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ADDENDUM TO
DRAFT FOCUSED FEASIBILITY STUDY
SOURCE CONTROL
SITE 09 - ALLEN HARBOR LANDFILL

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1.0 INTRODUCTION

A Draft Focused Feasibility Study (FFS) was prepared and submitted in March 1995 which described source control remedial alternatives for the Allen Harbor Landfill site (Site 09) located at the former Naval Construction Battalion Center (NCBC) in Davisville, Rhode Island. Included in the FFS were the following remedial alternatives:

- Alternative 1 - No Action
- Alternative 2 - RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Wall Storm Protection and Deed Restrictions
- Alternative 3 - RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Wall, Riprap Storm Protection and Deed Restrictions

Following a review of that document, the consideration of other source control alternatives was suggested. Therefore, the purpose of this document is to provide detailed analyses of selected supplemental alternatives, along with a comparative analysis of all alternatives considered to date. Following review and comment on this document, the information presented herein will be incorporated into the Draft Final FFS.

2.0 APPROACH

2.1 Background Information

Three source control remedial alternatives were developed and evaluated in detail in the Draft FFS. They include the following:

- **Alternative 1 - No Action**

  The no action alternative must be considered under the requirements of the NCP. A figure showing existing conditions at Site 09 is provided as Figure 2-1.

- **Alternative 2 - RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Wall Storm Protection, and Deed Restrictions**

  This alternative involves the capping of the landfill area with a RCRA Subtitle C multi-layer cap, construction of an upgradient slurry wall to minimize the migration of shallow and deep ground water into the landfill area from the west, construction of a sheet pile wall around the shoreline of the site to provide containment of the upper aquifer and the existing landfill face as well as protection against storm effects, and implementation of deed restrictions to limit future use and development of the site. A plan view of this alternative is provided in Figure 2-2. A cross-section through the RCRA multi-layer cap is provided in Figure 2-3. The sheet pile wall along the shoreline of the site extends vertically to an elevation of 15 feet NGVD, which is one foot higher than the 100-year still water storm elevation. A cross section through the eastern portion of the cap for Alternative 2 is provided in Figure 2-4.

- **Alternative 3 - RCRA Subtitle C Multi-layer Cap, Slurry Wall, Sheet Pile Wall, Riprap Storm Protection, and Deed Restrictions**

  This alternative is identical to Alternative 2, incorporating a RCRA Subtitle C multi-layer cap, a slurry wall along Sanford Road, and a sheet pile wall along the toe of the landfill, with the exception of the cap profile at the interface of the landfill and Allen Harbor. In Alternative 3, the sheet pile wall extends vertically to the seasonal high water level (as opposed to one foot higher than the 100-year still water storm elevation of Alternative 2). This alternative was developed to utilize the hydraulic containment of the sheet pile wall within the upper aquifer while providing greater conformance with the Coastal Resources Management Program regulatory preference for using revetments over sheet piling in shoreline erosion protection applications. Above the sheet pile wall, the existing face of the landfill would be cut back at a maximum 3:1 (3 horizontal to 1 vertical, or 33%) slope, with a stone revetment provided along the slope for storm and wave protection. As proposed in the Draft FFS, construction of this slope would involve installation of the sheet pile to an initially higher elevation, with construction at the toe of the slope then commencing. Upon completion of the slope, the sheet piling would be cut off to its final elevation. In this manner,

protection against storm and wave effects will be provided while also maintaining a construction zone at the toe of the slope. A plan view of this alternative is provided in Figure 2-5. While the 5% slopes of the final cap would be constructed consistent with the profile provided in Figure 2-3, the 33% side slopes along the shoreline would be constructed in accordance with the profile provided in Figure 2-6. A cross section through the eastern portion of the landfill for Alternative 3 is provided in Figure 2-7.

2.2 Objectives

The objective of developing supplemental alternatives is to consider alternative remedial designs, especially with respect to the design of the shoreline portion of the source control containment system. The alternative designs are also intended to more clearly comply with Rhode Island Solid Waste Regulations and/or the Coastal Resources Management Program requirements. The supplemental alternatives include installation of the sheet pile wall to a final elevation equal to the elevation of the toe of the existing landfill, thereby eliminating the above-grade portion of the sheet pile wall. Within this FFS Addendum, each of the supplemental alternatives are defined and evaluated with respect to the nine evaluation criteria specified under the NCP. A comparative evaluation of the supplemental alternatives to the existing alternatives is also conducted.

2.3 Supplemental Alternative Development

Several supplemental alternatives were considered based on regulatory comment and discussion of the Draft FFS. These are outlined below:

- An alternative in which the sheet pile does not extend above ground elevation and the revetment ties in at that elevation (see comment #21, RIDEM Draft FFS comment letter dated April 3, 1995);
- An alternative which would include the creation of wetlands to enhance shoreline stabilization; and
- An alternative in which a gabion wall would be used to provide shoreline protection.

An initial evaluation of each of these alternatives was conducted to determine its optimum configuration, as discussed below. Based on these analyses, the gabion wall alternative was eliminated from further consideration since it does not provide significant advantages over the

other alternatives being considered. Detailed analyses and comparative analyses of the remaining two alternatives are presented in Section 3.0.

2.3.1 Stone Revetment Slope Protection Alternative

An alternative which includes the elimination of above-grade sheet pile in combination with the use of a stone revetment to provide shoreline protection was evaluated. Several shoreline profile options were considered for this alternative, as presented in Appendix A. The option which was selected for detailed analysis is as follows:

> Alternative 4 - RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Subsurface Barrier, Riprap Storm Protection and Deed Restrictions

Under this alternative, the sheet pile is installed landward from the existing toe of slope such that the overlying revetment ends at the existing toe of slope and filling of existing wetlands and tidal waters is minimized. Alternative 4 and its associated options are evaluated in detail in Section 3.2.

2.3.2 Stone Revetment Slope Protection with Wetlands Creation

The possible development of an alternative which incorporates slope protection through coastal wetlands creation and subsequent shoreline stabilization was evaluated as an alternate means of meeting the Coastal Resources Management Council's policy of preserving, protecting, developing, and where possible, restoring the coastal resources of the state, as well as the policy that preservation and restoration of ecological systems shall be the primary guiding principle upon which environmental alteration of coastal resources will be measured, judged, and regulated (RIGL 46-23-1).

The Allen Harbor water area is classified within the Coastal Resources Management Program as Type 3 - High Intensity Boating. This category includes intensely utilized water areas where recreational boating activities dominate and where the adjacent shorelines are developed as marinas, boatyards, and associated water-enhanced and water-dependent business [200.3(A)]. The Council's goal for Type 3 waters is to preserve, protect, and where possible enhance Type 3 areas for high-intensity boating and the services that support this activity [200.3(C)]. Natural assets which are present in Type 3 waters and along the adjacent shoreline (e.g., coastal wetlands and the value these areas provide as fish and shellfish spawning and

juvenile rearing grounds) must also be considered with respect to proposed activities in Type 3 waters [200.3(B)(6)].

The coastal wetland areas south and north of Allen Harbor Landfill (Wetlands F and D in Figure 2-8) are designated for preservation within the Coastal Resources Management Program. The Council's goal is to preserve and, where possible, restore coastal wetlands [210.3(C)(1)]. The Council will encourage the building of new wetlands in areas selected on the basis of competent ecological study [210.3(C)(2)].

Therefore, the second alternative which will undergo detailed analysis within this document is as follows:

> Alternative 5 - RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Subsurface Barrier, Riprap Storm Protection, Coastal Wetlands Creation and Deed Restrictions

2.3.3 Gabion Wall Slope Protection

The final alternative considered was an alternative which would use a gabion wall in combination with slope cutback at the shoreline to provide storm protection. The intent of this alternative was to combine a gabion wall (which can be constructed as a revetment or a vertical bulkhead) with an optimum (i.e., a minimum) slope cutback. Several design options were considered for this alternative, as presented in Appendix A. As described therein, gabions consist of rectangular baskets or mattresses made of a steel wire mesh which are filled with stone. The wire mesh requires continued maintenance to replace damaged or corroded wire.

The analysis presented in Appendix A concludes that, based on the need to retain the impermeable cap as a source control measure behind/underneath any gabion wall configuration and the slope stability of the impermeable cap construction materials, the final slope of gabion wall/cap system is limited by the maximum design slope of the underlying cap. This factor combined with the long-term maintenance required for a gabion wall results in the lack of identification of significant advantages to the use of a gabion wall over a stone revetment. Therefore, based on the preliminary assessment, a gabion wall slope protection alternative was not retained for detailed evaluation.

2.4 Evaluation of Slurry Wall Relocation

Based on a review of the alternatives included in the Draft FFS, evaluation of the potential relocation of the slurry wall to the east to prevent the removal of existing trees along the eastern border of the site was requested. The Rhode Island Department of Environmental Management (RIDEM) requested the consideration of the relocation of the slurry wall from immediately adjacent to Sanford Road to a location approximately 60 feet to the east, thereby preventing the removal of existing trees which border the roadway. If the trees could be saved, they could provide a natural sight barrier during construction operations.

For such an option to be feasible, buried waste could not be present within this 60-foot wide corridor. A review of EM-31 and magnetometer readings collected on a 50-foot grid across the site during the Phase II RI indicates that it is possible that disposal activities originated at a distance of 50 to 100 feet from the edge of Sanford Road (see Figure 2-4 and 2-5, TRC, 1994a). Subsurface investigations, including the drilling of soil borings and monitoring wells and the digging of test pits, were conducted either immediately adjacent to Sanford Road (with no buried waste identified) or a minimum of 110 feet from Sanford Road (well 09-MW11S, where fill was detected to a depth of 8.7 feet). A review of historic aerial photographs indicates that disposal may have occurred within 50 feet of Sanford Road although the information provided by the photos is generally inconclusive. Activities within 50 feet of Sanford Road are visible in a 1957 aerial photograph, including the presence of vehicles and apparent piles of materials, but whether these activities constituted disposal or storage/operational activities is not clearly apparent. Most site activities visible in 1965 and 1970 aerial photographs are concentrated closer to the harbor-side of the landfill. The age of the trees along Sanford Road does not provide a reliable indication of whether filling occurred in the area, as the trees are relatively young. Since the area near the road would most likely have been the first area to be filled, these trees could have been planted after filling operations were completed in this area (filling operations occurred from 1946 to 1972).

Assuming that the slurry wall could be relocated 60 feet east of its current location, Figure 2-9 shows a plan view of the landfill with revised surface elevation contours based on Alternative 3, as presented in the Draft FFS. Based on the existing landfill surface contours, the average site elevation along the re-located slurry wall would be approximately 10 feet NGVD. Assuming drainage from the cap would be controlled within the area immediately

adjacent to and east of the relocated slurry wall (again, to prevent the removal of the trees to the west of the re-located slurry wall), and a 5% surficial slope, the maximum elevation achievable would be 25 feet NGVD. The average loss in final elevation over the western half of the landfill would be 5 feet. The total estimated loss in volume would be approximately 45,000 cubic yards. Under Alternative 2 of the Draft FFS, the estimated volume of borrow material required to construct the cap to the final elevations as shown was 9,000 cubic yards. Under Alternative 3 of the Draft FFS, an additional 15,700 cubic yards of waste excavation would be required to construct the 33% shoreline slopes, negating the need for borrow and resulting in slightly increased final cap elevations. With a net decrease in volume of 45,000 cubic yards due to re-location of the slurry wall, greater increases in final cap elevation would be required to accommodate the lost volume. A steeper final cap side slope could be utilized immediately adjacent to the slurry wall to maintain the final cap surface elevations of the original design (i.e., a 3H:1V slope which would transition into a 5% slope upon reaching the currently proposed final cap elevation). The final cap elevations would depend in part on the shoreline protection method selected, since an increase in the cutback of the existing shoreline slope would also result in increased waste materials which would require consolidation under the cap. In any case, additional field investigations (e.g., test pits) would be required to confirm the absence of waste in the slurry wall relocation corridor before a final decision to move the slurry wall could be made.

A detailed analysis of this design modification is not presented here because the evaluation would not significantly differ from the analysis of the slurry wall presented in the Draft FFS. The overall protection of human health and the environment, compliance with ARARs, and reduction in toxicity through treatment evaluations would remain unchanged. The relocation of the slurry wall would not significantly impact the long-term and short-term effectiveness and implementability evaluations, and the cost evaluation would be dependent on the shoreline protection method selected and the resultant final cap contours. If blocking the visibility of construction activities from Sanford Road is a significant concern, fencing to be provided along Sanford Road (as noted in the response to comments on the Draft FFS) could also provide a visual barrier.

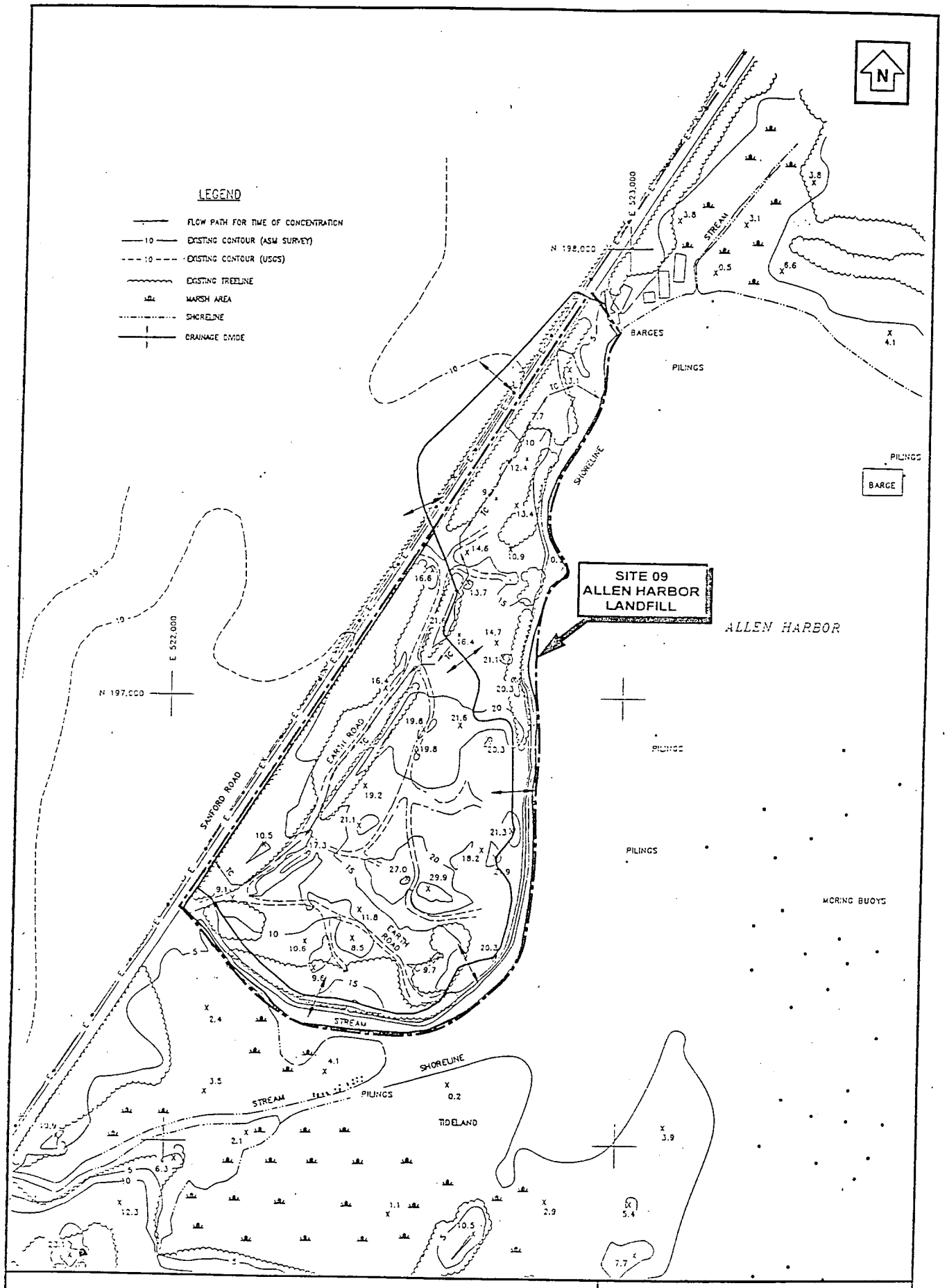

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FIGURE 2-1.

SITE 09 - ALLEN HARBOR LANDFILL

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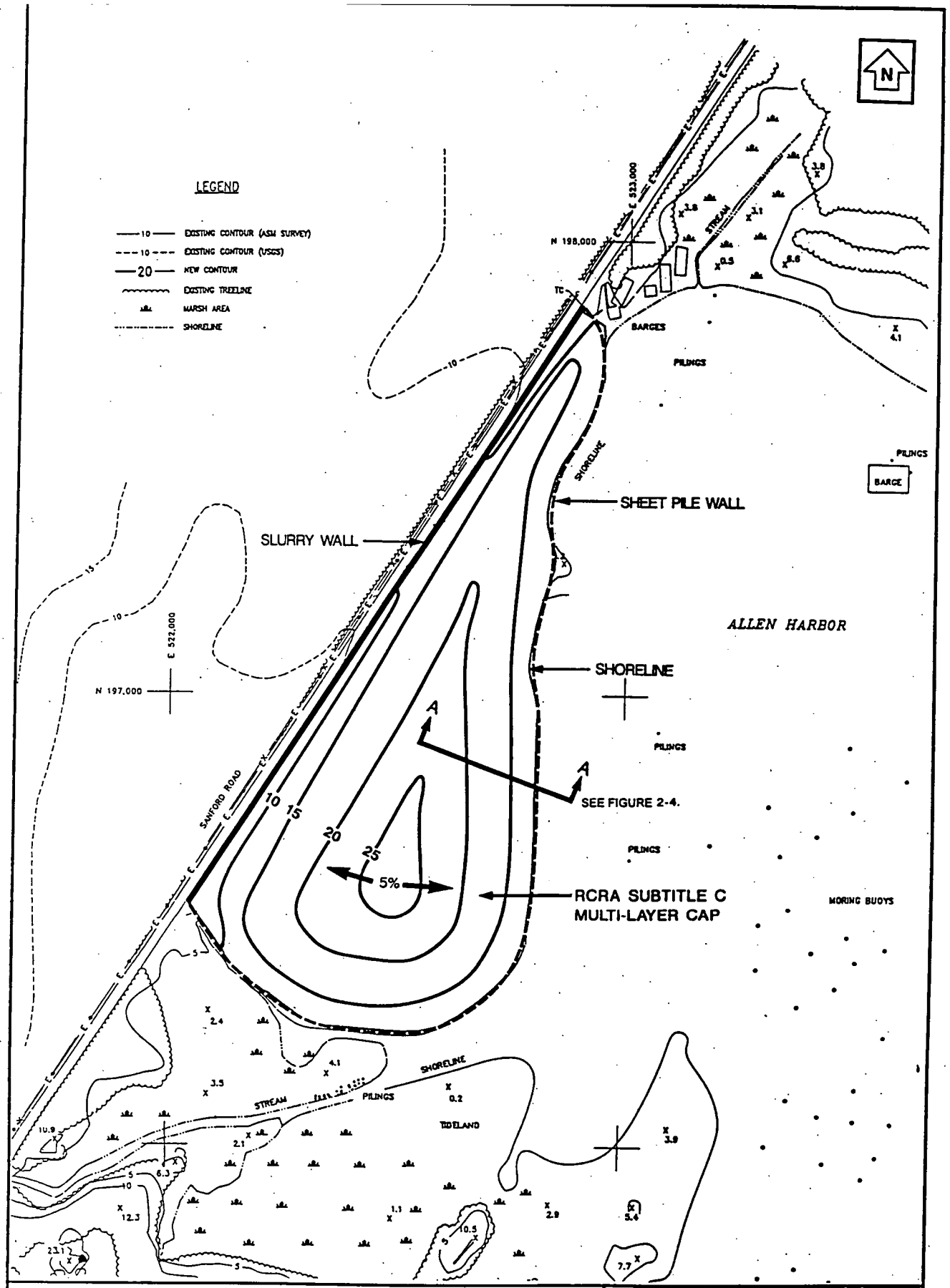

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FIGURE 2-2.
PLAN VIEW ALTERNATIVE 2
RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL, AND SHEET PILE WALL STORM PROTECTION

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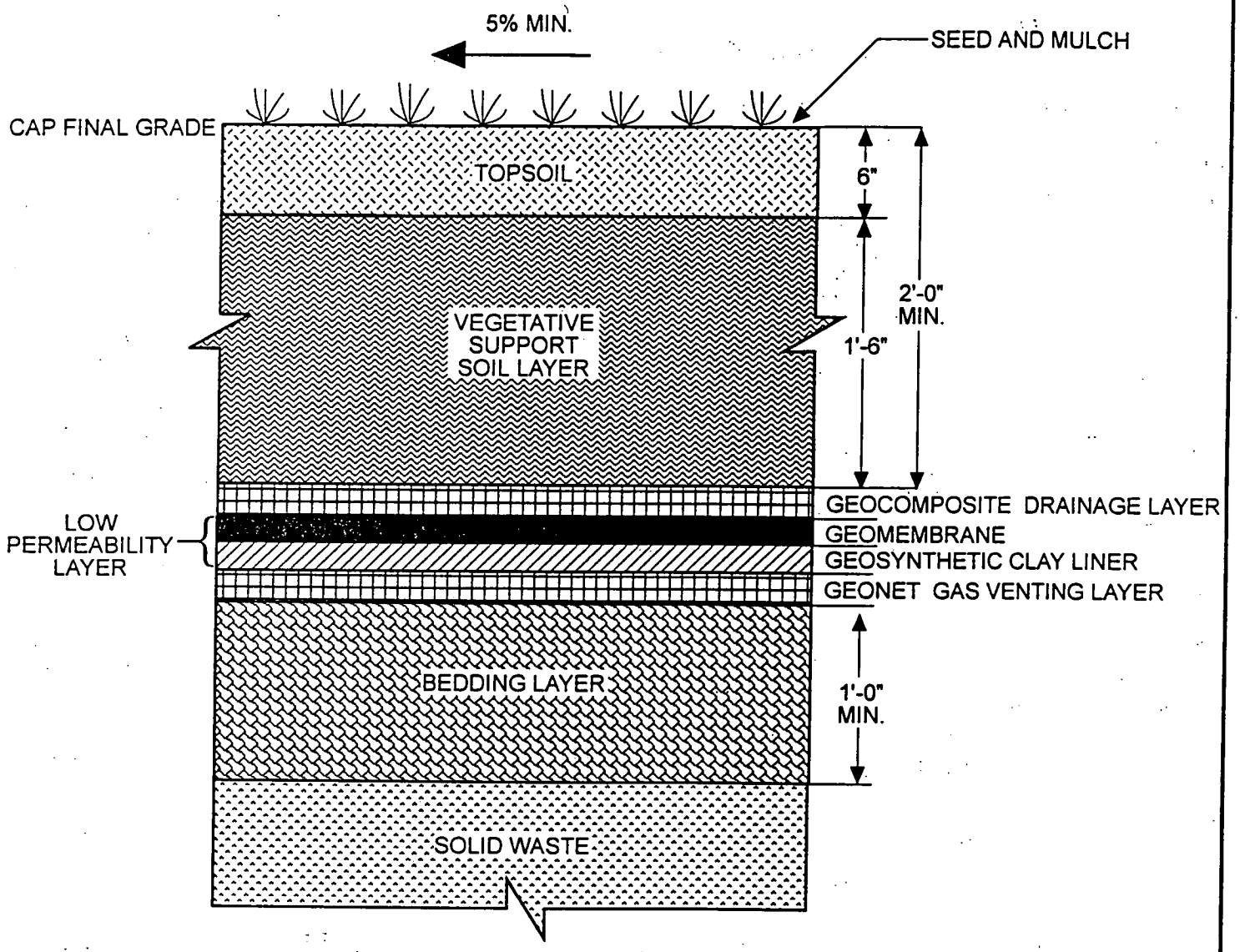

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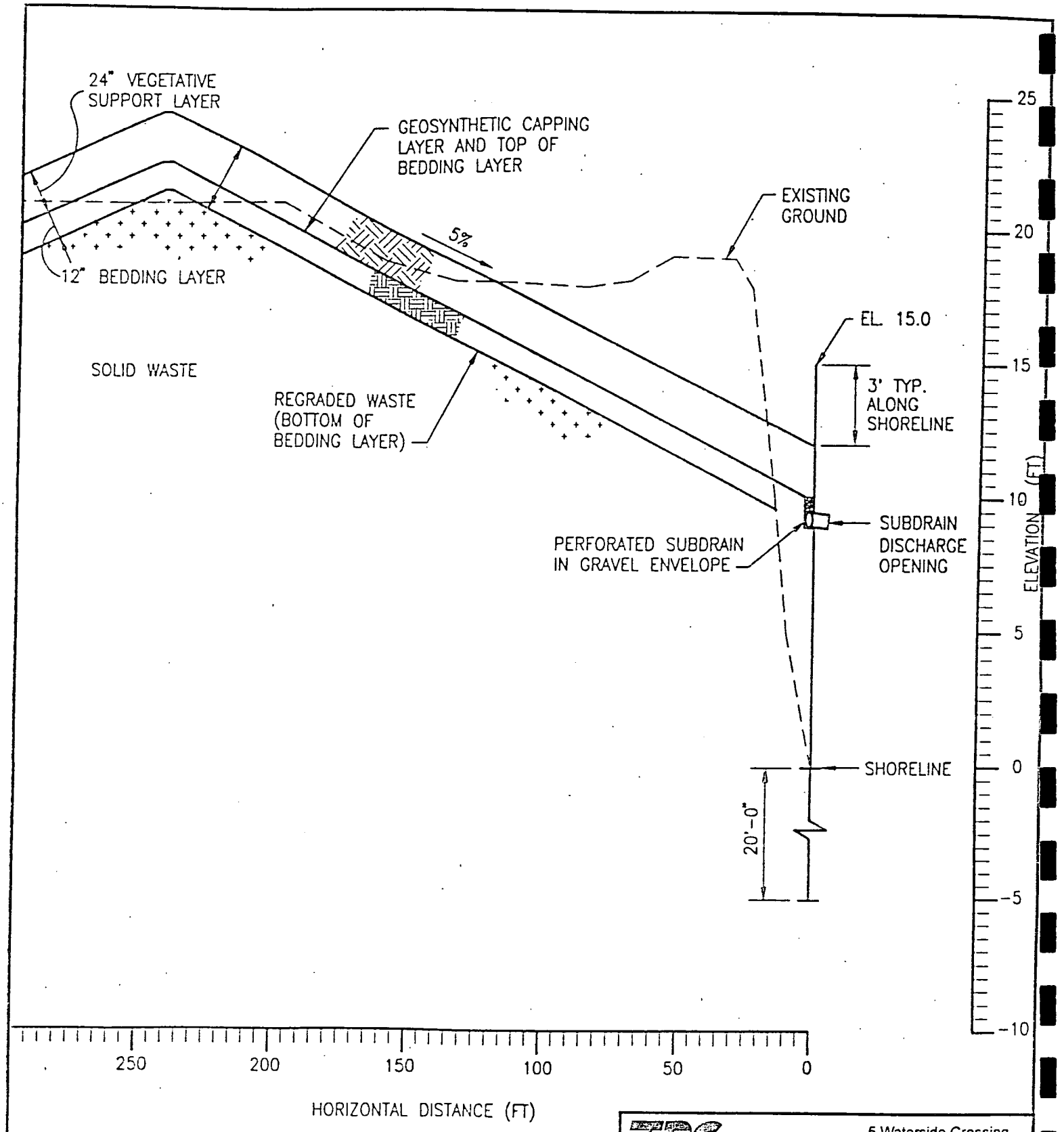
FIGURE 2-3.

SITE 09-ALLEN HARBOR LANDFILL
RCRA SUBTITLE C
MULTI-LAYER CAP CROSS-SECTION

Date: 5/95 | Drawing No. 02969-0030



SCALE: 1" = 5' VERT.
1" = 50' HORIZ.

SOURCE: EA ENGINEERING SCIENCE, AND TECHNOLOGY, INC.
REMEDIAL DESIGN FOR ALLEN HARBOR LANDFILL

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FIGURE 2-4.

SITE 09-ALLEN HARBOR LANDFILL CROSS SECTION A - ALTERNATIVE 2

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Drawing No. 02969-0030

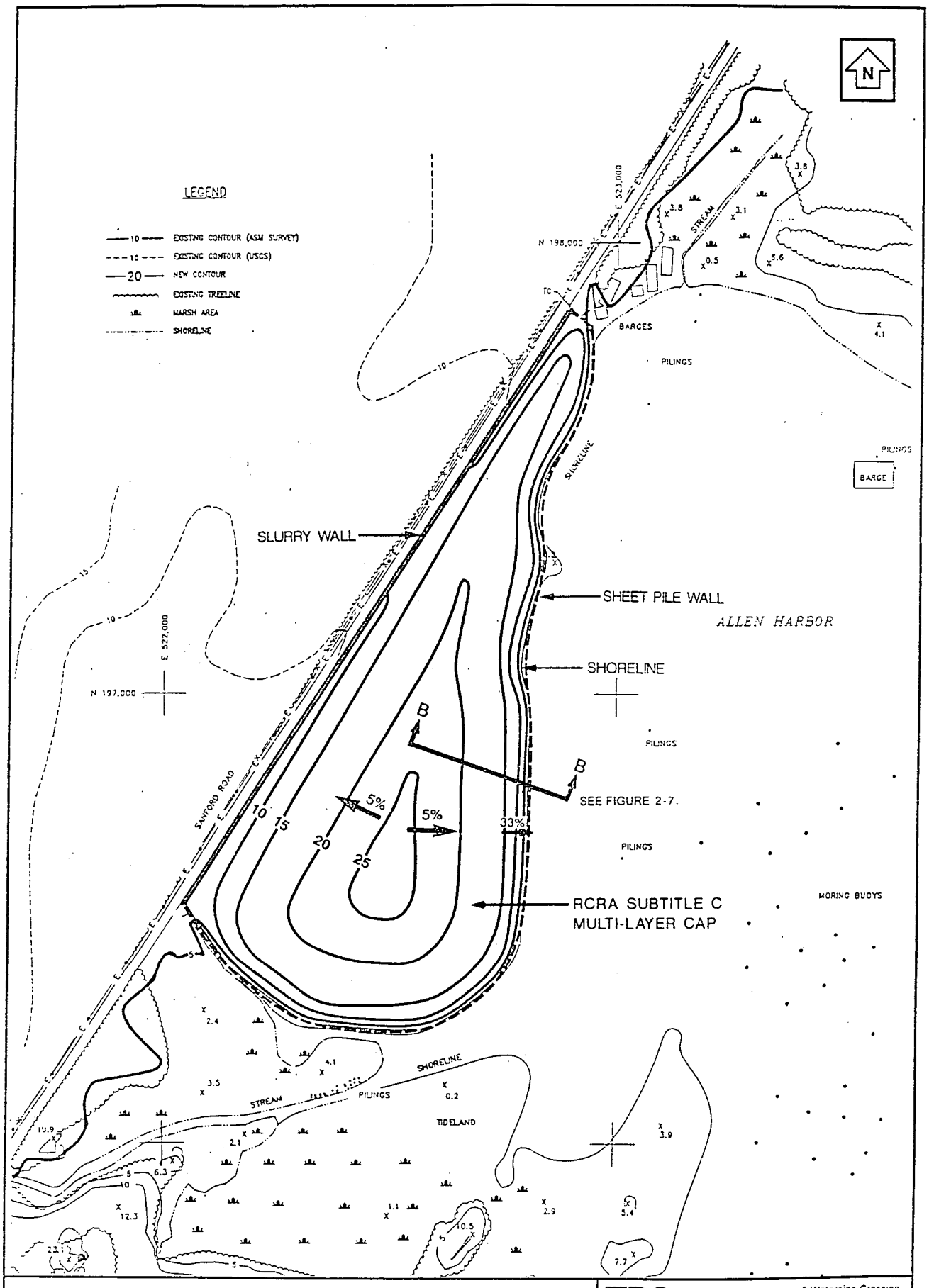

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FIGURE 2-5.
PLAN VIEW ALTERNATIVE 3 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL, SHEET PILE WALL, AND RIPRAP STORM PROTECTION

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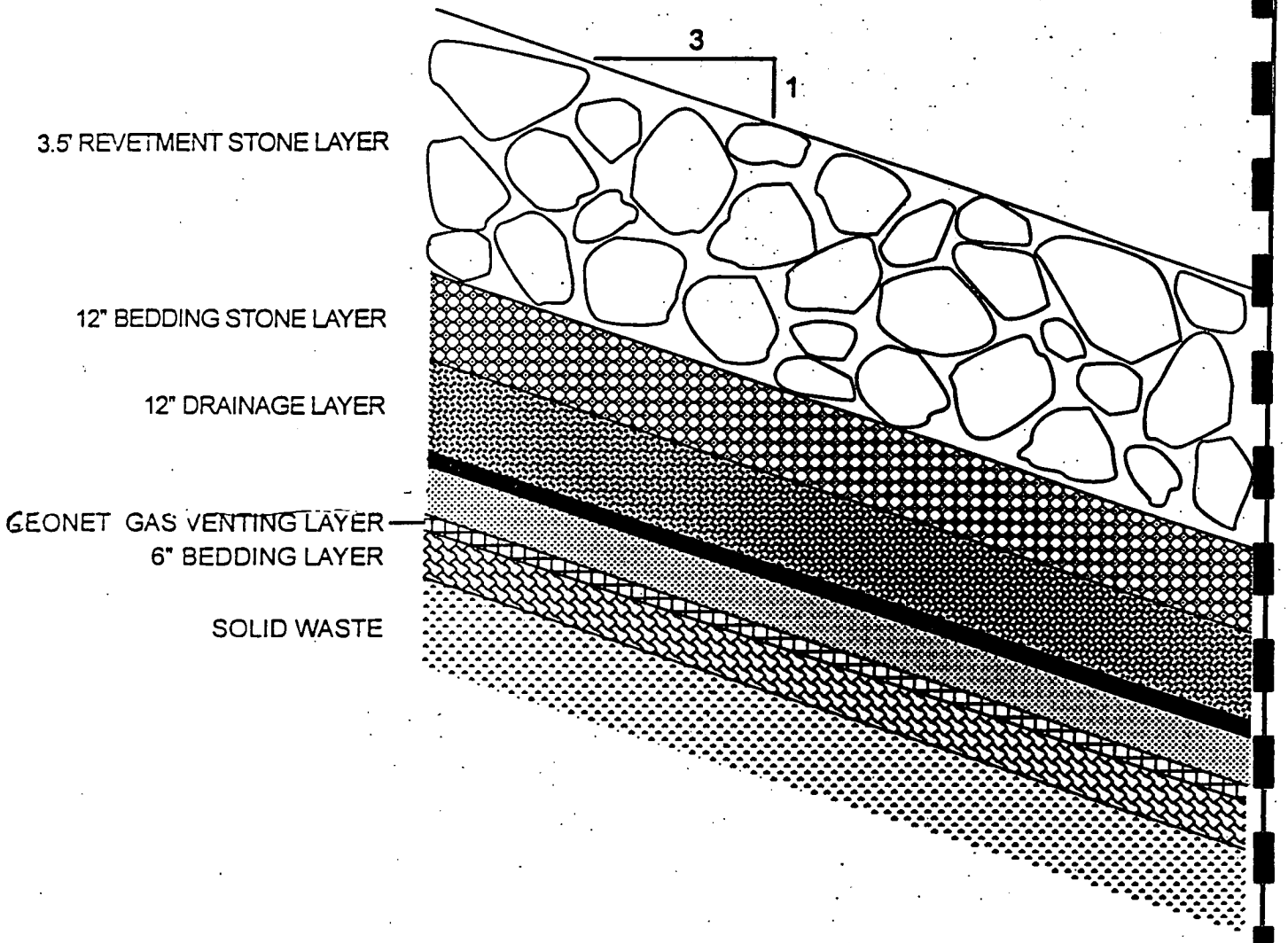

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FIGURE 2-6.

