ADDENDUM TO THE FOCUSED FEASIBILITY STUDY AREA A LANDFILL

INSTALLATION RESTORATION PROGRAM NAVAL SUBMARINE BASE - NEW LONDON GROTON, CONNECTICUT

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Northern Division
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Halliburton NUS Corporation
661 Anderson Drive
Foster Plaza 7
Pittsburgh, PA 15220-2745

Prepared By:

Atlantic Environmental Services, Inc.
P.O. Box 297 • 188 Norwich Avenue
Colchester, CT 06415
Telephone: (203) 537-0751
Fax: (203) 537-6347

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1.0 INTRODUCTION

This addendum to the Focused Feasibility Study (FFS) for the Area A Landfill was prepared in response to United States Environmental Protection Agency (EPA) comments dated April 28, 1995 and May 8, 1995 regarding certain design issues not addressed in the draft-final FFS for the Area A Landfill. Specifically, this addendum addresses slope stability and leachate collection.

There is a potential for slope failure at the toe of the landfill slope along the wetland due to the accumulation of groundwater behind the impermeable cap at this location. The toe of slope can be stabilized either by draining the groundwater accumulating behind the cap (i.e., by lowering the groundwater level); by providing an enhanced design for the cap toe, such that an acceptable factor of safety can be maintained in spite of potential groundwater accumulation beneath the cap; or by providing lateral resistance (e.g, sheet piles, slurry walls, retaining walls, or the equivalent) to prevent the failure of the slope.

The proposed cap and associated run-on control measures are likely to lower the groundwater level in the landfill; however, groundwater will still probably remain in contact with lower portions of the waste. To prevent the migration of leachate from beneath the landfill into the adjacent wetlands, leachate collection is desirable to make the source containment remedy provided by the cap final and complete.

Both of these design issues can be addressed by installation of a system which lowers groundwater/leachate levels at the landfill. Groundwater/leachate levels can be lowered by preventing the inflow of surface water and groundwater into the landfill area by isolation methods, by collecting and treating groundwater/leachate, or by a combination of these two methods. These methods are described below in Section 2.0.

The final method(s) to be used to lower groundwater levels at the Area A Landfill will be described in the Record of Decision (ROD). Regarding the alternatives discussed in the FFS, the addition of such measures into the final remedy will not affect the comparative analysis of alternatives in the FFS, as the groundwater lowering method will be included as part of any alternative selected. Additionally, inclusion of a leachate collection system will not change the environmental requirements established in the Applicable or Relevant and Appropriate Requirements (ARAR) tables within the FFS.

2.0 LEACHATE/GROUNDWATER ISOLATION, COLLECTION AND TREATMENT

The following two subsections describe leachate/groundwater isolation, and collection and treatment technologies potentially applicable to this site.

2.1 Leachate/Groundwater Isolation

Leachate/groundwater isolation technologies are implemented to either prevent or control groundwater flow into or through desired locations. Minimizing the volume of groundwater entering upgradient will reduce the amount of leachate generated. Three technology options potentially applicable to the site are presented as follows. The first option entails the interception of groundwater flow using a slurry wall. The second option uses sheet piles rather than a slurry wall to intercept groundwater flow. The third option is a downgradient interceptor trench in which leachate/groundwater is collected and withdrawn from the aquifer. An interceptor trench could be used by itself or in combination with a barrier wall. Slurry walls, sheet piles (or geomembrane walls), and interceptor trench technologies are described below.

2.1.1 Slurry Walls

Slurry walls are typically used as low permeability barriers and may be used as load bearing foundations. This technology is widely accepted as an effective low-permeability barrier for diversion of groundwater around impacted areas, or for containment of impacted water in shallow conditions (< 100 feet deep). These walls are installed using typical trench excavation techniques, and the trench is filled during excavation with a bentonite-based slurry that holds the excavation open and hardens into a low-permeability vertical zone.

Soil-bentonite slurry walls can only be installed in relatively flat areas since the slurry will flow under stress (gravity). Cement-bentonite slurry walls are set semi-rigid and provide a stronger barrier than soil-bentonite walls. The cement-bentonite slurry walls average higher in cost (30%), have a somewhat lower resistance to chemical degradation, and may require disposal of excavated soils. However, they require less installation area than soil-bentonite walls.

Subsurface drains can be placed upgradient of a slurry wall to prevent overtopping of the wall, and to minimize potentially impacted water (i.e., leachate) contact with the wall (the latter in case of downgradient walls). The leachate/groundwater could be discharged to the surface water, POTW reintroduced into an underlying formation, or shipped to an off-site industrial wastewater treatment facility. Drains can consist of perforated piping or gravel drains. Selection of the drain material is dependent on the characteristics of the groundwater and formation.

