedial Action Objectives
TBCs	To be considered (criteria)

TABLE 5-9

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 3 SOIL REMEDIAL ALTERNATIVES
LOWER SUBSASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	**Alternative S-3.1 No Action**	**Alternative S-3.2 LUCs (Engineering and Institutional Controls) and Monitoring**	**Alternative S-3.3 Capping to Allow I/C Site Use and Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring**	**Alternative S-3.4 In-Situ Treatment (Stabilization/ Solidification) to Allow I/C Site Use and Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring**	**Alternative S-3.5 Excavation to Meet I/C DECs and PMCs, Off-Site Disposal (Stabilization/ Solidification and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring**	**Alternative S-3.6 Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/ Solidification, LTTD and Landfilling)**
Overall Protection of Human Health and Environment	Not protective.	Protective.	More protective than Alternative S-3.2.	Approximately as protective as Alternative S-3.3.	More protective than Alternatives S-3.3 and S-3.4.	Most protective.
Compliance with ARARs and TBCs						
Chemical-Specific	Would not comply.	Would not fully comply. A variance would be needed.	Would comply.	Would comply.	Would comply.	Would comply.
Location-Specific	No location-specific ARARs.	Would comply.	Would comply.	Would comply.	Would comply.	Would comply.
Action-Specific	Not applicable.	Would comply.	Would comply	Would comply.	Would comply.	Would comply.
Long-Term Effectiveness and Permanence	Not effective.	Effective.	More effective than Alternative S-3.2.	Approximately as effective as Alternative S-3.3.	More effective than Alternatives S-3.3 and S-3.4.	Most effective.
Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment	There is no treatment.	There is no treatment.	There is no treatment.	Would reduce lead toxicity and mobility by in-situ chemical stabilization/ solidification. Total of 1,540 cy treated.	There is no treatment.	There is no treatment.

TABLE 5-9

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 3 SOIL REMEDIAL ALTERNATIVES
LOWER SUBSASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-3.1 No Action	Alternative S-3.2 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-3.3 Capping to Allow I/C Site Use and Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-3.4 In-Situ Treatment (Stabilization/ Solidification) to Allow I/C Site Use and Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-3.5 Excavation to Meet I/C DECs and PMCs, Off-Site Disposal (Stabilization/ Solidification and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-3.6 Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/ Solidification, LTTD and Landfilling)
Short-Term Effectiveness	No short-term risks. Would not achieve soil RAOs or meet Zone 3 soil PRGs.	Short-term risks to address: Worker exposure during GW sampling; No impacts to environment or community. Three months to implement and achieve soil RAOs. Zone 3 soil PRGs for I/C direct exposure or pollutant mobility would be met through engineering controls.	Short-term risks to address: Worker exposure during cap installation and GW sampling; Transport of contaminated soil through community; Dust from excavation. Six months to implement and achieve soil RAOs. Zone 3 soil PRGs for I/C direct exposure or pollutant mobility would be met through engineering controls and capping.	Short-term risks to address: Worker exposure during treatment and GW sampling; No impacts to environment or community. Six months to implement and achieve soil RAOs. Would meet Zone 3 soil PRGs for I/C pollutant mobility at completion.	Short-term risks to address: Worker exposure during excavation; Transport of contaminated soil through community; Dust from excavation. Six months to implement and achieve soil RAOs. Would meet Zone 3 soil PRGs for I/C direct exposure and pollutant mobility at completion.	Short-term risks to address: Worker exposure during excavation; Transport of contaminated soil through community; Dust from excavation. Eighteen months to implement and achieve soil RAOs. Would meet Zone 3 soil PRGs for residential direct exposure and pollutant mobility at completion.

TABLE 5-9

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 3 SOIL REMEDIAL ALTERNATIVES
LOWER SUBSASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-3.1 No Action	Alternative S-3.2 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-3.3 Capping to Allow I/C Site Use and Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-3.4 In-Situ Treatment (Stabilization/ Solidification) to Allow I/C Site Use and Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-3.5 Excavation to Meet I/C DECs and PMCs, Off-Site Disposal (Stabilization/ Solidification and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-3.6 Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/ Solidification, LTTD and Landfilling)
Implementability	Needs only 5-year reviews.	Issues include: Maintaining paved areas and MWs; No base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Construction may interfere with base activities; Underground utilities may interfere with construction; Maintaining paved areas and MWs; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Treatment may interfere with base activities; Underground utilities may interfere with treatment; Treatability tests needed; Maintaining paved areas and MWs; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Excavation may interfere with base activities; Underground utilities may interfere with excavation; Maintaining paved areas and MWs; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Shoring required to protect buildings; Dewatering system required; water treatment and disposal system required; Base construction permit needed; Resources are readily available.
Costs: Capital O&M NPW (Years) NPW (Years)	 $0 $55,000 (30) $55,000 (30)	 $34,000 $297,000 (30) $331,000 (30)	 $461,000 $297,000 (30) $758,000 (30)	 $698,000 $296,000 (30) $994,000 (30)	 $817,000 $297,000 (30) $1,114.000 (30)	 $5,704,000 $0 $5,704,000 (1)

TABLE 5-9

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 3 SOIL REMEDIAL ALTERNATIVES
LOWER SUBSASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

NOTES:

ARARs	Applicable or Relevant and Appropriate Requirements
cy	Cubic yards
DECs	Direct Exposure Criteria (Connecticut)
I/C	Industrial/commercial
LTTD	Low-temperature thermal desorption
LUCs	Land use controls
NPW	Net present worth
O&M	Operation and maintenance
PAHs	Polycyclic aromatic hydrocarbons
PMCs	Pollutant Mobility Criteria (Connecticut)
PRGs	Preliminary Remedial Goals
RAOs	Remedial Action Objectives
TBCs	To be considered (criteria)

TABLE 5-10

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 4 SOIL REMEDIAL ALTERNATIVES
LOWER SUBSASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-4.1 No Action	Alternative S-4.2 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-4.3 Capping to Allow I/C Site Use and Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-4.4 In-Situ Treatment (Enhanced Bioremediation or Stabilization/ Solidification) to Allow I/C Site Use and Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-4.5 Excavation to Meet I/C DECs and PMCs, Off-Site Disposal (Stabilization/ Solidification, LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-4.6 Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/ Solidification, LTTD, and Landfilling)
Overall Protection of Human Health and Environment	Not protective.	Protective.	More protective than Alternative S-4.2.	Approximately as protective as Alternative S-4.3.	More protective than Alternatives S-4.3 and S-4.4.	Most protective.
Compliance with ARARs and TBCs						
Chemical-Specific	Would not comply.	Would comply.	Would comply.	Would comply.	Would comply.	Would comply.
Location-Specific	No location-specific ARARs.	Would comply.	Would comply.	Would comply.	Would comply.	Would comply.
Action-Specific	Not applicable.	Would comply.	Would comply	Would comply.	Would comply.	Would comply.
Long-Term Effectiveness and Permanence	Not effective.	Effective.	More effective than Alternative S-4.2.	Approximately as effective as Alternative S-4.3.	More effective than Alternatives S-3.3 and S-4.4.	Most effective.
Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment	There is no treatment.	There is no treatment.	There is no treatment.	Would reduce toxicity, mobility, and volume of PAHs in 960 cy and TPH in 80 cy by in-situ enhanced bioremediation. Would reduce lead toxicity and mobility in 3,060 cy by in-situ chemical stabilization/ solidification.	There is no treatment.	There is no treatment.

TABLE 5-10

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 4 SOIL REMEDIAL ALTERNATIVES
LOWER SUBSASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-4.1 No Action	Alternative S-4.2 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-4.3 Capping to Allow I/C Site Use and Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-4.4 In-Situ Treatment (Enhanced Bioremediation or Stabilization/ Solidification) to Allow I/C Site Use and Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-4.5 Excavation to Meet I/C DECs and PMCs, Off-Site Disposal (Stabilization/ Solidification, LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-4.6 Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/ Solidification, LTTD, and Landfilling)
Short-Term Effectiveness	No short-term risks. Would not achieve soil RAOs.	Short-term risks to address: Worker exposure during GW sampling; No impacts to environment or community. Three months to implement and achieve soil RAOs. Zone 4 soil PRGs for I/C direct exposure or pollutant mobility would be met through engineering controls.	Short-term risks to address: Worker exposure during cap installation and GW sampling; Transport of contaminated soil through community; Dust from excavation. Nine months to implement and achieve soil RAOs. Would meet Zone 4 PAHs and TPH PRGs for I/C direct exposure and Zone 4 TPH PRG for I/C pollutant mobility at completion. Zone 4 lead PRG for I/C direct exposure or pollutant mobility would be met through engineering controls and capping.	Short-term risks to address: Worker exposure during treatment and GW sampling; No impacts to environment or community. Nine months to implement and achieve soil RAOs. Would meet Zone 4 lead PRG for I/C pollutant mobility at completion and Zone 4 PAHs and TPH PRGs for I/C direct exposure and Zone 4 TPH PRG for I/C pollutant mobility within 3 to 5 years. Would not meet Zone 4 lead PRG for I/C direct exposure.	Short-term risks to address: Worker exposure during excavation; Transport of contaminated soil through community; Dust from excavation. Nine months to implement and achieve soil RAOs. Would meet Zone 4 soil PRGs for I/C direct exposure and pollutant mobility at completion.	Short-term risks to address: Worker exposure during excavation; Transport of contaminated soil through community; Dust from excavation. One year to implement and achieve soil RAOs. Would meet Zone 4 soil PRGs for residential direct exposure and pollutant mobility at completion.

TABLE 5-10

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 4 SOIL REMEDIAL ALTERNATIVES
LOWER SUBSASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-4.1 No Action	Alternative S-4.2 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-4.3 Capping to Allow I/C Site Use and Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-4.4 In-Situ Treatment (Enhanced Bioremediation or Stabilization/ Solidification) to Allow I/C Site Use and Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-4.5 Excavation to Meet I/C DECs and PMCs, Off-Site Disposal (Stabilization/ Solidification, LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-4.6 Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/ Solidification, LTTD, and Landfilling)
Implementability	Needs only 5-year reviews.	Issues include: Maintaining paved areas and MWs; No base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Construction may interfere with base activities; Underground utilities may interfere with construction; Maintaining paved areas and MWs; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Treatment may interfere with base activities; Underground utilities may interfere with treatment; Treatability tests needed; Maintaining paved areas and MWs; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Excavation may interfere with base activities; Underground utilities may interfere with excavation; Maintaining paved areas and MWs; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Shoring required to protect buildings; Dewatering system required; water treatment and disposal system required; Base construction permit needed; Resources are readily available.
Costs:						
Capital	$0	$47,000	$1,265,000	$1,389,000	$1,984,000	$7,737,000
O&M NPW (Years)	$55,000 (30)	$413,000 (30)	$414,000 (30)	$417,000 (30)	$414,000 (30)	$0
NPW (Years)	$55,000 (30)	$460,000 (30)	$1,679,000 (30)	$1,806,000 (30)	$2,398,000 (30)	$7,737,000 (1)

TABLE 5-10

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 4 SOIL REMEDIAL ALTERNATIVES
LOWER SUBSASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

NOTES:

ARARs	Applicable or Relevant and Appropriate Requirements
cy	Cubic yards
DECs	Direct Exposure Criteria (Connecticut)
I/C	Industrial/commercial
LTTD	Low-temperature thermal desorption
LUCs	Land use controls
NPW	Net present worth
O&M	Operation and maintenance
PAHs	Polycyclic aromatic hydrocarbons
PMCs	Pollutant Mobility Criteria (Connecticut)
PRGs	Preliminary Remedial Goals
RAOs	Remedial Action Objectives
TBCs	To be considered (criteria)
TPH	Total petroleum hydrocarbons

TABLE 5-11

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 5 SOIL REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-5.1 No Action	Alternative S-5.2 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-5.3 In-Situ Treatment (Enhanced Bioremediation) to Meet I/C DECs and PMCs, LUCs, (Engineering and Institutional Controls) and Monitoring	Alternative S-5.4 Excavation to Meet I/C DECs and PMCs, Off-Site Disposal (LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-5.5 Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (LTTD and Landfilling)
Overall Protection of Human Health and Environment	Not protective.	Protective.	More protective than Alternative S-5.2.	More protective than Alternative S-5.3.	Most protective.
Compliance with ARARs and TBCs					
Chemical-Specific	Would not comply.	Would comply.	Would comply.	Would comply.	Would comply.
Location-Specific	No location-specific ARARs.	Not applicable.	Not applicable.	Not applicable.	Would comply.
Action-Specific	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Would comply.
Long-Term Effectiveness and Permanence	Not effective.	Effective.	More effective than Alternative S-5.2.	More effective than Alternative S-5.3.	Most effective.
Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment	There is no treatment.	There is no treatment.	Would reduce toxicity, mobility, and volume of TPH by in-situ enhanced bioremediation. Total of 230 cy treated.	There is no treatment.	There is no treatment.