SITE 09-ALLEN HARBOR LANDFILL CONCEPTUAL SECTION THROUGH SLOPE - ALTERNATIVE 3

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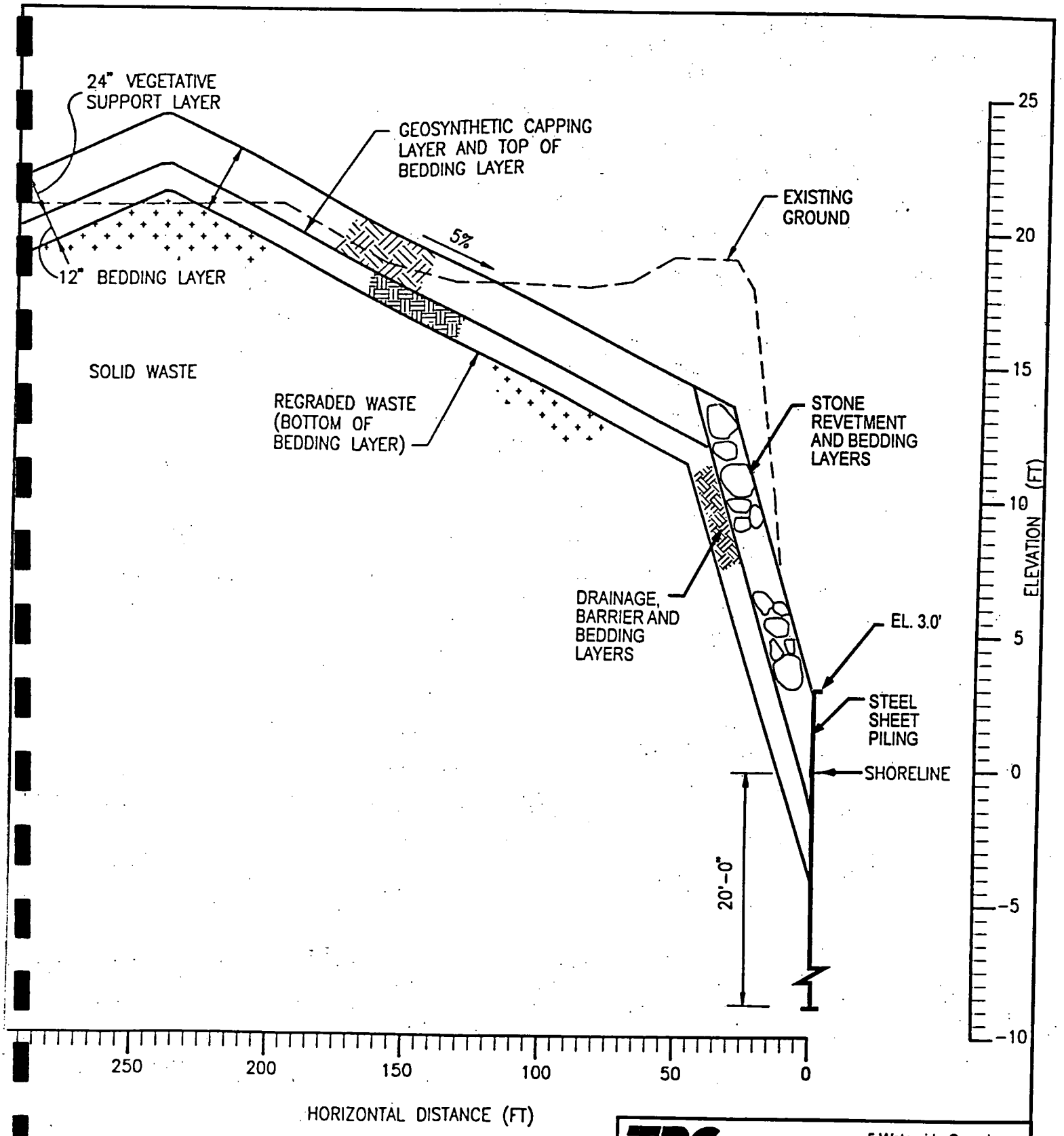

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FIGURE 2-7.

SITE 09-ALLEN HARBOR LANDFILL CROSS SECTION B - ALTERNATIVE 3

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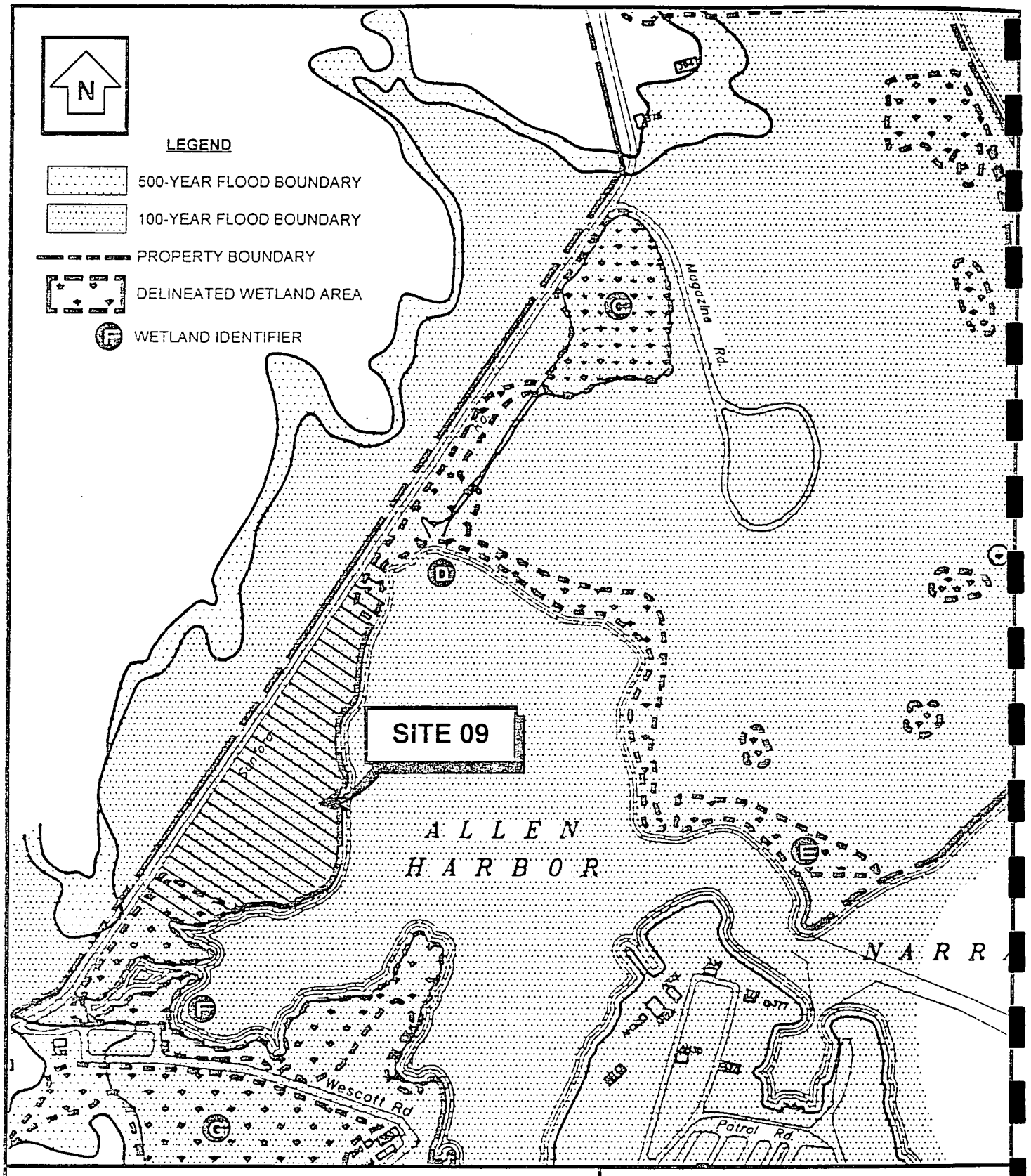

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FIGURE 2-8.

WETLAND AND FLOODPLAINS MAP

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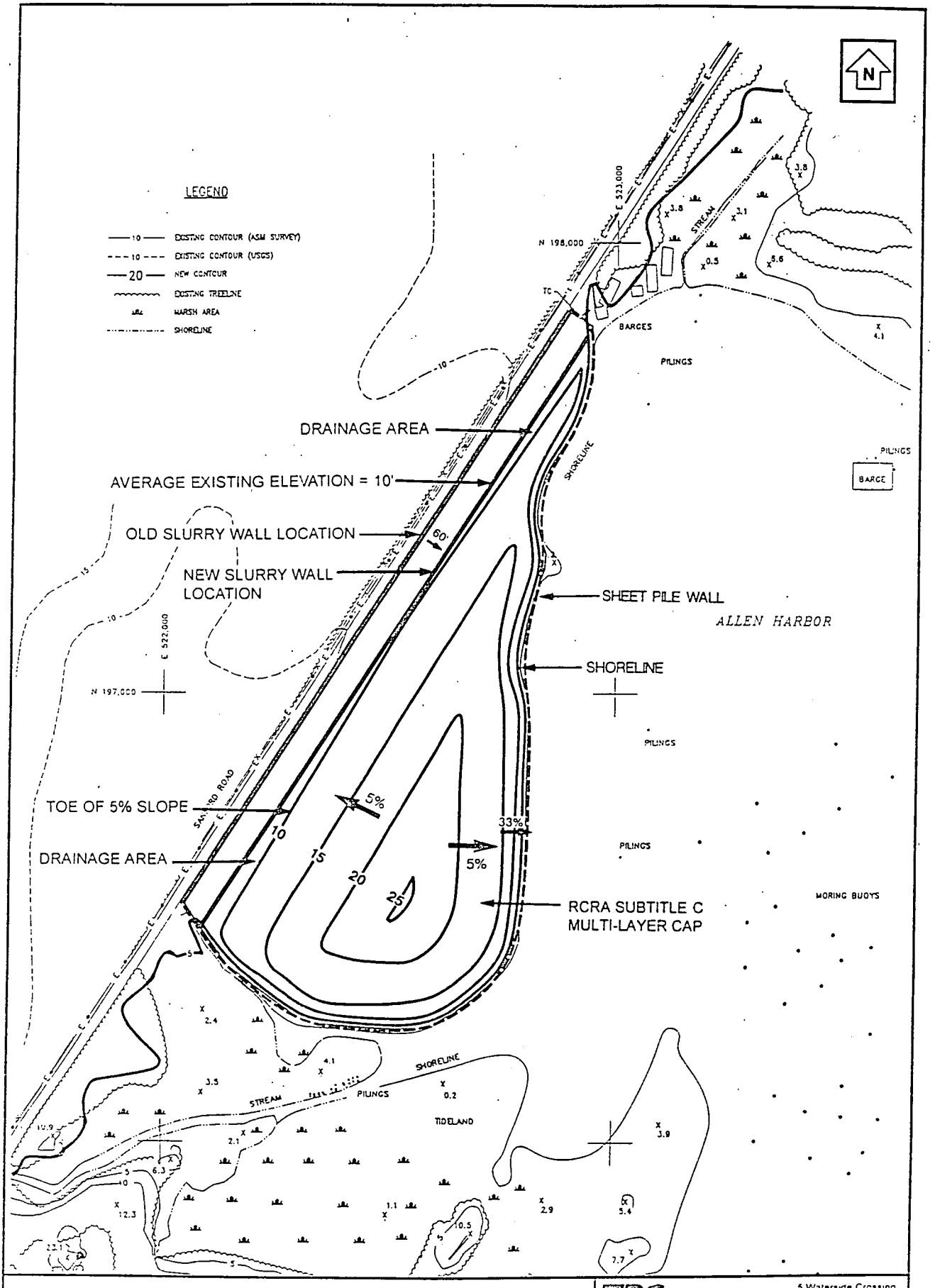

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FIGURE 2-9.
PLAN VIEW ALTERNATIVE 3 - WITH RELOCATION OF SLURRY WALL

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3.0 DETAILED ANALYSIS OF SUPPLEMENTAL REMEDIAL ALTERNATIVES

Each of the supplemental remedial alternatives developed for the site, as presented in Section 2.3, is further defined and then undergoes a detailed analysis. Following the detailed analysis of the individual supplemental alternatives, a comparative analysis is conducted between the supplemental alternatives and the alternatives originally presented in the Draft FFS.

3.1 Evaluation Criteria

The NCP defines nine evaluation criteria to be considered in the detailed analysis of alternatives. The evaluation criteria are divided into three groups: threshold criteria, which relate to statutory requirements that each alternative must satisfy; balancing criteria, which are the technical criteria that are considered during the detailed analysis; and modifying criteria, which are formally assessed after the public comment period. The nine criteria include the following:

Threshold Criteria

- Overall protection of human health and the environment;
- Compliance with applicable or relevant and appropriate requirements (ARARs);

Balancing Criteria

- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume through treatment;
- Short-term effectiveness;
- Implementability;
- Cost;

Modifying Criteria

- Community acceptance; and
- State acceptance.

When evaluating alternatives in terms of overall protection of human health and the environment, consideration is given to the manner in which site-related risks are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls. Long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs are given major consideration in determining the overall protection offered by each alternative.

The alternatives are assessed to determined whether they attain applicable or relevant and appropriate requirements (ARARs) under federal environmental laws and state environmental or facility siting laws. The identification of ARARs is a site-specific process which is dependent on the specific hazardous substances, pollutants, and contaminants at a site, the physical characteristics of a site and the remedial actions under consideration at a site. Therefore, it is an iterative process which requires re-examination throughout the RI/FS process, until a Record of Decision (ROD) is issued. In the following alternative analyses, the individual remedial alternatives will be evaluated in detail to determine their compliance with ARARs/TBCs which are applicable to the specific media being addressed by the remedial action, and the potential impacts of ARARs/TBCs on the alternative's implementation. No chemical-specific ARARs/TBCs apply to the alternatives being considered. Therefore, the following evaluations are limited to compliance with location-specific and action-specific ARARs/TBCs.

An alternative that does not meet an ARAR may be selected as a remedial action under several circumstances, including the following:

- If the alternative is an interim measure and will become part of a total remedial action that will attain the applicable or relevant and appropriate federal or state requirement;
- If compliance with the requirement will result in greater risk to human health and the environment than other alternatives;
- If compliance with the requirement is technically impracticable from an engineering perspective;
- If the alternative will attain an equivalent standard of performance through the use of another method or approach; or
- If the ARAR is a state requirement that the state has not consistently applied in similar circumstances.

Each alternative is also evaluated for long-term effectiveness and permanence, in which the magnitude of residual risk remaining from untreated waste or treatment residuals and the adequacy and reliability of containment systems and institutional controls is evaluated. The degree to which alternatives employ recycling or treatment to reduce toxicity, mobility or volume is assessed, including how treatment is used to address the principal threats at the site.

The short-term effectiveness evaluation takes into consideration the short-term risks that might be posed to on-site workers, the surrounding community, or the environment during implementation, as well as the time until protection is achieved. The analysis of implementability considers the technical feasibility and administrative feasibility of implementation, as well as the availability of required materials and services. The cost analysis evaluates capital (direct and indirect) costs and annual operation and maintenance (O&M). The net present value of capital and O&M costs is presented for each alternative.

The detailed analysis of Alternatives 1 through 3 is presented in Sections 4.2 through 4.4 of the Draft FFS. This document presents the detailed analysis of Alternatives 4 and 5 only.

In selecting a remedial action, the following criteria must be considered. Each selected remedial action shall meet the threshold criteria, and thereby be protective of human health and the environment. Provided the remedy meets the threshold criteria, it shall also be cost-effective. The overall effectiveness of an alternative is determined by evaluating long-term effectiveness and permanence, reduction of toxicity, mobility or volume through treatment, and short-term effectiveness. The alternative is then evaluated with regard to cost to ensure that it is cost-effective. Each remedial action shall also utilize permanent solutions and alternative treatment technologies to the maximum extent practicable. This requirement is fulfilled by selecting the alternative that satisfies the threshold criteria and provides the best balance of trade-offs among alternatives in terms of the five balancing criteria, with an emphasis on long-term effectiveness and reduction of toxicity, mobility and toxicity through treatment.

A comparative analysis of Alternatives 1, 2 and 3 was presented in Section 4.5 of the Draft FFS. That comparative analysis is re-evaluated to include Alternatives 4 and 5 within this document. Where possible, revisions to Alternatives 1, 2 and 3 which will be made on the basis of Draft FFS comments are incorporated into the comparative evaluation presented herein. Certain comments on the Draft FFS are currently undergoing additional evaluation and any resultant changes to the comparative evaluation which results from these evaluations will be incorporated into the Draft Final FFS document.

3.2 Alternative 4 - RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Subsurface Barrier, Riprap Storm Protection, and Deed Restrictions

3.2.1 Alternative Description

The components of Alternative 4 are identical to Alternatives 2 and 3, with the exception of the cap profile at the interface of the landfill and Allen Harbor. Alternative 4 includes a RCRA Subtitle C multi-layer cap, a slurry wall along Sanford Road, and a sheet pile wall to provide upper aquifer containment along the Allen Harbor shoreline. However, under Alternative 4, the sheet pile wall is installed approximately eighteen feet landward from the toe of the landfill and does not extend above grade (i.e., the top of sheet pile is set at an elevation of 0 feet NGVD). By installing the sheet piling at this distance in from the existing toe of the slope, the stone revetment will extend outward only to the existing toe of the slope. This alternative was developed to maintain the hydraulic containment of the shallow aquifer, which is provided by the sheet pile wall, while providing the greatest conformance with the CRMC preference for the use of revetment over sheet piling in coastal erosion control applications. The existing face of the landfill would be cut back over its total vertical elevation for a horizontal distance of approximately 18 feet, and from there cut back at a maximum 3:1 (3 horizontal to 1 vertical, or 33%) slope. Following capping, a stone revetment would be provided along the slope for storm and wave protection. This description will focus on those components of this alternative which differ from Alternative 3. For the purpose of this detailed analysis, the slurry wall and deed restriction components of Alternative 4 are identical to Alternative 2. Should the location of the slurry wall be relocated as requested by the RIDEM (see Section 2.4), the final cap surface elevations would be revised during the final design.

Cap Construction along Allen Harbor Shoreline - The description of the components of cap construction along the Allen Harbor shoreline (i.e., the individual cap layers) is identical to the discussion provided for Alternative 3 in Section 4.4.1 of the Draft FFS. The multi-layer cap would be constructed differently along the 3:1 slope of the shoreline portion of the landfill than over the remainder of the 5% sloped surface. The final design would take into consideration the potential for erosion along the steeper slope as well as slope stability concerns. The proposed design considers the draft technical paper Design Considerations for CERCLA Surface Cover Systems (Choi, 1990), which provides guidance used by USEPA Region I in evaluating the design of cover systems, including areas where the slope ranges from 8 degrees

(14%) to 3:1 (33%). Details associated with the proposed cap along the shoreline slope were previously provided in Figure 2-6. A plan view of the proposed landfill cap surface is provided in Figure 3-1. A cross-section through the eastern portion of the cap is provided in Figure 3-2. It is estimated that the volume of waste excavated along the shoreline for the slope cutbacks would add approximately one foot to the final cap elevations (as compared to Alternative 2).

Slope stability and storm impact evaluations would be essential to the development of the final design of the slope along Allen Harbor. If it is determined by the design engineer that an adequate factor of safety cannot be maintained for the design described herein, a shallower slope cut-back or revision in the proposed profile of the cap along the slope could be required. Any revisions would most likely result in additional waste excavation and additional cap material requirements. The final design of the revetment could also include a consideration of potential benthic habitat along the shoreline.

Sheet Pile Wall - The sheet pile wall proposed for Alternative 4 would be installed approximately 18 feet landward of the point where the existing toe of the landfill meets Allen Harbor, following the line of the existing landfill toe to the maximum extent practicable. The location of the sheet pile wall, 18 feet landward of the edge of Allen Harbor, would prevent the construction of the revetment from extending beyond the existing landfill toe into adjacent tidal waters or wetland areas. Since the revetment, bedding and drainage layers of the cap would be constructed over the sheet pile wall, the final elevation of the top of the sheet pile wall would be set at 0 feet NGVD. Since the sheet pile wall would not provide protection against storm or wave effects, the revetment features were incorporated into the design of the adjacent cap slope.

For Alternative 4, the sheet pile wall would be installed to the same depth as Alternatives 2 and 3 to provide containment of the upper portion of the aquifer, but it would not provide the element of structural stability along the shoreline edge of the landfill which is provided under Alternative 2. Construction of the sheet pile wall under this alternative would require cutting back the entire slope of the landfill adjacent to Allen Harbor approximately 20 feet prior to initiation of installation.

Site Drainage Controls - Final site drainage controls would be similar to those provided under Alternative 3. The main difference would be that the drainage layer sloping towards Allen Harbor would discharge at the elevation of the existing shoreline, above the sheet pile wall. The cap design along the slope would not only require consideration of slope stability and erosion

control issues, but would also require consideration of the potential effects of periodic inundation.

During construction along the toe of the landfill, cofferdams would be constructed to provide a means of containment of any material which would wash from the landfill face during cutback operations, to contain the waters of Allen Harbor during construction of the cap slope along Allen Harbor, and to provide a means of dewatering the construction area at the toe of the landfill face (see following section) to collect any accumulated runoff or shallow ground water discharge. For the purposes of this assessment, it has been assumed that portable cofferdams similar to those in use at the McAllister Point Landfill closure project located in Newport, RI would be utilized. These portable cofferdams consist of welded tubular steel support members and a flexible waterproof fabric membrane. The use of these materials allow for easy installation in many different configurations and over most bed contours. The limiting factor in using this type of portable cofferdam is the height, which is set at a maximum of ten feet.

Construction Sequence - Due to the change in design along the Allen Harbor shoreline, a revised construction sequence would be required. As in both Alternatives 2 and 3, construction of the slurry wall would be conducted prior to cap construction to prevent any disruption of the cap's barrier layers due to the presence of heavy equipment. The slurry wall construction would be followed by the construction work to be conducted along Allen Harbor. Because cofferdams are to be used to provide a dry working environment, slope cutback, the installation of the sheet pile wall, and the cap construction along the slope will be conducted in sequential sections. Initially, a section (assume 500 feet) of cofferdam would be constructed along the toe of the landfill within Allen Harbor. Once the cofferdam is in place, the slope within that section will be cut back to the final waste material grade. The preliminary design presented herein indicates that the slope cap construction activities would require excavation to depths which are below the existing shoreline elevation and below the surface of the shallow water table. Therefore, it is anticipated that dewatering would be required during the construction of the lowest elevations of the cap, with extracted water requiring on-site collection and off-site treatment. After the cut back for a given section is completed, the sheet pile wall will be installed to an elevation equal to the existing shoreline elevation. Construction of the cap along the 33% slope will then commence, tying the low permeability (geomembrane and soil barrier) and bottom bedding layers into the sheet pile wall and tying the stone revetment, top

bedding layer, and drainage layer into the existing shoreline. This sectional construction method of the cap along the shoreline slope would be continued until the entire shoreline slope is capped. Upon completion of the 33% slope portion of the cap along Allen Harbor the cap construction sequences for the top surface of the landfill would be conducted as described for Alternative 2.

3.2.2 Alternative Evaluation

The evaluation of Alternative 4 presented below consists of an evaluation of the alternative as a whole, as was conducted for Alternatives 2 and 3 in the Draft FFS. The comparative evaluation presented in Section 3.4 provides an evaluation of the differences between the alternatives previously evaluated within the Draft FFS and the alternatives evaluated herein which is focused upon the main differences between the alternatives, namely the cap construction features along the Allen Harbor shoreline.

Overall Protection of Human Health and the Environment - Alternative 4 provides overall protection of human health and the environment through the minimization of potential exposures to the site contaminants, by minimizing the potential migration of contaminants due to erosion, infiltration of precipitation and discharge of leachate seeps, and by providing containment of the landfill materials against lateral ground water migration, including containment of the shallow aquifer.

The RCRA Subtitle C cap, slurry wall and sheet pile wall containment features provide protection to human health and the environment by providing a degree of isolation of the landfill contents. The low permeability layer of the cap effectively reduces the volume of leachate produced by limiting the infiltration of precipitation into the landfill while the sheet pile wall would be effective in combination with the slurry wall in providing a degree of hydraulic isolation for the waste materials. Through deed restrictions and the construction of fencing along Sanford Road, this alternative would limit potential exposures due to direct human contact with contaminant source areas and would limit future site use. It would meet location-specific and action-specific ARARs, including federal and state hazardous waste landfill closure requirements, and would comply with the CRMC regulatory preference for the use of revetment for erosion protection rather than sheet piling. Due to the multi-layer design of the cap combined with the containment features of the slurry wall and sheet piling wall, the alternative

would be effective in the long-term. However, the cutback of waste slopes along Allen Harbor and construction of the slope protection would present increased short-term risks.

Overall Compliance with ARARs - The alternative would comply with location-specific ARARs, as listed in Table 3-1, and with action-specific ARARs, including federal and state ARARs applicable to venting of landfill gases and storm water discharge, as listed in Table 3-2. Location-specific ARARs applicable to Alternative 4 are identical to those applicable to Alternatives 2 and 3. However, the revetment storm protection feature of Alternative 4 would provide greater compliance with the CRMC regulatory preference for the use of revetment for erosion protection along the shoreline instead of a visible sheet pile wall. The action-specific ARARs applicable to Alternative 4 are identical to those applicable to Alternatives 2 and 3 and compliance would be achieved by the proposed design.

Long-Term Effectiveness and Permanence - Alternative 4 would significantly reduce the potential risks associated with direct contact with site-related contamination but some residual risk would remain since the source (the landfill) is not treated or removed. The RCRA Subtitle C cap would be effective in the long-term in minimizing future leachate generation and in enhancing the drainage of precipitation from the geocomposite barrier layer. The long-term effectiveness of landfill caps can be impacted by differential settlements of the landfill contents, large gas pressures under the cap, or slope erosion. While the age of the landfill should result in minimal future settlement of the contents, the potential for settlement would be considered in the final cap design. Landfill gas, which could impair the effectiveness of the cap, is also addressed through the landfill gas venting system. With proper maintenance, a RCRA Subtitle C cap offers reliable, long-term protection from risk associated with direct contact with contaminants. However, the presence of revetment materials over the barrier layers of the cap could compromise the integrity of the cap along the Allen Harbor shoreline slopes. The long-term effects of periodic inundation of the cap along the slope of the landfill during storm events could further impact the long-term effectiveness of the cap. Long-term maintenance activities would include maintenance of cap materials, vegetation, the stone revetment, and drainage controls.

The sheet pile wall, with a design life of up to 40 years, would be effective in the long-term in reducing shallow aquifer contaminant migration from the landfill area. None of the sheet pile wall will be exposed to the harbor; therefore, periodic maintenance would not be

required. The slurry wall would provide a barrier to migration of shallow and deep ground water along Sanford Road, although its permeability could be slightly increased if it comes into contact with salt water. Due to the depth to which wastes were placed within the landfill area, ground water would still remain in contact with waste materials in the southern portion of the site. Monitoring of ground water levels and contaminant levels would provide an indication of the effectiveness of the containment features.

Construction of additional fencing along Sanford Road in combination with existing fencing would deter trespassing, and deed restrictions would limit future site use and development, thus limiting the potential for future damage to the cap and potential exposures to site contaminants. Since wastes would remain on-site above levels that allow for unlimited use and unrestricted exposure, five-year reviews of Alternative 4 would be required.

Reduction in Toxicity, Mobility, or Volume through Treatment - Alternative 4 provides no treatment or destruction of site contamination. The presumptive remedy approach is based on the determination that treatment is not practicable for landfills characterized by large volumes and heterogeneous mixtures of waste, unless hot spot areas suitable for treatment exist.

Short-Term Effectiveness - Potential short-term risks associated with the implementation of Alternative 4 include the possibility of exposures to contaminants during the construction of the RCRA Subtitle C cap, the cutback of existing slopes along Allen Harbor, and the installation of the steel sheet pile and slurry walls. Little to no excavation of waste materials is anticipated during construction of the slurry wall. While trenching is required for slurry wall construction, the method of construction (i.e., as the trench is excavated, it is immediately backfilled with a slurry which provides structural support to the walls of the trench) precludes the potential for workers to enter the trench for any reason. The sheet pile wall installation would require an initial cutback of the existing slope along the Allen Harbor shoreline; therefore, workers would be exposed to waste along the cut of the slope during sheet pile installation. Construction of the cap would require regrading of topographic high spots along the top of the landfill, recompaction of excavated wastes and grade cutbacks along Allen Harbor. Therefore, sheet pile installation and cap construction are likely to present the greatest short-term risks to site workers. The construction of the toe of the cap along Allen Harbor would be conducted in a slightly more protected environment than other cap construction activities (i.e, between the exposed waste face and the portable cofferdam) and slightly increased contaminant levels in the breathing zone could

result. Construction of the cap along the toe of the landfill under Alternative 4 would require removal of a greater volume of material during the cutback operations than Alternatives 2 and 3, which could result in an increased short-term risk.

The human health risk assessment conducted during the RI (TRC, 1994a) evaluated potential risks to adult construction workers based on exposures to subsurface soils for a one year period. Exposure pathways included incidental ingestion and dermal contact with soils, and inhalation of particulates and volatiles during the construction activities. This evaluation was based on worker exposure under steady-state conditions (i.e., representative of an exposure on the surface of the landfill rather than in a trench-type situation). Steady-state conditions are expected to be representative of conditions experienced during the surficial cap construction activities. As described previously in Section 2.9 of the Draft FFS, elevated cancer risks and non-cancer hazard indices were identified under the steady-state future construction scenario evaluation, based on incidental ingestion of soil and inhalation of volatiles. As with Alternatives 2 and 3, the use of site monitoring and personal protective equipment, the implementation of proper engineering controls (e.g., dust minimization controls during waste disturbance activities) and the establishment of exclusion zones during construction would minimize these risks. Due to the potential for slightly increased risks during construction at the toe of the landfill slope along Allen Harbor, the use of more restrictive personal protective equipment could be required. In general, the use of more restrictive personal protective equipment can increase the probability of equipment failure, due to considerations such as worker mobility, visibility constraints and the potential for heat stress (USEPA, 1991a). The disruption of waste materials and the presence of landfill gas emissions also presents a potential for physical injury to construction workers due to physical hazards.

Another short-term effect of site remediation is the potential migration of contamination during construction due to run-off. Migration of contaminants due to run-off would be minimized through the use of drainage control systems such as silt fences along Sanford Road and at the toes of slopes. While additional wastes would be exposed to the elements during the cutback of the Allen Harbor shoreline slope, the presence of the cofferdam during construction will provide a degree of containment to prevent runoff and erosion of waste materials into Allen Harbor. Floating silt curtains could also be used, if necessary.

Off-site short-term impacts of construction would be expected to be minimal, although a short-term increase in local traffic could occur as a result of transporting cap materials to the site. The migration of volatiles or particulates off-site during construction is not expected to be significant, although it would potentially be greater than for Alternatives 2 and 3, due to the additional waste handling required. The construction time frame required for this alternative is estimated to be approximately less than one year.