Slurry walls may be keyed into low-permeability confining layers. Walls that are not keyed into confining layers are generally used in cases where gases or substances are found at or near the water table surface, or where impacted water is limited to very shallow depths. Where the integrity of a confining layer (i.e., fractured bedrock) is in doubt, drains or dewatering wells may be required within the barrier walls or grouting may be used to cut off subsurface flow. Grouting is a process during which a cementitious fluid is injected into a rock or soil mass for the purposes of reducing permeability and increasing strength. Grouting is best used for sealing fractures in rock. Grouting can be performed in formations below the water table. However, owing to possible interaction with leachate, grouting may not be effective if used within the barrier, where leachate is present.

2.1.2 Sheet Pile Walls

Sheet piles are also installed to provide low-permeability barriers. The installation of sheet piling involves physically driving interlocking steel sheets into the soil to form a thin, low-permeability barrier. The sections are driven individually into the ground by a pile driver or vibratory hammer. The piles are traditionally made of steel; however, synthetic materials (e.g., geomembrane walls) are also available for specific applications. Pile driving requires a relatively uniform, loose, boulder-free soil for ease of construction. Drains and dewatering may be used in the same manner as for slurry walls described in the previous subsection to improve the effectiveness of the sheet pile barrier.

2.1.3 Interceptor Trenches

Interceptor trenches act as buried conduits to convey and collect leachate/groundwater as it flows into the trench. Trenches function as an infinite line of extraction wells and therefore may be used to collect leachate or lower the groundwater table, in lieu of wells. Trenches and drains are more effective than pumping wells in strata with low or variable hydraulic conductivity.

Several technology options exist for interceptor trenches. A standard arrangement for subsurface drains consists of perforated pipe that is surrounded by a permeable aggregate wrapped in a geotextile fabric to prevent the migration of fine-grained soils into the system. Biopolymer slurry may be used during trench excavation to reduce excavation volumes in areas where there is inadequate room to perform traditional cutback excavation. The biopolymer slurry maintains the integrity of the trench while the gravel layer is installed. The trench is then backfilled as the slurry naturally biodegrades and seeps into the groundwater. Generally, collection sumps are installed at low points in the trenches to permit pumping of the collected water and transport. Collected leachate/groundwater would be treated and/or disposed in the same manner as leachate/groundwater collected by wells as described below in subsection 2.2.2.

2.2 Landfill Leachate Collection and Treatment

Landfill leachate collection and treatment technologies consist of both collection and treatment technologies. Most collection technologies are compatible with most treatment technologies and vice versa. Therefore, this section describes each component technology separately.

2.2.1 Leachate Collection

Leachate collection technologies are designed to minimize the potential for that leachate to impact the environment downgradient of the landfill. Potential applicable technologies for the site include leachate collection using interceptor trenches as described in subsection 2.1.3 and leachate collection through a network of well points.

A network of shallow wells may be installed at strategic locations and connected to form a collection system for leachate extraction. A well point system requires a shallow groundwater table or the ability to locate pockets or preferential pathways of leachate inside or beneath the landfill to effectively collect leachate. A collection tank could be constructed to contain collected leachate.

2.2.2 Leachate Treatment

Leachate treatment technologies are designed to treat collected leachate to meet discharge requirements. Discharge requirements are determined by the off-site treatment facility or surface water discharge requirements. Leachate treatment options consist of on-site or off-site technologies. Typical on-site treatment and pretreatment technologies include chemical treatment processes and physical treatment processes. On-site treatment would be required prior to any on-site discharge and may be required prior to any off-site treatment. Off-site treatment technologies consist of the use of the local POTW or an industrial wastewater treatment facility.

2.2.2.1 On-Site Treatment or Pretreatment

Chemical, physical, and biological processes may be used to remove contaminants from the leachate/groundwater. These processes may be employed separately or combined, where appropriate, to form a process treatment train that will treat the leachate/groundwater to the required levels. The treatment and pretreatment technology selection is based upon either on-site surface discharge criteria or off-site treatment facility acceptance requirements. For example, a POTW discharge, which receives further treatment off site, may only require physical treatment processes on site to remove insoluble materials, whereas an on-site discharge would require a

treatment train using physical treatment processes followed by one or more chemical processes to remove all contaminants below discharge requirements.