TABLE 5-11

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 5 SOIL REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-5.1 No Action	Alternative S-5.2 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-5.3 In-Situ Treatment (Enhanced Bioremediation) to Meet I/C DECs and PMCs, LUCs, (Engineering and Institutional Controls) and Monitoring	Alternative S-5.4 Excavation to Meet I/C DECs and PMCs, Off-Site Disposal (LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-5.5 Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (LTTD and Landfilling)
Short-Term Effectiveness	No short-term risks. Would not achieve soil RAOs.	Short-term risks to address: Worker exposure during GW sampling; No impacts to environment or community. Three months to implement and achieve soil RAOs. Zone 5 soil PRGs for I/C direct exposure or pollutant mobility would be met through engineering controls.	Short-term risks to address: Worker exposure during treatment and GW sampling; No impacts to environment or community. Six months to implement and achieve soil RAOs. Would meet Zone 5 soil PRGs for I/C direct exposure and pollutant mobility within 3 to 5 years.	Short-term risks to address: Worker exposure during excavation; Transport of contaminated soil through community; Dust from excavation. Six months to implement and achieve soil RAOs. Would meet Zone 5 soil PRGs for I/C direct exposure and pollutant mobility at completion.	Short-term risks to address: Worker exposure during excavation; Transport of contaminated soil through community; Dust from excavation. Nine months to implement and achieve soil RAOs. Would meet Zone 5 soil PRGs for residential direct exposure and pollutant mobility at completion.

TABLE 5-11

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 5 SOIL REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-5.1 No Action	Alternative S-5.2 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-5.3 In-Situ Treatment (Enhanced Bioremediation) to Meet I/C DECs and PMCs, LUCs, (Engineering and Institutional Controls) and Monitoring	Alternative S-5.4 Excavation to Meet I/C DECs and PMCs, Off-Site Disposal (LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-5.5 Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (LTTD and Landfilling)
Implementability	Needs only 5-year reviews.	Issues include: Maintaining paved areas and MWs; No base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Treatment may interfere with base activities; Underground utilities may interfere with treatment; Treatability tests needed; Maintaining paved areas and MWs; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Excavation may interfere with base activities; Underground utilities may interfere with excavation; Maintaining paved areas and MWs; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Shoring required to protect buildings; Dewatering system required; water treatment and disposal system required; Base construction permit needed; Resources are readily available.
<u>Costs</u>:					
Capital	$0	$27,000	$1,175,000	$220,000	$2,930,000
O&M NPW (Years)	$55,000 (30)	$276,000 (30)	$279,000 (30)	$276,000 (30)	$0
NPW (Years)	$55,000 (30)	$303,000 (30)	$1,454,000 (30)	$496,000 (30)	$2,930,000 (1)

TABLE 5-11

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 5 SOIL REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

NOTES:

ARARs	Applicable or Relevant and Appropriate Requirements
cy	Cubic yards
DECs	Direct Exposure Criteria (Connecticut)
I/C	Industrial/commercial
LTTD	Low-temperature thermal desorption
LUCs	Land use controls
NPW	Net present worth
O &M	Operation and maintenance
PAHs	Polycyclic aromatic hydrocarbons
PMCs	Pollutant Mobility Criteria (Connecticut)
PRGs	Preliminary Remedial Goals
RAOs	Remedial Action Objectives
TBCs	To be considered (criteria)
TPH	Total petroleum hydrocarbons

TABLE 5-12

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 6 SOIL REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-6.1 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-6.2 In-Situ Treatment (Enhanced Bioremediation) to Meet TPH PMC and I/C DEC, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-6.3 Excavation to Meet TPH PMC and I/C DECs, Off-Site Disposal (LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-6.4 Excavation to Meet TPH PMC and Residential DEC, On-Site Dewatering, and Off-Site Disposal (LTTD and Landfilling)
Overall Protection of Human Health and Environment	Protective.	More protective than Alternative S-6.2.	More protective than Alternative S-6.3.	Most protective.
Compliance with ARARs and TBCs				
Chemical-Specific	Would comply.	Would comply.	Would comply.	Would comply.
Location-Specific	Would comply.	Would comply.	Would comply.	Would comply.
Action-Specific	Would comply.	Would comply.	Would comply.	Would comply.
Long-Term Effectiveness and Permanence	Effective.	More effective than Alternative S-6.2.	More effective than Alternative S-6.3.	Most effective.
Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment	There is no treatment.	Would reduce toxicity, mobility, and volume of TPH by in-situ enhanced bioremediation. Total of 730 cy treated.	There is no treatment.	There is no treatment.

TABLE 5-12

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 6 SOIL REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-6.1 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-6.2 In-Situ Treatment (Enhanced Bioremediation) to Meet TPH PMC and I/C DEC, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-6.3 Excavation to Meet TPH PMC and I/C DECs, Off-Site Disposal (LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-6.4 Excavation to Meet TPH PMC and Residential DEC, On-Site Dewatering, and Off-Site Disposal (LTTD and Landfilling)
Short-Term Effectiveness	Short-term risks to address: Worker exposure during GW sampling; No impacts to environment or community. Three months to implement and achieve soil RAOs. Zone 6 soil PRGs for I/C direct exposure or pollutant mobility would be met through engineering controls.	Short-term risks to address: Worker exposure during treatment and GW sampling; No impacts to environment or community. Six months to implement and achieve soil RAOs. Would meet Zone 6 TPH PRGs for I/C direct exposure and pollutant mobility within 3 to 5 years.	Short-term risks to address: Worker exposure during excavation; Transport of contaminated soil through community; Dust from excavation. Six months to implement and achieve soil RAOs. Would meet Zone 6 TPH PRGs for I/C direct exposure and pollutant mobility at completion.	Short-term risks to address: Worker exposure during excavation; Transport of contaminated soil through community; Dust from excavation. Nine months to implement and achieve soil RAOs. Would meet Zone 6 soil PRGs for residential direct exposure and pollutant mobility at completion.

TABLE 5-12

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 6 SOIL REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-6.1 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-6.2 In-Situ Treatment (Enhanced Bioremediation) to Meet TPH PMC and I/C DEC, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-6.3 Excavation to Meet TPH PMC and I/C DECs, Off-Site Disposal (LTTD and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-6.4 Excavation to Meet TPH PMC and Residential DEC, On-Site Dewatering, and Off-Site Disposal (LTTD and Landfilling)
Implementability	Issues include: Maintaining paved areas and MWs; No base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Treatment may interfere with base activities; Underground utilities may interfere with treatment; Treatability tests needed; Maintaining paved areas and MWs; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Excavation may interfere with base activities; Underground utilities may interfere with excavation; Maintaining paved areas and MWs; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Shoring required to protect buildings; Dewatering system required; water treatment and disposal system required; Base construction permit needed; Resources are readily available.
Costs:				
Capital	$27,000	$2,192,000	$427,000	$2,812,000
O&M NPW (Years)	$297,000 (30)	$300,000 (30)	$297,000 (30)	$0
NPW (Years)	$324,000 (30)	$2,492,000 (30)	$724,000 (30)	$2,812,000 (1)

TABLE 5-12

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 6 SOIL REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

NOTES:

ARARs	Applicable or Relevant and Appropriate Requirements
cy	Cubic yards
DECs	Direct Exposure Criteria (Connecticut)
I/C	Industrial/commercial
LTTD	Low-temperature thermal desorption
LUCs	Land use controls
NPW	Net present worth
O&M	Operation and maintenance
PMCs	Pollutant Mobility Criteria (Connecticut)
PRGs	Preliminary Remedial Goals
RAOs	Remedial Action Objectives
TBCs	To be considered (criteria)
TPH	Total petroleum hydrocarbons

TABLE 5-13

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 7 SOIL REMEDIAL ALTERNATIVES
LOWER SUBSASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-7.1 No Action	Alternative S-7.2 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-7.3 Capping to Allow I/C Site Use and Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-7.4 In-Situ Treatment (Stabilization/ Solidification) to Allow I/C Site Use and Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-7.5 Excavation to Meet I/C DEC and PMCs, Off-Site Disposal (Stabilization/ Solidification and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-7.6 Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/ Solidification, LTTD and Landfilling)
Overall Protection of Human Health and Environment	Not protective.	Protective.	More protective than Alternative S-7.2.	Approximately as protective as Alternative S-7.3.	More protective than Alternatives S-7.3 and S-7.4.	Most protective.
Compliance with ARARs and TBCs						
Chemical-Specific	Would not comply.	Would comply.	Would comply.	Would comply.	Would comply.	Would comply.
Location-Specific	No location-specific ARARs.	Would comply.	Would comply.	Would comply.	Would comply.	Would comply.
Action-Specific	Not applicable.	Would comply.	Would comply	Would comply.	Would comply.	Would comply.
Long-Term Effectiveness and Permanence	Not effective.	Effective.	More effective than Alternative S-7.2.	Approximately as effective as Alternative S-7.3.	More effective than Alternatives S-7.3 and S-7.4.	Most effective.
Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment	There is no treatment.	There is no treatment.	There is no treatment.	Would reduce toxicity and mobility of antimony and lead in 5,600 cy by in-situ chemical stabilization/ solidification. Would reduce toxicity, mobility, and volume of PAHs in 3,900 cy by in-situ enhanced bioremediation.	There is no treatment.	There is no treatment.