Implementability - Several factors affect the implementability of Alternative 4. The slurry wall would be installed, requiring the use of equipment which is able to excavate a trench to a depth of approximately 75 feet. Site preparation would entail clearing of site vegetation and regrading. Installation of a cofferdam along the toe of the landfill would be required prior to slope cutback activities and sheet pile installation. The excavation of existing waste materials along the slope and recompaction of these materials elsewhere on the landfill face would be required. The construction of the sheet pile wall and cap along the slope of the landfill would be conducted in sections. Special attention will be required during construction of the cap along the slope to ensure that the various components of the cap are properly connected from section to section. To conduct construction activities at the toe of the slope, dewatering would be required and increased levels of personal protective equipment, which reduces productivity, may be required. In designing and constructing the 33% slope portions of the cap, special care would be required to ensure that slope stability requirements are met. Construction of the interface between the 5% cap profile and the 33% cap profile would also require special attention to ensure the continuity of the drainage, barrier, and gas vent layers. Fencing would be constructed along Sanford Road. Deed restrictions would be implemented if control of the property was relinquished by the federal government. Under these deed restrictions, future recreational site use could be restricted to ensure protection of the containment features and limit exposures to vented gases.

Cost - The main costs associated with this alternative are those associated with construction of the RCRA Subtitle C cap, the revetment along the Allen Harbor shoreline slope, the slurry wall and the sheet pile wall. An estimate of the present worth cost for Alternative 4 is $15,000,000. See Appendix C for a detailed cost analysis.

3.3 Alternative 5 - RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Subsurface Barrier, Riprap Storm Protection, Coastal Wetlands Creation and Deed Restrictions

3.3.1 Alternative Description

The components of Alternative 5 are identical to Alternative 4, with the exception of the provision of the coastal wetlands creation component and the resultant changes to the location of the sheet pile and capping layers along the shoreline of Allen Harbor. Alternative 5 includes a RCRA Subtitle C multi-layer cap, a slurry wall along Sanford Road, and a sheet pile wall to provide upper aquifer containment along the Allen Harbor shoreline. Under Alternative 5, the sheet pile wall is installed approximately 30 feet landward of its location under Alternative 4 (almost 50 feet from the existing toe of the landfill), with the overlying revetment ending approximately 30 feet from the existing toe of the landfill. The intervening 30 feet is the location of the constructed wetland area. For the purpose of this detailed analysis, the slurry wall and deed restriction components of Alternative 5 are identical to Alternative 2. Should the location of the slurry wall be relocated as requested by RIDEM (see Section 2.4), the final cap surface elevations would be revised during the final design. The following discussion focuses on the wetland creation aspect of this alternative.

Background - In general, created coastal wetlands are suitable for controlling erosion in low-wave energy areas. Coastal marshes occur naturally in the intertidal zone of moderate- to low-energy shorelines, along tidal rivers, and in bays and estuaries. They may be narrow fringes along steep shorelines or wide areas in shallow, gently sloping bays and estuaries. In the northeast, salt marshes are generally restricted to the shores of coastal embayments and rivers, and to tidal creeks.

Coastal marsh or salt marsh vegetation typically consists of herbaceous or grassy, salt-tolerant plant communities and is present along the shoreline in areas which are periodically inundated and drained by tides. Species typically found in these areas include members of the grass family (Poaceae), sedge family (Cyperacae) and rush family (Juncaceae), with halophytic grasses (e.g., *Spartina, Juncus,* and *Distichlis*) the dominant vegetation type. In the northeast, regularly flooded marshes are dominated by smooth cordgrass (*Spartina alterniflora*). Irregularly flooded marsh vegetation is more diverse and includes salt marsh hay (*Spartina patens*), salt grass (*Distichlis spicata*), black grass (*Juncus gerardii*), alkali grasses (*Puccinellia* spp.), and baltic rush (*Juncus balitcus*).

Salt marsh soils typically consist of peats, mucks, or sandy, clay or silt-clay soils. The most productive marsh soils are organic soils and clay or silt-clay mineral soils, which have greater density and higher nutrient concentrations than sandy soils.

Salt marshes exhibit complex patterns of zonation with respect to plants, animals and microbes, which reflect variations in factors such as salinity, water depth, and temperature. In general, salt marshes are inhabited by large numbers of relatively few species of animals, with high dominance and low species diversity. The dominant herbivorous marsh animals are insects of various types and gastropod mollusks. Many species of reptiles, birds, and mammals are transient residents of salt marshes. Plant material within a salt marsh can support grasshoppers, spiders and birds. Marsh grass rhizomes and culms can provide food for waterfowl. Algae within the vegetation can support periwinkles. The bacterial breakdown of dead grasses can result in detritus which, along with microalgae, can support fiddler crabs, snails and mussels. These fauna in turn provide food for mud crabs, fish, rails and raccoons.

One of the most important functions for estuarine wetlands is production export, the production of organic material and its subsequent physical transport from the wetland to other areas. Detritus exported from the marsh by tidal action along with submergent aquatic plants and plankton are important in the feeding of larvae and juvenile fish and shellfish.

In terms of shoreline protection, the aerial parts of marsh plants form a flexible mass which dissipates wave energy. As wave energy dissipates, transport of sediment is reduced. The presence of marsh plants may even create a depositional environment. The root systems of the plants also add stability to the shore sediment.

Site Characteristics and Existing Conditions - Currently Allen Harbor Landfill is characterized by the presence of wetland areas at its northern and southern ends. It is located along the edge of Allen Harbor which provides some protection against storm effects which are more intense in adjacent Narragansett Bay. While wetland areas are suspected to have been present in the area in which Allen Harbor Landfill currently exists prior to site development, the geometry of the shoreline in this area has been significantly modified by the filling activities (see Figure 3-4). The existing site conditions and characteristics which may impact wetlands creation activities are summarized below.

The Flood Insurance Rate Map for the Town of North Kingstown (FEMA, 1983) indicates that the 100-year storm still water elevation for the majority of the site is 14 feet

NGVD. Based on reported tidal data for the Newport tidal station and an interpolation of that data for East Greenwich and Wickford tidal stations (NOAA, 1992 and 1994), MHW is estimated to be at an elevation of 2.18 feet NGVD and the MLW is estimated to be at an elevation of -1.25 feet NGVD. The spring tidal range is estimated to be 4.85 feet.

The existing topographic map of the shoreline of Allen Harbor Landfill indicates that the horizontal distance from the shoreline to an elevation equal to the mean high water level is typically less than 5 feet along approximately 400 feet of shoreline along the east-central portion of the landfill. A bathymetric survey of Allen Harbor has not been conducted under the RI/FS investigations. Available information indicates the presence of water depths of 13 to 14 feet at a horizontal distance of approximately 170 to 200 feet from the shoreline (NOAA Chart 13223, Figure 8-1, Design Analysis, EA, 1994).

The southern end of the landfill is characterized by distances of 0 to 20 feet from the shoreline to the MHW elevation and by adjacent shallow off-shore marshlands and tidelands. The Wetlands and Floodplains Mapping of NCBC Davisville document (Ecology and Environment, Inc., 1993) identifies the southern off-shore area as Wetland F (see Figure 2-8), an extensive (9.5-acre) estuarine emergent wetland occupying the intertidal zone and shoreline above the intertidal zone. The wetlands are classified as estuarine intertidal emergent (E2EM) and estuarine intertidal flat (E2FL). The major plant communities in the wetland include salt marsh, salt meadow and common reed marsh. The area of salt marsh and salt meadow is relatively large compared to the area of common reed marsh, which distinguishes this wetland from other identified wetland areas in the Allen Harbor Landfill and adjacent Calf Pasture Point area. The wetland substrate consists of Matunuck mucky peat, a hydric organic soil, underlain by a thick layer of sand. The general topographic, hydrologic, soils substrate, and vegetational characteristics of Wetland F are also summarized in Appendix B.

Along the northern end of the landfill, the distance from the shoreline to the MHW elevation expands to approximately 55 feet at the very northern tip of the landfill. The Wetlands and Floodplains Mapping of NCBC Davisville document identifies this area as a 6.7-acre estuarine emergent wetland (Wetland D) which occupies most of the intertidal zone and narrow strip of the adjacent shoreline (see Figure 2-8). It consists of a salt marsh and common reed marsh. The soils underlying this wetland are mapped as Udorthents-Urban Land; however, soil sampling indicated the soils are very similar to Walpole sandy loam, which is considered to be

hydric. The general topographic, hydrologic, soils substrate, and vegetational characteristics of Wetland D are also summarized in Appendix B.

The ecological risk assessment conducted as part of the Phase II RI included observations of bird and wildlife species present at Allen Harbor Landfill and in the adjacent wetland areas. A list of birds and wildlife observed at the site and in the adjacent wetland areas is presented in Appendix B.

Sanford Ecological Services, Inc. (SES) visited the site in October 1993 to gather wetland field data for conducting a wetland functional analysis based upon criteria established by the U.S. Army Corps of Engineers Wetland Evaluation Technique manual (Adamus, et al, 1987, 1991). A summary of the primary and secondary functional values of wetlands within the Allen Harbor tributary system determined on the basis of that evaluation is presented in Table 3-3.

Additional wetlands mapping activities are currently underway at Site 09, including the mapping of the high and low water intertidal environment.

Approach - The approach used to develop the wetlands creation component of this alternative was based in part on several references. Wetlands, Guide to Science, Law, and Technology (Dennison and Berry, 1993) provides an overview of ecological principles, wetlands characteristics, wetlands delineation, regulatory requirements, and wetlands mitigation, restoration and creation. A Guide to Wetland Functional Design (Marble, 1992) provides conceptual design information needed to facilitate achieving functional replacement design goals for a particular wetland, based on the Wetland Evaluation Technique (WET). It provides design criteria, based on data reported in the literature or empirically derived, which may be used as suggested limits for conceptual wetland design. For each of the following functions, it provides a brief description of the function and associated general design concepts:

- Nutrient Removal/Transformation
- Sediment/Toxicant Retention
- Shoreline Stabilization (equivalent to Sediment Stabilization in WET)
- Floodflow Alteration
- Ground Water Recharge
- Production Export
- Aquatic Diversity/Abundance
- Wetland Dependent Bird Habitat Diversity

Also considered in the development of this alternative were Engineering and Design, Design of Coastal Revetments, Seawalls and Bulkheads, Engineer Manual, EM 1110-2-1614 (U.S. Army Corps of Engineers, 1985) and Engineering and Design, Environmental Engineering for Coastal Protection, Engineering Manual, EM 1110-2-1204 (U.S. Army Corps of Engineers, 1989).

For the purposes of this evaluation, shoreline stabilization/erosion control will be assumed to be the main function of the wetland area to be created. Wetland mitigation plans can serve multiple functions, with certain functions more compatible with each other than others. Functions which can be compatible with shoreline stabilization include floodflow alteration, sediment/toxicant retention, nutrient removal/transformation, and/or wetland dependent bird diversity habitat (Marble, 1992).

The function of a wetland is related to the hydroperiod which applies to that wetland. A hydroperiod is the periodic or regular occurrence of flooding and/or saturated soil conditions. The hydroperiods which occur in a tidal situation are illustrated in Figure 3-3 and consist of the following:

- Irregularly flooded - Tidal water floods the land surface less often than daily (soils are infrequently saturated)
- Regularly flooded - Tidal water alternatively floods and exposes the land surface at least once daily
- Irregularly exposed - The land surface is exposed by tides less often than daily
- Subtidal - The substrate is permanently flooded with tidal water (soils are permanently saturated)

As indicated in Figure 3-3, each of the tidal hydroperiods is also associated with a specific tidal water level. Therefore, the mean high water (MHW), mean low water (MLW), extreme high water of spring tides (EHWS) and extreme low water of spring tides (ELWS) elevations must be defined for a given site.

Pre-Design Analysis - Wetlands provide shoreline stabilization under erosive conditions primarily through the physical dissipation of erosive energy caused by waves, currents, tide or ice and also through the vegetation's ability to bind soils at the shoreline. The frictional resistance offered by a wetland depends on the vegetated width of the wetland, the density of vegetation, and the height of vegetation relative to incoming waves or currents. Frictional

resistance to high energy water may also be enhanced in a wetland whose morphology is flat or nearly flat, by causing the water to spread over a large area.

A Guide to Wetland Functional Design (Marble, 1992) describes eight site selection and site design features for shoreline stabilization based on the WET process. The site selection criteria include erosive conditions, fetch/exposure, shoreline geometry and resource protection, while the site design criteria include vegetated width, water/vegetation proportions, sheet flow, vegetation class, and shoreline geometry (shoreline geometry is both a site selection and site design criterion). Each of the site selection and site design criteria are evaluated with respect to the Allen Harbor Landfill shoreline below to provide an initial evaluation of the suitability of wetlands creation at the site. Because wetlands which meet the shoreline stabilization criteria already exist at the northern and southern ends of the shoreline, this evaluation will focus upon the potential creation of wetlands along the central portion of the landfill shoreline area.

Erosive Conditions - This reference indicates a wetland should be located where one or more of the following conditions are present in the adjacent area:

1) flowing water with velocities exceeding 1.5 feet/second;
2) boat wakes;
3) open water expanse greater than 100 feet across but less than 1.2 miles: and
4) unstable slopes exceeding 10 percent immediately adjacent to the wetland site, channelized tributaries immediately upstream, or large impoundments exceeding 20 feet in height at the outlet.

At a minimum, the open water expanse of Allen Harbor meets condition 3) and the existing landfill slopes meet condition 4); therefore, the shoreline of Allen Harbor is subject to erosive forces and could be a candidate for shoreline stabilization based on this feature. It is worth noting that, while these conditions are important in conducting a WET evaluation, shoreline stabilization functions do occur without these conditions.

Sheet Flow - This source indicates that the water should enter the wetland as sheet (unchannelled) flow, based on the fact that frictional resistance is higher when water spreads out over a large area. A topographically flat bottom lends itself to sheet flow conditions. Velocity conditions of less than 0.3 feet/second are recommended for wetlands greater than 20 feet wide. Although available bathymetric information for Allen Harbor is limited at this time, it would be expected that the created wetland would generally support sheet flow.

Vegetation Class - The preferred vegetation classes for shoreline stabilization include forested, scrub/shrub and persistent emergent vegetation. Such plants dissipate erosive forces by creating frictional drag through their rigidity, persistence and height. The

existing salt marsh and common reed marsh areas along the north and south ends of the landfill are characterized by the presence of persistent emergent vegetation.

Vegetated Width - Increased vegetation width near the shoreline provides increased frictional resistance to flowing water. The average width of vegetation should be greater than 30 feet perpendicular to flow, with average water depth not exceeding 50 percent of plant height at the time of establishment (Marble, 1992). Another reference indicates the practical minimum planting width is 20 feet (U.S. Army Corps of Engineers, 1989, as found in Knutsen, et al., 1981). Maintaining these criteria along the central shoreline portion of Allen Harbor Landfill will require filling of the harbor, cutback of the landfill slope, and/or creation of an off-shore breakwater or reef which could cause the accrual of a shoreline wetland area.

Water/Vegetation Proportions - Unvegetated open water, including water that is too deep to support persistent emergent vegetation, should be avoided. A high density of persistent emergent vegetation is required in areas supporting surface water. Since trees and shrubs bind soil better than persistent emergent vegetation, they are preferred for shoreline stabilization applications. Persistent emergent vegetation is appropriate where semi-permanent, permanent and intermittently exposed conditions are present, as would be the case along the Allen Harbor Landfill central shoreline area. The steep slope of the landfill limits the availability of land in irregularly flooded areas which would be suitable for planting trees and shrubs. Even if the existing slope were cut back, concerns regarding maintenance of an impermeable cap/sheet pile containment system would prevent the establishment of deep-rooted trees and shrubs along the slope. The effects of salt spray on such vegetation would further limit its use along the slope.

Fetch/Exposure - The restoration site should be located in an area which is perpendicular to the dominant wind direction and has an open water fetch greater than 100 feet but less than 1.2 miles. Erosive forces are amplified if fetch is great. Wetlands that intercept waves and protect shorelines are more likely to provide needed shoreline stabilization if they are first well established. Areas with extreme fetch are poor candidates for the establishment of intertidal vegetation. The distance of open water perpendicular to the restoration site and 45° either site of perpendicular should be measured and the average of the three values should not exceed 0.6 miles. Similarly, the longest of the three measurements should not exceed 1.2 miles. From the Allen Harbor shoreline, the curved nature of the harbor entrance effectively prevents a fetch (under normal water conditions) which extends into Narragansett Bay proper. Therefore, the maximum fetch across Allen Harbor is approximately 2,000 feet or 0.35 miles, The average fetch is approximately 1,300 feet or 0.25 miles. Therefore, the Allen Harbor Landfill shoreline meets the fetch/exposure criteria under normal water conditions. Under 100-year storm conditions, the water depth is sufficient to flood the inlet from Narragansett Bay to Allen Harbor, resulting in an effective fetch of approximately 25,000 feet (4.7 miles).

Shoreline Geometry - A restoration site is most appropriately located if the geometry of the shoreline effectively shelters it from waves. Sites located in coves are more effective than sites located on headlands which are exposed to waves from many directions. The shape of the Allen Harbor Landfill shoreline is more characteristic of a headland than a

cove, thereby exposing it to waves from several directions, although the presence of the site within Allen Harbor offers a degree of protection. If possible, a cove configuration should be created in the design process by physically modifying the shoreline; again, the Allen Harbor Landfill does not lend itself to modification to a cove configuration.

Resource Protection - The restoration site is most appropriately located adjacent to a resource requiring protection from sedimentation. Such resources can include navigable channels, significant wildlife areas, fish hatcheries, nurseries, and shellfish beds.

Of the site selection criteria (erosive conditions, fetch/exposure, shoreline geometry and resource protection) identified in A Guide to Wetland Functional Design (Marble, 1992), fetch/exposure and shoreline geometry are identified as being highly important to the wetland function while erosive conditions and resource protection are moderately important. While the fetch/exposure criteria are met under normal water conditions along the shoreline of Allen Harbor Landfill, the shoreline geometry is not ideal for the creation of a shoreline stabilization wetland area. Of the site design criteria (all remaining criteria plus shoreline geometry) identified in the same reference, vegetated width, water/vegetation proportions, and shoreline geometry are identified as being highly important to the wetland function while the remaining criteria (sheet flow and vegetation class) are moderately important. The ability to provide the appropriate vegetated width is limited by the existing shoreline configuration and the bathymetry of the harbor. Again, shoreline geometry is not conducive to the creation of a cove configuration.

As mentioned previously, the site evaluation based upon Marble's book provides an initial tool for evaluating the appropriateness of wetland creation at this site. While the weighing of criteria described within the reference may be applicable under the WET evaluation technique upon which the reference is based, a different weighing of criteria may be more important from an engineering/design standpoint (e.g., erosive conditions and the nature of erosive conditions in relation to other site features such as fetch, wave height, etc. may be of greater importance).

Other Considerations - Another consideration in the design or evaluation of a wetland creation alternative is the environmental quality of the sediment adjacent to the landfill within Allen Harbor and the potential impacts of contaminant migration from Allen Harbor Landfill on the harbor sediments and biota. Additional sediment and biota sampling is being conducted as part of the Phase III RI and an ecological risk assessment will be performed. Therefore, at this time the potential relationship between wetlands creation activities, the existing sediments and

biota within the harbor, and potential contaminant migration from the landfill has not been fully determined.

Salt marshes can have substantial absorptive capacities for potential pollutants such as nitrogen, phosphorus and heavy metals. While wetlands can be constructed to take advantage of these properties, some concern has also been expressed for intertidal marshes planted on polluted sediments in terms of their potential to release toxic heavy metals to estuarine systems (U.S. Army Corps of Engineers, 1989). If wetlands creation activities are conducted within the toe of the existing landfill area, and the wetland area is separated from the landfill by the RCRA Subtitle C cap and sheet pile containment features, the potential pollutant attenuation functions of the wetland will not be utilized to their fullest potential.

In designing a wetland area, the morphology of the proposed wetland area (e.g., size, shape, slope, depth) must be considered. Subtle changes in slope are more conducive to wetlands construction and establishment than abrupt changes. Wherever possible, slopes should be less than 10%, with slopes of 5% to 7% preferred (Dennison and Berry, 1993). The permeability and composition of the wetland soils must also be considered. If the base of the wetlands intersects shallow ground water, the soil permeability must be sufficient to allow water to flow freely in both horizontal and vertical directions. The soil must have sufficient nutrients available to support plant growth. Plants must be selected to support the desired wetland function.

Also worthy of consideration is the impact of waves on the wetland area during both the pre- and post- establishment periods. While guidelines specified by Marble indicate fetch conditions under normal water conditions are appropriate for the construction of a wetland area, a zero-damage wave height for constructed wetland areas has been defined as less than one foot (U.S. Army Corps of Engineers, 1985). The presence of the revetment above the wetland area introduces the likelihood of scour at the toe of the revetment in the wetland area. Further evaluation of potential wave impacts on the wetland area would be required during the design phase. If this evaluation indicated that additional protection from waves was required, construction of an off-shore breakwater or jetty could be considered.

Also to be considered in the development of this alternative are the regulatory requirements applicable to its implementation. As discussed in Appendix A, under most cases, the filling of tidal waters to create wetland areas is not encouraged. Construction of the wetland

within the toe of the existing landfill slope would provide the greatest compliance with regulations applicable to wetlands creation. While current wetland mitigation requirements are not applicable to the historic landfilling activities, a consideration of the function of wetlands which may have historically been present in the landfill area is appropriate in designing the created wetland area.

Conceptual Design - The proposed configuration of Alternative 5 is indicated in Figures 3-5 and 3-6. As stated previously, Alternative 5 is identical to Alternative 4, with the exception of the landfill's profile at the shoreline of the site. Under Alternative 5, the location of the toe of the revetment would be shifted a minimum of 30 feet landward from the existing landfill toe to provide sufficient space between the toe of the revetment and the existing toe of the landfill to support wetland construction. It is estimated that the volume of waste excavated along the shoreline for the slope cutback would add approximately three feet to the final cap elevations (as compared to Alternative 2).

The 33% slope of the cap along the shoreline and the need to maintain containment (i.e., RCRA Subtitle C cap) along the slope prevent the use of deep-rooted trees and shrubs as protective vegetation. Therefore the applicable vegetation for shoreline protection would be limited to persistent emergent vegetation. Due to the minimal height to which persistent emergent vegetation grows, additional slope protection would still be required to protect the shoreline above the mean high water level against the extreme actions of major storms or significant waves. The revetment component of Alternative 5 would provide this protection.

To construct Alternative 5, a similar sequence of construction to that described for Alternative 4 in Section 3.2.1 would be employed. Following completion of the cap and revetment layers, the fill soils which would support the establishment of the wetland plants would be backfilled in the excavated area between the edge of the revetment and the former location of the existing landfill toe. The fill soil should consist of topsoil, hydric soil or other soil amended with nutrients or organics to support the subsequent plantings. Typically, a minimum depth of 6 inches is required, with 12 to 18 inches preferred (Dennison and Berry, 1993).

Vegetative plantings are more effective than seeding in quickly establishing vegetation. Due to the site's location and exposure to wave action, timely establishment of the vegetation is key to the successful establishment of a wetland area. Smooth cordgrass (*Spartina*

alterniflora) has been successfully used for wetland establishment along the Atlantic coast (U.S. Army Corps of Engineers, 1989). The selection of appropriate species for planting at this site would require a detailed vegetation plan to ensure that shoreline stabilization as well as habitat enhancement goals are met. For example, a species such as common reed (*Phragmites communis*) would not be desirable because, although it could be successful in limiting erosion, it would be of little direct value to wildlife and could aggressively crowd out other desirable species. The use of non-native species could also result in aggressive colonization, with a lack of diseases or predators to control their spread. The layout and spacing of the plants would be determined during the design stage. For the purposes of this evaluation, a 2-foot by 2-foot grid spacing has been assumed.

Once constructed, the wetland will require maintenance and monitoring. As-built conditions should be documented to form a basis for comparison with future site conditions. A monitoring plan should be developed which defines the frequency and nature of monitoring data collection. Since wetlands are defined by hydrology, soils and vegetation, monitoring of these parameters is useful. Wildlife habitat value can be monitored using Habitat Evaluation Procedure techniques (U.S. Fish and Wildlife Service, 1980). Depending on the results of the management of migration operable unit for the site, monitoring of surface water or sediment quality may be desirable and could also be incorporated into the wetlands monitoring plan. The establishment of permanent photographic stations and the periodic photography of the site can provide an excellent means of monitoring the long-term success of a wetlands creation project. The results of site monitoring can allow for the timely identification and correction of problems.

3.3.2 Alternative Evaluation

The evaluation of Alternative 5 presented below consists of an evaluation of the alternative as a whole, as was conducted for Alternative 4 in Section 3.2.2. The comparative evaluation presented in Section 3.4 provides an evaluation of the differences between the alternatives previously evaluated within the Draft FFS and the alternatives evaluated herein which is focused upon the main difference between the alternatives, namely the cap construction features along the Allen Harbor shoreline.

Overall Protection of Human Health and the Environment - Alternative 5 provides overall protection of human health and the environment through the minimization of potential exposures

to the site contaminants, by minimizing the potential migration of contaminants due to erosion, infiltration of precipitation and discharge of leachate seeps, and by providing containment of the landfill materials against lateral ground water migration, including containment of the shallow aquifer. While the creation of a wetland area along the shoreline does not impact the ability of the alternative to provide source control, it has the potential to enhance environmental conditions at the site, provided a sustainable wetland area can be constructed.

The RCRA Subtitle C cap, slurry wall and sheet pile wall containment features provide protection to human health and the environment by providing a degree of isolation of the landfill contents. The low permeability layer of the cap effectively reduces the volume of leachate produced by limiting the infiltration of precipitation into the landfill while the sheet pile wall would be effective in combination with the slurry wall in providing a degree of hydraulic isolation for the waste materials. Through deed restrictions and the provision of fencing along Sanford Road, this alternative would limit potential exposures due to direct human contact with contaminant source areas and would limit future site use. It would meet location-specific and action-specific ARARs, including federal and state hazardous waste landfill closure requirements, and would comply with the CRMC regulatory preference for the use of revetment for erosion protection rather than sheet piling. Due to the multi-layer design of the cap combined with the containment features of the slurry wall and sheet piling wall, the alternative would be effective in the long-term in providing source control. However, the cutback of waste slopes along Allen Harbor and construction of the slope protection would present increased short-term risks. The creation of a wetland area along the shoreline, if successful, would enhance the environmental value of the site as well as the stabilization of the shoreline. However, the long-term sustainability of the wetland area is uncertain.

Overall Compliance with ARARs - The alternative would comply with location-specific ARARs, as previously listed in Table 3-1, and with action-specific ARARs, including federal and state ARARs applicable to venting of landfill gases, storm water discharge, and wetland creation, as previously listed in Table 3-2. Location-specific ARARs applicable to Alternative 5 are identical to those applicable to Alternative 4 with the addition of CRMC regulations applicable to wetland creation. The action-specific ARARs applicable to Alternative 5 are identical to those applicable to Alternative 4 and compliance would be achieved by the proposed design.

Long-Term Effectiveness and Permanence - Alternative 5 would significantly reduce the potential risks associated with direct contact with site-related contamination but some residual risk would remain since the source (the landfill) is not treated or removed. The RCRA Subtitle C cap would be effective in the long-term in minimizing future leachate generation and in enhancing the drainage of precipitation from the low permeability layer. The long-term effectiveness of landfill caps can be impacted by differential settlements of the landfill contents, large gas pressures under the cap, or slope erosion. While the age of the landfill should result in minimal future settlement of the contents, the potential for settlement would be considered in the final cap design. Landfill gas, which could impair the effectiveness of the cap, is also addressed through the landfill gas venting system. With proper maintenance, a RCRA Subtitle C cap offers reliable, long-term protection from risk associated with direct contact with contaminants. However, the presence of revetment materials over the barrier layers of the cap could compromise the integrity of the cap along the Allen Harbor shoreline slopes. The long-term effects of periodic inundation of the revetment and cap could further impact the long-term effectiveness of the cap. Long-term maintenance activities would include maintenance of cap materials, vegetation, the stone revetment and drainage controls.

The sheet pile wall, with a design life of up to 40 years, would be effective in the long-term in reducing shallow aquifer contaminant migration from the landfill area. The lack of above-grade sheet piling minimizes its long-term maintenance requirements. The slurry wall would provide a barrier to migration of shallow and deep ground water along Sanford Road, although its permeability could be slightly increased if it comes into contact with salt water. Due to the depth to which wastes were placed within the landfill area, ground water would still remain in contact with waste materials in the southern portion of the site. Monitoring of ground water levels and contaminant levels would provide an indication of the effectiveness of the containment features.

The long-term effectiveness of the wetland creation component of the alternative is not critical to ensuring source control but is a component of the overall environmental protection provided by the alternative. The long-term effectiveness of the created wetlands is dependent upon many factors. In general, wetland construction projects experience various rates of success due to their complexity. The initial establishment of the wetlands is crucial to its success. While wetlands are expected to have existed in the Allen Harbor Landfill area prior to filling,

the modifications to the shoreline geometry which resulted may impact the ability to re-create wetlands in this area. The subsequent sustainability of the wetland at the foot of the revetment may be difficult due to the erosive conditions which typically occur at the foot of such structural elements. The slope of the adjacent harbor bottom would also have to be considered in the remedial design in terms of the stability of the filled wetland materials. Provided the wetland can be constructed, the effectiveness of a 30-foot wetland area vegetated with a grass such as *Spartina alterniflora* in providing wave dissipation is fairly limited in comparison to the effectiveness of a larger or wider wetland area with more diverse plantings. However, the nature of the created wetland is limited by the construction requirements (e.g., existing slope cutback and final slope requirements) of the landfill cap. Overall a fairly high degree of uncertainty would be associated with the ability to sustain a wetland area at the toe of the revetment. Should the created wetland fail, the main impact would be the erosion of the wetland substrate materials into the adjacent areas of Allen Harbor. If sustainable, the created wetlands would require long-term monitoring. Maintenance would also be required until such time that the wetland is clearly established and functioning. The potential need to re-establish plantings once the cofferdams are removed may present difficulties in terms of implementation.

Existing and proposed fencing deters trespassing, and deed restrictions would limit future site use and development, thus limiting the potential for future damage to the cap and potential exposures to site contaminants. Since wastes would remain on-site above levels that allow for unlimited use and unrestricted exposure, five-year reviews of Alternative 5 would be required.

Reduction in Toxicity, Mobility, or Volume through Treatment - Alternative 5 provides no treatment or destruction of site contamination. The presumptive remedy approach is based on the determination that treatment is not practicable for landfills characterized by large volumes and heterogenous mixtures of waste, unless hot spot areas suitable for treatment exist.

Short-Term Effectiveness - Potential short-term risks associated with the implementation of Alternative 5 include the possibility of exposures to contaminants during the construction of the RCRA Subtitle C cap, the cutback of existing slopes along Allen Harbor, and the installation of the steel sheet pile and slurry walls. Little to no excavation of waste materials is anticipated during construction of the slurry wall. While trenching is required for slurry wall construction, the method of construction (i.e., as the trench is excavated, it is immediately backfilled with a slurry which provides structural support to the walls of the trench) precludes the potential for

workers to enter the trench for any reason. The sheet pile wall installation would require an initial cutback of the existing slope along the Allen Harbor Shoreline; therefore, workers would be exposed to waste along the cut of the slope during sheet pile wall installation. Construction of the cap would require regrading of topographic high spots along the top of the landfill, recompaction of excavated wastes, and grade cutbacks along Allen Harbor. Therefore, sheet pile wall installation and cap construction are likely to present the greatest short-term risks to site workers. The construction of the toe of the cap along Allen Harbor would be conducted in a slightly more protected environment than other cap construction activities (i.e., between the exposed waste face and the portable cofferdam) and slightly increased contaminant levels in the breathing zone could result. Alternative 5 requires the greatest volume of existing waste excavation to cut back the shoreline slope of the landfill and, as such, results in the greatest exposure of workers to waste materials during both excavation and recompaction on the landfill's surface.

The human health risk assessment conducted during the RI (TRC, 1994a) evaluated potential risks to adult construction workers based on exposures to subsurface soils for a one year period. Exposure pathways included incidental ingestion and dermal contact with soils, and inhalation of particulates and volatiles during the construction activities. This evaluation was based on worker exposure under steady-state conditions (i.e., representative of an exposure on the surface of the landfill rather than in a trench-type situation). Steady-state conditions are expected to be representative of conditions experienced during the cap construction activities, but as described in the previous paragraph, slightly increased exposures may occur during construction of the cap toe along Allen Harbor. As described in Section 2.9 of the Draft FFS, elevated cancer risks and non-cancer hazard indices were identified under the steady-state future construction scenario evaluation, based on incidental ingestion of soil and inhalation of volatiles. The use of site monitoring and personal protective equipment, the implementation of proper engineering controls (e.g., dust minimization controls during waste disturbance activities) and the establishment of exclusion zones during construction would minimize these risks. Due to the potential for slightly increased risks during construction at the toe of the landfill slope along Allen Harbor, the use of more restrictive personal protective equipment could be required. In general, the use of more restrictive personal protective equipment can increase the probability of equipment failure, due to considerations such as worker mobility, visibility constraints and

the potential for heat stress (USEPA, 1991a). The disruption of waste materials and the presence of landfill gas emissions also presents a potential for physical injury to construction workers due to physical hazards.

Another short-term effect of site remediation is the potential migration of contamination during construction due to run-off. Migration of contaminants due to run-off would be minimized through the use of drainage control systems such as silt fences along Sanford Road and at the toes of slopes. While additional wastes would be exposed to the elements during the cutback of the Allen Harbor shoreline slope, the presence of the cofferdam during construction will provide a degree of containment to prevent runoff and erosion of waste materials into Allen Harbor. Floating silt curtains could also be used, if necessary. The cofferdams may require a longer implementation period or some other wave mitigation means may be required to minimize the short-term potential erosion of soils from the wetland construction area during its establishment period.