Understanding the general nature of leachate production in a landfill serves to reinforce the analytical characterization of the leachate formed during the investigations and offers insight into treatment processes that may be appropriate. Measured Biological Oxygen Demand (BOD) of the leachate is low (<5 mg/l) which can be explained by the relatively young age of the Area A Landfill and by the fact that only limited amounts of sanitary wastes were disposed in it. Accordingly, biological treatment of the landfill leachate is most likely not applicable and the treatment options are restricted to chemical and physical processes.

Chemical Treatment Processes. *Neutralization* is the mixing of an acid or a base into an aqueous stream to achieve a desired pH. This can be a batch or a continuous process.

Coagulation/flocculation is the process by which colloidal material agglomerates, with help from chemical additives, to form a small floc (coagulation) which then combines (flocculates) to produce larger particles that separate from the liquid. Adding lime raises the pH of the solution and lowers the solubility of heavy metals. Lime is a preferred coagulant for the precipitation of heavy metals. Polymers are another common coagulant.

Precipitation is a process that transforms soluble matter into a solid phase that can be removed by settling.

Oxidation involves the use of a strong oxidation agent to break down complex organic compounds. Typical materials include chlorine, potassium permanganate, ozone, and hydrogen peroxide. Highly efficient destruction of toxic and hazardous materials has been achieved when chemical oxidation is combined with ultraviolet (UV) irradiation.

Physical Treatment Processes. *Physical liquid-solid separation* includes sedimentation, specific gravity separation, filtration, and flotation processes, and is used to remove soluble and insoluble matter from aqueous streams. Sedimentation is a purely physical process that uses gravity and inertia to settle suspended particles from solution. Specific gravity separation refers to the separation of fluids based on the specific gravity of its components. Filtration removes suspended solids from a liquid via disposable or backwashable filter media. Floatation is a process which uses the release of dissolved air or other gas to carry suspended particles to the top of a tank where they may be removed by skimming.

Air Stripping involves the transfer of volatile compounds from the aqueous phase or the gaseous phase. Air pollution control equipment may be required to contain the volatiles in the gaseous phase.

Adsorption is the process by which material is transferred from a gas or liquid to the surface of a material (sorbent) because of either physical or chemical surface forces. Activated carbon is the most widely accepted sorbent for volatile compounds and can remove metals at low quantity levels. Carbon can be used in both powder and granular form.

2.2.2.2 Off-Site Treatment

Transportation options consist of over-the-road transportation, railroad, or pipeline. Over-the-road transportation involves on-site storage and uses tanker trucks to periodically transport collected leachate. Railroad transportation involves staging several tanker cars and subsequent delivery to the facility. Pipeline transportation consists of constructing an underground or aboveground steel or plastic pipe to the nearest treatment facility connection. A description of industrial treatment facility and POTW facilities is provided in the following subsections. Facility treatment requirements for various physical and chemical parameters determine the off-site treatment options.

Industrial Wastewater Treatment Facility. Industrial facilities are commercial facilities that typically accept and treat a variety of industrial wastewater, including landfill leachates. These facilities generally feature a broad range of treatment processes which allow them to successfully remove a wide spectrum of contaminants. As such, these facilities normally have less stringent waste acceptance criteria than POTWs and often do not require pretreatment.

POTW. POTWs generally feature treatment processes specifically targeted for the decontamination of sanitary sewage. As such, many POTWs only have a limited ability to properly treat incoming foreign/industrial wastewater and, therefore, require relatively stringent pretreatment criteria for these wastewaters. In addition, approval is required from the local water pollution control authority to discharge wastewater to the POTW. Depending on the POTW requirements, on-site pretreatment may be required. Applicable pretreatment processes are presented in subsection 2.2.2.1. It remains to be determined if the local POTW can effectively treat the leachate or if it is willing to accept this discharge.

3.0 COST

The estimated costs are shown in Tables 3-1 and 3-2. These costs are preliminary and are presented to give a range of potential costs. The estimated costs are based on the following assumptions and the unit costs shown in Tables 3-1 and 3-2.

- Barriers, if installed, will surround the landfill (5,000 linear feet [LF]) and will have an average depth of 10 feet.

- Interceptor trenches, if used, will be installed along the downgradient (northern) limit of the landfill and the easterly and westerly limits; they will have a total length of 2,900 LF. If vertical barriers are installed, the trench will only be required along the downgradient limit (2,100 LF).

- If dewatering wells are used, ten will be required without barriers and seven will be required with barriers.

- To dewater the landfill without vertical barriers, whether interceptor trenches or dewatering wells are used, the groundwater withdrawal rate required is 150,000 gallons per day (GPD), or 54,750 thousand gallons per year (TGPY).