TABLE 5-13

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 7 SOIL REMEDIAL ALTERNATIVES
LOWER SUBSASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-7.1 No Action	Alternative S-7.2 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-7.3 Capping to Allow I/C Site Use and Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-7.4 In-Situ Treatment (Stabilization/ Solidification) to Allow I/C Site Use and Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-7.5 Excavation to Meet I/C DEC and PMCs, Off-Site Disposal (Stabilization/ Solidification and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-7.6 Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/ Solidification, LTTD and Landfilling)
Short-Term Effectiveness	No short-term risks. Would not achieve soil RAOs.	Short-term risks to address: Worker exposure during GW sampling; No impacts to environment or community. Three months to implement and achieve soil RAOs. Zone 7 soil PRGs for I/C direct exposure or pollutant mobility would be met through engineering controls.	Short-term risks to address: Worker exposure during cap installation and GW sampling; Transport of contaminated soil through community; Dust from excavation. One year to implement and achieve soil RAOs. Zone 2 soil PRGs for I/C direct exposure or pollutant mobility would be met through engineering controls and capping.	Short-term risks to address: Worker exposure during cap installation and GW sampling; Transport of contaminated soil through community; Dust from excavation. One year to implement and achieve soil RAOs. Would meet Zone 7 antimony and lead PRGs for I/C pollutant mobility at completion and Zone 7 PAHs and TPH PRGs for I/C direct exposure and Zone 7 TPH PRG for I/C pollutant mobility within 3 to 5 years. Would not meet Zone 4 lead PRG for I/C direct exposure.	Short-term risks to address: Worker exposure during excavation; Transport of contaminated soil through community; Dust from excavation. One year to implement and achieve soil RAOs. Would meet Zone 7 soil PRGs for I/C direct exposure and pollutant mobility at completion.	Short-term risks to address: Worker exposure during excavation; Transport of contaminated soil through community; Dust from excavation. Eighteen months to implement and achieve soil RAOs. Would meet Zone 7 soil PRGs for residential direct exposure and pollutant mobility at completion.

TABLE 5-13

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 7 SOIL REMEDIAL ALTERNATIVES
LOWER SUBSASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative S-7.1 No Action	Alternative S-7.2 LUCs (Engineering and Institutional Controls) and Monitoring	Alternative S-7.3 Capping to Allow I/C Site Use and Prevent Leaching, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-7.4 In-Situ Treatment (Stabilization/ Solidification) to Allow I/C Site Use and Meet I/C PMCs, LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-7.5 Excavation to Meet I/C DEC and PMCs, Off-Site Disposal (Stabilization/ Solidification and Landfilling), LUCs (Engineering and Institutional Controls), and Monitoring	Alternative S-7.6 Excavation to Meet Residential DECs and PMCs, On-Site Dewatering, and Off-Site Disposal (Stabilization/ Solidification, LTTD and Landfilling)
Implementability	Needs only 5-year reviews.	Issues include: Maintaining paved areas and MWs; No base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Construction may interfere with base activities; Underground utilities may interfere with construction; Maintaining paved areas and MWs; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Treatment may interfere with base activities; Underground utilities may interfere with treatment; Treatability tests needed; Maintaining paved areas and MWs; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Excavation may interfere with base activities; Underground utilities may interfere with excavation; Maintaining paved areas and MWs; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Shoring required to protect buildings; Dewatering system required; water treatment and disposal system required; Base construction permit needed; Resources are readily available.
Costs: Capital O&M NPW (Years) NPW (Years)	 $0 $55,000 (30) $55,00 (30)	 $79,000 $648,000 (30) $727,000 (30)	 $2,745,000 $648,000 (30) $3,393,000 (30)	 $2,388,000 $660,000 (30) $3,048,000 (30)	 $4,488,000 $648,000 (30) $5,136,000 (30)	 $22,979,000 $0 $22,979,000 (1)

TABLE 5-13

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 7 SOIL REMEDIAL ALTERNATIVES
LOWER SUBSASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

NOTES:

ARARs	Applicable or Relevant and Appropriate Requirements
cy	Cubic yards
DECs	Direct Exposure Criteria (Connecticut)
I/C	Industrial/commercial
LTTD	Low-temperature thermal desorption
LUCs	Land use controls
NPW	Net present worth
O&M	Operation and maintenance
PAHs	Polycyclic aromatic hydrocarbons
PMCs	Pollutant Mobility Criteria (Connecticut)
PRGs	Preliminary Remedial Goals
RAOs	Remedial Action Objectives
TBCs	To be considered (criteria)
TPH	Total petroleum hydrocarbons

TABLE 5-14

COMPARATIVE ASSESSMENT OF GROUNDWATER ALTERNATIVES COMPLIANCE WITH CHEMICAL-SPECIFIC ARARs AND TBCs
ZONES 1, 4, AND 7
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR				
		Alternatives GW-1.1, GW-4.1, GW-7.1: No Action	**Alternatives GW-1.2, GW-4.2, GW-7.2: LUCs and Monitoring**	**Alternatives GW-1.3, GW-4.3, GW-7.3: In-Situ Treatment, LUCs, and Monitoring**	**Alternatives GW-1.4, GW-4.4, GW-7.4: Extraction, Discharge and Disposal to Off-Site POTW, LUCs, and Monitoring**	**Alternatives GW-1.5, GW-4.5, GW-7.5: Extraction, On-Site Treatment, Discharge to Thames River, LUCs, and Monitoring**
FEDERAL						
Cancer Slope Factors (CSFs)	United States Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) and others	To be considered (TBC). Would not comply. Although there are no unacceptable risks from exposure to contaminated groundwater under the current industrial/commercial (I/C) site use because the Lower Subase aquifer is classified as GB and its use is restricted, the No Action alternatives would not include a formal enforcement of this restriction and this could allow future groundwater uses that would result in unacceptable risks. In addition, the No Action alternatives would not provide any warning of the potential migration of groundwater chemicals of concern (COCs) to the Thames River.	TBC. Would not comply.	TBC. Would comply. There are no unacceptable risks from direct exposure to contaminated groundwater under the current industrial site use. The aquifer beneath the Lower Subase has been classified as GB, and Alternatives GW-1.3, GW-4.3, and GW-7.3 would include in-situ treatment that would actively remove COCs from the groundwater and LUCs that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.	TBC. Would comply. There are no unacceptable risks from direct exposure to contaminated groundwater under the current industrial site use and the aquifer beneath the Lower Subase has been classified as GB. Alternatives GW-1.4, GW-4.4, and GW-7.4 would include extraction that would actively remove chemicals of concern (COCs) from groundwater and land use controls (LUCs) that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.	TBC. There are no unacceptable risks from direct exposure to contaminated groundwater under the current industrial site use and the aquifer beneath the Lower Subase has been classified as GB. Alternatives GW-1.5, GW-4.5, and GW-7.5 would include extraction that would actively remove COCs from groundwater and LUCs that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.
Cancer Reference Doses (RfDs)	EPA IRIS and others	TBC. Would not comply. Although there are no unacceptable risks from exposure to contaminated groundwater under the current I/C site use because the Lower Subase aquifer is classified as GB and its use is restricted, the No Action alternatives would not include a formal enforcement of this restriction and this could allow future groundwater uses that would result in unacceptable risks. In addition, the No Action alternatives would not provide any warning of the potential migration of groundwater COCs to the Thames River.	TBC. Would not comply.	TBC. Would comply. There are no unacceptable risks from direct exposure to contaminated groundwater under the current industrial site use. The aquifer beneath the Lower Subase has been classified as GB, and Alternatives GW-1.3, GW-4.3, and GW-7.3 would include in-situ treatment that would actively remove COCs from the groundwater and LUCs that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.	TBC. Would comply. There are no unacceptable risks from direct exposure to contaminated groundwater under the current industrial site use and the aquifer beneath the Lower Subase has been classified as GB. Alternatives GW-1.4, GW-4.4, and GW-7.4 would include extraction that would actively remove chemicals of concern (COCs) from groundwater and land use controls (LUCs) that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.	TBC. There are no unacceptable risks from direct exposure to contaminated groundwater under the current industrial site use and the aquifer beneath the Lower Subase has been classified as GB. Alternatives GW-1.5, GW-4.5, and GW-7.5 would include extraction that would actively remove COCs from groundwater and LUCs that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.

TABLE 5-14

COMPARATIVE ASSESSMENT OF GROUNDWATER ALTERNATIVES COMPLIANCE WITH CHEMICAL-SPECIFIC ARARs AND TBCs
ZONES 1, 4, AND 7
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR				
		Alternatives GW-1.1, GW-4.1, GW-7.1: No Action	**Alternatives GW-1.2, GW-4.2, GW-7.2: LUCs and Monitoring**	**Alternatives GW-1.3, GW-4.3, GW-7.3: In-Situ Treatment, LUCs, and Monitoring**	**Alternatives GW-1.4, GW-4.4, GW-7.4: Extraction, Discharge and Disposal to Off-Site POTW, LUCs, and Monitoring**	**Alternatives GW-1.5, GW-4.5, GW-7.5: Extraction, On-Site Treatment, Discharge to Thames River, LUCs, and Monitoring**
FEDERAL (Continued)						
Guidelines for Carcinogen Risk Assessment	EPA/630/P-03/001F	TBC. Would not comply. Although there are no unacceptable risks from exposure to contaminated groundwater under the current I/C site use because the Lower Subase aquifer is classified as GB and its use is restricted, the No Action alternatives would not include a formal enforcement of this restriction and this could allow future groundwater uses that would result in unacceptable risks. In addition, the No Action alternatives would not provide any warning of the potential migration of groundwater COCs to the Thames River.	TBC. Would not comply.	TBC. Would comply. There are no unacceptable risks from direct exposure to contaminated groundwater under the current industrial site use. The aquifer beneath the Lower Subase has been classified as GB, and Alternatives GW-1.3, GW-4.3, and GW-7.3 would include in-situ treatment that would actively remove COCs from the groundwater and LUCs that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.	TBC. Would comply. There are no unacceptable risks from direct exposure to contaminated groundwater under the current industrial site use and the aquifer beneath the Lower Subase has been classified as GB. Alternatives GW-1.4, GW-4.4, and GW-7.4 would include extraction that would actively remove chemicals of concern (COCs) from groundwater and land use controls (LUCs) that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.	TBC. There are no unacceptable risks from direct exposure to contaminated groundwater under the current industrial site use and the aquifer beneath the Lower Subase has been classified as GB. Alternatives GW-1.5, GW-4.5, and GW-7.5 would include extraction that would actively remove COCs from groundwater and LUCs that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	EPA/630/R-03/003F (March 2005)	TBC. Would not comply. Although there are no unacceptable risks from exposure to contaminated groundwater under the current I/C site use because the Lower Subase aquifer is classified as GB and its use is restricted, the No Action alternatives would not include a formal enforcement of this restriction and this could allow future groundwater uses that would result in unacceptable risks. In addition, the No Action alternatives would not provide any warning of the potential migration of groundwater COCs to the Thames River.	TBC. Would not comply.	TBC. Would comply. There are no unacceptable risks from direct exposure to contaminated groundwater under the current industrial site use. The aquifer beneath the Lower Subase has been classified as GB, and Alternatives GW-1.3, GW-4.3, and GW-7.3 would include in-situ treatment that would actively remove COCs from the groundwater and LUCs that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.	TBC. Would comply. There are no unacceptable risks from direct exposure to contaminated groundwater under the current industrial site use and the aquifer beneath the Lower Subase has been classified as GB. Alternatives GW-1.4, GW-4.4, and GW-7.4 would include extraction that would actively remove chemicals of concern (COCs) from groundwater and land use controls (LUCs) that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.	TBC. There are no unacceptable risks from direct exposure to contaminated groundwater under the current industrial site use and the aquifer beneath the Lower Subase has been classified as GB. Alternatives GW-1.5, GW-4.5, and GW-7.5 would include extraction that would actively remove COCs from groundwater and LUCs that would regulate access to and use of groundwater. In addition, these alternatives would include groundwater monitoring to establish trends in groundwater quality and provide a warning of the potential migration of COCs from groundwater to the Thames River.