Off-site short-term impacts of construction would be expected to be minimal, although a short-term increase in local traffic could occur as a result of transporting cap materials to the site. The migration of volatiles or particulates off-site during construction is not expected to be significant, although it would potentially be greater than for other alternatives, due to the additional waste handling required. The construction time frame required for this alternative is estimated to be approximately less than one year, although the period for establishment of the wetland area could be longer.

Implementability - Several factors affect the implementability of Alternative 5. The slurry wall would be installed, requiring the use of equipment which is able to excavate a trench to a depth of approximately 75 feet. Slurry wall construction would be followed by the clearing of site vegetation, regrading and cutback of the existing landfill slope. Prior to the initiation of slope cutback activities and sheet pile installation, the cofferdam would need to be installed. The excavation of existing waste materials along the slope and recompaction of these materials elsewhere on the landfill surface would follow. The construction of the sheet pile wall and cap along the slope of the landfill would be conducted in sections. Special attention will be required during construction of the cap along the slope to ensure that the various components of the cap are properly connected from section to section. To conduct construction activities at the toe of the slope, dewatering would be required and increased levels of personal protective equipment,

which reduces productivity, may be required. The sheet pile wall would be installed prior to initiation of cap construction activities. In designing and constructing the 33% slope portions of the cap, special care would be required to ensure that slope stability requirements are met. Construction of the interface between the 5% cap profile and the 33% cap profile would also require special attention to ensure the continuity of the drainage, barrier, and gas vent layers. Construction of the wetland area would commence following completion of the cap and revetment protection along the shoreline slope. Fencing would be constructed along Sanford Road. Deed restrictions would be implemented if control of the property was relinquished by the federal government. Under these deed restrictions, future recreational site use could be restricted to ensure protection of the containment features and limit exposures to vented gases.

Cost - The main costs associated with this alternative are those associated with construction of the RCRA Subtitle C cap, the revetment along the Allen Harbor shoreline slope, the slurry wall, the sheet pile wall and the wetland area. An estimate of the present worth cost for Alternative 5 is $16,200,000. Additional currently undefined costs may be associated with the wetlands creation component, such as pilot study and additional site characterization costs. If erosive conditions are caused by the presence of the revetment, long-term maintenance costs could be significant. See Appendix C for a detailed cost analysis.

3.4 Comparative Evaluation of Alternatives

A comparative analysis is conducted to evaluate the significant differences between the alternatives based on the threshold and balancing criteria. Tabular comparisons of the alternatives based on the seven evaluation criteria are presented in Tables 3-4 through 3-10. The tables are formatted to allow for a comparison of the common containment features of Alternatives 2 through 5 to the no action alternative, and also to provide a comparison between the shoreline protection features that distinguish Alternatives 2, 3, 4, and 5.

3.4.1 Overall Protection of Human Health and the Environment

A comparative analysis of the remedial alternatives with respect to overall protection of human health and the environment is presented in Table 3-4. This evaluation draws from the evaluations presented in the following sections, focusing on each alternative's compliance with

ARARs (see Section 3.4.2), long-term effectiveness and permanence (see Section 3.4.3), and short-term effectiveness (see Section 3.4.5).

Alternatives 2, 3, 4, and 5 provide the greatest degree of long-term protection of human health and the environment through the minimization of potential exposures to site contaminants and by minimizing the potential migration of contaminants. The RCRA Subtitle C landfill cap provides a physical barrier to exposures to surficial contaminants and minimizes the infiltration of precipitation and generation of leachate seeps. The sheet pile wall along Allen Harbor provides a means of containment of the upper aquifer, while the slurry wall provides a barrier to the migration of ground water into or out of the landfill area along Sanford Road. Alternative 1 provides no protection against potential exposures to contaminants or containment of the ground water. Alternatives 2, 3, 4, and 5 each comply with ARARs, although implementation of Alternatives 2 and 3 would require an exception to CRMC's preference for using revetment over vertical steel as an erosion control method in shoreline applications. Alternatives 4 and 5 would meet the CRMC's preference for the use of revetment for erosion protection rather than sheet piling. Alternative 5 would also comply with CRMC's goals for restoring coastal resources through the creation of wetlands and the wetlands component would provide greater compliance with CRMC's preference for non-structural erosion control. Alternative 1 would not comply with location-specific ARARs which prohibit continued contamination of wetlands or waters.

Long-term effectiveness for Alternatives 2, 3, 4, and 5 is expected to be good in comparison to Alternative 1, which provides no long-term effectiveness or permanence. The long-term effectiveness of the slurry wall component of Alternatives 2, 3, 4, and 5 could be impacted by the presence of salt water, which could affect the permeability of the slurry wall over the long-term. Under Alternatives 2 and 3, the long-term effectiveness of the exposed sheet piling would depend on proper maintenance and the design life of the construction materials. Under Alternatives 3, 4, and 5, the long-term effectiveness of the cutback slope would depend on its ability to withstand storm effects without erosion or slope failure, the ability of the geomembrane barrier to withstand the forces of the overlying revetment layer, and the ability of the cap at the toe of the slope to withstand periodic inundations and maintain drainage discharge capabilities. Under each alternative, failure of the slope protection system due to slope or sheet pile failure, if it should occur, would result in a release of waste materials. Under

Alternatives 3, 4, and 5, a discharge could also occur through the slow leaching of contaminants through tears in the geomembrane barrier which could result from the placement of the overlying revetment. While the created wetland component of Alternative 5 could provide treatment or retention of such contaminants, a high degree of uncertainty is associated with the sustainability of the wetland area over the long-term. Provided a wetland area could be established, the created wetlands would require long-term monitoring and maintenance until such time that the wetland is clearly established and functioning.

Alternatives 2, 3, 4, and 5 present increased short-term risks to on-site workers whereas Alternative 1 presents no increased short-term risks but also does not meet remedial action objectives. The main differences between Alternatives 2, 3, 4 and 5 are with respect to the short-term risks associated with construction. The construction of the shoreline slope of Alternative 5 will require the greatest volume of excavation and cutback of the existing waste slope, followed by Alternative 4, Alternative 3, and then Alternative 2. Therefore, Alternative 5 is likely to present the greatest short-term risks to site workers. In addition, based on the proposed construction sequence for Alternative 2, part of the construction activities will occur in a less exposed area, which could also result in greater potential short-term risks to construction workers.

3.4.2 Compliance with ARARs

A comparative analysis of the remedial alternatives with respect to their compliance with ARARs is presented in Table 3-5.

Alternatives 2, 3, 4 and 5 provide the greatest compliance with location-specific and action-specific ARARs/TBCs. The alternatives would be designed to comply with relevant and appropriate hazardous waste landfill closure regulations, air regulations applicable to landfill gas venting, and storm water discharge requirements. Location-specific requirements related to the protection of wetlands would be complied with or mitigation actions would be taken, as necessary. Alternatives 4 and 5 provide the greatest compliance with the Coastal Resource Management Program's preference for the use of revetment over vertical steel as an erosion control method for shoreline protection. Alternative 5 would also utilize a preferred non-structural erosion control means (wetland creation) in combination with the structural revetment erosion control. Alternative 3, which combines sheet pile and revetment for shoreline

protection, does not provide the same degree of compliance with the preference for revetment over vertical steel, while Alternative 2 provides the least degree of compliance with this preference.

3.4.3 Long-Term Effectiveness and Permanence

A comparative analysis of the remedial alternatives with respect to long-term effectiveness and permanence is presented in Table 3-6.

The common components of Alternatives 2, 3, 4, and 5 provide a greater degree of long-term effectiveness and permanence than Alternative 1 by significantly reducing the potential risks associated with direct contact with and migration of site-related contaminants. For Alternatives 2, 3, 4, and 5, some residual risks would remain since the source (the landfill) is not treated or removed. The RCRA Subtitle C cap would be effective in the long-term in minimizing infiltration and preventing leachate seeps. The long-term effectiveness of the landfill cap can be impacted by differential settlements of the landfill contents, large gas pressures under the cap, or slope erosion. However, with proper maintenance, Alternatives 2, 3, 4, and 5 offer reliable, long-term protection from risk associated with direct contact to contaminants. Alternative 1 would not be effective in the long-term since no controls would be implemented to limit potential exposures to site contamination.

The long-term effectiveness of the shoreline protection features of Alternatives 2, 3, 4, and 5 is dependent upon the individual designs. The subsurface portion of the sheet pile wall, with a design life of up to 40 years, would be effective in the long-term in reducing shallow aquifer contaminant migration from the landfill area. The exposed portion of the sheet piling for Alternatives 2 and 3 would require periodic maintenance due to its exposure to the elements and could be expected to have a shorter life span, although compliance with the RCRA 30-year post-closure maintenance and monitoring period is expected. The Alternative 2 design elevation of 15 feet NGVD would be effective in the long-term in preventing cap erosion and promoting drainage from the cap since the design elevation is one foot above the 100-year storm elevation. Under Alternative 3, the lower final elevation of the sheet pile wall will result in more frequent overtopping of the sheet pile during storm events, greater periods of inundation of the cap layer and greater potential for erosion during storm events. The 33% slope of the final cap along the shoreline could also contribute to potential long-term erosion or slope stability problems.

Finally, the presence of revetment materials over the geomembrane over the long-term could impact its long-term effectiveness, due to the additional stresses placed on the membrane. If tears in the geomembrane should form, leaching of contaminants through the cap could occur. Under Alternative 4, the stone revetment will provide the only protection to storm and wave action. With the sheet pile wall ending at grade, the cap can drain freely over the sheet pile wall and into the harbor, unlike under Alternative 3. The revetment-covered slope under Alternatives 3, 4 and 5 would require periodic inspections and maintenance. The sustainability of the wetland component of Alternative 5 over the long-term is uncertain, due to the potential effects of scour at the toe of the revetment, the geometry of the shoreline and other site-specific factors. If sustainable wetlands could be created, they could provide a dissipation of wave energy over the long-term. The creation of wetlands under Alternative 5 could also provide nutrient treatment or contaminant retention should the cap be damaged and subsequent leaching of contaminants through the cap occur. Long-term monitoring of the wetland would be required, as well as maintenance until such time that the wetland becomes established.

The slurry wall for Alternatives 2, 3, 4, and 5 would provide long-term protection against the migration of ground water into or out of the landfill along Sanford Road, although its permeability could be increased if it comes into contact with salt water. Due to the depth to which wastes were placed within the landfill area, ground water would still remain in contact with waste materials in the southern portion of the site.

Deed restrictions provided under Alternatives 2, 3, 4, and 5 would limit future site use and development, thus limiting the potential for future damage to the cap and potential exposures to site contaminants. The vertical face of the sheet piling of Alternative 2 would be more effective than the cutback slope of Alternatives 3, 4, and 5 in restricting site access from the shoreline. The presence of wetlands along the shoreline under Alternative 5 could also discourage potential trespassers. Long-term ground water monitoring would provide an indication of the effectiveness of the containment features. All of the alternatives would require five-year reviews since wastes would remain on-site above levels that allow for unlimited use and unrestricted exposures.

3.4.4 Reduction of Toxicity, Mobility and Volume through Treatment

A comparative analysis of the remedial alternatives with respect to reductions of toxicity, mobility and volume through treatment is presented in Table 3-7.

None of the five alternatives provide treatment or destruction of site contamination and therefore no associated reduction in contaminant toxicity, mobility, or volume through treatment. Alternatives 2, 3, 4, and 5 were developed using the presumptive remedy approach which is based on the determination that treatment is not practicable for landfills characterized by large volumes and heterogeneous mixtures of waste, unless hot spot areas suitable for treatment exist.

3.4.5 Short-Term Effectiveness

A comparative analysis of the remedial alternatives with respect to short-term effectiveness is presented in Table 3-8.

Alternative 1 requires no remedial activities to be conducted and therefore results in no increase in short-term risks. However, it does not achieve remedial response objectives.

Alternatives 2, 3, 4, and 5 would result in some increased short-term risks to workers during the construction of the RCRA Subtitle C cap and installation of the sheet piling and slurry walls. Little or no excavation of waste materials is anticipated during construction of the slurry wall for either Alternatives 2, 3, 4, or 5. While trenching is required for slurry wall construction, the method of construction (i.e., as the trench is excavated, it is immediately backfilled with a slurry which provides structural support to the walls of the trench) precludes the potential for workers to enter the trench for any reason. Sheet pile installation for both Alternatives 2 and 3 would result in minimal short-term risks since the installation requires no excavation of waste materials or trenching-type situations. Sheet pile installation for Alternatives 4 and 5 will require cutbacks of the landfill slope prior to installation, increasing the potential short-term risks to workers.

Construction of the cap for Alternatives 2, 3, 4, and 5 will require regrading of topographic high spots along the top of the landfill and is likely to present short-term risks to site workers as evaluated under the future construction scenario of the human health risk assessment (see Section 2.9 of the Draft Focus Feasibility Study). However, the use of site monitoring and personal protective equipment, the implementation of proper engineering controls (e.g. dust minimization controls during waste disturbance activities) and the establishment of exclusion zones during construction would minimize these risks.

Additional short-term risks to workers could result under Alternative 3 during the cutback of existing slopes along Allen Harbor to a maximum 3:1 slope. Alternative 4 would require a greater slope cutback than Alternative 3 and could result in increased short-term risks to workers. Alternative 5 requires the greatest slope cutback and the greatest period of exposure to waste materials. In addition, the construction of the toe of the cap along Allen Harbor, especially under Alternative 3, would be conducted in a more protected environment (i.e., between the exposed waste face and the sheet pile wall for Alternative 3 and between the exposed waste face and the portable cofferdam for Alternatives 4 and 5) than cap construction under Alternative 2 and could result in increased contaminant levels in the breathing zone. While personal protective equipment could also be used to minimize these risks, a higher level of protection could be required, which in itself can increase risks due to reduced mobility or visibility.

Due to the disruption of waste materials and the presence of landfill gas emissions under Alternatives 2, 3, 4, and 5, a potential for physical injury to construction workers due to physical hazards also exists. Another short-term effect of the site containment alternatives is the potential migration of contamination during construction due to run-off. Migration of contaminants due to run-off would be minimized through the use of drainage control systems such as silt fences along Sanford Road, at the toes of slopes and at drainage discharge points in the sheet pile wall. Under Alternative 3, containment would also be provided by the sheet pile wall during cap construction along the slope. Under Alternatives 4 and 5, the portable cofferdam would be used to provide a degree of containment during construction along the slope.

Off-site impacts of construction activities would be expected to be minimal for Alternatives 2, 3, 4, and 5, although a short-term increase in local traffic could occur as a result of transporting cap construction materials to the site. The construction time frames for Alternatives 2, 3, 4, and 5 are estimated to be approximately less than one year, although the additional slope construction activities and the time required to establish the wetland area under Alternative 5 would significantly increase its overall remedial implementation period in comparison to Alternative 2, 3, and 4.

3.4.6 Implementability

A comparative analysis of the remedial alternatives with respect to implementability is presented in Table 3-9.

Alternative 1 requires no implementation other than five year reviews. This alternative would not limit the implementation of other remedial actions.

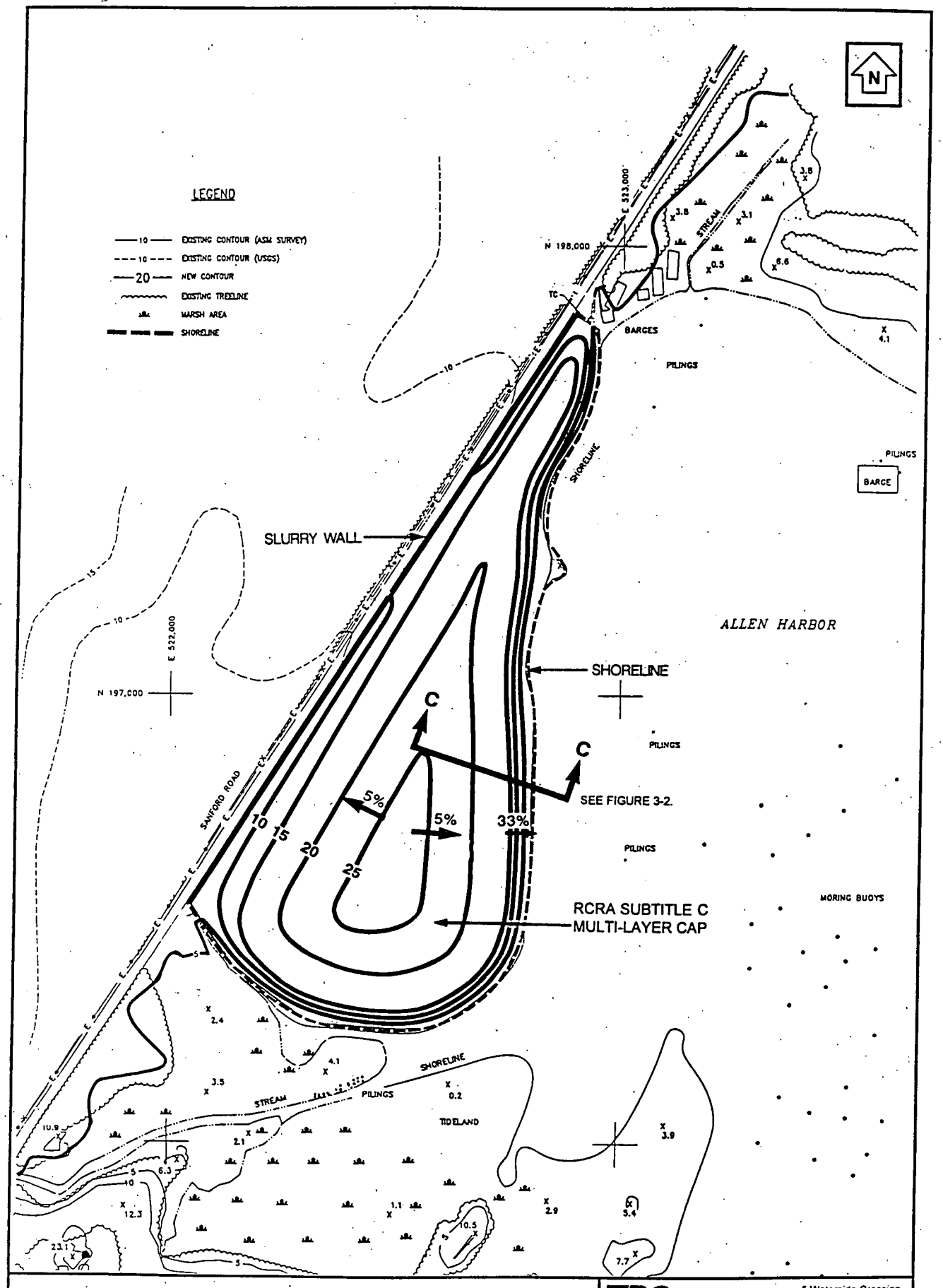
Alternatives 2, 3, 4, and 5 would be relatively complicated to implement. Each of the alternatives would require clearing of existing site vegetation and regrading. Sheet pile wall and slurry wall installation would be required prior to cap construction. Some movement and recompaction of existing waste materials present at topographic high points on the landfill surface would also be required prior to cap construction. The construction of the RCRA Subtitle C cap requires special care and equipment to ensure the cover materials are properly placed. The design of the cap would require consideration of inundation where final elevations are within the 100-year floodplain (e.g., along Sanford Road). For Alternatives 2, 3, 4, and 5 the slurry wall installation would require the use of equipment which is able to excavate a trench to a depth of approximately 75 feet. Services and materials for construction of the containment features are generally available.

Based on the cap construction activities at the landfill's interface with Allen Harbor, the implementation of Alternative 5 would be the most difficult, followed by Alternatives 4, 3, and then 2. Under Alternative 2, the RCRA Subtitle C cap would simply be tied to the sheet pile wall. Under Alternative 3, the sheet pile wall would be installed prior to the cutback of the existing slope along Allen Harbor to provide protection against storms and wave action during the construction period. Additional volumes of waste would be excavated during the cutback of the slopes and recompacted on the surface of the landfill. Implementation of Alternative 4 requires a greater slope cutback than Alternative 3 and the additional associated movement and recompaction of existing waste materials prior to cap construction. The sheet pile wall must be installed after slope cut back and before cap construction under Alternatives 4 and 5. Alternative 5 requires the greatest amount of slope cutback of all alternatives and the additional associated movement and recompaction of existing waste materials prior to cap construction. The greater potential exposures to waste materials could require the use of a higher level of personal protective equipment, which generally reduces productivity. Alternative 5 also would require the creation of the adjacent wetland following cap and revetment construction. Under Alternatives 3, 4, and 5, additional types of materials would be required for cap construction

and the construction of the interface between the 5% slope and 33% slope would require special care to ensure continuity of the various cap layers. Construction at the toe of the slope under Alternatives 3, 4, and 5 would also require dewatering. Under Alternatives 4 and 5, the use of portable cofferdams would be required during construction along the toe of the landfill.

3.4.7 Cost

A comparative analysis of the remedial alternatives with respect to present worth cost is presented in Table 3-10. No costs are associated with the implementation of the no action alternative, other than the nominal costs which would be associated with conducting five-year reviews. The present worth costs of Alternatives 2, 3, 4 and 5 reflect the constructability issues associated with each alternative, as well as long-term monitoring costs. Alternative 2 is the lowest cost alternative of the four, with a total present worth cost of approximately $13,700,000. Implementation of Alternative 4 follows at an estimated total present worth cost of approximately $15,000,000. Alternative 3 is the next most expensive alternative to implement, at $15,500,000, while Alternative 5 is the most expensive alternative at $16,200,000.



200 100 0 200
GRAPHIC SCALE IN FEET

SOURCE: EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC. 1994

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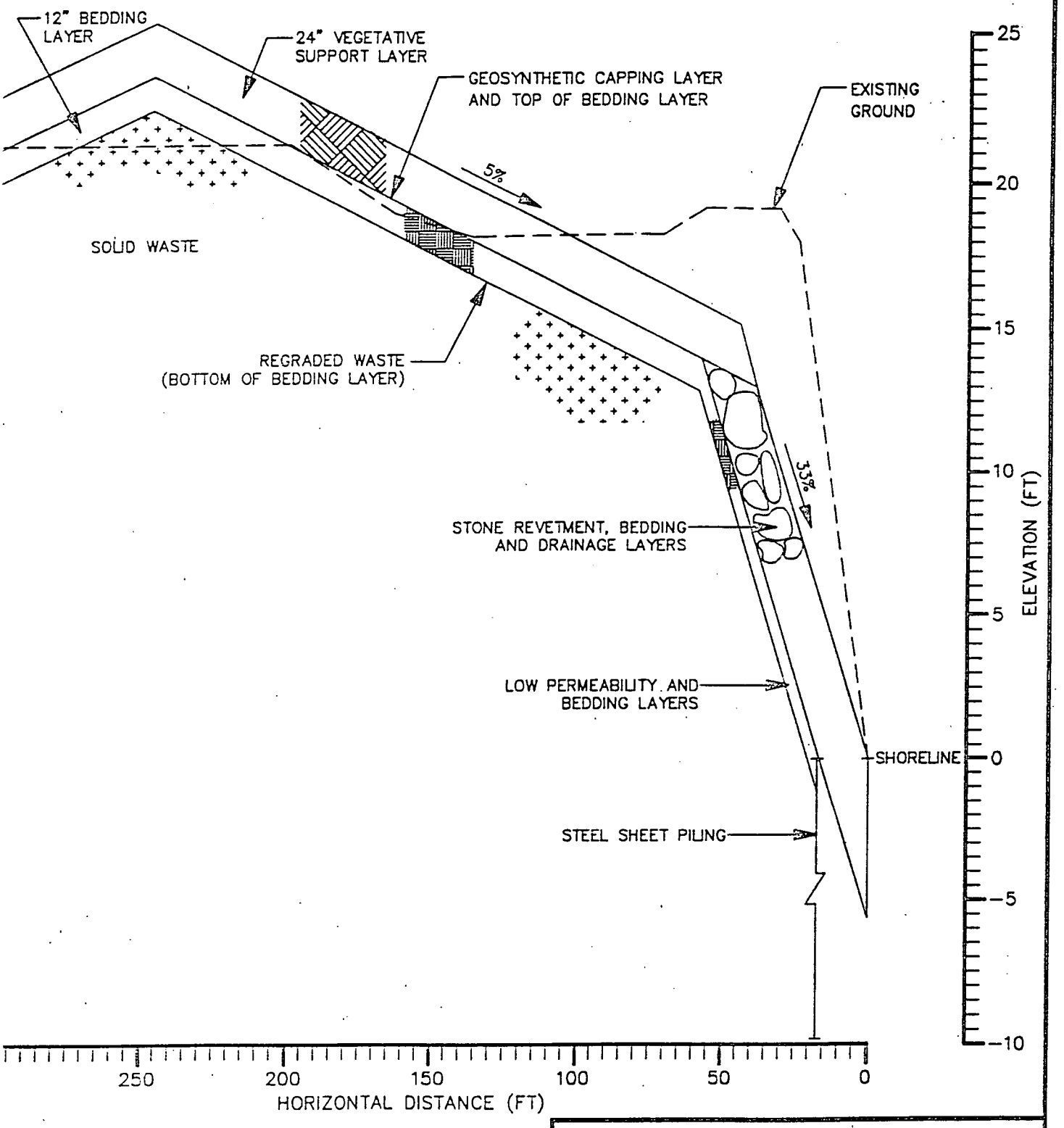
FIGURE 3-1.
PLAN VIEW ALTERNATIVE 4 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL, SHEET PILE SUBSURFACE BARRIER AND RIPRAP STORM PROTECTION

Date: 5/95
Project No. 02969-0030



SCALE: 1"=5' VERT.
1"=50' HORIZ.

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NAVAL CONSTRUCTION BATTALION CENTER

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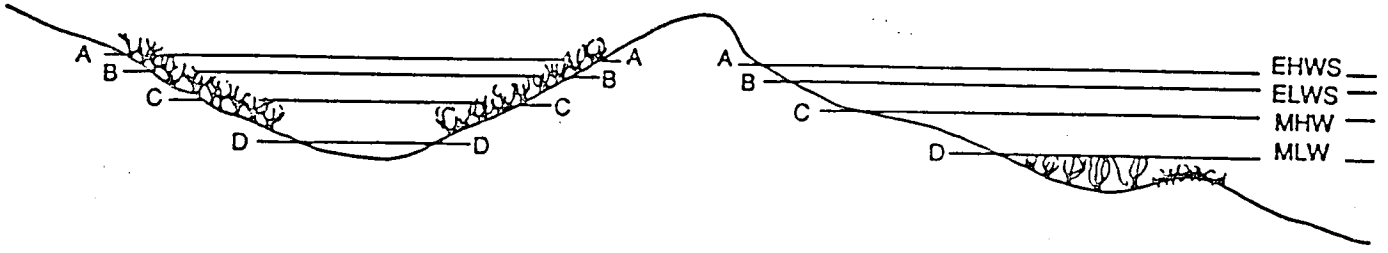
FIGURE 3-2.
SITE 09-ALLEN HARBOR LANDFILL
CROSS SECTION C-C
ALTERNATIVE 4

Date: 5/95 | Drawing No. 02969-0030

02969AT4



A - Irregularly flooded
B - Regularly flooded
C - Irregularly exposed
D - Subtidal
EHWS - Extreme high water of spring tides
ELWS - Extreme low water of spring tides
MHW - Mean high water
MLW - Mean low water

Source: Cowardin et al., 1979.

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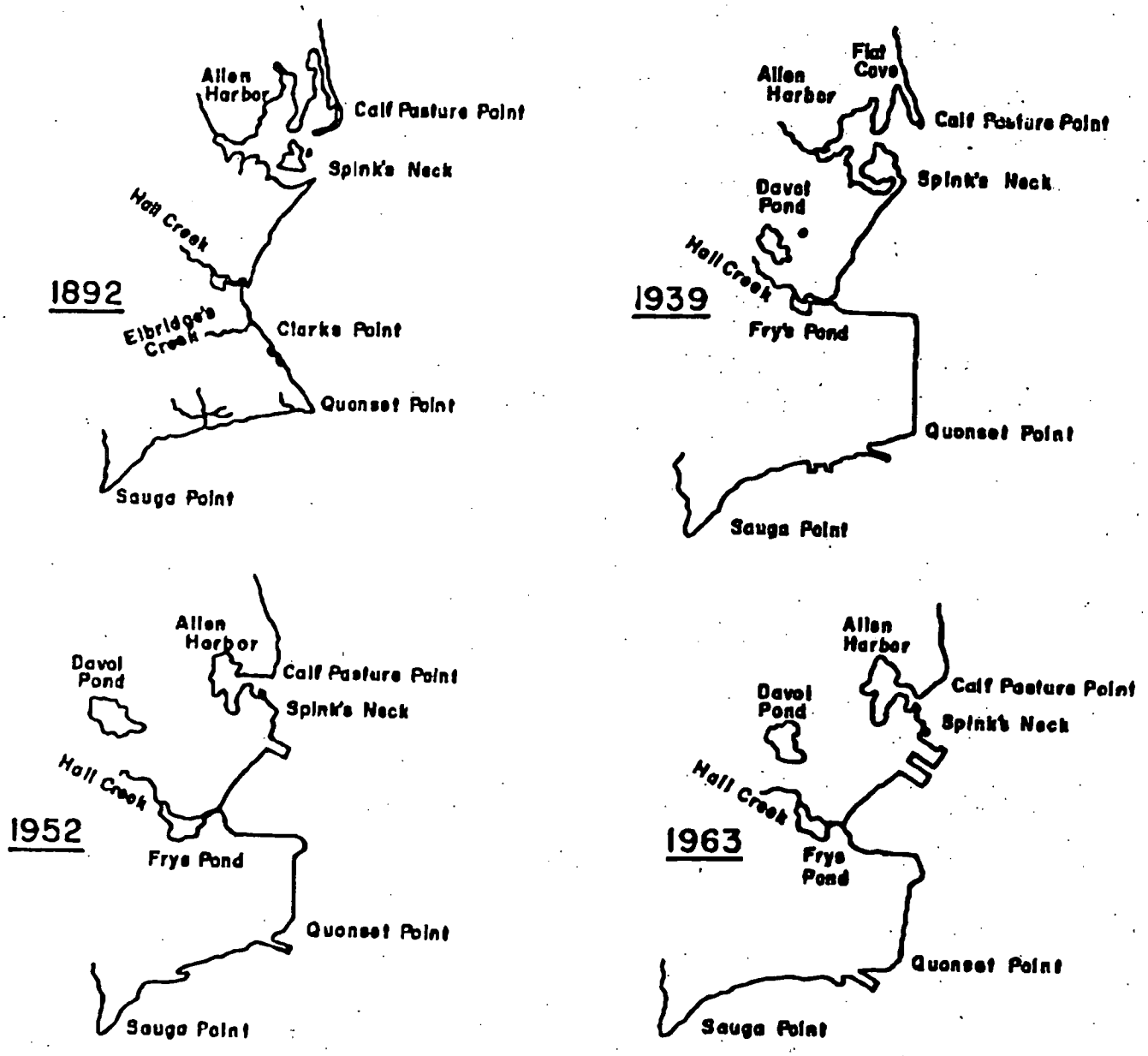
FIGURE 3-3.

SITE 09-ALLEN HARBOR LANDFILL TIDAL HYDROPERIODS

Date: 5/95

Drawing No. 02969-0030



Source: The Redevelopment of Quonset/Davisville: An Environmental Assessment, Marine Technical Report #55, Coastal Resources Center, University of Rhode Island, 1977

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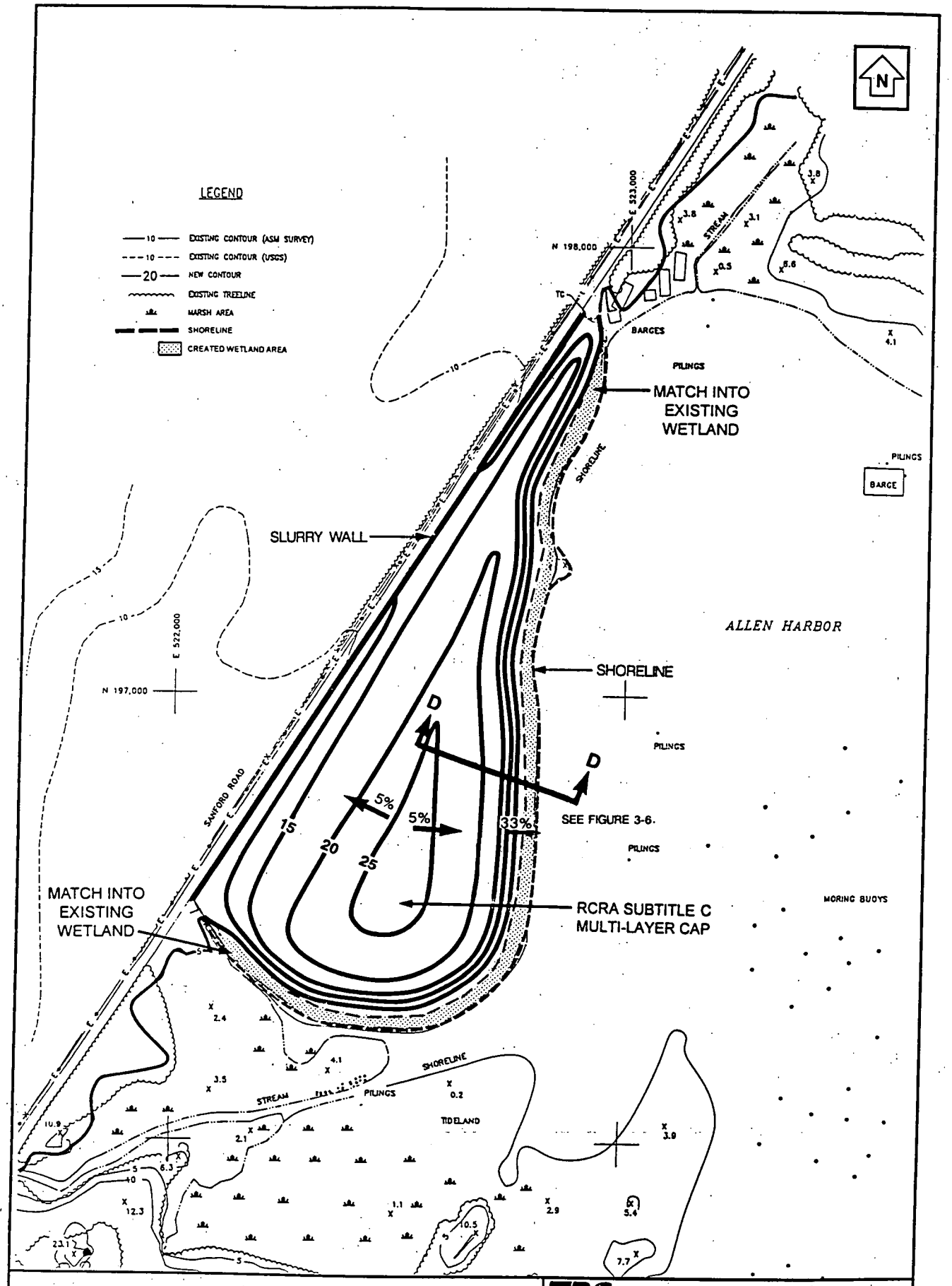
NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE RHODE ISLAND

FIGURE 3-4.