- To dewater the landfill with vertical barriers, the groundwater withdrawal rate required is 10 percent of that without barriers, or 5,470 TGPY.

- All operation and maintenance (O&M) costs are computed on a present value basis and assume a time period of 30 years and an interest rate of 10 percent.

Costs were estimated for two sets of alternatives. One set of alternatives does not include any vertical barriers and contains four alternatives as follows:

- **Alternative 1: $462,000.** This alternative utilizes interceptor trenches which surround the landfill to collect groundwater, and the groundwater collected is discharged directly (without treatment) to the POTW.

- **Alternative 2: $1,492,000.** This alternative also utilizes interceptor trenches which surround the landfill to collect groundwater; however, the collected groundwater is treated and discharged on site. Treatment consists of filtration followed by carbon adsorption.

- **Alternative 3: $207,000.** This alternative uses dewatering wells to collect groundwater, and the groundwater collected is discharged directly (without treatment) to the POTW.

- **Alternative 4: $1,237,000.** This alternative also uses dewatering wells to collect groundwater; however, the collected groundwater is treated and discharged on site. Treatment consists of filtration followed by carbon adsorption.

The other set of alternatives are the same as the first set except they all include the addition of vertical barriers. It was assumed that the amount of groundwater to be collected and treated under this scenario would be reduced 90% by installation of the vertical barriers. Total costs are as follows:

Alternative 1a: $1,978,00
Alternative 2a: $2,125,000
Alternative 3a: $1,790,000
Alternative 4a: $1,936,000

Based on the assumptions made in the cost estimates, the first set of alternatives which do not use a vertical barrier are cheaper. Among this first set, the most cost-effective alternative utilizes dewatering wells to collect groundwater and directly discharge this groundwater to the POTW. Further hydrogeologic characterization and analysis would be required to confirm the assumptions made. With better hydrogeologic data and more detailed cost estimates, the cost of these alternatives may vary.

Table 3-1
Preliminary Cost Estimates
Area A Landfill
Groundwater Collection and Disposal

Process Option		Quantity	Units	Unit Cost	ALT. 1	ALT.2	ALT. 3	ALT. 4
Slurry walls	CAP	50000	SF	$25.00				
Sheet pile walls	CAP	50000	SF	$25.00				
Interceptor Trenches	CAP	2900	LF	$100.00	$290,000	$290,000		
	O&M	1	LS	$725.00	$6,835	$6,835		
Dewatering wells	CAP	10	EACH	$10,000.00			$100,000	$100,000
	O&M	1	LS	$500.00			$4,713	$4,713
POTW	CAP	1	LS	$25,000.00	$25,000		$25,000	
	O&M	54750	TGPY	$0.05	$25,806		$25,806	
On-site treatment	CAP	1	EACH	$500,000.00		$500,000		$500,000
	O&M	54750	TGPY	$0.63		$325,158		$325,158
Engineering & cont.	33%				$114,721	$370,257	$51,321	$306,858
				TOTAL:	**$462,362**	**$1,492,250**	**$206,841**	**$1,236,729**

CAP - capital cost
O&M - operation and maintenance cost. Present value.
SF - square feet
LF - linear foot
LS - lump sum
TGPY - thousand gallons per year

Table 3-2
Preliminary Cost Estimates
Area A Landfill
Vertical Containment and Groundwater
Collected and Disposed

Process Option		Quantity	Units	Unit Cost	ALT. 1a	ALT.2a	ALT. 3a	ALT. 4a
Slurry walls	CAP	50000	SF	$25.00				
Sheet pile walls	CAP	50000	SF	$25.00	$1,250,000	$1,250,000	$1,250,000	$1,250,000
Interceptor Trenches	CAP	2100	LF	$100.00	$210,000	$210,000		
	O&M	1	LS	$525.00	$4,949	$4,949		
Dewatering wells	CAP	7	EACH	$10,000.00			$70,000	$70,000
	O&M	1	LS	$350.00			$3,299	$3,299
POTW	CAP	1	LS	$20,000.00	$20,000		$20,000	
	O&M	5475	TGPY	$0.05	$2,581		$2,581	
On-site treatment	CAP	1	EACH	$100,000.00		$100,000		$100,000
	O&M	5475	TGPY	$0.63		$32,516		$32,516
Engineering & cont.	33%				$490,885	$527,163	$444,140	$480,419
				TOTAL:	**$1,978,415**	**$2,124,628**	**$1,790,020**	**$1,936,234**

CAP - capital cost
O&M - operation and maintenance cost. Present value.
SF - square feet
LF - linear foot
LS - lump sum
TGPY - thousand gallons per year