TABLE 5-14

COMPARATIVE ASSESSMENT OF GROUNDWATER ALTERNATIVES COMPLIANCE WITH CHEMICAL-SPECIFIC ARARs AND TBCs
ZONES 1, 4, AND 7
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR				
		Alternatives GW-1.1, GW-4.1, GW-7.1: No Action	**Alternatives GW-1.2, GW-4.2, GW-7.2: LUCs and Monitoring**	**Alternatives GW-1.3, GW-4.3, GW-7.3: In-Situ Treatment, LUCs, and Monitoring**	**Alternatives GW-1.4, GW-4.4, GW-7.4: Extraction, Discharge and Disposal to Off-Site POTW, LUCs, and Monitoring**	**Alternatives GW-1.5, GW-4.5, GW-7.5: Extraction, On-Site Treatment, Discharge to Thames River, LUCs, and Monitoring**
STATE OF CONNECTICUT						
Remediation Standard Regulations (RSRs)	Connecticut General Statutes (CGS) §22a-133k; Regulations of Connecticut State Agencies (RCSA) §22a-133k - 1 through 3	Applicable. Would not comply. Historical exceedances of the Standard Surface Water Protection Criterion (SWPC) for copper and lead have been detected in Zones 1 and 4, respectively, and exceedances of the Alternative SWPC for arsenic have been detected in Zones 1, 4, and 7.	Applicable. Would not comply.	Applicable. Would comply. Alternative GW-1.3 would actively treat groundwater contaminated with copper from Zone 1 and Alternative GW-4.3 would actively treat groundwater contaminated with lead from Zone 4 until the Standard SWPCs for these COCs are met. In addition, Alternatives GW-1.3, GW-4.3, and GW-7.3 would actively treat groundwater contaminated with arsenic from Zones 1, 4, and 7 until the Alternative SWPC for this COC is met.	Applicable. Would eventually comply. Alternative GW-1.4 would actively remove and treat groundwater contaminated with copper from Zone 1 and Alternative GW-4.4 would actively remove and treat groundwater contaminated with lead from Zone 4 until the Standard SWPCs for these COCs are met. In addition, Alternatives GW-1.4, GW-4.4, and GW-7.4 would actively remove and treat groundwater contaminated with arsenic from Zones 1, 4, and 7 until the Alternative SWPC for this COC is met.	Applicable. Would comply. Alternative GW-1.5 would actively remove and treat groundwater contaminated with copper from Zone 1 and Alternative GW-4.5 would actively remove and treat groundwater contaminated with lead from Zone 4 until the Standard SWPCs for these COCs are met. In addition, Alternatives GW-1.5, GW-4.5, and GW-7.5 would actively remove and treat groundwater contaminated with arsenic from Zones 1, 4, and 7 until the Alternative SWPC for this COC is met.

TABLE 5-15

COMPARATIVE ASSESSMENT OF GROUNDWATER ALTERNATIVES COMPLIANCE WITH LOCATION-SPECIFIC ARARs AND TBCs
ZONES 1, 4, AND 7
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR				
		Alternatives GW-1.1, GW-4.1, GW-7.1: No Action	**Alternatives GW-1.2, GW-4.2, GW-7.2: LUCs and Monitoring**	**Alternatives GW-1.3, GW-4.3, GW-7.3: In-Situ Treatment, LUCs, and Monitoring**	**Alternatives GW-1.4, GW-4.4, GW-7.4: Extraction, Discharge and Disposal to Off-Site POTW, LUCs, and Monitoring**	**Alternatives GW-1.5, GW-4.5, GW-7.5: Extraction, On-Site Treatment, Discharge to Thames River, LUCs, and Monitoring**
FEDERAL						
Coastal Zone Management Act	16 USC Parts 1451 *et. seq.*	Not Applicable	Not Applicable	Applicable. Would comply. The in-situ treatment, LUCs, and monitoring activities of Alternatives GW-1.3 and GW-4.3 would comply with the substantive requirements of this act. This act would not be applicable to Alternative GW-7.3 because there are no above ground structures or major physical disturbances of the landscape associated with it.	Applicable. Would comply. The extraction, discharge and disposal to off-site POTW, LUCs, and monitoring activities of Alternatives GW-1.4, GW-4.4, and GW-7.4 would comply with the substantive requirements of this act.	Applicable. Would comply. The extraction, on-site treatment, discharge to Thames River, LUCs, and monitoring activities of Alternatives GW-1.5, GW-4.5, and GW-7.5 would comply with the substantive requirements of this act.
Fish and Wildlife Coordination Act	16 USC Part 661 *et. seq.*, 40 CFR 122	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Applicable. Would comply. The treatment prior to discharge to Thames River of Alternatives GW-1.5, GW-4.5, and GW-7.5 would be protective of fish and wildlife in the river. Federal resource agencies would be consulted to prevent, mitigate, or compensate for loss of fish and wildlife.
Floodplain Management and Protection of Wetlands	44 CFR 9	Not Applicable	Relevant and appropriate. The monitoring activities and establishment and long-term maintenance of the cover system of Alternatives GW-1.2, GW-4.2, and GW-7.2 conducted within the 500-year floodplain of the Thames River or within federal jurisdictional wetlands will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.	Relevant and appropriate. The in-situ treatment, LUCs, and monitoring activities of Alternatives GW-1.3, GW-4.3, and GW-7.3 conducted within the 500-year floodplain of the Thames River or within federal jurisdictional wetlands will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.	Relevant and appropriate. The extraction, discharge and disposal to off-site POTW and monitoring activities of Alternatives GW-1.4, GW-4.4, and GW-7.4 conducted within the 500-year floodplain of the Thames River or within federal jurisdictional wetlands will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.	Relevant and appropriate. The extraction, on-site treatment, discharge to Thames River, and monitoring activities of Alternatives GW-1.5, GW-4.5, and GW-7.5 conducted within the 500-year floodplain of the Thames River or within federal jurisdictional wetlands will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.
STATE OF CONNECTICUT						
Coastal Management Act	Regulations of Connecticut State Agencies (RCSA) §22a-90 to 112	Applicable	Not Applicable	Applicable. Would comply. The in-situ treatment, LUCs, and monitoring activities of Alternatives GW-1.4, GW-4.4, and GW-7.4 would comply with the substantive requirements of this act. This act would not be applicable to Alternative GW-7.3 because there are no above ground structures or major physical disturbances of the landscape associated with it.	Applicable. Would comply. The extraction, discharge and disposal to off-site POTW, LUCs, and monitoring activities of Alternatives GW-1.4, GW-4.4, and GW-7.4 would comply with the substantive requirements of this act.	Applicable. Would comply. The extraction, on-site treatment, discharge to Thames River, LUCs, and monitoring activities of Alternatives GW-1.5, GW-4.5, and GW-7.5 would comply with the substantive requirements of this act.
Tidal Wetlands and Watercourses	RCSA §22a-30-1 through 17	Applicable	Not Applicable	Applicable. Would comply. The in-situ treatment, LUCs, and monitoring activities of Alternatives GW-1.4, GW-4.4, and GW-7.4 would be managed to prevent erosion and other disturbance to tidal wetlands and the Thames River. This regulation would not be applicable to Alternative GW-7.3 because it will not physically affect tidal wetlands or watercourses.	Applicable. Would comply. The treatment and monitoring activities of Alternatives GW-1.4, GW-4.4, and GW-7.4 would be managed to prevent erosion and other disturbance to tidal wetlands and the Thames River.	Applicable. Would comply. The treatment and monitoring activities of Alternatives GW-1.5, GW-4.5, and GW-7.5 would be managed to prevent erosion and other disturbance to tidal wetlands and the Thames River.

TABLE 5-15

COMPARATIVE ASSESSMENT OF GROUNDWATER ALTERNATIVES COMPLIANCE WITH LOCATION-SPECIFIC ARARs AND TBCs
ZONES 1, 4, AND 7
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR				
		Alternatives GW-1.1, GW-4.1, GW-7.1: No Action	**Alternatives GW-1.2, GW-4.2, GW-7.2: LUCs and Monitoring**	**Alternatives GW-1.3, GW-4.3, GW-7.3: In-Situ Treatment, LUCs, and Monitoring**	**Alternatives GW-1.4, GW-4.4, GW-7.4: Extraction, Discharge and Disposal to Off-Site POTW, LUCs, and Monitoring**	**Alternatives GW-1.5, GW-4.5, GW-7.5: Extraction, On-Site Treatment, Discharge to Thames River, LUCs, and Monitoring**
STATE OF CONNECTICUT (Continued)						
Flood Management Regulations	(RCSA 25-68h-1 through 25-68h-3)	Not Applicable	Not Applicable	Applicable. Would comply. The in-situ treatment, LUCs, and monitoring activities of Alternatives GW-1.4, GW-4.4, and GW-7.4 would consider the potential for disturbance of floodplains. Any work in flood plains would comply with the substantive provisions of the regulations. This regulation would not be applicable to Alternative GW-7.3 because it will not physically alter the landscape and result in flooding or storm water runoff issues.	Applicable. Would comply. The extraction, discharge and disposal to off-site POTW, LUCs, and monitoring activities of Alternatives GW-1.4, GW-4.4, and GW-7.4 would consider the potential for disturbance of floodplains. Any work in flood plains would comply with the substantive provisions of the regulations.	Applicable. Would comply. The extraction, on-site treatment, discharge to Thames River, LUCs, and monitoring activities of Alternatives GW-1.5, GW-4.5, and GW-7.5 would consider the potential for disturbance of floodplains. Any work in flood plains would comply with the substantive provisions of the regulations.
Connecticut Endangered Species Act	CGS § 26-303 thru 314	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Would comply. The treatment and discharge of Alternatives GW-1.5, GW-4.5, and GW-7.5 would not disturb aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon.