MODIFICATIONS OF THE QUONSET/ DAVISVILLE SHORELINE FROM 1892 - 1963

Date: 5/95 | Drawing No. 02969-0030



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GRAPHIC SCALE IN FEET

SOURCE. EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC. 1994

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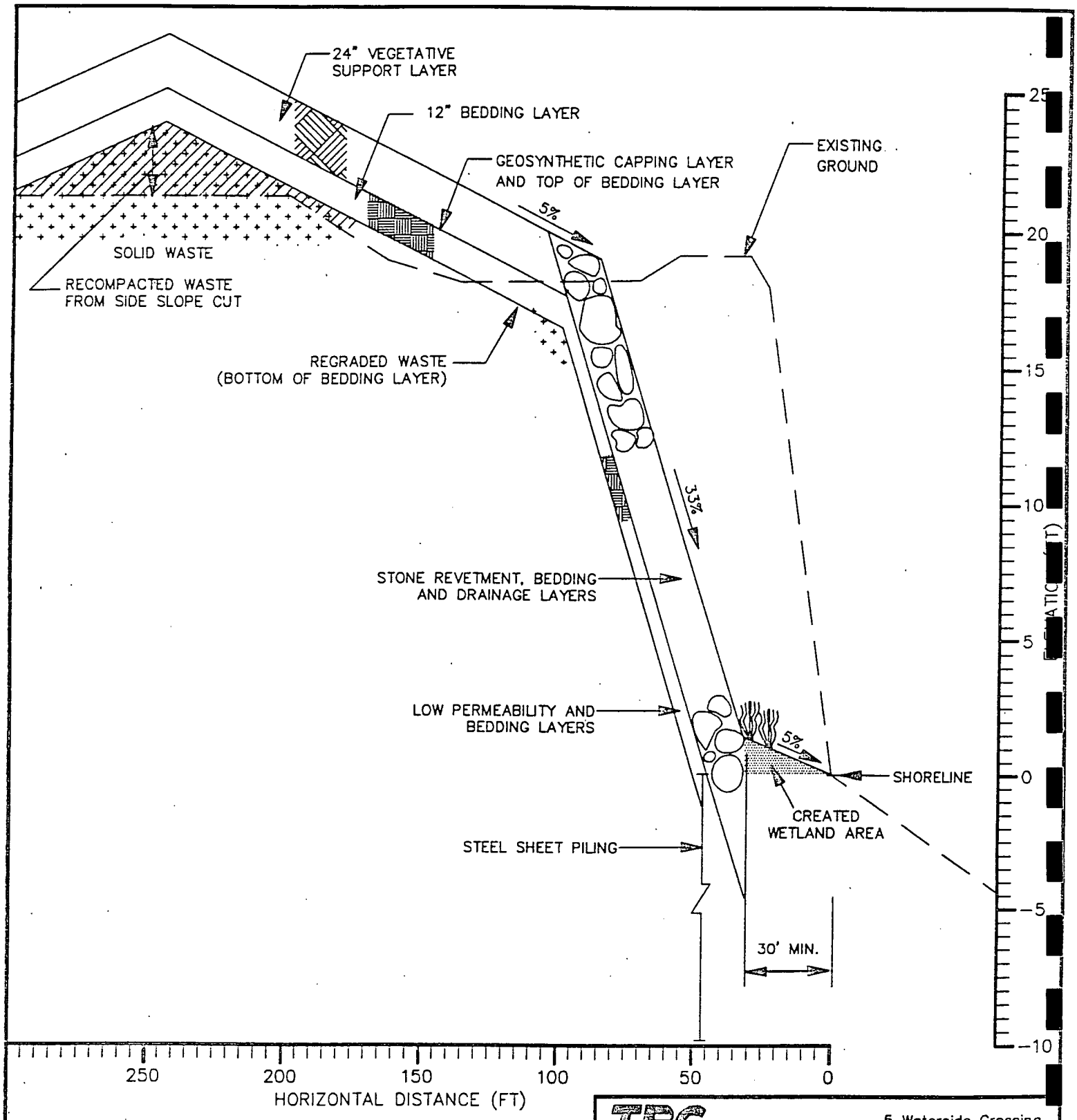
FIGURE 3-5.
PLANVIEW ALTERNATIVE 5 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL, SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION AND COASTAL WETLANDS CREATION

Date: 5/95
Project No. 02069-0030



SCALE: 1"=5' VERT.
1"=50' HORIZ.

SOURCE: EA ENGINEERING SCIENCE, AND TECHNOLOGY, INC.
REMEDIAL DESIGN FOR ALLEN HARBOR LANDFILL

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FIGURE 3-6.
SITE 09-ALLEN HARBOR LANDFILL
CROSS SECTION D-D
ALTERNATIVE 5

Date: 5/95 | Drawing No. 02969-0030

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TABLE 3-1

FEDERAL AND STATE LOCATION-SPECIFIC ARARs AND TBCs
ALTERNATIVE 4 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL,
SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION, AND DEED RESTRICTIONS
ALTERNATIVE 5 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL,
SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION,
COASTAL WETLANDS CREATION, AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
FEDERAL				
Wetlands/Water Resources--				
	Executive Order 11988 and 11990; Statement on Proceedings of Floodplain Management and Wetlands Protection (40 CFR 6, Appendix A)	Applicable	Requires action to avoid whenever possible the long- and short-term impacts associated with the destruction of wetlands and the occupancy and modifications of floodplains and wetlands whenever there is a practicable alternative which promotes the preservation and restoration of the natural and beneficial values of wetlands and floodplains.	There is no practicable alternative that will have less adverse impact on wetlands and the floodplain. Therefore, these remedial actions will be designed and conducted so that impacts to wetlands and floodplains will be minimized and mitigated.
	Clean Water Act Section 404 (40 CFR 230.10) Requirements for Discharge of Dredge or Fill Material and Rivers and Harbors Act (Section 10) Prohibition of Filling a Navigable Water	Applicable	Prohibits the discharge of dredged or fill material to a water of the United States if there is a practicable alternative which poses less of an adverse impact on the aquatic ecosystem or if it causes significant degradation of the water. Rivers and Harbors Act prevents filling of a navigable water.	Applicable if cap construction or shoreline protection impact wetlands and waters, or cause degradation of water. If construction cannot be limited to within toeprint of existing landfill, mitigation of impacted wetlands may be required.
	Fish and Wildlife Coordination Act of 1958 (16 U.S.C. 661) Protection of Wildlife Habitats	Applicable	Requires consultation with federal and state conservation agencies during planning and decision-making process which may impact water bodies, including wetlands. Measures to prevent, mitigate or compensate for losses of fish and wildlife will be given due consideration whenever a modification of a water body is proposed.	ARAR for cap construction if it impacts Allen Harbor, and for shoreline protection.

TABLE 3-1 (continued)
FEDERAL AND STATE LOCATION-SPECIFIC ARARs AND TBCs
ALTERNATIVE 4 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL,
SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION, AND DEED RESTRICTIONS
ALTERNATIVE 5 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL,
SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION,
COASTAL WETLANDS CREATION, AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
Endangered Species--				
	Endangered Species Act of 1973 (16 U.S.C. 1531) Protection of Endangered Species	Applicable	Remedial actions may not jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their critical habitats.	Grasshopper sparrows, upland sandpipers and the least tern have been identified in the general area of the Allen Harbor Landfill, although not specifically on the landfill or the adjacent wetlands. If any of these species are identified on the landfill or the adjacent wetland, appropriate measures will be taken during construction to ensure that the remedial action does not adversely affect the species r its habitat. In addition, the final cap and/or the created wetlands of Alternative 5 may provide habitat for these species.
STATE				
Wetlands--				
	Rhode Island Wetlands Laws (RIGL 2-1-18 et seq.); Rhode Island Department of Environmental Management Rules Governing the Enforcement of the Fresh-water Wetlands Act - as amended, Dec. 21, 1986.	Applicable	Defines and establishes provisions for the protection of swamps, marshes and other freshwater wetlands and adjacent land in the state. Requires actions to prevent the undesirable drainage, excavation, filling, alteration, encroachment or any other form of disturbance or destruction to a wetland.	If cap construction, slurry wall, or shoreline protection impact a freshwater wetland, appr priate mitigation measures will be developed and implemented to prevent disturbance or destruction of the wetland.
	· Section 7.02	Applicable	States that the impacts of any changes in drainage in a wetland area must be assessed.	Impact of source control remedial action features on fresh water wetland areas will be assessed and mitigated if impacts are found.
	· Section 7.03	Applicable	Requires that flood storage capacity be maintained at a site.	Impact of source control remedial action features on fresh water wetland areas will be assessed t ensure that flood storage capacity will be maintained.

TABLE 3-1 (continued)
FEDERAL AND STATE LOCATION-SPECIFIC ARARs AND TBCs
ALTERNATIVE 4 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL,
SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION, AND DEED RESTRICTIONS
ALTERNATIVE 5 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL,
SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION,
COASTAL WETLANDS CREATION, AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
	Section 7.04	Applicable	Requires implementation of sediment controls and surface water discharge controls to minimize sedimentation of wetland areas.	Construction runoff control methods and final drainage control methods will be designed to minimize sediment runoff.
Coastal Zone--	Rhode Island Coastal Resources Management Law, (RIGL, Title 46, Chapter 23) and Regulations	Applicable	Creates Coastal Resources Management Council and sets standards and authorizes promulgation of regulations for management and protection of coastal resources.	Since Allen Harbor Landfill is located in a coastal area, the Navy will coordinate with the Rhode Island Coastal Resources Management Council and will ensure that all actions are consistent, to the maximum extent practicable, with the Coastal Zone Management Plan. ARAR for capping, shorelin protection, and wetland creation.

TABLE 3-2

FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE 4 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL,
SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION, AND DEED RESTRICTIONS
ALTERNATIVE 5 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL,
SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION,
COASTAL WETLANDS CREATION, AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
FEDERAL Capping/ Monitoring	Migratory Bird Treaty Act (16 U.S.C. 703-712)	Applicable	Prohibits hunting, possessing, killing, or capturing of migratory birds, birds in danger of extinction, and those birds' eggs or nests.	Since construction activities during the breeding season may "take" birds or their nests, actions must be taken to avoid destroying nests during breeding season.
	RCRA 40 CFR 264.10-264.18 Subpart B - General Facility Standards	Relevant and Appropriate	General requirements regarding waste analysis, security, training, inspections, and location applicable to a facility which stores, treats, or disposes of hazardous wastes (a TSDF facility).	The substantive provisions of this regulation will be met if the remedial action addresses a waste which is a listed or characteristic waste under RCRA and the remedial action constitutes current treatment, storage, or disposal as defined by RCRA.
	RCRA 40 CFR 264.30-264.37 Subpart C - Preparedness and Prevention	Relevant and Appropriate	Requirements applicable to the design and operation, equipment, and communications associated with a TSDF facility, and to arrangements with local response departments.	The substantive provisions of this regulation will be met if the remedial action addresses a waste which is a listed or characteristic waste under RCRA and the remedial action constitutes current treatment, storage, or disposal as defined by RCRA.
	RCRA 40 CFR 264.50-264.56 Subpart D - Contingency Plan and Emergency Procedures	Relevant and Appropriate	Emergency planning procedures applicable to a TSDF facility.	The substantive provisions of this regulation will be met if the remedial action addresses a waste which is a listed or characteristic waste under RCRA and the remedial action constitutes current treatment, storage, or disposal as defined by RCRA.
	RCRA 40 CFR 264.90-254.101 Subpart F - Ground Water Protection	Relevant and Appropriate	Ground water monitoring/corrective action requirements; dictates adherence to MCLs unless ACLS are appropriate and establishes points of compliance.	Monitoring standards will be met through the implementation of ground water monitoring in conjunction with the management of migration operable unit.

TABLE 3-2 (continued)
FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE 4 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL,
SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION, AND DEED RESTRICTIONS
ALTERNATIVE 5 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL,
SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION,
COASTAL WETLANDS CREATION, AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
FEDERAL Capping/ Monitoring (cont.)	RCRA 40 CFR 264.110-118 Subpart G - Closure/Post Closure Requirements	Relevant and Appropriate	Establishes requirements for the closure and long-term management of a hazardous disposal facility.	Relevant and appropriate closure/post closure standards and requirements will be met.
	RCRA 40 CFR 264.303-264.310; Subpart N - Landfill Requirements	Relevant and Appropriate	Placement of cap over hazardous waste requires a cover designed and constructed to comply with regulations. Installation of final cover to provide long-term minimization of infiltration. Restricts post-closure use of property as necessary to prevent damage to cover.	Cap design meets relevant and appropriate requirements. Cap maintenance, closure and post-closure substantive requirements will be met.
	RCRA Proposed Rule 52 FR 8712, 53 FR 51446 Proposed Amendments for Landfill Closures	To Be Considered	Provides an option for the application of alternate closure and post-closure requirements based on a consideration of site-specific conditions including exposure pathways of concern.	Cap and post-closure monitoring designs take into account exposure pathways of concern.
	EPA Technical Guidance Document: Final Covers on Hazardous Waste Landfills and Surface Impoundments (EPA 530-SW-89-047)	To Be Considered	EPA Technical Guidance for landfill covers. Presents recommended technical specifications for multilayer landfill cover design.	These standards will be considered in development of the cap design. Cap construction should conform to these standards.

TABLE 3-2 (continued)
FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE 4 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL,
SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION, AND DEED RESTRICTIONS
ALTERNATIVE 5 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL,
SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION,
COASTAL WETLANDS CREATION, AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
Venting/ Discharges to Air	Clean Air Act (40 CFR 60) New Source Performance Standards (NSPS) Proposed Subpart WWW 56 FR 24468-24528 (5/30/91)	To Be Considered	Requires Best Demonstrated Technology (BDT) for new sources, and sets emissions limitations. Proposed Subpart WWW sets a performance standard for non-methane organic compounds (NMOC) emissions of 150 Mg/yr (167 tpy) for existing municipal solid waste landfills.	This standard will be met by the landfill gas venting system, if the threshold of the standard is exceeded.
	Clean Air Act, Section 5 171 through 178, 42 USC 7471-7478 (Requirements for Non-Attainment Areas)	Applicable or Relevant and Appropriate (Depending on Modeling Results)	RI has adopted State Implementation Plan (SIP) requirements approved and enforceable by EPA which meet the New Source Review (NSR) requirement of the CAA. These provisions require that new or modified major sources of VOCs, (defined as a source which has the potential to emit 50 tpy) install equipment to meet Lowest Available Emissions Rate (LAER), which is set on a case-by-case basis and is either the most stringent emissions limitation contained in any SIP for that category or source or the most stringent emissions limitation which is achieved for the source. NSR requirements apply to non-attainment pollutants, which are VOCs and NO_x in RI.	If modeling indicates that the thresholds of this standard are exceeded based on the emissions levels, the requirements of this standard will be met.

TABLE 3-2 (continued)
FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE 4 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL,
SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION, AND DEED RESTRICTIONS
ALTERNATIVE 5 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL,
SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION,
COASTAL WETLANDS CREATION, AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
Venting/ Discharges to Air (cont.)	Clean Air Act, Section 5 160 through 169A - Prevention of Significant Deterioration Provisions	Applicable or Relevant and Appropriate (Depending on Modeling Results)	RI has adopted SIP requirements approved and enforceable by EPA which meet the Prevention of Significant Deterioration (PSD) requirements of the CAA. These provisions require that new or modified major sources of VOCs, defined as a source which has the potential to emit 25 tons/year, install equipment to meet Best Available Control Technology (BACT). PSD requirements apply to attainment pollutants, which are SO2, CO, lead and particulates in Rhode Island.	If modeling indicates that the thresholds of this standard are exceeded based on the emissions levels, the requirements of this standard will be met.
STATE Drainage/ Discharge/ Hydraulic Control	RI Water Pollution Control Act			
	• RI Water Quality Regulations for Water Pollution Control (RIGL 46-12, et seq.) RI Water Quality Standards	Applicable	Establishes general requirements and effluent limits for discharge to area waters.	In compliance with these regulations, RIPDES requirements pertaining to storm water discharges would be met.
	• Regulations for the RI Pollutant Discharge Elimination System (RIPDES) (RIGL 46-12, et seq.)	Applicable	Permits contain applicable effluent (i.e. technology - based and/or water quality - based), monitoring requirements, and standards and special conditions for discharges, including storm water discharges from land disposal facilities which have received industrial waste.	Storm water discharge improvements would be designed to provide compliance with these regulations and drainage/discharge would be monitored in compliance with these regulations.

FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE 4 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL, SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION, AND DEED RESTRICTIONS
ALTERNATIVE 5 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL, SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION, COASTAL WETLANDS CREATION, AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
STATE Capping/ Monitoring	RI Hazardous Waste Management Act of 1978 (RIGL 23-19.1 et seq.) Hazardous Waste Management Rules and Regulations	Relevant and Appropriate	Rules and regulations for hazardous waste generation, transportation, treatment, storage and disposal. They incorporate by reference the relevant and appropriate Federal RCRA requirements set forth above.	Substantive requirements applicable to closure will be met and adhered to on-site.
	Section 7	Relevant and Appropriate	Restricts location, design, construction, and operation of landfills from endangering ground water, wetlands or floodplains.	Remedial actions will be designed so as to prevent contamination of ground water, wetlands, or floodplains to the maximum extent practicable.
	Section 8	Relevant and Appropriate	Contains requirements for landfill closure, ground water monitoring, general waste analysis, security procedures, inspections, safety, and training.	Remedial actions will comply with substantive portions of this section applicable to landfill closure.
	Section 9	Relevant and Appropriate	Contains operational requirements for treatment, storage, and disposal facilities, including proper management and conditions for tanks, ground water monitoring, inspections, training, preparedness and prevention, and contingency planning and emergency procedures.	Remedial actions, including ground water monitoring, will comply with substantive portions of this section applicable to landfill closure.
	Section 10	Relevant and Appropriate	Contains design and operations requirements for land disposal facilities, including landfills.	Remedial actions will meet all non-location specific requirements of this section applicable to landfill closure.
	RI Refuse Disposal Law Rules & Regulations for Solid Waste Management Facilities			
	Section 14.12	Relevant and Appropriate	Sets performance standard for landfill covers of maximum remolded permeability of 1×10^{-7} m/sec.	Design of landfill cover will meet this requirement.

TABLE 3-2 (continued)
FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE 4 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL,
SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION, AND DEED RESTRICTIONS
ALTERNATIVE 5 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL,
SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION,
COASTAL WETLANDS CREATION, AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
Venting/ Discharges to Air	RI Clean Air Act (RIGL, Title 23, Chapter 23) General Air Quality and Air Emissions Requirements - RI Air Pollution Control Regulations, RI Dept. of Health, Div. of Air Pollution Control, effective 8/2/67, most recently amended 5/20/91			
	- Regulation No. 1 - Visible Emissions	Applicable	No air contaminant emissions are allowed for more than 3 minutes in any one hour which are greater than or equal to 20% opacity.	Air emissions from remedial actions will meet emission levels in regulation.
	- Regulation No. 5 - Fugitive Dust	Applicable	Requires that reasonable precaution be taken to prevent particulate matter from becoming airborne.	On-site remedial actions will use good industrial practices to prevent particulate matter from becoming airborne.
	- Regulation No. 7 - Emissions Detrimental to Person or Property	Applicable	Prohibits emissions of contaminants which may be injurious to human, plant or animal life or cause damage to property or which reasonably interferes with the enjoyment of life and property.	All emissions from landfill vents will meet this requirement or gas treatment will be required.
	- Regulation No. 9 - Approval to Construct, Install, Modify or Operate	Applicable	Establishes guidelines for the construction, installation, modification or operation of potential air emission units. Establishes permissible emission rates for some contaminants.	Construction, installation, modification, or operation of landfill gas vents will meet these requirements.
	- Regulation N . 15 - C ntrol of Organic Solvent Emissions	Applicabl	Limits th amount f organic solvents emitted to the atmosphere.	If landfill gas emissions exc ed limits in this regulation, emission controls will be designed and implemented to meet these requirements.

TABLE 3-2 (continued)
FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE 4 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL,
SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION, AND DEED RESTRICTIONS
ALTERNATIVE 5 - RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL,
SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION,
COASTAL WETLANDS CREATION, AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
Venting/ Discharges to Air (cont.)	- Regulation No. 17 - Odors	Applicable	Prohibits the emission of air contaminants which create an objectionable odor beyond the property line of the site.	Gas vent emissions and construction activities will meet this requirement to the maximum extent practicable.
	- Regulation No. 22 - Air Toxics	Applicable if air emissions contain regulated substances	Prohibits the emission of specified contaminants at rates which would result in ground level concentrations greater than acceptable ambient levels or acceptable ambient levels with LAER, as set in the regulation.	If necessary to meet these standards, air emissions control equipment will be designed for landfill gas emissions control.

TABLE 3-3
FUNCTIONAL SUMMARY TABLE
Allen Harbor Tributary System
Site 09 - Allen Harbor Landfill

Component Drainage Areas
Wetland C/D • scrub-shrub • reed meadow • salt marsh Wetland E • salt marsh • reed meadow Wetland G/F • scrub-shrub • reed meadow • salt marsh
Primary Functional Values
• sediment stabilization • toxicant retention • nutrient removal • production export • aquatic diversity • wildlife diversity
Secondary Functional Values
• floodflow alteration

TABLE 3-4

COMPARISON AMONG ALTERNATIVES
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
SITE 09 - ALLEN HARBOR LANDFILL
NCBC - DAVISVILLE, RI

ACTION	COMPARISON OF OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
Alternative 1 - No Action	Least protective alternative; No control of potential exposures to site-related contamination or containment are provided; Does not comply with location-specific ARARs; Not effective in the short -term or long-term
Alternatives 2, 3, 4 and 5 - Common Components RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Wall (Upper Aquifer Containment), Deed Restrictions	Provides protection of human health and the environment by providing a physical barrier to exposures to surficial contamination and protection against infiltration of precipitation into the landfill and generation of leachate seep; Sheet pile wall along Allen Harbor would provide containment of the shallow aquifer; Slurry wall minimizes migration of upgradient ground water into waste disposal area; Complies with location-specific and action specific ARARs/TBCs, provided sheet pile wall is installed within the footprint of the existing landfill; Cap design would meet relevant and appropriate RCRA hazardous waste landfill closure requirements; Some increased short-term risks would result during implementation as a result of waste re-grading on the surface of the landfill; Would be effective in the long-term
Alternative 2 - Sheet Pile Wall Storm Protection	Presents no short-term risks beyond those described above; Long-term effectiveness and permanence are dependent on the life of the sheet piling; Conformance with the 30-year post-closure period specified under RCRA is anticipated; Complies with ARARs; Does not meet CRMC regulatory preference for non-structural erosion control methods
Alternative 3 - Combined Riprap/Sheet Pile Wall Storm Protection	Slope cutbacks and construction at the toe of the landfill slope are expected to result in increased short-term risks to on-site workers; Long-term effectiveness and permanence are dependent upon the slope's stability, its ability to withstand erosion, the long-term effects of the placement of revetment upon the barrier layer and the life of the above-grade portion of the sheet piling; Long-term periodic inundation of the cap at the toe of the slope and the difficulty of maintaining drainage from the underlying cap drainage layer could also impact the overall long-term effectiveness and permanence; Complies with ARARs and provides greater complicance with CRMC regulatory preference for non-structural erosion control methods than Alternative 2

TABLE 3-4 (Continued)
COMPARISON AMONG ALTERNATIVES
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
SITE 09 - ALLEN HARBOR LANDFILL
NCBC - DAVISVILLE, RI

ACTION	COMPARISON OF OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
Alternative 4 - Riprap Storm Protection	Requires greater slope cutbacks which, combined with construction at the toe of the landfill slope, may result in increased short-term risks to on-site workers; Long-term effectiveness and permanence are dependent upon the slope's stability, its ability to withstand erosion, and the long-term effects of the placement of revetment upon the barrier layer; Long-term periodic inundation of the cap at the toe of the slope could also impact the overall long-term effectiveness and permanence; Complies with ARARs and provides greatest compliance with CRMC regulatory preference for non-structural erosion control methods
Alternative 5 - Riprap Storm Protection with Coastal Wetland Creation	Requires greatest slope cutbacks of all alternatives considered which, combined with construction at the toe of the landfill slope, may result in increased short-term risks to on-site workers; Long-term effectiveness and permanence are dependent upon the slope's stability, its ability to withstand erosion, the long-term effects of the placement of revetment upon the barrier layer and the establishment of a stable wetland area; Long-term periodic inundation of the cap at the toe of the slope could also impact the overall long-term effectiveness and permanence; The geometry of the shoreline and presence of revetment above the wetland area may lead to its erosion due to wave action; If established, the wetland area will support slope stabilization, minimize normal wave action on the slope and enhance the environment; Complies with ARARs and provides greatest compliance with CRMC regulatory preference for non-structural erosion control methods as well as CRMC goals for restoring coastal resources

TABLE 3-5
COMPARISON AMONG ALTERNATIVES
COMPLIANCE WITH ARARs/TBCs
SITE 09 - ALLEN HARBOR LANDFILL
NCBC - DAVISVILLE, RI

ACTION	CHEMICAL-SPECIFIC	LOCATION-SPECIFIC	ACTION-SPECIFIC
Alternative 1 - No Action	Not applicable	Does not comply with wetlands or floodplains requirements	Not applicable
Alternatives 2, 3, 4 and 5 - Common Components RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Wall (Upper Aquifer Containment), Deed Restrictions	Not applicable	Cap, slurry wall and sheet pile wall construction would comply with wetlands, water resources, coastal zone, and endangered species requirements.	Cap would comply with state and federal hazardous waste landfill closure requirements, air regulations applicable to the venting of landfill gases, and storm water discharge requirements; If containment features cannot be constructed within the existing extent of the landfill, mitigation actions will be taken to replace any wetlands destroyed by the remedial action in accordance with applicable regulations; If slurry wall construction impacts flood storage capacity of freshwater wetlands, appropriate mitigation actions will be taken; The need for implementation of mitigation actions will be determined through the design process
Alternative 2 - Sheet Pile Wall Storm Protection	Not applicable	Sheet pile wall construction would comply with floodplain and coastal zone requirements, although it would not satisfy the preference for the use of riprap revetments over vertical walls for shoreline protection	Not applicable
Alternative 3 - Combined Riprap/Sheet Pile Wall Storm Protection	Not applicable	Shoreline slope protection would comply with floodplain and coastal zone requirements and would provide greater compliance with the preference for the use of riprap revetments over vertical walls for shoreline protection identified in coastal zone regulations	Not applicable

TABLE 3-5 (Continued)
COMPARISON AMONG ALTERNATIVES
COMPLIANCE WITH ARARs/TBCs
SITE 09 - ALLEN HARBOR LANDFILL
NCBC - DAVISVILLE, RI

ACTION	CHEMICAL-SPECIFIC	LOCATION-SPECIFIC	ACTION-SPECIFIC
Alternative 4 - Riprap Storm Protection	Not applicable	Shoreline slope protection would comply with floodplain and coastal zone requirements and would provide the greatest compliance with the preference for the use of riprap revetments over vertical walls for shoreline protection since no sheet pile would extend above grade	Not applicable
Alt rnative 5 - Riprap Storm Protection with Coastal Wetland Creation	Not applicable	Shoreline slope protection would comply with floodplain and coastal zone requirements; a riprap revetment would be used in combination with a preferred non-structural method for controlling erosion (wetland creation); Wetland construction activities would comply with coastal wetland mitigation requirements applicable to created wetland construction	Not applicable

TABLE 3-6
COMPARISON AMONG ALTERNATIVES
LONG-TERM EFFECTIVENESS AND PERMANENCE
SITE 09 - ALLEN HARBOR LANDFILL
NCBC - DAVISVILLE, RI

ACTION	COMPARISON OF LONG-TERM EFFECTIVENESS AND PERMANENCE
Alternative 1 - No Action	Existing site-related risks to human health and the environment remain; No controls implemented to limit potential exposures to site contamination or to provide containment of contaminants; Requires five-year reviews
Alternatives 2, 3, 4 and 5 - Common Components RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Wall (Upper Aquifer Containment), Deed Restrictions	Containment of contamination is provided through the physical barrier of the RCRA double-barrier cap but residual risk remains due to the continued presence of the landfilled wastes; Effective in limiting potential physical exposures to surficial contamination as well as minimizing infiltration of precipitation and leachate seeps, containing contamination within the shallow aquifer and preventing the inflow of upgradient ground water; Potential generation of landfill gas, which could impair the effectiveness of the cap, would be addressed through the provision of a landfill gas venting system; RCRA Subtitle C multi-layer cap, sheet pile cut-off walls and slurry walls are all accepted means of long-term containment for waste disposal sites although the design life of the materials of construction will determine each barrier's ultimate long-term effectiveness; The potential for contact between the slurry wall and salt water may increase the permeability of the slurry wall; All barrier components will require long-term maintenance and ground water monitoring; Since wastes remain in-place, five-year reviews would be required
Alternative 2 - Sheet Pile Wall Storm Protection	Long-term effectiveness and permanence are dependent upon the life of the sheet piling; Compliance with the 30-year post-closure maintenance and monitoring period required under RCRA is anticipated; Long-term maintenance will consist of periodic painting of the exposed face of the sheet piling; Failure of the sheet pile wall could result in the exposure of waste materials
Alternative 3 - Combined Riprap/Sheet Pile Wall Storm Protection	Long-term effectiveness and permanence are dependent upon the stability of the final slope, upon the ability of the slope to withstand erosional forces, upon the long-term effect of the presence of the revetment materials on the barrier system and on the life of the above grade portion of the sheet piling; The long-term effects of periodic inundation behind the sheet pile wall and the difficulty of maintaining drainage from the underlying cap drainage layer could further impact the effectiveness of the cap in the shoreline area; Long-term maintenance will consist of periodic painting of the exposed face of the sheet piling and inspections of the revetment-covered slope and repair, if necessary; Exposure of waste materials could occur either through a slope-related failure, a sheet pile failure, or through slow leaching of contaminants through tears in the geomembrane barrier

TABLE 3-6 (Continued)
COMPARISON AMONG ALTERNATIVES
LONG-TERM EFFECTIVENESS AND PERMANENCE
SITE 09 - ALLEN HARBOR LANDFILL
NCBC - DAVISVILLE, RI

ACTION	COMPARISON OF LONG-TERM EFFECTIVENESS AND PERMANENCE
Alternative 4 - Riprap Storm Protection	Long-term effectiveness and permanence are dependent upon the stability of the final slope, upon the ability of the slope to withstand erosional forces, and upon the long-term effect of the presence of the revetment materials on the barrier system; The long-term effects of periodic inundation could further impact the effectiveness of the cap in the shoreline area; Long-term maintenance will ocnsist of periodic inspections of the revetment-covered slope and repair, if necessary; Exposure of waste materials could occur either through a slope-related failure or through slow leaching of contaminants through tears in the geomembrane barrier
Alternative 5 - Riprap Storm Protection with Coastal Wetland Creation	Long-term effectiveness and permanence are dependent upon the stability of the final slope, upon the successful establishment of wetland vegetation, upon the ability of the slope and wetland area to withstand erosional forces, and upon the long-term effect of the presence of the revetment materials on the barrier system and wetland area; The long-term effects of periodic inundation could further impact the effectiveness of the cap in the shoreline area although the presence of the wetland would minimize normal wave effects on the slope; Long-term maintenance will consist of periodic inspections of the revetment-covered slope and repair, if necessary, and monitoring and maintenance of the created wetland area; Exposure of waste materials could occur either through a slope-related failure or through slow leaching of contaminants through tears in the geomembrane barrier; An established wetland could provide nutrient treatment or contaminant retention should such a slow leak occur; Scour at the toe of the revetment and the shoreline geometry could prevent the long-term sustainability of a created wetland

TABLE 3-7
COMPARISON AMONG ALTERNATIVES
REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT
SITE 09 - ALLEN HARBOR LANDFILL
NCBC - DAVISVILLE, RI

ACTION	COMPARISON OF REDUCTION IN TOXICITY, MOBILITY OR VOLUME
Alternative 1 - No Action	Provides no reduction in toxicity, mobility or volume through treatment
Alternatives 2, 3, 4 and 5 - Common Components RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Wall (Upper Aquifer Containment), Deed Restrictions	Provides no treatment of site contamination and therefore no associated reduction in contaminant toxicity, mobility, or volume
Alternative 2 - Sheet Pile Wall Storm Protection	Provides no treatment of site contamination and therefore no associated reduction in contaminant toxicity, mobility, or volume
Alternative 3 - Combined Riprap/Sheet Pile Wall Storm Protection	Provides no treatment of site contamination and therefore no associated reduction in contaminant toxicity, mobility, or volume
Alternative 4 - Riprap Storm Protection	Provides no treatment of site contamination and therefore no associated reduction in contaminant toxicity, mobility, or volume
Alternative 5 - Riprap Storm Protection with Coastal Wetland Creation	Provides no treatment of site contamination and therefore no associated reduction in contaminant toxicity, mobility, or volume

TABLE 3-8
COMPARISON AMONG ALTERNATIVES
SHORT-TERM EFFECTIVENESS
SITE 09 - ALLEN HARBOR LANDFILL
NCBC - DAVISVILLE, RI

ACTION	COMPARISON OF SHORT-TERM EFFECTIVENESS
Alternative 1 - No Action	No remedial activities conducted; Therefore, no short-term risks result; Remedial response objectives not achieved
Alternatives 2, 3, 4 and 5 - Common Components RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Wall (Upper Aquifer Containment), Deed Restrictions	Regrading of the landfill surface prior to cap construction will require some excavation and recompaction of wastes, which could present short-term risks to construction workers; Appropriate personal protective equipment will be utilized to minimize those risks; The presence of uncovered wastes and landfill gas could also present short-term physical risks to construction workers; The establishment of exclusion zones and the consideration of physical hazards in the development of site construction plans will minimize such risks; Construction activities could result in a short-term increase in the potential for contaminant migration via stormwater runoff; Runoff control systems will be utilized to minimize any potential impacts; A short-term increase in local traffic could result from the transportation of construction materials to the site; Construction time frame is estimated to be less than one year.
Alternative 2 - Sheet Pile Wall Storm Protection	No increased short-term risks or impacts beyond those described above are associated with the installation of sheet piling as storm protection along Allen Harbor.
Alternative 3 - Combined Riprap/Sheet Pile Wall Storm Protection	Due to additional slope cutback requirements and the potential exposure of workers to waste materials within a more protected area during construction of the toe of the slope along Allen Harbor, increased short-term risks to workers could result; Higher levels of personal protective equipment could be required for construction activities in this area, which in itself may present additional risks to workers due to reduced visibility, physical maneuverability and other factors; While the additional exposure of waste materials along the shoreline could increase the potential for short-term migration of associated contaminants to Allen Harbor or adjacent wetland areas, the presence of the sheet pile wall will provide a degree of containment; Additional construction activities in slope area would increase the overall remedial construction period.

TABLE 3-8 (Continued)
COMPARISON AMONG ALTERNATIVES
SHORT-TERM EFFECTIVENESS
SITE 09 - ALLEN HARBOR LANDFILL
NCBC - DAVISVILLE, RI

ACTION	COMPARISON OF SHORT-TERM EFFECTIVENESS
Alternative 4 - Riprap Storm Protection	Requires greater slope cutback than Alternative 3, installation of sheet piling at the toe of the excavated waste slope and recompaction of excavated wastes on landfill surface; Therefore, increased short-term risks to workers could result; Higher levels of personal protective equipment could be required for these construction activities, which in itself may present additional risks to workers due to reduced visibility, physical maneuverability and other factors; While the additional exposure of waste materials along the shoreline could increase the potential for short-term migration of associated contaminants to Allen Harbor or adjacent wetland areas, a cofferdam would be used to provide a degree of containment; Additional construction activities in the slope area would slightly increase the overall remedial construction period.
Alternative 5 - Riprap Storm Protection with Coastal Wetland Creation	Requires greatest slope cutback of all alternatives, installation of sheet piling at the toe of the excavated waste slope and recompaction of excavated wastes on landfill surface; Therefore, increased short-term risks to workers could result; Higher levels of personal protective equipment could be required for these construction activities, which in itself may present additional risks to workers due to reduced visibility, physical maneuverability and other factors; While the additional exposure of waste materials along the shoreline could increase the potential for short-term migration of associated contaminants to Allen Harbor or adjacent wetland areas, a cofferdam would be used to provide a degree of containment; Should a significant storm event occur during the wetland establishment period, significant damage to the wetland could occur; Additional construction activities in the slope area would slightly increase the overall remedial construction period while the time required to establish the wetland area would significantly increase the overall remedial implementation period.

TABLE 3-9
COMPARISON AMONG ALTERNATIVES
IMPLEMENTABILITY
SITE 09 - ALLEN HARBOR LANDFILL
NCBC - DAVISVILLE, RI

ACTION	COMPARISON OF IMPLEMENTABILITY
Alternative 1 - No Action	Requires no implementation other than a five-year review; Would not limit the implementation of other remedial actions
Alternatives 2, 3, 4 and 5 - Common Components RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Wall (Upper Aquifer Containment), Deed Restrictions	Relatively complicated to implement; Site preparation would entail clearing of site vegetation and regrading; Sheet pile wall and slurry wall installation would be required prior to cap construction; Some movement and recompaction of existing waste materials would be required prior to cap construction; Requires special equipment and materials for geomembrane/geosynthetic clay layer installation and extra care in placement of overlying cap materials to prevent puncture of the geomembrane; Services and materials for construction are generally available; Potential for periodic inundation of the cap in floodplain areas must be considered in the design process; Implementation of future remedial actions would require maintenance of the integrity of the cap, slurry wall, and sheet pile barrier systems.
Alternative 2 - Sheet Pile Wall Storm Protection	Implementation requires the cap be tied to the sheet pile wall; no other barriers to implementability other than those described above are anticipated.
Alternative 3 - Combined Riprap/Sheet Pile Wall Storm Protection	Implementation requires the existing slopes along Allen Harbor be cut back to 3:1 slopes and the associated movement and recompaction of existing waste materials prior to cap construction; The sheet pile wall could be installed prior to slope cutback; Requires the use of additional capping materials and special construction efforts in making the conversion from the slope cap profile to the surface cap profile; Construction at the toe of the slope could require dewatering and the use of a higher level of personal protective equipment, which generally reduces productivity; Placement of revetment could require the implementation of water-based construction equipment (i.e., barge-mounted).

TABLE 3-9 (Continued)
COMPARISON AMONG ALTERNATIVES
IMPLEMENTABILITY
SITE 09 - ALLEN HARBOR LANDFILL
NCBC - DAVISVILLE, RI

ACTION	COMPARISON OF IMPLEMENTABILITY
Alternative 4 - Riprap Storm Protection	Implementation requires greater slope cutback than Alternative 3 and the additional associated movement and recompaction of existing waste materials prior to cap construction; The sheet pile wall must be installed after slope cutback and before cap construction; The greater potential exposures to waste materials could require the use of a higher level of personal protective equipment, which generally reduces productivity; Requires the use of additional capping materials and special construction efforts in making the conversion from the slope cap profile to the surface cap profile; Construction at the toe of the slope could require dewatering; Placement of revetment could require the implementation of water-based construction equipment (i.e., barge-mounted).
Alternative 5 - Riprap Storm Protection with Coastal Wetland Creation	Implementation requires the greatest amount of slope cutback of all alternatives and the additional associated movement and recompaction of existing waste materials prior to cap construction; The sheet pile wall must be installed after slope cutback and before cap construction; The greater potential exposures to waste materials could require the use of a higher level of personal protective equipment, which generally reduces productivity; Requires the use of additional capping materials and special construction efforts in making the conversion from the slope cap profile to the surface cap profile; Construction at the toe of the slope could require dewatering; Placement of revetment could require the implementation of water-based construction equipment (i.e., barge-mounted); Following cap and revetment construction, the adjacent wetland must be created and maintained until established.

TABLE 3-10
COMPARISON AMONG ALTERNATIVES
COST
SITE 09 - ALLEN HARBOR LANDFILL
NCBC - DAVISVILLE, RI

ACTION	TOTAL CAPITAL COST	ANNUAL O&M COST	PRESENT WORTH O&M COST [1]	TOTAL PRESENT WORTH [2]
Alternative 1 - No Action	--	--	--	Nominal [3]
Alternative 2 - RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Wall Storm Protection and Deed Restrictions	$8,710,000	$172,000 [4]	$2,740,000	$13,700,000
Alternative 3 - RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Wall, Riprap Storm Protection, and Deed Restrictions	$10,300,000	$172,000	$2,640,000	$15,500,000
Alternative 4 - RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Subsurface Barrier, Riprap Storm Protection, and Deed Restrictions	$9,900,000	$172,000	$2,640,000	$15,000,000
Alternative 5 - RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Subsurface Barrier, Riprap Storm Protection, Coastal Wetlands Creation, and Deed Restrictions	$10,700,000	$187,000	$2,870,000	$16,200,000

(1) - Based on 5% discount rate.
(2) - Includes 20% contingency on all components.
(3) - The only cost associated with the implementation of Alternative 1 would be that associated with conducting a five-year review of the no action decision.
(4) - The cost of periodic painting of the sheet pile wall is not included as an annual O&M cost but is included in the overall present worth O&M cost of Alternative 2.

4.0 REFERENCES

Adamus, P.R., Clairain, E.J., Jr., Smith, R.D., and Young, R.E., 1987. Wetland Evaluation Technique (WET), Volume II: Methodology, Operation Draft Technique Report.

Adamus, P.R., Stockwell, L.T., Clairain, E.J., Jr., Morrow, M.E., Rozas, L.P., and Smith, R.D., 1991. Wetland Evaluation Technique (WET), Volume I: Literature Review and Evaluation Rationale, U.S. Army Corps of Engineers, Waterways Experimental Station, Wetland Research Program Technical Report ERP-DE-2.

Choi, Yoon-Jean, 1990. Design Considerations for CERCLA Surface Cover Systems, Draft, December 1990.

Dennison, M. S. and Berry, J. F., 1993. Wetlands, Guide to Science, Law, and Technology

EA Engineering, Science, and Technology, 1994. Design Analysis, Remediation of Allen Harbor Landfill, Naval Construction Battalion Center, Davisville, Rhode Island, April 1994.

Ecology and Environment, Inc., 1993. Wetlands and Floodplains Mapping of NCBC Davisville, 1993.

FEMA, 1983. Flood Insurance Rate Map for the Town of North Kingstown, Community Panel Number 445404 0005 B, revised February 16, 1983.

Marble, A. D., 1992. A Guide to Wetland Functional Design

NOAA, 1992. Tide Tables, 1992, High and Low Water Predictions, East Coast of North and South America, U.S. Department of Commerce, National Oceanographic and Atmospheric Administration, Issued 1991.

NOAA, 1994. Data, Period of Record (1960 - 1978), Station Number 845-2660, Newport, Rhode Island.

TRC Environmental Corporation, 1994a. Draft Final Allen Harbor Landfill Remedial Investigation Report, Naval Construction Battalion Center, Davisville, Rhode Island. Prepared for Northern Division, Naval Facilities Engineering Command, Philadelphia, PA. Contract No. N62472-86-C-1282, June 1994.

TRC Environmental Corporation, 1994b. Draft Final Phase II Remedial Investigation Report, Naval Construction Battalion Center, Davisville, Rhode Island. Prepared for Northern Division, Naval Facilities Engineering Command, Philadelphia, PA. Contract No. N62472-86-C-1282, June 1994.

URI, 1977. The Redevelopment of Quonset/Davisville: An Environmental Assessment, Marine Technical Report #55, Coastal Resources Center, University of Rhode Island.

U.S. Army Corps of Engineers, 1985. Engineering and Design, Design of Coastal Revetments, Seawalls and Bulkheads, Engineer Manual, EM 1110-2-1614, Department of the Army, Corps of Engineers, 30 April 1985.

U.S. Army Corps of Engineers, 1989. Engineering and Design, Environmental Engineering for Coastal Protection, Engineer Manual, EM 1110-2-1204, Department of the Army, Corps of Engineers, 10 July 1989.

USEPA, 1991a. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part C, Risk Evaluation of Remedial Alternatives), Interim, EPA/540/R-92/004, December 1991.

U.S. Fish and Wildlife Service, 1980. Habitat Evaluation Procedures (HEP), U.S. Fish and Wildlife Service Ecological Services Manual 101, 1980.

APPENDIX A

INITIAL ANALYSIS OF SHORELINE DESIGN OPTIONS

INITIAL ANALYSIS OF SHORELINE DESIGN OPTIONS

Introduction:

This Appendix is intended to represent the thought process behind the development of the alternatives selected for detailed analysis within this document. As such, it presents in summary form the design options considered, the information upon which their evaluations were based, a brief evaluation in terms of advantages and disadvantages pertinent to the alternative selection process, and the selected design to be evaluated in detail. The comparative evaluation used to select a specific design option is not intended to be an exhaustive evaluation of all of the advantages and disadvantages associated with each option but a summary of the major considerations used in the selection process.

SECTION A-1
STONE REVETMENT SLOPE PROTECTION ALTERNATIVE

Basic assumptions:

Assume cap profile (i.e., cap layers as identified in Figure 2-6) along harbor slope remains as previously proposed for Alternative 3; maximum side slope = 33%

Option development:

Designs of revetment/sheet pile at shoreline which were considered (sketches are attached):

- Option 1 - Geomembrane ties into the sheet pile at the existing toe of slope
- Option 2 - Top of revetment is at top of sheet pile; geomembrane is tied to sheet pile below the toe
- Option 3 - Design similar to McAllister Point Landfill shoreline cap design - Geomembrane ends before toe of existing slope
- Option 4 - Sheet pile is installed some distance in from existing toe of slope such that the revetment extends outward only to the existing toe of slope (i.e., identical to Option 1 but shifted to the west a distance of approximately 15 to 20 feet, based on a cap thickness above the sheet pile of 5.5 feet [vertical height of 5.8 feet] and 3H:1V slope)

Comparative evaluation of advantages and disadvantages of each option:

<u>Option 1 - Geomembrane ties into the sheet pile at the existing toe of slope</u>

Advantages:
Least slope cutback required of all alternatives except Alternative 2
Drainage layer drains freely over top of sheet pile
Requires least excavation at toe of slope of all alternatives except Alternative 2
Least inundation of cap behind sheet pile of all alternatives except Alternative 2
No sheet piling is visible from harbor

Disadvantages: Revetment extends into harbor, requiring filling of wetland areas or tidal waters

Option 2 - Top of revetment is at top of sheet pile; geomembrane is tied to the sheet pile below the toe of the existing slope

Advantages: Revetment does not extend into harbor
No sheet piling is visible from harbor

Disadvantages: Requires additional slope cutback (greater than Option 1 and existing Alternatives 2 and 3)
Requires deeper excavation at toe of slope (greater than Option 1 and existing Alternatives 2 and 3)
Cap along shoreline will be inundated at greater frequency than for Option 1 and existing Alternatives 2 and 3
Drainage layer will be below grade at point where it meets the sheet pile wall

Option 3 - Design similar to McAllister Point Landfill design - Geomembrane ends before toe of existing slope

This option is immediately rejected because containment is not provided between the end of geomembrane and sheet pile wall. This was not an issue at McAllister Point since containment of the shallow aquifer along the shoreline was not included in the source control remedial action.

Option 4 - Sheet pile is installed some distance in from existing toe of slope such that the revetment extends outward only to the existing toe of slope (i.e., identical to Option 1 but shifted to the west a distance of approximately 15 to 20 feet, based on a cap thickness above the sheet pile of 5.5 feet [vertical height of 5.8 feet] and 3H:1V slope)

Advantages: Revetment does not extend into harbor
No sheet piling is visible from harbor
Drainage from drainage layer is not contained by sheet pile

Disadvantages: Requires same slope cutback as Option 2
Requires same degree of excavation at toe of slope as Option 2
Since geomembrane begins at a higher elevation, it will not be inundated to the same degree as Option 2 although it will be inundated at greater frequency than Option 1 and existing Alternatives 2 and 3
Would require containment and dewatering for revetment construction between sheet pile and toe of existing slope (other options could be constructed behind sheet pile, as described for Alternative 3 in FFS)

Selection of option for detailed analysis

Based on the evaluation presented above, Option 4 was selected for detailed analysis due to its ability to provide containment of the waste materials while also minimizing the filling of wetlands or tidal waters during construction. This alternative will be referred to as follows within the body of this report:

> Alternative 4 - RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Subsurface Barrier, Riprap Storm Protection and Deed Restrictions

TRC
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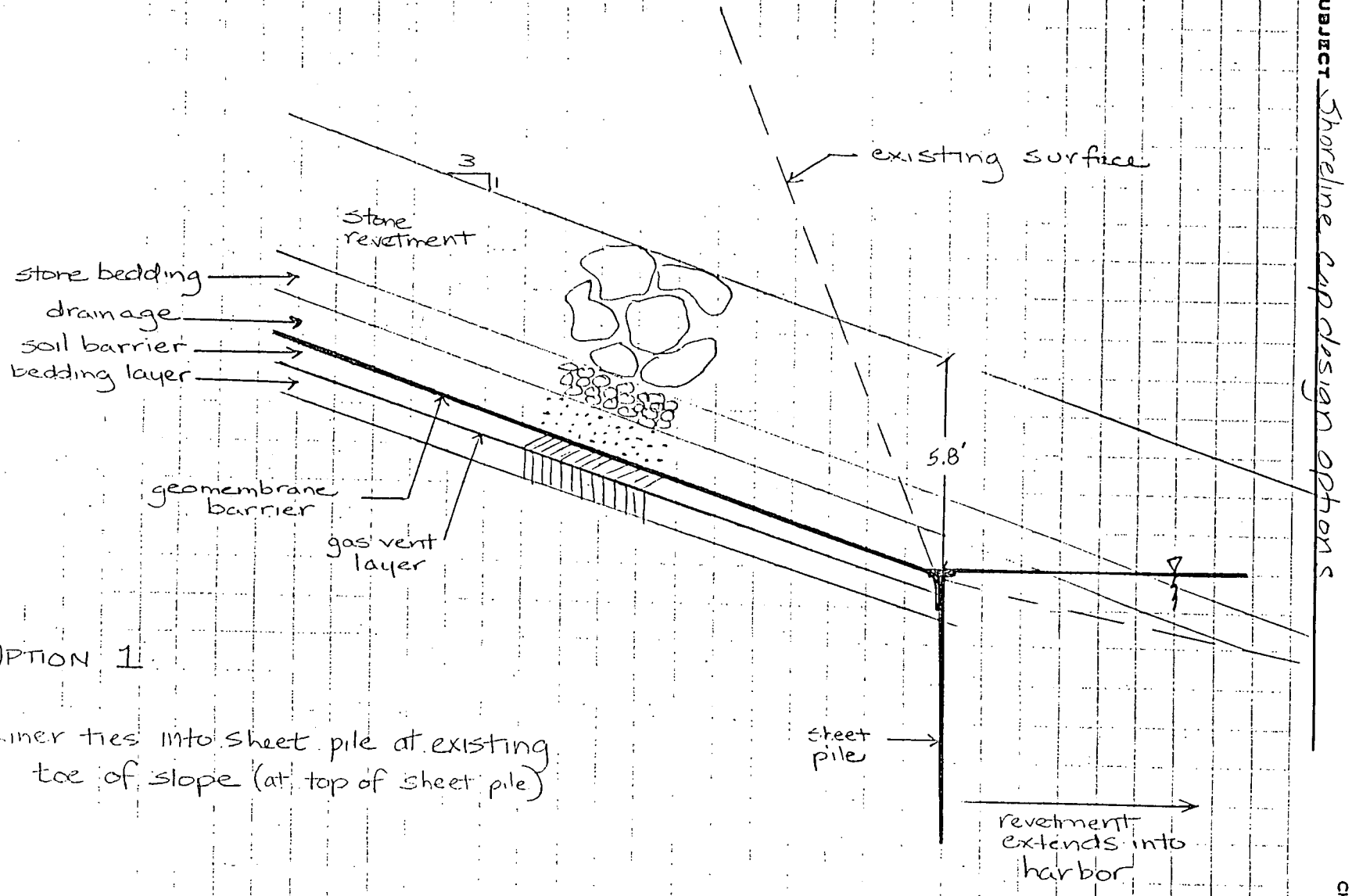
SUBJECT Shoreline cap design options



OPTION 1

Liner ties into sheet pile at existing toe of slope (at top of sheet pile)

SHEET NO. 1 OF 4
PROJECT NO. 02969-0030
DATE 4/21/95
BY JMO
CHK'D

TRC
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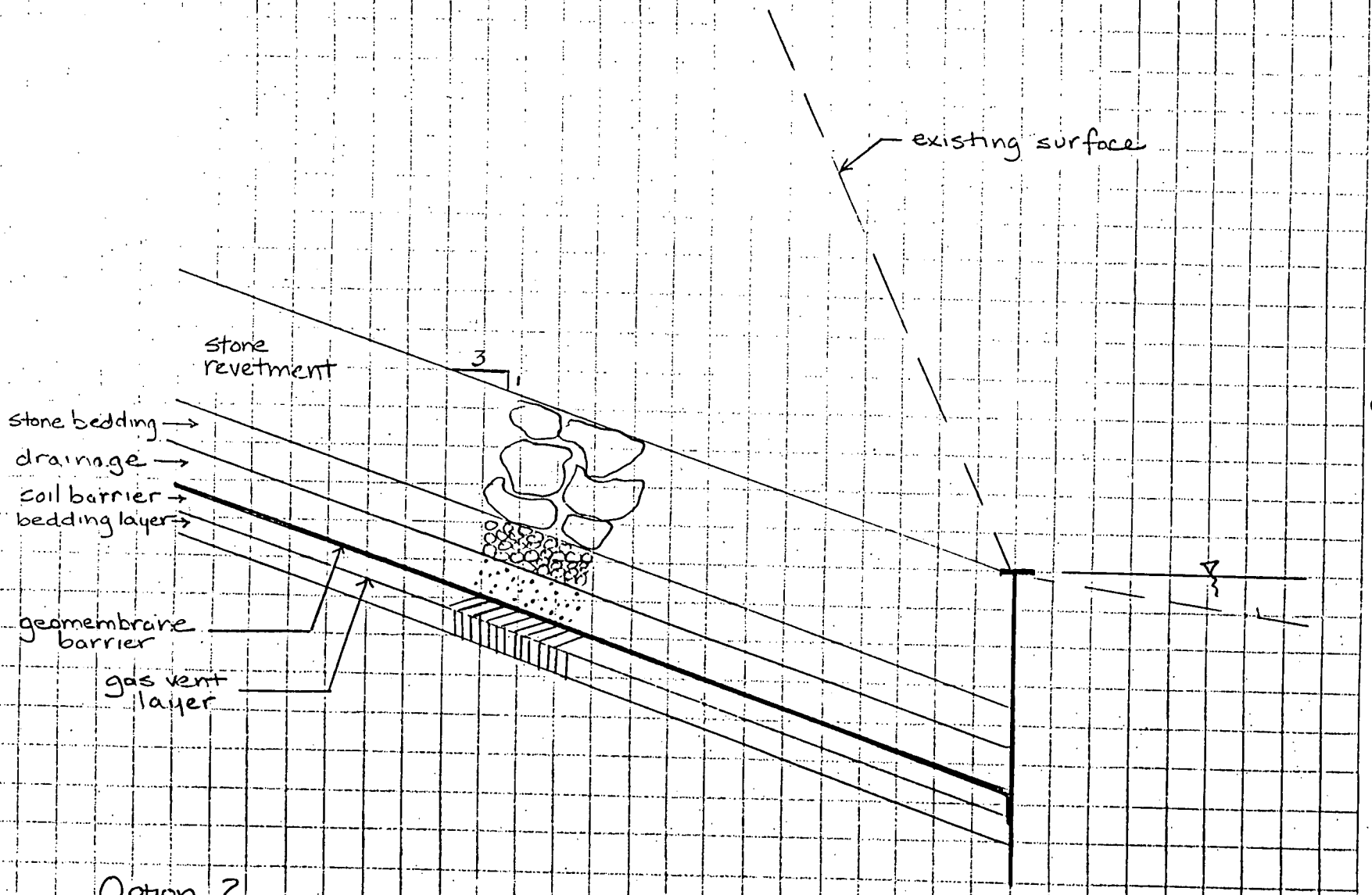
SUBJECT Shoreline Cap Design Options



Option 2
Top of revetment equals top of sheet pile
Liner ties into sheet pile below grade

SHEET NO. 2 OF 4
PROJECT NO. 02969-0030
DATE 4/21/95
BY JMO
CHK'D

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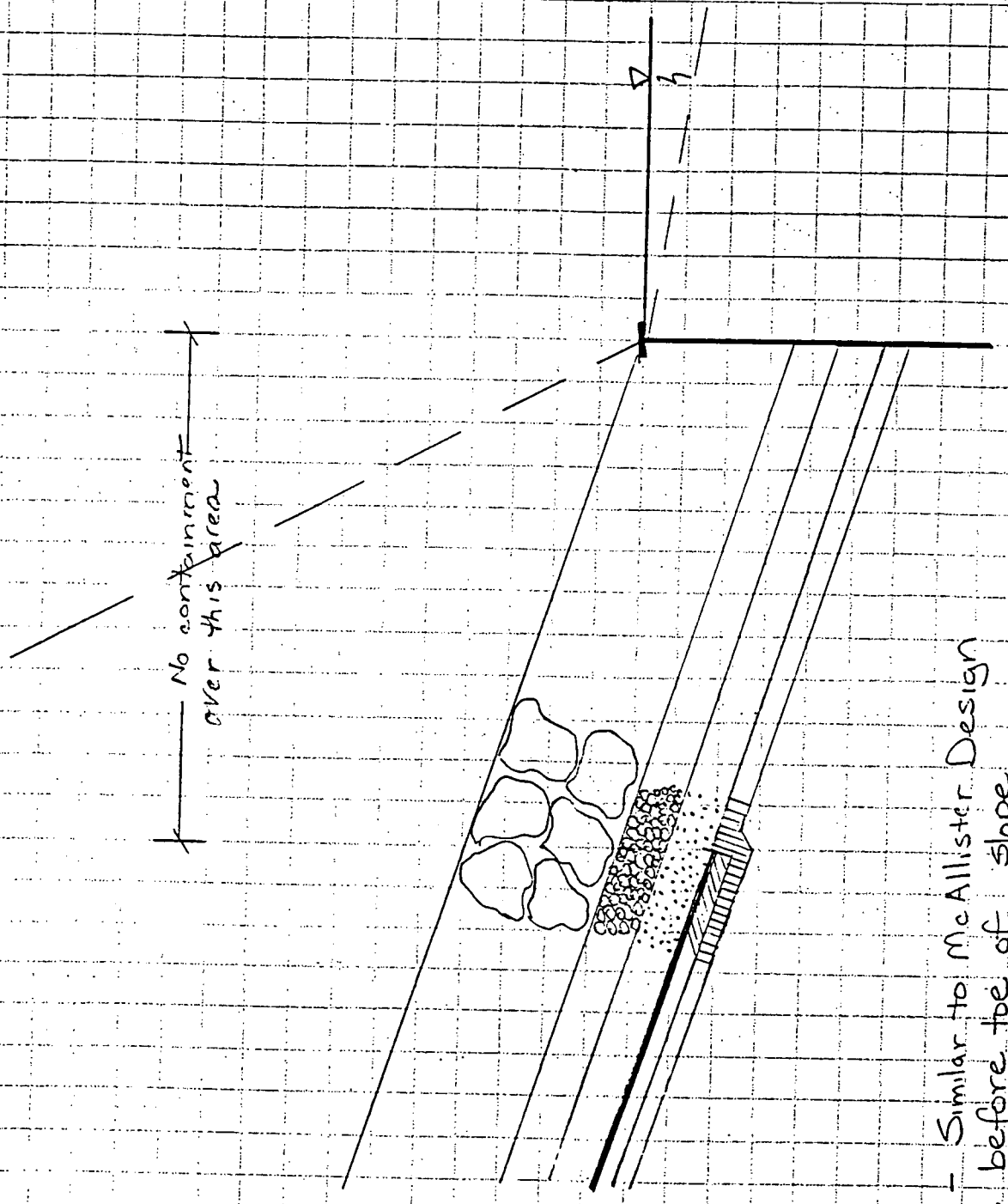
SHEET NO. 3 OF 4
PROJECT NO. 02969-0030
DATE 4/21/95
BY JMO
CHK'D

SUBJECT Shoreline Cap Design Options



Option 3 - Similar to McAllister Design
Liner ends before toe of slope
- before sheet pile

TRC

TRC Environmental Corporation

SHEET NO. 4 OF 4

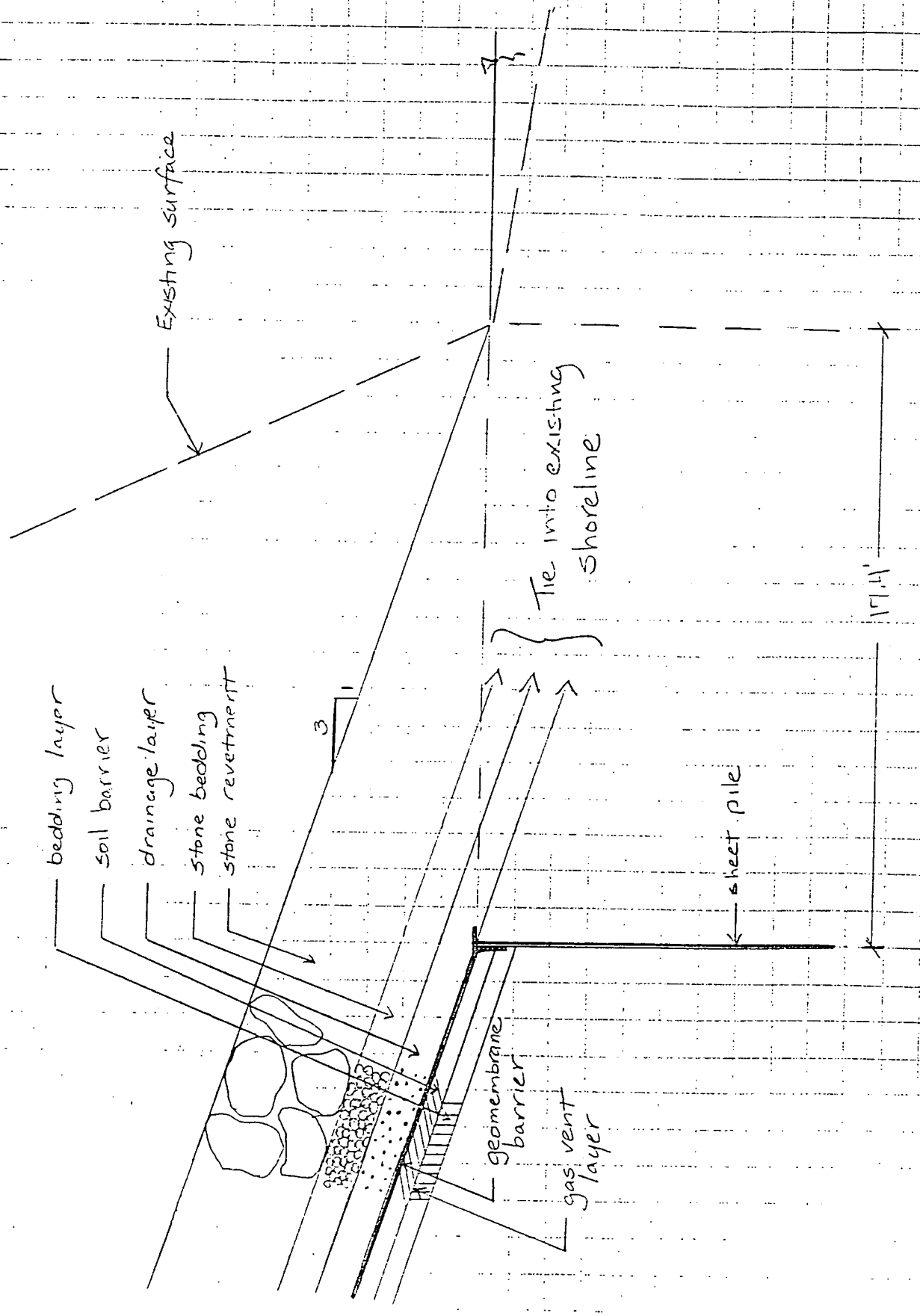
PROJECT NO. 02969-003

DATE 4/21/95

BY JMO

CHK'D

SUBJECT Shoreline cap design options



Option 4 - Same as Option 2 but sheet pile shifted inward from toe of slope

INITIAL ANALYSIS OF SHORELINE DESIGN OPTIONS

SECTION A-2
STONE REVETMENT SLOPE PROTECTION WITH WETLANDS CREATION ALTERNATIVE

Background:

As stated in Section 2.3.2, the possible development of an alternative which incorporates slope protection through coastal wetlands creation and subsequent shoreline stabilization was evaluated as a means of providing greater compliance with the Coastal Resources Management Council's policy of preserving, protecting, developing, and where possible, restoring the coastal resources of the state, as well as the policy that preservation and restoration of ecological systems shall be the primary guiding principle upon which environmental alteration of coastal resources will be measured, judged, and regulated (RIGL 46-23-1).