TABLE 5-16

COMPARATIVE ASSESSMENT OF GROUNDWATER ALTERNATIVES COMPLIANCE WITH ACTION-SPECIFIC ARARs AND TBCs
ZONES 1, 4, AND 7
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR			
		Alternatives GW-1.2, GW-4.2, GW-7.2: Natural Attenuation, LUCs, and Monitoring	**Alternatives GW-1.3, GW-4.3, GW-7.3: In-Situ Treatment, LUCs, and Monitoring**	**Alternatives GW-1.4, GW-4.4, GW-7.4: Extraction, Discharge and Disposal to Off-Site POTW, LUCs, and Monitoring**	**Alternatives GW-1.5, GW-4.5, GW-7.5: Extraction, On-Site Treatment, Discharge to Thames River, LUCs, and Monitoring**
FEDERAL					
Clean Water Act (CWA), Section 403, Pretreatment Regulations	40 CFR § 403	Not Relevant and Appropriate. Alternatives GW-1.2, GW-4.2, and GW-7.2 would not include any groundwater extraction and discharge or disposal.	Not relevant and appropriate. Alternatives GW-1.3, GW-4.3, and GW-7.3 would not include any groundwater extraction and discharge or disposal.	Relevant and appropriate. Would comply. Alternative GW-1.4, GW-4.4, and GW-7.4 would include discharge of contaminated groundwater to the Lower Subase sanitary sewer system and from there to the Town of Groton publicly owned treatment works (POTW). These alternatives would comply with pretreatment standards.	Not relevant and appropriate. Alternative GW-1.5, GW-4.5, and GW-7.5 would include groundwater extraction, but no discharge and disposal to a POTW. Instead, the extracted groundwater would be treated on-site and then discharged to the Thames River.
CWA, National Pollution Discharge Elimination System (NPDES)	33 Unites States Code (USC) 1342 and 40 Code of Federal Regulations (CFR) Parts 122 through 125, and 131	Not Relevant and Appropriate. Alternatives GW-1.2, GW-4.2, and GW-7.2 would not include any groundwater extraction and discharge or disposal.	Not relevant and appropriate. Alternatives GW-1.3, GW-4.3, and GW-7.3 would not include any groundwater extraction and discharge or disposal.	Not relevant and appropriate. Alternatives GW-1.4, GW-4.4, and GW-7.4 would include groundwater extraction, but no direct discharge to surface water. Instead, the extracted groundwater would be discharged to Lower Subase sanitary sewer system and from there to the Town of Groton POTW.	Relevant and appropriate. Would comply. Alternatives GW-1.5, GW-4.5, and GW-7.5 would include groundwater extraction, on-site treatment, and discharge of the treated groundwater to the Thames River. These alternatives would comply with the NPDES requirements, including permitting.
Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites	OSWER Directive 9200.4-17P (April 21, 1999)	TBC. Would not comply. Monitored natural attenuation alternatives would only meet these standards if natural attenuation would attain all groundwater cleanup standards within a reasonable time frame.	Not applicable.	Not Applicable.	Not Applicable.
Underground Injection Control	40 CFR 144, 146, 147.350	Not applicable.	Applicable. Would comply. The subsurface injection of chemical substances for the purpose of in-situ remediation in Alternatives GW-1.3, GW-4.3, and GW-7.3 would comply with the general requirements of these standards.	Not Applicable.	Not Applicable.
STATE OF CONNECTICUT					
Hazardous Waste Management: Generator and Handler Requirements, Listing and Identification	Regulations of Connecticut State Agencies (RCSA) § 22a-449(c) 100-101	Applicable. Would comply. Hazardous waste determinations would be performed on wastes (contaminated soils, sediments and groundwater) created from the implementation of alternatives GW-1.2, GW-4.2, and GW-7.2. Any wastes determined to be hazardous would be managed in accordance with requirements of these regulations.	Would comply. Hazardous waste determinations would be performed on wastes (contaminated soils, sediments and groundwater) created from the implementation of alternatives GW-1.3, GW-4.3, and GW-7.3. Any wastes determined to be hazardous would be managed in accordance with requirements of these regulations.	Would comply. Alternative GW-1.4, GW-4.4, and GW-7.4 would require hazardous waste determination would be performed on contaminated groundwater removed to determine that the levels of regulated constituents do not exceed applicable limits.	Would comply. Alternatives GW-1.5, GW-4.5, and GW-7.5 would require hazardous waste determination would be performed on contaminated groundwater removed to determine that the levels of regulated constituents do not exceed applicable limits.
Hazardous Waste Management: Generator Standards	RCSA § 22a-449(c)-102	Applicable. Would comply. Any hazardous waste that is generated from treated groundwater would be handled and disposed of in compliance with these standards.	Would comply. Any hazardous waste that is generated from treated groundwater would be handled and disposed of in compliance with these standards.	Would comply. Alternative GW-1.4, GW-4.4, and GW-7.4 would require any hazardous waste that is generated (groundwater) would be handled and disposed of in compliance with these standards.	Would comply. Alternatives GW-1.5, GW-4.5, and GW-7.5 would require any hazardous waste that is generated (groundwater) would be handled and disposed of in compliance with these standards.

TABLE 5-16

COMPARATIVE ASSESSMENT OF GROUNDWATER ALTERNATIVES COMPLIANCE WITH ACTION-SPECIFIC ARARs AND TBCs
ZONES 1, 4, AND 7
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Status / Evaluation of Alternatives Compliance with ARAR			
		Alternatives GW-1.2, GW-4.2, GW-7.2: Natural Attenuation, LUCs, and Monitoring	**Alternatives GW-1.3, GW-4.3, GW-7.3: In-Situ Treatment, LUCs, and Monitoring**	**Alternatives GW-1.4, GW-4.4, GW-7.4: Extraction, Discharge and Disposal to Off-Site POTW, LUCs, and Monitoring**	**Alternatives GW-1.5, GW-4.5, GW-7.5: Extraction, On-Site Treatment, Discharge to Thames River, LUCs, and Monitoring**
STATE OF CONNECTICUT (continued)					
Underground Injection Control	RCSA § 22a-430-3, 4, and 8	Not applicable.	Applicable. Would comply. Alternatives GW-1.3, GW-4.3, and GW-7.3 involve the injection of chemical substances into the subsurface for the purpose of in-situ remediation. These actions would comply with the general requirements of these standards.	Not Applicable.	Not Applicable.
Water Quality Standards (WQSs)	Connecticut General Statutes (CGS) 22a-426	Applicable. Would comply. Stormwater standards would be complied with under these regulations. If necessary, it would be used for monitoring standards for groundwater beyond the compliance boundary for any waste management area and to monitor the Thames River.	Applicable. Would comply. Stormwater standards would be complied with under these regulations. If necessary, it would be used for monitoring standards for groundwater beyond the compliance boundary for any waste management area and to monitor the Thames River.	Applicable. Would comply. Stormwater standards would be complied with under these regulations. If necessary, it would be used for monitoring standards for groundwater beyond the compliance boundary for any waste management area and to monitor the Thames River.	Applicable. Would comply. Stormwater standards would be complied with under these regulations. If necessary, it would be used for monitoring standards for groundwater beyond the compliance boundary for any waste management area and to monitor the Thames River.
Water Pollution Control Act	RCSA §22a – 430-3, 4, and 8	Not Applicable. Alternatives GW-1.2, GW-4.2, and GW-7.2 would not include any groundwater extraction and discharge or disposal.	Applicable. Would comply. Alternatives GW-1.3, GW-4.3, and GW-7.3 would not include any groundwater extraction and discharge or disposal. These alternatives would meet the substantive environmental criteria contained in these requirements.	Applicable. Would comply. Alternatives GW-1.4, GW-4.4, and GW-7.4 would include groundwater extraction and discharge to the Lower Subase sanitary sewer system and from there to the Town of Groton POTW. These alternatives would comply with applicable pretreatment requirements.	Applicable. Would comply. Alternatives GW-1.5, GW-4.5, and GW-7.5 would include groundwater extraction, on site treatment, and discharge of the treated groundwater to the Thames River. These alternatives would comply with the NPDES requirements, including permitting.

TABLE 5-17

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 1 GROUNDWATER REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative GW-1.1 No Action	Alternative GW-1.2 Natural Attenuation, LUCs (Institutional Controls), and Monitoring	Alternative GW-1.3 In-Situ Treatment (Enhanced Bioremediation and Chemical Precipitation and Oxidation), LUCs (Institutional Controls), and Monitoring	Alternative GW-1.4 Extraction, Discharge and Disposal to Off-Site POTW, LUCs (Institutional Controls), and Monitoring	Alternative GW-1.5 Extraction, On-Site Treatment (Filtration, Oxidative Filtration, and Liquid-Phase GAC Adsorption), Discharge to Thames River, LUCs (Institutional Controls), and Monitoring
Overall Protection of Human Health and Environment	Not protective.	Not protective.	More protective than Alternative GW-1.2.	Approximately as protective as Alternative GW-1.3.	Approximately as protective as Alternative GW-1.3.
Compliance with ARARs and TBCs					
Chemical-Specific	Would not comply.	Would comply.	Would comply.	Would comply.	Would comply.
Location-Specific	No location-specific ARARs.	Would comply.	Would comply.	Would comply.	Would comply.
Action-Specific	Not applicable.	Would comply.	Would comply.	Would comply.	Would comply.
Long-Term Effectiveness and Permanence	Not effective.	Not effective due of long time to reach PRGs.	More effective than Alternative GW-1.2.	Approximately as effective as Alternative GW-1.3.	Approximately as effective as Alternative GW-1.3.
Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment	There is no treatment.	There is no treatment.	Would reduce toxicity, mobility, and volume of COCs by in-situ enhanced bioremediation and chemical precipitation and oxidation. Would remove 5,300 pounds of TPH , 0.04 pounds of arsenic, and 0.4 pounds of copper. Arsenic removal might not be fully permanent and irreversible.	There is no treatment.	Would reduce toxicity, mobility, and volume of COCs by extraction and on-site treatment. Would remove 5,300 pounds of TPH, 0.04 pounds of arsenic, and 0.4 pounds of copper.

TABLE 5-17

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 1 GROUNDWATER REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative GW-1.1 No Action	Alternative GW-1.2 Natural Attenuation, LUCs (Institutional Controls), and Monitoring	Alternative GW-1.3 In-Situ Treatment (Enhanced Bioremediation and Chemical Precipitation and Oxidation), LUCs (Institutional Controls), and Monitoring	Alternative GW-1.4 Extraction, Discharge and Disposal to Off-Site POTW, LUCs (Institutional Controls), and Monitoring	Alternative GW-1.5 Extraction, On-Site Treatment (Filtration, Oxidative Filtration, and Liquid-Phase GAC Adsorption), Discharge to Thames River, LUCs (Institutional Controls), and Monitoring
Short-Term Effectiveness	No short-term risks.	Short-term risks to address: Worker exposure during GW sampling; No impacts to environment or community. Three months to achieve groundwater RAO No. 1. Would meet PRGs through natural attenuation within 42 years in Copper/TPH Plume and 219 years in Arsenic/Copper Plume.	Short-term risks to address: Worker exposure during treatment system installation and operation and GW sampling; No impacts to environment or community. One year to achieve groundwater RAO No. 1. Would meet PRGs within in Copper/TPH and Arsenic/Copper Plumes within 1 year.	Short-term risks to address: Worker exposure during extraction system installation, treatment, and operation and GW sampling; discharge of contaminated water to the sanitary sewer and POTW. One year to achieve groundwater RAO No. 1. Would meet PRGs within 27 years in Copper/TPH Plume and 26 years in Arsenic/Copper Plume.	Short-term risks to address: Worker exposure during treatment system installation and operation and GW sampling; Transport of treatment residuals through community. Eighteen months to achieve groundwater RAO No. 1. Would meet PRGs within 27 years in Copper/TPH Plume and 26 years in Arsenic/ Copper Plume.