The Allen Harbor water area is classified within the Coastal Resources Management Program as Type 3 - High Intensity Boating. This category includes intensely utilized water areas where recreational boating activities dominate and where the adjacent shorelines are developed as marinas, boatyards, and associated water-enhanced and water-dependent business [200.3(A)]. The Council's goal for Type 3 waters is to preserve, protect, and where possible enhance Type 3 areas for high-intensity boating and the services that support this activity [200.3(C)]. Natural assets which are present in Type 3 waters and along the adjacent shoreline (e.g., coastal wetlands and the value these areas provide as fish and shellfish spawning and juvenile rearing grounds) must also be considered with respect to proposed activities in Type 3 waters [200.3(B)(6)].

The coastal wetland areas south and north of Allen Harbor Landfill (see Figure 2-8) are designated for preservation within the Coastal Resources Management Program. The Council's goal is to preserve and, where possible, restore coastal wetlands [210.3(C)(1)]. The Council will encourage the building of new wetlands in areas selected on the basis of competent ecological study [210.3(C)(2)].

Available information:

The coastal wetlands in the vicinity of Allen Harbor Landfill have been mapped, as described within Wetlands and Floodplains Mapping of NCBC Davisville (Ecology and Environment, Inc., 1993) and are currently being flagged in the field. While a functional assessment was included in the Phase II RI ecological risk assessment (TRC, 1994b), EA Engineering, Science and Technology is currently conducting additional functional assessment activities for these wetland areas. A bathymetric survey of Allen Harbor was not conducted as part of this assessment. Available information (URI, 1977) indicates the harbor's overall depth is ten feet deep with this depth reached withing approximately 50 feet of the shoreline.

Prior to and during the evaluation of this alternative, natural resource trustees and regulators were contacted to determine their interest in pursuing such an alternative. In general, the filling of one resource (e.g., tidal waters) to create another resource (e.g., coastal wetlands) is typically not an accepted action. In most cases, wetland construction is conducted landward of the existing shoreline so as not to destroy existing shoreline resources. In the case of Allen Harbor Landfill, construction of a wetland area landward of the existing shoreline would require additional cutback of landfill wastes and recompaction on the surface of the landfill prior to capping. The additional disruption of waste and increase in ultimate landfill height must be weighed against the benefits of wetland creation. A summary of the initial input provided by representatives of each agency contacted is attached.

Basic assumptions:

Protection of the shoreline slope of the landfill against the 100-year storm event must be maintained, with the created wetlands constructed along the shoreline between the existing north and south wetland areas.

Option development:

Wetland creation options which were considered include the following (sketches are attached):

- Option 1 - Alternative 4 with wetlands extending from the toe of the existing landfill into the adjacent harbor waters (i.e. tidal waters)
- Option 2 - Alternative 4 but with landfill slope cut back further to allow wetlands creation between edge of revetment and toe of existing landfill slope
- Option 3 - Utilization of an off-shore breakwater to minimize wave action, combined with the elimination of the revetment slope protection

Constructed wetlands have been used in many instances to provide water treatment. The abilities of wetlands to remove nutrients have resulted in the use of created wetlands to treat wastes such as domestic sewage. Constructed wetlands also can provide a depositional environment for contaminated sediments where organic soils in wetland areas may permanently complex with metals and synthetic organic contaminants such as PCBs. The contaminants are eventually chemically broken down, buried, or assimilated into plant and animal tissues. Therefore, a fourth option, Option 4, in which wetland creation alone would be utilized to minimize contaminant migration and provide contaminant attenuation was also developed.

Under this option, wetland creation would be combined with a soil cap. Soil caps can be effective in controlling erosion and in preventing direct human contact with waste materials. Whereas a soil cap may provide more protection against infiltration and subsequent leachate production than existing site conditions provide, the main purpose of the soil cover would be habitat value, since a soil cap can support other types of vegetation than a RCRA Subtitle C cap is capable of supporting. The habitat provided by the vegetated soil cap would complement that provided by the wetland in terms of restoring the ecological value of the site as a whole. The revetment slope protection would be maintained under this option to provide protection of the shoreward slope of the landfill against storm events.

Comparative evaluation of advantages and disadvantages of each option:

Option 1 - Alternative 4 with wetlands extending from the toe of the existing landfill into the adjacent harbor waters (i.e. tidal waters)

Advantages:
Requires no additional cutback of existing landfill materials
Intended to create additional wetland areas for shoreline stabilization and wildlife habitat

Disadvantages:
Filling of tidal waters is not an accepted action under the Coastal Resources Management Program
Presence of revetment could cause scour and erosion of wetland area; therefore, permanence is not ensured.

Option 2 - Alternative 4 but with landfill slope cut back further to allow wetlands creation between edge of revetment and toe of existing landfill slope

Advantages:
Does not require filling of tidal waters
Intended to create additional wetland areas for shoreline stabilization and wildlife habitat

Disadvantages:
Requires additional cutback of existing landfill materials
Results in increased final elevation of landfill cap due to need for consolidation of excavated landfill materials over the surface of the landfill
Depth to which waste materials were deposited may affect implementation
Presence of revetment could cause scour and erosion of wetland area; therefore permanence is not ensured

Option 3 - Option 2, minus revetment but with an off-shore breakwater added

Advantages:
Alternate means of providing protection against wave energy
Intended to create additional wetland areas for shoreline stabilization and wildlife habitat due to depositional area which is formed between the shoreline and breakwater
Breakwater structure can provide reef-like habitat, including spawning, nursery, shelter and/or foraging habitat for fish and shellfish

Disadvantages:
Requires cutback of existing landfill materials similar to Option 2
Results in increased final elevation of landfill cap due to need for consolidation of excavated landfill materials over the surface of the landfill similar to Option 2
Depth to which waste materials were deposited may affect implementation
Depth of water in Allen Harbor and substrate conditions may limit the feasibility of constructing such a structure within the harbor
Presence of breakwater may impact current recreational usage of the harbor

Aesthetically pleasing smaller breakwater will not protect shoreline slope against 100-year storm event while construction of a larger, more protective breakwater may not be feasible based on cost, aesthetics, and recreational use considerations

Option 4 - Landfill slope cutback to allow wetland creation between edge of cutback and toe of existing landfill slope with stone revetment for shoreline protection, soil cap over the remainder of the landfill and habitat enhancement through a terrestrial revegetation plan

Advantages: Does not require filling of tidal waters
Creates additional wetland areas for shoreline stabilization and wildlife habitat as well as enhanced terrestrial habitat value
Utilizes wetland functions to minimize contaminant migration and provide contaminant attenuation
When established soil and wetland vegetation could provide a self sustainable ecological system for source control

Disadvantages: Does not meet RCRA ARARs for landfill closure
Does not include any ground water containment features and therefore does not address potential contaminant migration to areas where wetlands may not be present to provide contaminant attenuation

Selection of options for detailed analysis:

Based on the evaluation presented above, Option 2 was selected for detailed analysis since it meets the objectives of wetland creation while providing shoreline protection, minimizes the filling of tidal waters, and provides the greatest compliance with ARARs. This alternative will be referred to as follows within the body of this report:

Alternative 5 - RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Subsurface Barrier, Riprap Storm Protection, Coastal Wetlands Creation and Deed Restrictions

Option 3 could be a candidate for further evaluation if engineering analysis and design indicates that the sustainability of the created wetland is reduced by the wave energy reflected off the overlying revetment during storm events. However, a demonstration of the ability of the option to ensure shoreline protection (i.e., protection of the RCRA cap) during the 100-year storm event would be required. Option 4 could also potentially offer advantages through the use of natural nutrient removal/transformation and toxicant retention wetland functions to address leachate or shallow contaminated ground water migration in combination with soil capping to enhance terrestrial habitat value. However, previous regulatory comments indicate that this option's lack of compliance with RCRA landfill closure ARARs inhibits its further consideration. While landfills are identified as potentially appropriate nutrient, sediment and contaminant sources for created wetland functions, the implementation of Option 4 is further inhibited by site characteristics which do not meet certain recommended design parameters for the desired functions. For example, Marble (1992) reports that nutrient removal/transformation or sediment/toxicant retention are best accomplished in sheltered

wetlands with minimized fetch and exposure in which the outflow of water is restricted. For wetlands without a constricted outlet, an average total vegetated width of greater than 500 feet is recommended for nutrient removal (Marble, 1992). The provision of such a vegetated width would not be achievable at Allen Harbor Landfill.

ATTACHMENT TO SECTION A-2

SUMMARY OF TELEPHONE CONVERSATIONS REGARDING WETLAND CREATION ALTERNATIVE

Phone calls initiated by Jean Oliva, TRC Environmental Corporation at the direction of EA Engineering, Science, and Technology and the U.S. Navy Northern Division (memo dated May 3, 1995 regarding Coastal Wetland Restoration Alternatives) to discuss options for wetland creation alternatives which could be incorporated into source control actions at Allen Harbor Landfill. Requested input regarding feasibility, objectives and features of such an action, if it were to be incorporated into a source control alternative. Note that the summaries presented below are based on TRC's notes and recollection of the telephone conversations and have not been reviewed or otherwise confirmed by the other parties involved.

Phone Conversation with David Reis, Coastal Resources Management Council (CRMC):
May 8, 1995

Construction of a wetland area along the central portion of the landfill shoreline would require filling of tidal waters, which is not allowed under the Coastal Resources Management Program. Typically, filling of tidal waters is considered as an option only when there is no other alternative for getting rid of dredge spoils.

In most situations where wetlands mitigation or creation is required due to filling of wetland areas, it is conducted by cutting back the existing landmass and creating the wetland area landward of the existing shoreline. However, Mr. Reis stated that he was not necessarily recommending such an action (i.e. cutback of existing landfill slopes to create a wetland area) as being appropriate for Site 09.

Phone Conversation with Tim Prior, US Fish & Wildlife Service (USFWS):
May 8, 1995

Mr. Prior stated that since a physical structure (e.g. revetment) will be required along the shoreline of Allen Harbor Landfill, USFWS would consider various alternatives for the shoreline. However, the USFWS wetland personnel have a basic position that conversion of one wetland type to another wetland type is undesirable, similar to CRMC's objections to filling of tidal waters. Mr. Prior stated he would check with USFWS wetlands personnel to determine if they have any recommendations for a wetlands creation alternative. He also indicated his concern for options (e.g., cutback of the existing landfill slope to create a wetland landward of the existing shoreline) which would result in a higher final elevation for the landfill (i.e., creation of a "mountain").

Phone Conversation with Tim Prior, US Fish & Wildlife Service (USFWS):
May 9, 1995

Mr. Prior confirmed that, based on his discussions with USFWS wetlands personnel, USFWS would frown upon the conversion of one wetland type to another (e.g., conversion of tidal waters to coastal wetlands). Such a conversion would be considered in a case where an existing area was so severely degraded that it is not functioning appropriately. Mr. Prior indicated that, based on available information, he does not necessarily consider this to be the case at Site 09. Questions raised regarding a wetlands creation alternative would include how successful such an effort would be considering the wave energy formed by storm events and the subsequent impact on the shoreline edge of the landfill and the amount of filling which would be required to create the wetland area. Mr. Prior also confirmed that USFWS is willing to review and comment on a wetlands creation alternative, should one be evaluated. In lieu of wetlands creation, the Navy might evaluate the materials of construction based on habitat considerations, to ensure that materials most suitable to habitat support are used when possible.

Phone conversation with Judy Graham, RIDEM:
May 16, 1995

Ms. Graham confirmed her interest in the detailed presentation and evaluation of an alternative which includes wetlands creation, especially an alternative which would minimize the presence of riprap and maximize the area of created wetlands. She recommended that Bob Johnston, one of the authors of the Risk Assessment Pilot Studies conducted in Allen Harbor, as described in Section 2.7 of the Draft FFS, be contacted for his input with respect to the development and analysis of this alternative.

Phone conversation with Christine Williams, USEPA Region I:
May 16, 1995

Ms. Williams indicated concern over the potential development of an alternative which would include above grade sheet piling in combination with wetland creation (i.e., Alternative 3 of the Draft FFS modified to include wetland creation). Specific concerns included potential impacts to the wetlands should the sheet piling wall fail. She had no specific comments with respect to an alternative where the sheet piling would not extend above grade but indicated she would discuss it further with EPA's wetlands personnel.

Phone conversation with Ken Finklestein, NOAA:
May 17, 1995

Mr. Finklestein indicated that he was interested in seeing a wetland creation alternative considered for this site and noted that he was in favor of constructing a wetland in front of the revetment along

the side slope of the cap. His main interest in such a project would be with respect to its wildlife value, especially in the increase of the habitat value for animals such as small fish. He also suggested incorporating some small channels into the wetland design to allow for the entry and exit of fish.

Phone conversation with Bob Johnston, Environmental Research Laboratory:
May 16, 1995

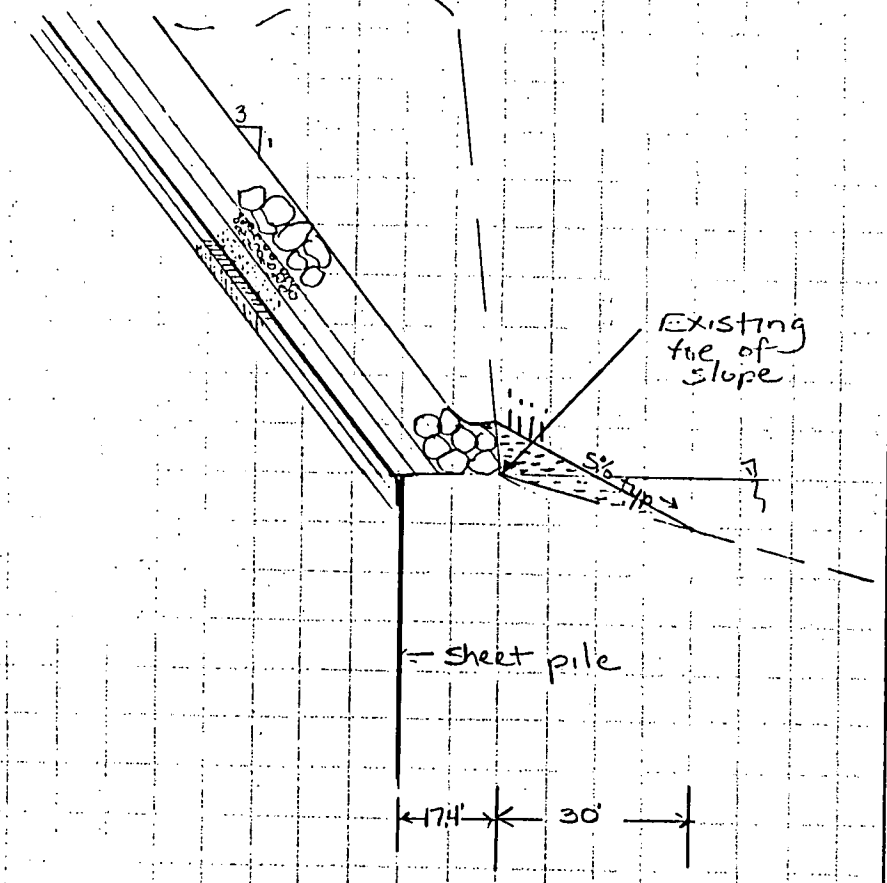
Mr. Johnston was pleased to hear that a wetlands creation alternative is being considered and thinks that there is a fair chance of success based on the fact that, prior to landfill construction, wetlands existed in this portion of Allen Harbor. He recommended the creation of as near of a natural progression from the tidal areas toward upland areas as possible. As taller vegetation occurs with distance upland, wave energy is further dissipated. The substrate for the created wetland provides adsorptive capacity for contaminants such as metals and inorganics, an additional benefit of a created wetland. Should the cap be damaged, leachate seeps similar to those characterized during site investigations to date which may be released from beneath the cap would be adsorbed by the substrate materials. Adverse effects to the wetland would occur only if a high-strength contaminant release occurred which would exceed the substrate's adsorptive capacity. Another purpose of the created wetland would be to provide functional value. A created wetland can be a sustainable resource which can support the ecology of Allen Harbor. The wetland could provide primary productivity into the ecological system and supply the food chain, thereby remedying a major ecological impact of the original development of the landfill - physical disturbance and habitat loss. Wetland creation could be used to address what Mr. Johnston feels is a main remediation goal, the remediation of the harbor and associated food chain. Due to the observed depth of Allen Harbor, creation of a breakwater to protect created wetlands could be difficult. The bottom surface of Allen Harbor has been extensively modified over time and is not representative of natural conditions. The relatively quick increase in water depth from the shoreline into Allen Harbor must be considered with respect to the stability of any created wetlands or adjacent slopes. Filling of tidal waters to create wetlands would be difficult due to the change in depth as well as fill material source issues.

TRC
TRC Environmental Corporation

SUBJECT: Shoreline Cap Design Options - Wetland Creation

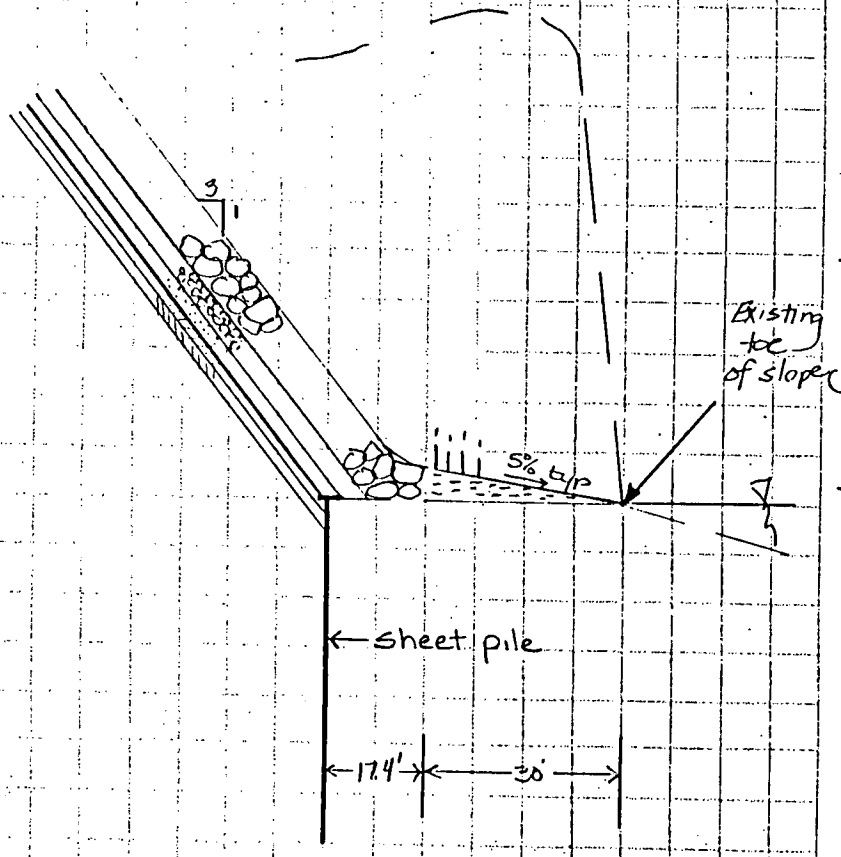
SHEET NO. 1 OF 1
PROJECT NO. p2969-0030
DATE 5/8/95, rev 5/17/95
BY JMD
CHK'D

OPTION 1



Alternative 4 with wetlands extending from existing toe of slope into adjacent harbor waters

OPTION 2



Alternative 4 with additional slope cut-back - wetland ends at existing toe of slope

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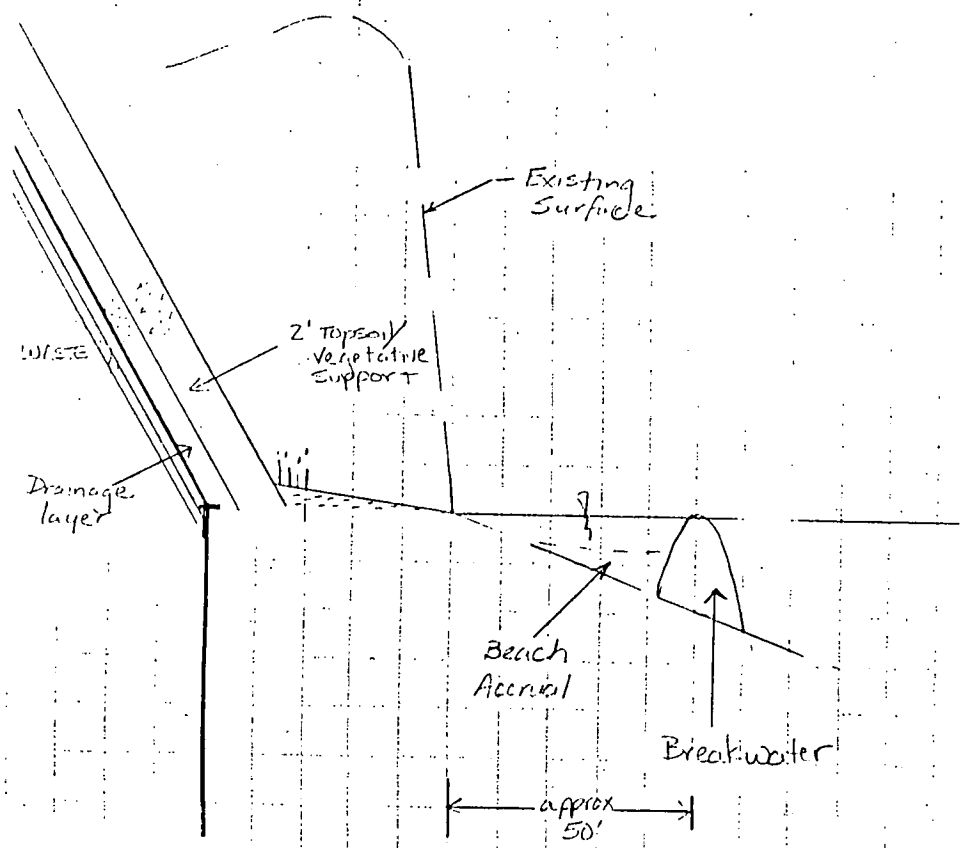
TRC Environmental Corporation

SUBJECT Shoreline Cap Design Options - Wetland Creation

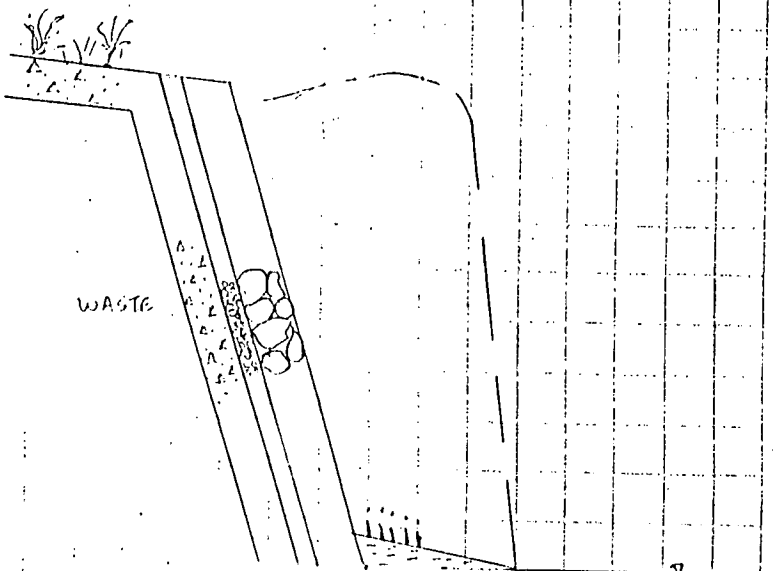
SHEET NO. 2 OF 2
PROJECT NO. 02219-0030-00030
DATE 5/17/95
BY TMO
CHK'D

Option 3



Option 2 minus the revetment, plus a breakwater

Option 4



Wetland creation, revetment and soil cap

INITIAL ANALYSIS OF SHORELINE DESIGN OPTIONS

SECTION A-3
GABION/SLOPE CUTBACK SHORELINE PROTECTION ALTERNATIVE

Description:

Since gabions have not been previously evaluated within the FFS, a brief description is appropriate. Gabions are rectangular baskets or mattresses made of steel wire in a hexagonal mesh. The wire may be galvanized or PVC-coated. They are subdivided into approximately equally sized cells. Standard gabion baskets are 3 feet wide and 6, 9, or 12 feet long, and 1, 1.5, or 3 feet deep. The baskets are unfolded on-site and assembled by lacing the edges together with steel wire. The individual baskets are then wired together and filled with 4- to 8-inch diameter stone. The lids are closed and laced to the baskets, forming a large, heavy mass. A filter material (i.e., filter cloth or a gravel filter) is required beneath the gabions to minimize loss of backfill materials.

Gabions can be constructed on a slope, as a revetment, or can be stacked vertically to construct a bulkhead. They can also be stepped up a slope. Toe protection can be provided by extending baskets out along the bottom a distance sufficient to limit scour and provide stability against sliding and rotation.

Gabions can be built without heavy equipment and can maintain their function even if the underlying foundation material settles. They can be opened by wave action, however. Since structural performance depends on the continuity of the wire mesh, abrasion and damage to the PVC coating or galvanized wire can lead to rapid corrosion of the wire and failure of the baskets. Repairs are possible by opening the baskets, refilling them and re-wiring them shut. Periodic inspections are required to enable repairs to be made before serious damage occurs. By tightly packing the baskets with stone, movement of the stone and subsequent damage to the wire can be minimized.

Reported design factors for gabion baskets include the following (U.S. Army Corps of Engineers, 1985):

- Zero-damage wave height: 5 feet
- Wave runup potential: 80% of smooth slope runup
- Wave reflection potential: High

Basic assumptions:

Impermeable layer must be maintained behind/below gabions to maintain containment features

Option development:

Two designs of gabion shoreline protection methods at the shoreline were considered (sketches attached):

- Option 1 - Maintain height of sheet pile to protect against 100-year storm (as in Alternative 2) but front the sheet pile with gabions stacked vertically; sheet pile wall acts as impermeable layer
- Option 2 - Stack gabions in benched manner with the toe of the gabions and the top of the sheet pile at the existing toe of slope; impermeable cap beneath the gabions provides containment; geomembrane of underlying cap is tied to the sheet pile under the lowermost gabion

Option 2 requires the construction of an impermeable cap at a slope behind the gabion wall. As stated previously in the Draft FFS, the maximum slope obtainable for the impermeable cap is limited by the side slope stability of the cap, given the materials of construction. RIDEM regulations applicable to solid waste landfill construction and closure call for a maximum slope of 33%. Assuming the maximum acceptable slope of the underlying cap is 33%, the optimum (maximum) slope of the overlying gabion wall is effectively limited to 33%.

Comparative evaluation of advantages and disadvantages of each option:

<u>Option 1 - Maintain height of sheet pile to protect against 100-year storm (as in Alternative 2) but front the sheet pile with gabions stacked vertically; sheet pile wall acts as impermeable layer</u>

Advantages:
Least slope cutback required of all alternatives except Alternative 2
Drainage layer drains freely over top of sheet pile
Requires least excavation at toe of slope of all alternatives except Alternative 2
Least inundation of cap behind sheet pile of all alternatives except Alternative 2
No sheet piling is visible from harbor

Disadvantages:
Gabions extend slightly beyond toe of slope into harbor
Slope protection function provided by the gabions is redundant with the slope protection offered by the sheet pile wall

<u>Option 2 - Stack gabions in benched manner with the toe of the gabions and the top of the sheet pile at the existing toe of slope; impermeable cap beneath the gabions provides containment; geomembrane of underlying cap is tied to the sheet pile under the lowermost gabion</u>

Advantages:
Gabions do not extend into harbor
No sheet piling is visible from harbor

Disadvantages:
Requires additional slope cutback (greater than Option 1 and existing Alternatives 2 and 3)
Requires deeper excavation at toe of slope (greater than Option 1 and existing Alternatives 2 and 3)

Cap along shoreline will be inundated at greater frequency than for Option 1 and existing Alternatives 2 and 3

Drainage layer will be below grade at point where it meets the sheet pile wall

Selection of option for detailed analysis

Based on the evaluation presented above, Option 2 provides the greatest degree of slope protection. However, since the maximum slope achievable is dependent on the maximum slope allowable for the underlying cap, Option 2 does not provide any significantly greater advantage than the stone revetment slope protection alternative undergoing detailed analysis and has greater disadvantages associated with its long-term effectiveness and maintenance, due to the potential for corrosion of the wire mesh. Reported cost information (U.S. Army Corps of Engineers, 1985) indicates that while construction costs may be less for gabion revetment or bulkhead construction as compared to a stone revetment, annual maintenance costs are higher. Over a long-term maintenance period, costs for the two options are comparable. Therefore, based on long-term effectiveness and maintenance considerations, neither of the gabion alternatives will be retained for detailed analysis.

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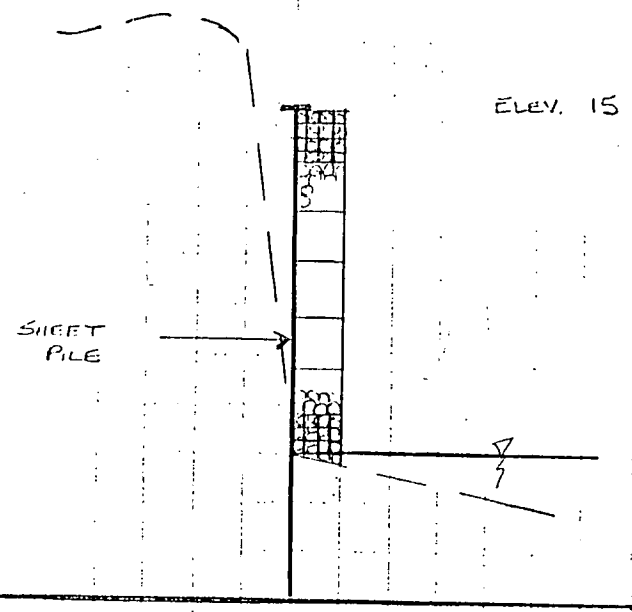
TRC Environmental Corporation

SUBJECT Shoreline Cap Design Options - Gabion Wall

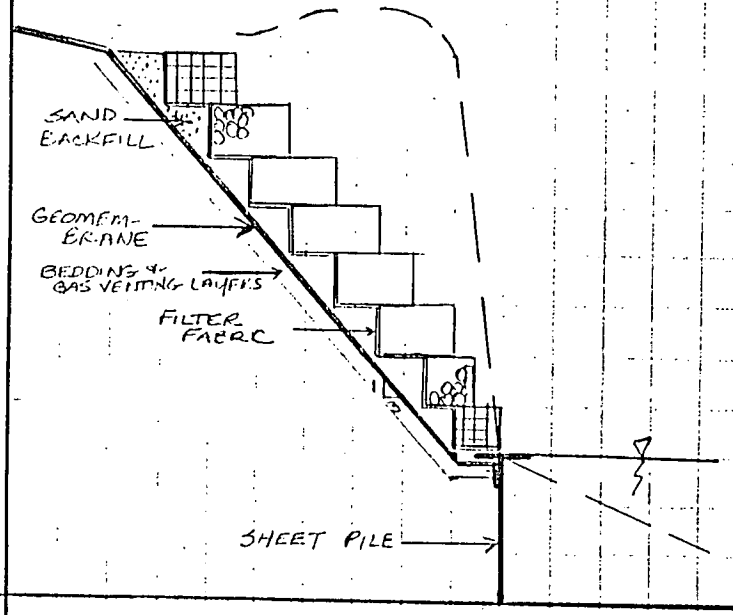
SHEET NO. 1 OF 1
PROJECT NO. D2969-0030
DATE 5/8/95
BY TMO
CHK'D

OPTION 1



Vertical gabion wall in front of vertical sheet pile wall

OPTION 2



Stacked gabions over impermeable cap

APPENDIX B

SITE-SPECIFIC WILDLIFE AND WETLAND OBSERVATIONS

Summary of Bird and Wildlife Observations NCBC Davisville

Location: Allen Harbor Watershed Landfill

Date: July 22

Birds	Comment
Brown thrasher	
White-breasted nuthatch	
House wren	
Downy woodpecker	
Black-capped chickadee	Terr. song
Common flicker	
Song sparrow	Terr. song
Northern cardinal	
Gray catbird	
Cedar waxwing	
American goldfinch	Terr. song
House finch	
Barn swallow	
Tree swallow	
Common yellowthroat	Terr. song
American robin	
Red-winged blackbird	Fledged family
Blue jay	
Northern mocking bird	
Carolina wren	Terr. song
Mourning dove	
American crow	Fledged family

Mammals

White tailed deer

Amphibians

Reptiles

Vegetation

Willows
Bittersweet
Wild grape

Field Comments: Lepidoptera; hymenoptera; diptera common

Summary of Bird and Wildlife Observations NCBC Davisville

Location: Allen Harbor Watershed Landfill and Adjoining Marsh Date: May 20

	Comment:
Birds	
Upland on Landfill	
Fish crow	
Field sparrow	Terr. song
American robin	Terr. song
Northern cardinal	Terr. song
Savannah sparrow	Migrant
Rufous-sided towhee	Terr. song
Mourning dove	Terr. song
House finch	
Red-winged blackbird	
Yellow warbler	
Gray catbird	
Song sparrow	Terr. song and abundant
House finch	Terr. and abundant
Common yellowthroat	Terr. song
Prairie warbler	Terr. song
House wren	Terr. song
Salt Marsh and Harbor	
Snowy egret	
Little blue heron	
Glossy ibis	
Green-backed heron	
Black-crowned nigh-heron	
Double-crested cormorant	
Mute swan pair	
Canada goose	
Osprey	
Mammals	
Raccoon tracks	
Amphibians	
Reptiles	

Location: Allen Harbor Watershed Landfill and Adjoining Marsh Date: May 20

Vegetation

Spartina
Phragmites
Staghorn sumac
Red cedar
Bittersweet
White pine
Autumn olive

Field Comments: Depaupaerate rel to calf pasture

TABLE 4. WETLAND D. COVER TYPE: Salt Marsh/Reed Meadow

I. TOPOGRAPHY: Gradual topography, abundant depressions, contains braided stream system; located on valley bottom; borders Allen Harbor.