TABLE 5-17

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 1 GROUNDWATER REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative GW-1.1 No Action	Alternative GW-1.2 Natural Attenuation, LUCs (Institutional Controls), and Monitoring	Alternative GW-1.3 In-Situ Treatment (Enhanced Bioremediation and Chemical Precipitation and Oxidation), LUCs (Institutional Controls), and Monitoring	Alternative GW-1.4 Extraction, Discharge and Disposal to Off-Site POTW, LUCs (Institutional Controls), and Monitoring	Alternative GW-1.5 Extraction, On-Site Treatment (Filtration, Oxidative Filtration, and Liquid-Phase GAC Adsorption), Discharge to Thames River, LUCs (Institutional Controls), and Monitoring
Implementability	Needs only 5-year reviews.	Implementability issues include: No base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Implementability issues include: Treatment may interfere with base activities; Underground utilities may interfere with treatment; Treatability tests needed; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Implementability issues include: Treatment may interfere with base activities; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Discharge to POTW must be negotiated; Resources are readily available.	Implementability issues include: Treatment may interfere with base activities; Treatability tests needed; Base construction permit needed; LUC RD can be readily developed and implemented; Treatment plant operator required; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.
Costs					
Capital	$0	$38,000	$482,000	$329,000	$942,000
O&M NPW (Years)	$55,000	$338,000 (30)	$619,000 (5)	$3,561,000 (30)	$2,011,000 (30)
NPW (Years)	$55,000	$376,000 (30)	$1,101,000 (5)	$3,890,000 (30)	$2,953,000 (30)

TABLE 5-17

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 1 GROUNDWATER REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

NOTES:

ARARs	Applicable or Relevant and Appropriate Requirements
LUCs	Land use controls
NPW	Net present worth
O&M	Operation and maintenance
POTW	Publically owned treatment works
PRGs	Preliminary Remedial Goals
RAOs	Remedial Action Objectives
TBCs	To be considered (criteria)
TPH	Total petroleum hydrocarbons

TABLE 5-18

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 4 GROUNDWATER REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative GW-4.1 No Action	Alternative GW-4.2 Natural Attenuation, LUCs (Institutional Controls), and Monitoring	Alternative GW-4.3 In-Situ Treatment (Enhanced Bioremediation and Chemical Precipitation and Oxidation), LUCs (Institutional Controls), and Monitoring	Alternative GW-4.4 Extraction, Discharge and Disposal to Off-Site POTW, LUCs (Institutional Controls), and Monitoring	Alternative GW-4.5 Extraction, On-Site Treatment (Filtration, Oxidative Filtration, Chemical Precipitation, and Liquid-Phase GAC Adsorption), Discharge to Thames River, LUCs (Institutional Controls), and Monitoring
Overall Protection of Human Health and Environment	Not protective.	Not protective.	More protective than Alternative GW-4.2.	Approximately as protective as Alternative GW-4.3.	Approximately as protective as Alternative GW-4.3.
Compliance with ARARs and TBCs					
Chemical-Specific	Would not comply.	Would comply.	Would comply.	Would comply.	Would comply.
Location-Specific	No location-specific ARARs.	Would comply.	Would comply.	Would comply.	Would comply.
Action-Specific	Not applicable.	Would comply.	Would comply.	Would comply.	Would comply.
Long-Term Effectiveness and Permanence	Not effective.	Not effective due of long time to reach PRGs.	More effective than Alternative GW-4.2.	Approximately as effective as Alternative GW-4.3.	Approximately as effective as Alternative GW-4.3.
Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment	There is no treatment.	There is no treatment.	Would reduce toxicity, mobility, and volume of COCs by in-situ enhanced bioremediation and chemical precipitation and oxidation. Would remove 1,030 pounds of TPH , 0.08 pound of arsenic, and 4.06 pounds of lead. Arsenic removal might not be fully permanent and irreversible.	There is no treatment.	Would reduce toxicity, mobility, and volume of COCs by extraction and on-site treatment. Would remove 1,030 pounds of TPH, 0.08 pounds of arsenic, and 4.06 pounds of lead.

TABLE 5-18

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 4 GROUNDWATER REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative GW-4.1 No Action	Alternative GW-4.2 Natural Attenuation, LUCs (Institutional Controls), and Monitoring	Alternative GW-4.3 In-Situ Treatment (Enhanced Bioremediation and Chemical Precipitation and Oxidation), LUCs (Institutional Controls), and Monitoring	Alternative GW-4.4 Extraction, Discharge and Disposal to Off-Site POTW, LUCs (Institutional Controls), and Monitoring	Alternative GW-4.5 Extraction, On-Site Treatment (Filtration, Oxidative Filtration, Chemical Precipitation, and Liquid-Phase GAC Adsorption), Discharge to Thames River, LUCs (Institutional Controls), and Monitoring
Short-Term Effectiveness	No short-term risks. Would not achieve groundwater RAOs	Short-term risks to address: Worker exposure during GW sampling; No impacts to environment or community. Three months to implement and achieve groundwater RAO No. 1. Would meet PRGs through natural attenuation within 22 years in Arsenic/TPH Plume and 548 years in Lead Plume.	Short-term risks to address: Worker exposure during treatment system installation and operation and GW sampling; No impacts to environment or community. One year to implement and achieve groundwater RAO No. 1. Would meet PRGs in Arsenic/TPH and Lead Plumes within 1 year.	Short-term risks to address: Worker exposure during extraction system installation, treatment, and operation and GW sampling; discharge of contaminated water to the sanitary sewer and POTW. One year to implement and achieve groundwater RAO No. 1. Would meet PRGs within 11 years in Arsenic/TPH Plume and 27 years in Lead Plume.	Short-term risks to address: Worker exposure during treatment system installation and operation and GW sampling; Transport of treatment residuals through community. Eighteen months to implement and achieve groundwater RAO No. 1. Would meet PRGs within 11 years in Arsenic/TPH Plume and 27 years in Lead Plume.

TABLE 5-18

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 4 GROUNDWATER REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative GW-4.1 No Action	Alternative GW-4.2 Natural Attenuation, LUCs (Institutional Controls), and Monitoring	Alternative GW-4.3 In-Situ Treatment (Enhanced Bioremediation and Chemical Precipitation and Oxidation), LUCs (Institutional Controls), and Monitoring	Alternative GW-4.4 Extraction, Discharge and Disposal to Off-Site POTW, LUCs (Institutional Controls), and Monitoring	Alternative GW-4.5 Extraction, On-Site Treatment (Filtration, Oxidative Filtration, Chemical Precipitation, and Liquid-Phase GAC Adsorption), Discharge to Thames River, LUCs (Institutional Controls), and Monitoring
Implementability	Needs only 5-year reviews.	Implementability issues include: No base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Implementability issues include: Treatment may interfere with base activities; Underground utilities may interfere with treatment; Treatability tests needed; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Implementability issues include: Treatment may interfere with base activities; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Discharge to POTW must be negotiated; Resources are readily available.	Implementability issues include: Treatment may interfere with base activities; Treatability tests needed; Base construction permit needed; LUC RD can be readily developed and implemented; Treatment plant operator required; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.
Costs					
Capital	$0	$33,000	$548,000	$518,000	$1,535,000
O&M NPW (Years)	$55,000	$338,000 (30)	$445,000 (5)	$7,777,000 (30)	$2,641,000 (30)
NPW (Years)	$55,000	$371,000 (30)	$993,000 (5)	$8,295,000 (30)	$4,176,000 (30)

TABLE 5-18

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 4 GROUNDWATER REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

NOTES:

ARARs	Applicable or Relevant and Appropriate Requirements
LUCs	Land use controls
NPW	Net present worth
O&M	Operation and maintenance
POTW	Publically owned treatment works
PRGs	Preliminary Remedial Goals
RAOs	Remedial Action Objectives
TBCs	To be considered (criteria)
TPH	Total petroleum hydrocarbons

TABLE 5-19

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 7 GROUNDWATER REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative GW-7.1 No Action	Alternative GW-7.2 Natural Attenuation, LUCs (Institutional Controls), and Monitoring	Alternative GW-7.3 In-Situ Treatment (Chemical Precipitation and Oxidation), LUCs (Institutional Controls), and Monitoring	Alternative GW-7.4 Extraction, Discharge and Disposal to Off-Site POTW, LUCs (Institutional Controls), and Monitoring	Alternative GW-7.5 Extraction, On-Site Treatment (Filtration and Oxidative Filtration), Discharge to Thames River, LUCs (Institutional Controls), and Monitoring
Overall Protection of Human Health and Environment	Not protective.	Protective.	More protective than Alternative GW-7.2.	Approximately as protective as Alternative GW-7.3.	Approximately as protective as Alternative GW-7.3.
Compliance with ARARs and TBCs					
Chemical-Specific	Would not comply.	Would comply.	Would comply.	Would comply.	Would comply.
Location-Specific	No location-specific ARARs.	Would comply.	Would comply.	Would comply.	Would comply.
Action-Specific	Not applicable.	Would comply.	Would comply.	Would comply.	Would comply.
Long-Term Effectiveness and Permanence	Not effective.	Considered effective although a long time is needed to reach PRGs.	More effective than Alternative GW-7.2.	Approximately as effective as Alternative GW-7.3.	Approximately as effective as Alternative GW-7.3.
Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment	There is no treatment.	There is no treatment.	Would reduce toxicity, mobility, and volume of COCs by in-situ chemical precipitation and oxidation. Would remove 0.04 pound of arsenic. Removal might not be fully permanent and irreversible.	There is no treatment.	Would reduce toxicity, mobility, and volume of COCs by extraction and on-site treatment. Would remove 0.04 pound of arsenic.

TABLE 5-19

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 7 GROUNDWATER REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative GW-7.1 No Action	Alternative GW-7.2 Natural Attenuation, LUCs (Institutional Controls), and Monitoring	Alternative GW-7.3 In-Situ Treatment (Chemical Precipitation and Oxidation), LUCs (Institutional Controls), and Monitoring	Alternative GW-7.4 Extraction, Discharge and Disposal to Off-Site POTW, LUCs (Institutional Controls), and Monitoring	Alternative GW-7.5 Extraction, On-Site Treatment (Filtration and Oxidative Filtration), Discharge to Thames River, LUCs (Institutional Controls), and Monitoring
Short-Term Effectiveness	No short-term risks. Would not achieve groundwater RAOs	Short-term risks to address: Worker exposure during GW sampling; No impacts to environment or community. Three months to implement and achieve groundwater RAO No. 1. Would meet groundwater arsenic PRG through natural attenuation within 34 years.	Short-term risks to address: Worker exposure during treatment system installation and operation and GW sampling; No impacts to environment or community. One year to implement and achieve groundwater RAO No. 1. Would meet groundwater arsenic PRG within 1 year.	Short-term risks to address: Worker exposure during extraction system installation, treatment, and operation and GW sampling; discharge of contaminated water to the sanitary sewer and POTW. One year to implement and achieve groundwater RAO No.1. Would meet groundwater arsenic PRG within 18 years.	Short-term risks to address: Worker exposure during treatment system installation and operation and GW sampling; Transport of treatment residuals through community. Eighteen months to implement and achieve groundwater RAO No. 1. Would meet groundwater arsenic PRG within 18 years.

TABLE 5-19

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 7 GROUNDWATER REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative GW-7.1 No Action	Alternative GW-7.2 Natural Attenuation, LUCs (Institutional Controls), and Monitoring	Alternative GW-7.3 In-Situ Treatment (Chemical Precipitation and Oxidation), LUCs (Institutional Controls), and Monitoring	Alternative GW-7.4 Extraction, Discharge and Disposal to Off-Site POTW, LUCs (Institutional Controls), and Monitoring	Alternative GW-7.5 Extraction, On-Site Treatment (Filtration and Oxidative Filtration), Discharge to Thames River, LUCs (Institutional Controls), and Monitoring
Implementability	Needs only 5-year reviews.	Implementability issues include: No base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Implementability issues include: Treatment may interfere with base activities; Underground utilities may interfere with treatment; Treatability tests needed; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Implementability issues include: Treatment may interfere with base activities; Base construction permit needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Discharge to POTW must be negotiated; Resources are readily available.	Implementability issues include: Treatment may interfere with base activities; Treatability tests needed; Base construction permit needed; LUC RD can be readily developed and implemented; Treatment plant operator required; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.
Costs					
Capital	$0	$24,000	$282,000	$265,000	$499,000
O&M NPW (Years)	$55,000	$318,000 (30)	$149,000 (5)	$1,938,000 (30)	$929,000 (30)
NPW (Years)	$55,000	$342,000 (30)	$431,000 (5)	$2,203,000 (30)	$1,428,000 (30)

TABLE 5-19

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 7 GROUNDWATER REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

NOTES:

ARARs	Applicable or Relevant and Appropriate Requirements
LUCs	Land use controls
NPW	Net present worth
O&M	Operation and maintenance
POTW	Publically owned treatment works
PRGs	Preliminary Remedial Goals
RAOs	Remedial Action Objectives
TBCs	To be considered (criteria)
TPH	Total petroleum hydrocarbons

TABLE 5-20

COMPARATIVE ASSESSMENT OF SEDIMENT ALTERNATIVES COMPLIANCE WITH CHEMICAL-SPECIFIC ARARs AND TBCs
ZONE 4 AND OUTER PIER 1
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Evaluation of Alternatives Compliance with ARAR	
		Alternative SD-1 No Action	**Alternatives SD-3, SD-4, SD-6, SD-7 Dredging, Capping (SD-3, SD-4), Dewatering, On-Site Treatment and Discharge to Thames River (SD-3, SD-6), and Off-Site Disposal**
FEDERAL			
Cancer Slope Factors (CSFs)	United States Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) and others	To be considered (TBC). Would not comply. These standards would be used to determine that there are no unacceptable carcinogenic risks from direct exposure to contaminated sediment. The No Action alternative would not meet these standards because risks identified would not be addressed.	TBC for all alternatives. Would comply. These standards would be used to determine that there are no unacceptable carcinogenic risks from direct exposure to contaminated sediment. Alternatives SD-3, SD-4, SD-6, and SD-7 would meet these standards because potential risk from adult exposure to contaminated sediment would be addressed through capping or dredging and off-site disposal of contaminated sediment.
Reference Doses (RfDs)	EPA IRIS and others	TBC. Would not comply. These standards would be used to determine that there are no unacceptable non-carcinogenic risks from direct exposure to contaminated sediment. The No Action alternative would not meet these standards because risks identified would not be addressed.	TBC for all alternatives. Would comply. These standards would be used to determine that there are no unacceptable carcinogenic risks from direct exposure to contaminated sediment. Alternatives SD-3, SD-4, SD-6, and SD-7 would meet these standards because potential risk from adult exposure to contaminated sediment would be addressed through capping or dredging and off-site disposal of contaminated sediment.
Guidelines for Carcinogen Risk Assessment	EPA/630/P-03/001F (March 2005)	TBC. Would not comply. These standards would be used to determine that there are no unacceptable non-carcinogenic risks from direct exposure to contaminated sediment. The No Action alternative would not meet these standards because risks identified would not be addressed.	TBC for all alternatives. Would comply. These standards would be used to determine that there are no unacceptable carcinogenic risks from direct exposure to contaminated sediment. Alternatives SD-3, SD-4, SD-6, and SD-7 would meet these standards because potential risk from adult exposure to contaminated sediment would be addressed through capping or dredging and off-site disposal of contaminated sediment.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	EPA/630/R-03/003F (March 2005)	TBC. Would not comply. These standards would be used to determine that there are no unacceptable non-carcinogenic risks from direct exposure to contaminated sediment. The No Action alternative would not meet these standards because risks identified would not be addressed.	TBC for all alternatives. Would comply. These standards would be used to determine that there are no unacceptable carcinogenic risks from direct exposure to contaminated sediment. Alternatives SD-3, SD-4, SD-6, and SD-7 would meet these standards because potential risk from adult exposure to contaminated sediment would be addressed through capping or dredging and off-site disposal of contaminated sediment.
Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil	EPA-540-R-03-001, OSWER Dir #9285.7-54 (January 2003)	TBC. Would not comply. The No Action alternatives would not meet these standards because risks identified from lead-contaminated sediment would not be addressed.	TBC for all alternatives. Would comply Alternatives SD-3, SD-4, SD-6, and SD-7 would meet this standard because potential lead risk from adult exposure to lead in contaminated sediment would be addressed through capping or dredging and off-site disposal.

TABLE 5-20

COMPARATIVE ASSESSMENT OF SEDIMENT ALTERNATIVES COMPLIANCE WITH CHEMICAL-SPECIFIC ARARs AND TBCs
ZONE 4 AND OUTER PIER 1
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Evaluation of Alternatives Compliance with ARAR	
		Alternative SD-1 No Action	**Alternatives SD-3, SD-4, SD-6, SD-7 Dredging, Capping (SD-3, SD-4), Dewatering, On-Site Treatment and Discharge to Thames River (SD-3, SD-6), and Off-Site Disposal**
FEDERAL (Continued)			
Effect Range Median-Quotient (ERM-Q)	Long, Edward, et al, 1995. Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments, and Long and Morgan, 1991. Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program.	TBC. Would not comply. The document would be used to develop standards used for evaluating risk to aquatic ecological receptors exposed to contaminated sediment. Guidance was used to establish sediment PRGs. The No Action alternative would not meet these standards because risks identified would not be addressed.	Would comply. The document would be used to develop standards used for evaluating risk to aquatic ecological receptors exposed to contaminated sediment. Guidance was used to establish sediment PRGs. Alternatives SD-3, SD-4, SD-6, and SD-7 would meet the standards because potential risk to aquatic ecological receptors to contaminated sediment would be addressed through capping or dredging and off-site disposal of contaminated sediment.
STATE OF CONNECTICUT			
None			

TABLE 5-21

COMPARATIVE ASSESSMENT OF SEDIMENT ALTERNATIVES COMPLIANCE WITH LOCATION-SPECIFIC ARARs AND TBCs
ZONE 4 AND OUTER PIER 1
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Evaluation of Alternatives Compliance with ARAR Alternatives SD-3, SD-4, SD-6, SD-7 Dredging, Capping (SD-3, SD-4), Dewatering, On-Site Treatment and Discharge to Thames River (SD-3, SD-6), and Off-Site Disposal
FEDERAL		
Clean Water Act (CWA) Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material	33 United States Code (USC) 1344; 40 Code of Federal Regulations (CFR) Part 230 and 320-323	Applicable to all alternatives. All alternatives would comply. Dredging and sediment dewatering would be conducted so as to minimize discharges to wetlands or navigable waters. Resource agencies have indicated that mitigation would not be required for altering aquatic habitat. Capping (Alternatives SD-3 and SD-4 only) would also meet these standards
Rivers and Harbors Act, Section 10	33 USC 403; 33 CFR Parts 320-323	Applicable to all alternatives. All alternatives would comply. The dredging, dewatering, and potentially capping (Alternatives SD-3 and SD-4 only) of all alternatives would meet the substantive environmental requirements of these standards.
Fish and Wildlife Coordination Act	16 USC Part 661 *et seq.*,	Applicable to all alternatives. All alternatives would comply. The dredging, dewatering, and potentially capping (Alternatives SD-3 and SD-4 only) of all alternatives would be conducted so as to minimize impacts to fish and wildlife in the Thames River. Federal and State resource agencies would be consulted to prevent, mitigate, or compensate for loss of fish and wildlife.
Coastal Zone Management Act	16 USC Parts 1451 *et seq*.	Applicable to all alternatives. All alternatives would comply. The dredging, dewatering, and potentially capping (Alternatives SD-3 and SD-4 only) of all alternatives would be conducted so as to comply with the substantive requirements of this act.
Floodplain Management and Protection of Wetlands	44 CFR 9	Applicable to all alternatives. All alternatives would comply. The dredging, dewatering, and potentially capping (Alternatives SD-3 and SD-4 only) of all alternatives that would be conducted within the 500-year floodplain of the Thames River or within federal jurisdictional wetlands will be implemented in compliance with these standards. The Navy will solicit public comment as part of the proposed plan on the measures taken through the remedial action to protect floodplain and wetland resources.
STATE OF CONNECTICUT		
Connecticut Coastal Management Act	Regulations of Connecticut State Agencies (RCSA) §22a-90 to 112	Applicable to all alternatives. All alternatives would comply. The dredging, dewatering, and potentially capping (Alternatives SD-3 and SD-4 only) of all alternatives would be conducted so as to as to comply with the substantive requirements of this act.

TABLE 5-21

COMPARATIVE ASSESSMENT OF SEDIMENT ALTERNATIVES COMPLIANCE WITH LOCATION-SPECIFIC ARARs AND TBCs
ZONE 4 AND OUTER PIER 1
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Evaluation of Alternatives Compliance with ARAR Alternatives SD-3, SD-4, SD-6, SD-7 Dredging, Capping (SD-3, SD-4), Dewatering, On-Site Treatment and Discharge to Thames River (SD-3, SD-6), and Off-Site Disposal
STATE OF CONNECTICUT (Continued)		
Regulation of Dredging and Erection of Structures and Placement of Fill in Tidal, Coastal, or Navigable Waters	CGS 22a-359 through 363f	Applicable to all alternatives. All alternatives would comply. The dredging, dewatering, and potentially capping (Alternatives SD-3 and SD-4 only) of all alternatives would be conducted so as to as to comply with the substantive requirements of this act.
Tidal Wetlands and Watercourses	RCSA §22a-30-1 through 17	Applicable to all alternatives. All alternatives would comply. The dredging, dewatering, and potentially capping (Alternatives SD-3 and SD-4 only) of all alternatives would be conducted so as to prevent erosion, sedimentation and other disturbance to tidal wetlands and watercourses.
Flood Management Regulations	RCSA 25-68h-1 through 25-68h-3	Relevant and Appropriate to all alternatives. All alternatives would comply. Any shoreline activities within the 100-year coastal flood hazard zone would comply with the substantive provisions of these regulations.
Endangered Species Act	CGS §26-303 through 314	Applicable to all alternatives. All alternatives would comply. The dredging, dewatering, and potentially capping (Alternatives SD-3 and SD-4 only) of all alternatives would be conducted so as to minimize disturbance to aquatic habitats in the Thames River which are used by the state-threatened Atlantic Sturgeon.