II. SUBSTRATE: Layer of silty organic sand.

III. HYDROLOGIC CHARACTERISTICS: Permanently flooded portions; receives drainage via 4'-15' stream from Wetland C, 4' channel from wetland to West of site (via road culvert). Surface water depth 0"-12", groundwater at surface..

IV. WATER QUALITY: Clear with no sign of turbidity.

V. PLANT COMMUNITY:

	% Canopy Cover	Avg. Height (Ft.)	Dominant Plant Species
Trees.....	----	----	----------
Shrubs.....	10%	3'	Marsh Elder
Low Evergreen Cover.	----	----	----------
Herbs/Forbs.....	10%	1.5'	Sea Lavender, Glasswort
Grass-like Plants...	80%	4'	Spartina, Reeds
Mosses.....	----	----	----------

TABLE 6. WETLAND F. COVER TYPE: Salt Marsh

I. TOPOGRAPHY: Gradual topography; abundant depressions, braided intermittent streams with shallow water (1-2" deep, 1'-3' wide); contains larger stream systems (5-20' wide, 1'-2' deep, 3-18" water).

II. SUBSTRATE: Layer of silty organic sand.

III. HYDROLOGIC CHARACTERISTICS: Permanent and ephemeral flooded portions, borders Allen Harbor, receives drainage via stream from Wetland G. Surface water depth 0"-2".

IV. WATER QUALITY: Clear with no sign of turbidity.

V. PLANT COMMUNITY:

	% Canopy Cover	Avg. Height (Ft.)	Dominant Plant Species
Trees.....	5%	30'	Quaking Aspen, Willow, Cedar
Shrubs.....	10%	3'	Marsh Elder, Bayberry, Sumac
Low Evergreen Cover.	----	----	----------
Herbs/Forbs.....	5%	1.5'	Glasswort, Sea Lavender
Grass-like Plants...	85%	1'-3'	*Spartina*, Reeds
Mosses.....	----	----	----------

APPENDIX C

REMEDIAL COST ESTIMATES

REMEDIAL COST ESTIMATES

Cost estimates for Alternatives 1, 2 and 3 were originally provided within the Draft FFS. However, due to the variations in the design of the landfill cap and containment systems along the shoreline of Allen Harbor incorporated within Alternatives 4 and 5, a more detailed analysis of the unit volumes required for cap construction was required for each of Alternatives 3, 4 and 5 to ensure that the differences in cost between these three alternatives were representative. Therefore, the original cost estimate presented in the Draft FFS for Alternative 3 has been revised and cost estimates were prepared for Alternatives 4 and 5. The cost estimates are presented in the attached tables as follows:

Table C-1 Alternative 3 Cost Estimate (Revised 5/95) - RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Wall, Riprap Storm Protection and Deed Restrictions

Table C-2 Alternative 4 Cost Estimate - RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Subsurface Barrier, Riprap Storm Protection and Deed Restrictions

Table C-3 Alternative 5 Cost Estimate - RCRA Subtitle C Multi-Layer Cap, Slurry Wall, Sheet Pile Subsurface Barrier, Riprap Storm Protection, Coastal Wetland Creation and Deed Restrictions

TABLE C-1
ALTERNATIVE 3 COST ESTIMATE (REVISED 5/95)
RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL, SHEET PILE WALL,
RIPRAP STORM PROTECTION AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

Item	Quantity	Units	Unit Price	Basis Year	Escalation	1995 Unit Costs	1995 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - DIRECT									
Permitting and Regulatory Approvals	1	lump sum	$50,000.00	1993	1.045	$52,250.00	$52,250.00		
Site Preparation									
- Clear Vegetation and Brush	15	acres	$2,875.00	1995	1.000	$2,875.00	$43,125.00		
- Regrade Site	56,000	cu. yd.	$9.80	1994	1.007	$9.87	$552,641.60		
- Health and Safety (20%)							$119,153.32		
- Shoreline Excavation and Waste Consolidation	15,700	cu. yd.	$15.00	1994	1.007	$15.11	$237,148.50		
- Health and Safety (37.5%)							$88,930.69		
- Temporary Road Construction and Removal	1	lump sum	$40,000.00	1994	1.007	$40,280.00	$40,280.00		
Total Site Preparation Cost									$1,133,529.11
Landfill Cap Construction									
- Bedding Layer (12" and 6")	22,400	cu. yd.	$10.53	1994	1.007	$10.60	$237,477.99		
- Non-woven Geotextile	659,000	sq. ft.	$0.29	1994	1.007	$0.30	$195,102.22		
- Geonet	659,000	sq. ft.	$0.35	1994	1.007	$0.35	$232,264.55		
- Non-woven Geotextile	659,000	sq. ft.	$0.29	1994	1.007	$0.30	$195,102.22		
- Geosynthetic Clay Layer	557,000	sq. ft.	$0.77	1994	1.007	$0.78	$431,892.23		
- Geomembrane (smooth)	557,000	sq. ft.	$0.84	1994	1.007	$0.85	$471,155.16		
- Soil Barrier (6")	1,900	cu. yd.	$13.30	1994	1.007	$13.39	$25,446.89		
- Geomembrane (textured)	102,000	sq. ft.	$1.23	1994	1.007	$1.24	$126,543.65		
- Drainage Layer (12")	3,600	cu. yd.	$17.85	1994	1.007	$17.97	$64,709.82		
- Geonet	561,000	sq. ft.	$0.35	1994	1.007	$0.35	$197,724.45		
- Non-woven Geotextile	658,000	sq. ft.	$0.29	1994	1.007	$0.30	$194,806.16		
- 18" Vegetative Support Soil Layer	31,800	cu. yd.	$10.53	1994	1.007	$10.60	$337,133.93		
- 6" Topsoil Layer	10,600	cu. yd.	$15.78	1994	1.007	$15.89	$168,417.53		
- Seed, Fertilizer, Mulch	572	msf	$46.00	1995	1.000	$46.00	$26,312.00		
- Vertical Gas Vent Pipes	18	each	$980.00	1994	1.007	$986.86	$17,763.48		
- Health & Safety (20%)							$584,370.46		
Total Landfill Cap Construction Cost									$3,506,222.74

TABLE C-1 (continued)
ALTERNATIVE 3 COST ESTIMATE (REVISED 5/95)
RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL, SHEET PILE WALL,
RIPRAP STORM PROTECTION AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

Item	Quantity	Units	Unit Price	Basis Year	Escalation	1995 Unit Costs	1995 Costs	Years (O&M)	(1) Present Value (O&M)
Sheet Piling Wall Construction (18-inch) (2,400 ft x 35 ft)									
- Mob/Demob	1	time	$15,100.00	1995	1.000	$15,100.00	$15,100.00		
- Steel Piles	84,000	vsf	$25.62	1995	1.000	$25.62	$2,152,080.00		
- Health & Safety (20%)							$433,436.00		
Total Sheet Pile Wall Construction Cost									$2,600,616.00
Slurry Wall Construction									
- Mob/Demob	1	time	$643.00	1994	1.007	$647.50	$647.50		
- 1.5 cu. yd. Hydraulic Backhoe	9,000	cu.yd.	$4.32	1995	1.000	$4.32	$38,880.00		
- Bulldozer (300 hp)	9,000	cu.yd.	$1.71	1995	1.000	$1.71	$15,390.00		
- Soil/Bentonite Trench	81,000	sq.ft.	$5.00	1994	1.007	$5.04	$407,835.00		
- Health & Safety (17%)							$78,667.93		
- Water Tank Rental	3	mo.	$3,225.00	1995	1.007	$3,247.58	$9,742.73		
- Pumping Mixing Equipment	3	mo.	$8,250.00	1994	1.007	$8,307.75	$24,923.25		
Total Slurry Wall Construction Cost									$576,086.40
Shoreline Protection and Drainage Controls									
- Cut Drainage Ditches	1,550	l. ft.	$1.00	1988	1.205	$1.21	$1,867.75		
- Subdrain Piping (6-inch)	2,350	l. ft.	$2.10	1995	1.000	$2.10	$4,935.00		
- Pipe Bedding	2,350	l. ft.	$2.07	1995	1.000	$2.07	$4,864.50		
- Drainage along Sheet Pile Wall (Coarse Aggregate)	530	cu. yd.	$19.05	1995	1.000	$19.05	$10,096.50		
- Steel Drainage Pipe (6-inch)	2,400	l. ft.	$6.40	1995	1.000	$6.40	$15,360.00		
- Silt Fence	5,000	l. ft.	$0.98	1994	1.007	$0.99	$4,934.30		
- Stone Revetment and Bedding (Type IV)	8,400	sq. yd.	$100.00	1994	1.007	$100.70	$845,880.00		
- Non-woven Geotextile	86,000	sq. ft.	$0.38	1994	1.007	$0.38	$32,735.56		
Total Shoreline Protection and Drainage C ntrols									$920,673.61

TABLE C-4 (continued)
ALTERNATIVE 3 COST ESTIMATE (REVISED 5/95)
RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL, SHEET PILE WALL,
RIPRAP STORM PROTECTION AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

Item	Quantity	Units	Unit Price	Basis Year	Escalation	1995 Unit Costs	1995 Costs	Years (O&M)	(1) Present Value (O&M)
Dewatering During Side Slope Construction									
- Pump	2	each	$2,400.00	1995	1.000	$2,400.00	$4,800.00		
- Labor (24 hr/day)	960	hrs	$27.86	1995	1.000	$27.86	$26,743.20		
- Health & Safety (20%)							$5,348.64		
- Portable Generator	2	months	$1,200.00	1995	1.000	$1,200.00	$2,400.00		
- Water Tank Rental	2	months	$3,225.00	1995	1.000	$3,225.00	$6,450.00		
- Water Disposal	310,000	gal.	$0.56	1994	1.007	$0.56	$174,815.20		
Total Dewatering During Side Slope Construction									$220,557.04
Site Survey	1	lump sum	$5,000.00	1995	1.000	$5,000.00	$5,000.00		$5,000.00
Equipment Decontamination									
- Rental of Steam Cleaner	8	months	$435.00	1995	1.000	$435.00	$3,480.00		
- Construction of Decon Pit									
Excavate Pit	15	cu. yd.	$2.51	1995	1.000	$2.51	$37.65		
Polyethylene Tarpaulin	400	sq. ft.	$0.36	1995	1.000	$0.36	$144.00		
- Tanker Truck Rental	8	months	$910.00	1994	1.007	$916.37	$7,330.96		
- Disposal (Tanker Truck)	2	each	$1,600.00	1992	1.092	$1,747.20	$3,494.40		
Total Equipment Decontamination Cost									$14,487.01
Dust Control									
- Water Tank Sprayer	8	months	$2,125.00	1995	1.000	$2,125.00	$17,000.00		$17,000.00
Engineering Mgmt. Mob/Demob									
- 2 Trailers	8	months	$785.00	1995	1.000	$785.00	$6,280.00		$6,280.00
Security									
- Chain Link Fence Along Sanford Rd.	1700	lin. ft.	$12.35	1995	1.000	$12.35	$20,995.00		
- Access Gates	2	ea	$755.00	1995	1.000	$755.00	$1,510.00		
Total Security Cost									$22,505.00
Direct Capital Cost Subtotal									$9,022,956.91

TABLE C-1 (continued)
ALTERNATIVE 3 COST ESTIMATE (REVISED 5/95)
RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL, SHEET PILE WALL,
RIPRAP STORM PROTECTION AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

Item	Quantity	Units	Unit Price	Basis Year	Escalation	1995 Unit Costs	1995 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - INDIRECT									
Engineering and Design (10%)							$902,295.69		
Legal and Administrative (4%)							$360,918.28		
Total Indirect Capital Cost									$1,263,213.97
TOTAL CAPITAL COSTS									$10,286,170.88
OPERATION AND MAINTENANCE COSTS									
Soil Cap O & M									
- Cap Annual Inspection and Repairs	1	each	$5,000.00	1988	1.205	$6,025.00	$6,025.00	30	$92,616.30
Quarterly Ground Water Monitoring									
(Includes 1 trip blank, field blank, and duplicate sample per quarter)									
- Sampling	92	each	$300.00	1994	1.007	$302.10	$27,793.20	30	$427,237.07
- Analyses	92	each	$1,125.00	1994	1.007	$1,132.88	$104,224.50	30	$1,602,139.01
- Report Preparation	1	each	$14,000.00	1994	1.007	$14,098.00	$14,098.00	30	$216,714.46
Storm Water Discharge Monitoring									
(5 discharge points semi-annually)									
- Collection and Reporting	1	lump sum	$15,000.00	1994	1.007	$15,105.00	$15,105.00	30	$232,194.06
- Sample Analysis	10	each	$449.00	1994	1.007	$452.14	$4,521.43	30	$69,503.42
ANNUAL O&M COST							$171,767.13		
TOTAL NET PRESENT VALUE OF O & M									$2,640,404.32
SUBTOTAL COST									$12,926,575.20
CONTINGENCY (20%)									$2,585,315.04
TOTAL PRESENT VALUE COST FOR ALTERNATIVE 3									$15,511,890.24

(1) - Calculated based on 5% interest rate.

TABLE C-2
ALTERNATIVE 4 COST ESTIMATE
RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL, SHEET PILE SUBSURFACE BARRIER,
RIPRAP STORM PROTECTION AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

Item	Quantity	Units	Unit Price	Basis Year	Escalation	1995 Unit Costs	1995 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - DIRECT									
Permitting and Regulatory Approvals	1	lump sum	$50,000.00	1993	1.045	$52,250.00	$52,250.00		
Site Preparation									
- Clear Vegetation and Brush	15	acres	$2,875.00	1995	1.000	$2,875.00	$43,125.00		
- Regrade Site	56,000	cu. yd.	$9.80	1994	1.007	$9.87	$552,641.60		
- Health and Safety (20%)							$119,153.32		
- Shoreline Excavation and Waste Consolidation	22,700	cu. yd.	$15.00	1994	1.007	$15.11	$342,883.50		
- Health and Safety (37.5%)							$128,581.31		
- Temporary Road Construction and Removal	1	lump sum	$40,000.00	1994	1.007	$40,280.00	$40,280.00		
Total Site Preparation Cost									$1,278,914.73
Landfill Cap Construction									
- Bedding Layer (12" and 6")	21,300	cu. yd.	$10.53	1994	1.007	$10.60	$225,816.12		
- Non-woven Geotextile	616,000	sq. ft.	$0.29	1994	1.007	$0.30	$182,371.73		
- Geonet	616,000	sq. ft.	$0.35	1994	1.007	$0.35	$217,109.20		
- Non-woven Geotextile	616,000	sq. yd.	$0.29	1994	1.007	$0.30	$182,371.73		
- Geosynthetic Clay Layer	535,000	sq. ft.	$0.77	1994	1.007	$0.78	$414,833.65		
- Geomembrane (smooth)	535,000	sq. ft.	$0.84	1994	1.007	$0.85	$452,545.80		
- Soil Barrier (6")	1,600	cu. yd.	$13.30	1994	1.007	$13.39	$21,428.96		
- Geomembrane (textured)	80,900	sq. ft.	$1.23	1994	1.007	$1.24	$100,366.48		
- Drainage Layer (12")	4,500	cu. yd.	$17.85	1994	1.007	$17.97	$80,887.28		
- Geonet	539,000	sq. ft.	$0.35	1994	1.007	$0.35	$189,970.55		
- Non-woven Geotextile	659,000	sq. ft.	$0.29	1994	1.007	$0.30	$195,102.22		
- 18" Vegetative Support Soil Layer	30,600	cu. yd.	$10.53	1994	1.007	$10.60	$324,411.90		
- 6" Topsoil Layer	10,200	cu. yd.	$15.78	1994	1.007	$15.89	$162,062.15		
- Seed, Fertilizer, Mulch	550	msf	$46.00	1995	1.000	$46.00	$25,300.00		
- Vertical Gas Vent Pipes	18	each	$980.00	1994	1.007	$986.86	$17,763.48		
- Health & Safety (20%)							$558,468.25		
Total Landfill Cap Construction Cost									$3,350,809.50

TABLE C-2 (continued)
ALTERNATIVE 4 COST ESTIMATE
RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL, SHEET PILE SUBSURFACE BARRIER,
RIPRAP STORM PROTECTION AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

Item	Quantity	Units	Unit Price	Basis Year	Escalation	1995 Unit Costs	1995 Costs	Years (O&M)	(1) Present Value (O&M)
Sheet Piling Wall Construction (18-inch) (2,400 ft x 20 ft)									
- Mob/Demob	1	time	$15,100.00	1995	1.000	$15,100.00	$15,100.00		
- Steel Piles	48,000	vsf	$25.62	1995	1.000	$25.62	$1,229,760.00		
- Health & Safety (20%)							$248,972.00		
Total Sheet Pile Wall Construction Cost									$1,493,832.00
Slurry Wall Construction									
- Mob/Demob	1	time	$643.00	1994	1.007	$647.50	$647.50		
- 1.5 cu. yd. Hydraulic Backhoe	9,000	cu.yd.	$4.32	1995	1.000	$4.32	$38,880.00		
- Bulldozer (300 hp)	9,000	cu.yd.	$1.71	1995	1.000	$1.71	$15,390.00		
- Soil/Bentonite Trench	81,000	sq.ft.	$5.00	1994	1.007	$5.04	$407,835.00		
- Health & Safety (17%)							$78,667.93		
- Water Tank Rental	3	mo.	$3,225.00	1995	1.007	$3,247.58	$9,742.73		
- Pumping Mixing Equipment	3	mo.	$8,250.00	1994	1.007	$8,307.75	$24,923.25		
Total Slurry Wall Construction Cost									$576,086.40
Shoreline Protection and Drainage Controls									
- Cut Drainage Ditches	1,550	l. ft.	$1.00	1988	1.205	$1.21	$1,867.75		
- Subdrain Piping (6-inch)	2,350	l. ft.	$2.10	1995	1.000	$2.10	$4,935.00		
- Pipe Bedding	2,350	l. ft.	$2.07	1995	1.000	$2.07	$4,864.50		
- Drainage along Sheet Pile Wall (Coarse Aggregate)	530	cu. yd.	$19.05	1995	1.000	$19.05	$10,096.50		
- Steel Drainage Pipe (6-inch)	2,400	l. ft.	$6.40	1995	1.000	$6.40	$15,360.00		
- Silt Fence	5,000	l. ft.	$0.98	1994	1.007	$0.99	$4,934.30		
- Stone Revetment and Bedding (Type IV)	11,000	sq. yd.	$100.00	1994	1.007	$100.70	$1,107,700.00		
- Non-woven Geotextile	109,000	sq. ft.	$0.38	1994	1.007	$0.38	$41,490.41		
Total Shorelin Protection and Drainage Controls									$1,191,248.46

TABLE C-2 (continued)
ALTERNATIVE 4 COST ESTIMATE
RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL, SHEET PILE SUBSURFACE BARRIER,
RIPRAP STORM PROTECTION AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

Item	Quantity	Units	Unit Price	Basis Year	Escalation	1995 Unit Costs	1995 Costs	Years (O&M)	(1) Present Value (O&M)
Dewatering During Side Slope Construction									
- Portable Cofferdam	1	l.s.	$450,000.00	1995	1.000	$450,000.00	$450,000.00		
- Pump	2	each	$2,400.00	1995	1.000	$2,400.00	$4,800.00		
- Labor (24 hr/day)	1,920	hrs	$27.86	1995	1.000	$27.86	$53,486.40		
- Health & Safety (20%)							$10,697.28		
- Portable Generator	3	months	$1,200.00	1995	1.000	$1,200.00	$3,600.00		
- Water Tank Rental	3	months	$3,225.00	1995	1.000	$3,225.00	$9,675.00		
- Water Disposal	310,000	gal.	$0.56	1994	1.007	$0.56	$174,815.20		
Total Dewatering During Side Slope Construction									$707,073.88
Sit Survey	1	lump sum	$5,000.00	1995	1.000	$5,000.00	$5,000.00		$5,000.00
Equipment Decontamination									
- Rental of Steam Cleaner	9	months	$435.00	1995	1.000	$435.00	$3,915.00		
- Construction of Decon Pit									
Excavate Pit	15	cu. yd.	$2.51	1995	1.000	$2.51	$37.65		
Polyethylene Tarpaulin	400	sq. ft.	$0.36	1995	1.000	$0.36	$144.00		
- Tanker Truck Rental	9	months	$910.00	1994	1.007	$916.37	$8,247.33		
- Disposal (Tanker Truck)	3	each	$1,600.00	1992	1.092	$1,747.20	$5,241.60		
Total Equipment Decontamination Cost									$17,585.58
Dust Control									
- Water Tank Sprayer	9	months	$2,125.00	1995	1.000	$2,125.00	$19,125.00		$19,125.00
Engineering Mgmt. Mob/Demob									
- 2 Trailers	9	months	$785.00	1995	1.000	$785.00	$7,065.00		$7,065.00
Security									
- Chain Link Fence Along Sanford Rd.	1700	lin. ft.	$12.35	1995	1.000	$12.35	$20,995.00		
- Access Gates	2	ea	$755.00	1995	1.000	$755.00	$1,510.00		
Total Security Cost									$22,505.00
Direct Capital Cost Subtotal									$8,669,245.55

TABLE C-2 (continued)
ALTERNATIVE 4 COST ESTIMATE
RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL, SHEET PILE SUBSURFACE BARRIER,
RIPRAP STORM PROTECTION AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

Item	Quantity	Units	Unit Price	Basis Year	Escalation	1995 Unit Costs	1995 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - INDIRECT									
Engineering and Design (10%)							$866,924.56		
Legal and Administrative (4%)							$346,769.82		
Total Indirect Capital Cost									$1,213,694.38
TOTAL CAPITAL COSTS									$9,882,939.93
OPERATION AND MAINTENANCE COSTS									
Soil Cap O & M									
- Cap Annual Inspection and Repairs	1	each	$5,000.00	1988	1.205	$6,025.00	$6,025.00	30	$92,616.30
Quarterly Ground Water Monitoring									
(Includes 1 trip blank, field blank, and duplicate sample per quarter)									
- Sampling	92	each	$300.00	1994	1.007	$302.10	$27,793.20	30	$427,237.07
- Analyses	92	each	$1,125.00	1994	1.007	$1,132.88	$104,224.50	30	$1,602,139.01
- Report Preparation	1	each	$14,000.00	1994	1.007	$14,098.00	$14,098.00	30	$216,714.46
Storm Water Discharge Monitoring									
(5 discharge points semi-annually)									
- Collection and Reporting	1	lump sum	$15,000.00	1994	1.007	$15,105.00	$15,105.00	30	$232,194.06
- Sample Analysis	10	each	$449.00	1994	1.007	$452.14	$4,521.43	30	$69,503.42
ANNUAL O&M COST							$171,767.13		
TOTAL NET PRESENT VALUE OF O & M									$2,640,404.32
SUBTOTAL COST									$12,523,344.25
CONTINGENCY (20%)									$2,504,668.85
TOTAL PRESENT VALUE COST FOR ALTERNATIVE 4									$15,028,013.10

(1) - Calculated based on 5% interest rate.

TABLE C-3
ALTERNATIVE 5 COST ESTIMATE
RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL, SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION, COASTAL WETLAND CREATION AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

Item	Quantity	Units	Unit Price	Basis Year	Escalation	1995 Unit Costs	1995 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - DIRECT									
Permitting and Regulatory Approvals	1	lump sum	$50,000.00	1993	1.045	$52,250.00	$52,250.00		
Site Preparation									
- Clear Vegetation and Brush	15	acres	$2,875.00	1995	1.000	$2,875.00	$43,125.00		
- Regrade Site	56,000	cu. yd.	$9.80	1994	1.007	$9.87	$552,641.60		
- Health and Safety (20%)							$119,153.32		
- Shoreline Excavation and Waste Consolidation	54,000	cu. yd.	$15.00	1994	1.007	$15.11	$815,670.00		
- Health and Safety (37.5%)							$305,876.25		
- Temporary Road Construction and Removal	1	lump sum	$40,000.00	1994	1.007	$40,280.00	$40,280.00		
Total Site Preparation Cost									$1,928,996.17
Landfill Cap Construction									
- Bedding Layer (12" and 6")	18,000	cu. yd.	$10.53	1994	1.007	$10.60	$190,830.53		
- Non-woven Geotextile	550,000	sq. ft.	$0.29	1994	1.007	$0.30	$162,831.90		
- Geonet	550,000	sq. ft.	$0.35	1994	1.007	$0.35	$193,847.50		
- Non-woven Geotextile	550,000	sq. ft.	$0.29	1994	1.007	$0.30	$162,831.90		
- Geosynthetic Clay Layer	430,000	sq. ft.	$0.77	1994	1.007	$0.78	$333,417.70		
- Geomembrane (smooth)	430,000	sq. ft.	$0.84	1994	1.007	$0.85	$363,728.40		
- Soil Barrier (6")	2,200	cu. yd.	$13.30	1994	1.007	$13.39	$29,464.82		
- Geomembrane (textured)	117,000	sq. ft.	$1.23	1994	1.007	$1.24	$145,153.01		
- Drainage Layer (12")	5,800	cu. yd.	$17.85	1994	1.007	$17.97	$104,254.71		
- Geonet	433,000	sq. ft.	$0.35	1994	1.007	$0.35	$152,610.85		
- Non-woven Geotextile	589,000	sq. ft.	$0.29	1994	1.007	$0.30	$174,378.16		
- 18" Vegetative Support Soil Layer	24,700	cu. yd.	$10.53	1994	1.007	$10.60	$261,861.89		
- 6" Topsoil Layer	8,200	cu. yd.	$15.78	1994	1.007	$15.89	$130,285.26		
- Seed, Fertilizer, Mulch	444	msf	$46.00	1995	1.000	$46.00	$20,424.00		
- Vertical Gas Vent Pipes	18	each	$980.00	1994	1.007	$986.86	$17,763.48		
- Health & Safety (20%)							$488,736.82		
Total Landfill Cap Construction Cost									$2,932,420.93

TABLE C-3 (continued)
ALTERNATIVE 5 COST ESTIMATE
RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL, SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION, COASTAL WETLAND CREATION AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

Item	Quantity	Units	Unit Price	Basis Year	Escalation	1995 Unit Costs	1995 Costs	Years (O&M)	(1) Present Value (O&M)
Sheet Piling Wall Construction (18-inch) (2,400 ft x 20 ft)									
- Mob/Demob	1	time	$15,100.00	1995	1.000	$15,100.00	$15,100.00		
- Steel Piles	48,000	vsf	$25.62	1995	1.000	$25.62	$1,229,760.00		
- Health & Safety (20%)							$248,972.00		
Total Sheet Pile Wall Construction Cost									$1,493,832.00
Slurry Wall Construction									
- Mob/Demob	1	time	$643.00	1994	1.007	$647.50	$647.50		
- 1.5 cu. yd. Hydraulic Backhoe	9,000	cu.yd.	$4.32	1995	1.000	$4.32	$38,880.00		
- Bulldozer (300 hp)	9,000	cu.yd.	$1.71	1995	1.000	$1.71	$15,390.00		
- Soil/Bentonite Trench	81,000	sq.ft.	$5.00	1994	1.007	$5.04	$407,835.00		
- Health & Safety (17%)							$78,667.93		
- Water Tank Rental	3	mo.	$3,225.00	1995	1.007	$3,247.58	$9,742.73		
- Pumping Mixing Equipment	3	mo.	$8,250.00	1994	1.007	$8,307.75	$24,923.25		
Total Slurry Wall Construction Cost									$576,086.40
Shoreline Protection, Wetland Creation and Drainage Controls									
- Cut Drainage Ditches	1,550	l. ft.	$1.00	1988	1.205	$1.21	$1,867.75		
- Subdrain Piping (6-inch)	2,350	l. ft.	$2.10	1995	1.000	$2.10	$4,935.00		
- Pipe Bedding	2,350	l. ft.	$2.07	1995	1.000	$2.07	$4,864.50		
- Silt Fence	5,000	l. ft.	$0.98	1994	1.007	$0.99	$4,934.30		
- Stone Revetment and Bedding (Type IV)	15,000	sq. yd.	$100.00	1994	1.007	$100.70	$1,510,500.00		
- Non-woven Geotextile	145,000	sq. ft.	$0.38	1994	1.007	$0.38	$55,193.67		
- Wetlands Backfill	2,700.00	cu. yd.	$15.78	1994	1.007	$15.89	$42,898.80		
- Herbaceous Plants	18,000	each	$0.85	1995	1.000	$0.85	$15,300.00		
Total Shoreline Protection, Wetland Creation, and Drainage Controls									$1,640,494.02

TABLE C-5 (continued)
ALTERNATIVE 5 COST ESTIMATE
RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL, SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION, COASTAL WETLAND CREATION AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

Item	Quantity	Units	Unit Price	Basis Year	Escalation	1995 Unit Costs	1995 Costs	Years (O&M)	(1) Present Value (O&M)
Dewatering During Side Slope Construction									
- Portable cofferdam	1	lump sum	$450,000.00	1995	1.000	$450,000.00	$450,000.00		
- Pump	2	each	$2,400.00	1995	1.000	$2,400.00	$4,800.00		
- Labor (24 hr/day)	1,920	hrs	$27.86	1995	1.000	$27.86	$53,486.40		
- Health & Safety (20%)							$10,697.28		
- Portable Generator	3	months	$1,200.00	1995	1.000	$1,200.00	$3,600.00		
- Water Tank Rental	3	months	$3,225.00	1995	1.000	$3,225.00	$9,675.00		
- Water Disposal	310,000	gal.	$0.56	1994	1.007	$0.56	$174,815.20		
Total Dewatering During Side Slope Construction									$707,073.88
Site Survey	1	lump sum	$5,000.00	1995	1.000	$5,000.00	$5,000.00		$5,000.00
Equipment Decontamination									
- Rental of Steam Cleaner	10	months	$435.00	1995	1.000	$435.00	$4,350.00		
- Construction of Decon Pit									
Excavate Pit	15	cu. yd.	$2.51	1995	1.000	$2.51	$37.65		
Polyethylene Tarpaulin	400	sq. ft.	$0.36	1995	1.000	$0.36	$144.00		
- Tanker Truck Rental	10	months	$910.00	1994	1.007	$916.37	$9,163.70		
- Disposal (Tanker Truck)	4	each	$1,600.00	1992	1.092	$1,747.20	$6,988.80		
Total Equipment Decontamination Cost									$20,684.15
Dust Control									
- Water Tank Sprayer	10	months	$2,125.00	1995	1.000	$2,125.00	$21,250.00		$21,250.00
Engineering Mgmt. Mob/Demob									
- 2 Trailers	10	months	$785.00	1995	1.000	$785.00	$7,850.00		$7,850.00
Security									
- Chain Link Fence Along Sanford Rd.	1700	lin. ft.	$12.35	1995	1.000	$12.35	$20,995.00		
- Access Gates	2	ea	$755.00	1995	1.000	$755.00	$1,510.00		
Total Security Cost									$22,505.00
Direct Capital Cost Subtotal									$9,356,192.55

TABLE C-3 (continued)
ALTERNATIVE 5 COST ESTIMATE
RCRA SUBTITLE C MULTI-LAYER CAP, SLURRY WALL, SHEET PILE SUBSURFACE BARRIER, RIPRAP STORM PROTECTION, COASTAL WETLAND CREATION AND DEED RESTRICTIONS
SITE 09 - ALLEN HARBOR LANDFILL

Item	Quantity	Units	Unit Price	Basis Year	Escalation	1995 Unit Costs	1995 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - INDIRECT									
Engineering and Design (10%)							$935,619.26		
Legal and Administrative (4%)							$374,247.70		
Total Indirect Capital Cost									$1,309,866.96
TOTAL CAPITAL COSTS									$10,666,059.51
OPERATION AND MAINTENANCE COSTS									
Soil Cap O & M									
- Cap Annual Inspection and Repairs	1	each	$5,000.00	1988	1.205	$6,025.00	$6,025.00	30	$92,616.30
Quarterly Ground Water Monitoring (Includes 1 trip blank, field blank, and duplicate sample per quarter)									
- Sampling	92	each	$300.00	1994	1.007	$302.10	$27,793.20	30	$427,237.07
- Analyses	92	each	$1,125.00	1994	1.007	$1,132.88	$104,224.50	30	$1,602,139.01
- Report Preparation	1	each	$14,000.00	1994	1.007	$14,098.00	$14,098.00	30	$216,714.46
Wetland Maintenance, Monitoring and Reporting	1	lump sum	$15,000.00	1995	1.000	$15,000.00	$15,000.00	30	$230,580.00
Storm Water Discharge Monitoring (5 discharge points semi-annually)									
- Collection and Reporting	1	lump sum	$15,000.00	1994	1.007	$15,105.00	$15,105.00	30	$232,194.06
- Sample Analysis	10	each	$449.00	1994	1.007	$452.14	$4,521.43	30	$69,503.42
ANNUAL O&M COST							$186,767.13		
TOTAL NET PRESENT VALUE OF O & M									$2,870,984.32
SUBTOTAL COST									$13,537,043.83
CONTINGENCY (20%)									$2,707,408.77
TOTAL PRESENT VALUE COST FOR ALTERNATIVE 5									$16,244,452.60

(1) - Calculated based on 5% interest rate.