TABLE 5-22

COMPARATIVE ASSESSMENT OF SEDIMENT ALTERNATIVES COMPLIANCE WITH ACTION-SPECIFIC ARARs AND TBCs
ZONE 4 AND OUTER PIER 1
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Evaluation of Alternatives Compliance with ARAR Alternatives SD-3, SD-4, SD-6, SD-7 Dredging, Capping (SD-3, SD-4), Dewatering, On-Site Treatment and Discharge to Thames River (SD-3, SD-6), and Off-Site Disposal
FEDERAL		
Clean Water Act (CWA), Section 304; National Recommended Water Quality Criteria ("NRWQC")	33 United States Code (USC) 1314; 40 Code of Federal Regulations (CFR) 122.44	Relevant and Appropriate to all alternatives. All alternatives would comply. Water quality monitoring would ensure that these criteria are not exceeded during dredging and dewatering operations. Alternatives SD-3 and SD-4 that include capping and leaving waste in place might require long-term monitoring of water quality under these standards.
CWA, Section 402, National Pollution Discharge Elimination System (NPDES)	33 USC 1342; 40 CFR 122 through 125	Applicable to Alternatives SD-3 and SD-6 (discharge to Thames River. Not applicable to Alternatives SD-4 and SD-7. Alternatives SD-3 and SD-6 would comply. Dewatering operations would meet these standards through active or passive treatment before dewatering fluid is discharged back to the Thames River.
CWA; General Pretreatment Regulations for Existing and New Sources of Pollution	40 C.F.R. § 403	Potentially applicable to Alternatives SD-4 and SD-7 (off-site disposal). Not applicable to Alternatives SD-3 and SD-6 (discharge to Thames River). Alternatives SD-4 and SD-7 would comply with these standards if off-site disposal of dewatering fluid involves discharge to a publicly owned treatment work (POTW).
Toxic Substance Control Act (TSCA), PCB Remediation Waste Risk-Based Standards	15 U.S.C. § 2601 *et seq.*; 40 C.F.R 761.61(c)	Applicable to all alternatives. Alternatives SD-3 and SD-4 would comply by capping polychlorinated biphenyl (PCB) contaminated sediment in place to prevent risks to humane health and the environment. Alternatives SD-6 and SD-7 would comply because sediment exceeding the unrestricted use, risk-based standard of 1 milligram per kilogram (mg/kg) would be excavated/dredged and disposed of off-site. The Navy will seek public comment in the Proposed Plan as to whether the finding that the proposed remedy for PCB contamination at the Site will not pose an unreasonable risk of injury to health or the environment. An EPA finding that the remedy meets these standards will be included in the Record of Decision.
Clean Air Act (CAA), National Emissions Standards for Hazardous Air Pollutants (NESHAPs),	42 U.S.C. §12(b)(1); 40 C.F.R. Part 61	Applicable to all alternatives. All alternatives would comply. If removal activities, including excavation/dredging or processing of contaminated sediment, generate regulated air pollutants, measures would be implemented to meet these standards.
United States Environmental Protection Agency (U.S. EPA) Contaminated Sediment Remediation Guidance for Hazardous Waste Sites	EPA-540-R-05-012; OSWER 9355.0-85 December 2005	To Be Considered (TBC) for all alternatives. All Alternatives would comply. Capping and dredging alternatives would be designed and implemented utilizing this guidance.
STATE OF CONNECTICUT		
Hazardous Waste Management: Generator and Handler Requirements, Listing and Identification	Regulations of Connecticut State Agencies (RCSA) ' 22a-449(c) 100-101	Applicable to all alternatives. All alternatives would comply. Hazardous waste determinations would be performed on all contaminated sediment excavated/dredged to determine that the levels of regulated constituents do not exceed applicable limits. Any contaminated sediments which exceed hazardous waste standards would be managed in accordance with requirements of these regulations. Also, wastes produced from dewatering process would be tested to determine whether they exceed applicable limits.

TABLE 5-22

COMPARATIVE ASSESSMENT OF SEDIMENT ALTERNATIVES COMPLIANCE WITH ACTION-SPECIFIC ARARs AND TBCs
ZONE 4 AND OUTER PIER 1
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Requirement	Citation	Evaluation of Alternatives Compliance with ARAR Alternatives SD-3, SD-4, SD-6, SD-7 Dredging, Capping (SD-3, SD-4), Dewatering, On-Site Treatment and Discharge to Thames River (SD-3, SD-6), and Off-Site Disposal
STATE OF CONNECTICUT (continued)		
Hazardous Waste Management: Generator Standards	RCSA § 22a-449(c)-102	Applicable to all alternatives. All alternatives would comply. Any hazardous waste generated as a result of either excavation/dredging or dewatering operations would be handled and disposed of in compliance with these standards.
Hazardous Waste Management Facility Siting	RSCA § 22a-116-B-1	Applicable to all alternatives. All alternatives would comply. Any sediment management and/or dewatering facility that manages material that exceeds hazardous waste thresholds would comply with these siting standards.
Solid Waste Management	RSCA §22a-209 -1 through 16	Applicable to solid waste managed on-site (all alternatives). All alternatives would comply. All material that does not exceed hazardous waste threshold that would be managed on-site as solid waste and disposed off-site in an appropriate licensed solid waste facility.
Water Pollution Control	RCSA §22a-430-1 through 8	Applicable to Alternatives SD-3 and SD-6 (discharge to Thames River. Not applicable to Alternatives SD-4 and SD-7 (off-site disposal). Alternatives SD-3 and SD-6 would comply. Dewatering operations would meet these standards through active or passive treatment before dewatering fluid is discharged back to the Thames River.
Air Pollution Control	RCSA §22a-174 1-20	Applicable to all alternatives. All alternatives would comply. If removal activities, including excavation/dredging or processing of contaminated sediment, generates regulated air pollutants, measures would be implemented to meet these standards.
Connecticut Guidelines for Soil Erosion and Sediment Control	Connecticut Council on Soil and Water Conservation	TBC for all alternatives. All alternatives would comply. Excavation/dredging operations would include an appropriate erosion and sedimentation control program that would comply with this guidance.

TABLE 5-23

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 4 AND OUTER PIER 1 SEDIMENT REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative SD-1 No Action	Alternative SD-3 Capping with Pre-Dredging to Meet RAOs, Dewatering, On-Site Treatment and Discharge of Dewatering Fluid, Off-Site Disposal of Dewatered Sediment, LUCs (Institutional Controls), and Monitoring	Alternative SD-4 Capping with Pre-Dredging to Meet RAOs, Dewatering, Off-Site Disposal of Dewatered Sediment and Dewatering Fluid, LUCs (Institutional Controls), and Monitoring	Alternative SD-6 Dredging to Meet PRGs, Dewatering, On-Site Treatment and Discharge of Dewatering Fluid, and Off-Site Disposal of Dewatered Sediment	Alternative SD-7 Dredging to Meet PRGs, Dewatering, and Off-Site Disposal of Dewatered Sediment and Dewatering Fluid
Overall Protection of Human Health and Environment	Not protective.	Protective.	As protective as Alternative SD-3.	More protective than Alternatives SD-3 and SD-4.	As protective as Alternative SD-6.
Compliance with ARARs and TBCs					
Chemical-Specific	Would not comply.	Would comply.	Would comply.	Would comply	Would comply
Location-Specific	Would not comply	Would comply.	Would comply.	Would comply	Would comply
Action-Specific	No location-specific ARARs.	Would comply.	Would comply.	Would comply	Would comply
Long-Term Effectiveness and Permanence	Not effective.	Effective.	Slightly less effective than Alternative SD-3	More effective than Alternative SD-7. Most effective	More effective than Alternatives SD-3 and SD-4.
Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment	There is no treatment.	Would treat on-site 246,000 gallons of dewatering fluid and discharge to the Thames River.	There is no treatment.	Would also treat on-site 471,000 gallons of dewatering fluid and discharge them to the Thames River.	There is no treatment.
Short-Term Effectiveness	No short-term risks. Would not achieve sediment RAOs or meet sediment PRGs.	Short-term risks to address: Worker exposure during dredging, capping, monitoring, dewatering, and treatment; Transport of contaminated sediment through community; Solids in surface water from dredging; Effect of dredging and cap on benthic organisms. Four months to implement and achieve sediment RAOs and meet sediment PRGs.	Short-term risks to address: Worker exposure during dredging, capping, monitoring, and dewatering; Transport of contaminated sediment and dewatering fluid through community; Solids in surface water from dredging; Effect of dredging and cap on benthic organisms. Four months to implement and achieve sediment RAOs and meet sediment PRGs.	Short-term risks to address: Worker exposure during dredging, monitoring, dewatering, and treatment; Transport of contaminated sediment through community; Solids in surface water from dredging; Effect of dredging on benthic organisms. Risks would be properly mitigated. Six months to implement and achieve sediment RAOs and meet sediment PRGs.	Short-term risks to address: Worker exposure during dredging, monitoring, and dewatering; Transport of contaminated sediment and dewatering fluid through community; Solids in surface water from dredging; Effect of dredging on benthic organisms. Six months to implement and achieve sediment RAOs and meet sediment PRGs.
Implementability	Needs only 5-year reviews.	Issues include: Dredging depth control; Cap placement control; Base construction permit needed; LUC RD can be readily developed and implemented; Resources are readily available.	Issues include: Dredging depth control; Cap placement control; Base construction permit needed; LUC RD can be readily developed and implemented; Resources are readily available.	Issues include: Dredging depth control; Base construction permit needed; LUC RD can be readily developed and implemented; Resources are readily available.	Issues include: Dredging depth control; Base construction permit needed; LUC RD can be readily developed and implemented; Resources are readily available.
Costs:					
Capital	$0	$5,716,000	$5,289,000	$8,165,000	$7,359,000
O&M NPW (Years)	$55,000	$398,000 (30)	$396,000 (30)	$0	$0
NPW (Years)	$55,000	$6,114,000 (30)	$5,685,000 (30)	$8,165,000 (1)	$7,359,000 (1)

TABLE 5-23

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 4 AND OUTER PIER 1 SEDIMENT REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

NOTES:

ARARs	Applicable or Relevant and Appropriate Requirements	O&M	Operation and maintenance
COCs	Chemicals of concern	PRGs	Preliminary Remedial Goals
cy	Cubic yard	RAOs	Remedial Action Objectives
LUCs	Land use controls	TBCs	To be considered (criteria)
NPW	Net present worth		

TABLE 5-24

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 1 LNAPL REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative LN-1 Skimming, Off Site Disposal, LUCs, and Monitoring	Alternative LN-2 In-Situ Treatment, LUCs, and Monitoring
Overall Protection of Human Health and Environment	Protective.	Most protective.
Long-Term Effectiveness and Permanence	Effective.	Most effective.
Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment	There is not treatment.	Would reduce toxicity, mobility, and volume of LNAPL and soil-bound TPH with in-situ enhanced bioremediation. Total of 3,900 gallons of LNAPL and 91,700 pounds of soil-bound TPH removed.
Short-Term Effectiveness	Short-term risks to address: Worker exposure during installation and skimming; Transport of recovered oil through community. Six months to achieve LNAPL Remedial Goal Nos. 1 and 3. Would remove LNAPL and achieve LNAPL Remedial Goal No. 2 within an estimated 10 to 11 years.	Short-term risks to address: Construction may interfere with base activities; Underground utilities may interfere with construction; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available. Six months to achieve LNAPL Remedial Goal Nos. 1 and 3. Would remove LNAPL and achieve LNAPL Remedial Goal No. 2 within 8 to 10 years.
Implementability	Issues include: Construction may interfere with base activities; Underground utilities may interfere with construction; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.	Issues include: Construction may interfere with base activities; Underground utilities may interfere with construction; Treatability tests needed; LUC RD can be readily developed and implemented; Inspections and reviews readily performed; Property transfer (if needed) could be readily accomplished; Resources are readily available.

TABLE 5-24

SUMMARY OF COMPARATIVE ANALYSIS OF ZONE 1 LNAPL REMEDIAL ALTERNATIVES
LOWER SUBASE FEASIBILITY STUDY
NSB-NLON, GROTON, CONNECTICUT

Evaluation Criterion	Alternative LN-1 Skimming, Off Site Disposal, LUCs, and Monitoring	Alternative LN-2 In-Situ Treatment, LUCs, and Monitoring
Costs:		
Capital	$337,000	$713,000
O&M NPW (Years)	$1,543,000 (30)	$1,565,000 (10)
NPW (Years)	$1,880,000 (30)	$2,278,000 (10)

NOTES:

LNAPL Light non-aqueous phase liquid
LUCs Land use controls
NPW Net present worth
O&M Operation and maintenance
TPH Total petroleum hydrocarbons

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