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SUPPLEMENTAL INVESTIGATION REPORT & REMEDIAL ACTION PLAN NON-PUBLIC PROPERTIES STUDY AREA HAMDEN, CONNECTICUT

Prepared for:

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MARCH 2005

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ENVIRONMENTAL ENGINEERS, SCIENTISTS & PLANNERS

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DOCUMENT CERTIFICATION

I have personally examined and am familiar with the information submitted in this document and all attachments thereto, and I certify, based on reasonable investigation, including my inquiry of those individuals responsible for obtaining the information, that the submitted information is true, accurate and complete to the best of my knowledge and belief. I understand that any false statement made in the submitted information is punishable as a criminal offense under §53a-157b of the Connecticut General Statutes and any other applicable law.

____

Chief Executive Officer (or duly authorized representative)
Olin Corporation

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Malcolm Pirnie, Inc.
Responsible for document preparation

1.0 INTRODUCTION

1.1 REGULATORY STATUS

On July 10, 2001, the Connecticut Department of Environmental Protection (CTDEP) issued unilateral Order No. SRD-128 to Olin Corporation and three other potentially responsible parties. This order was subsequently appealed by all parties and resulted in Consent Order No. SRD-128 (the original unilateral order number was retained) being entered on April 16, 2003 as the final decision of the hearing officer (see Appendix A). It separates the Hamden Middle School and adjacent area, located in Hamden, Connecticut (see Figure 1-1), into Public Properties and Non-Public Properties (NPP) study areas, which together make up the "site".

As shown on Figure 1-1 and Sheet 1, the 100-acre site is located in the southern portion of Hamden, Connecticut, east of Dixwell Avenue and just north of the border with New Haven. The 36-acre Public Properties study area consists of:

- Hamden Middle School, 550-560 Newhall Street (formerly the Michael J. Whalen Junior High School).
- Hamden Community Center, 496 Newhall Street (formerly the Newhall Street School).
- Rochford Field.
- Mill Rock Park (a.k.a. Rochford Field Annex).
- Two Hamden Housing Authority properties, 249-251 and 253-255 Morse Street.
- The sewage pump station, 1099 Winchester Avenue.

The approximately 64-acre NPP study area has two portions, a smaller approximately 5.6-acre portion lying north of, and a larger approximately 58.4-acre portion lying south of, the intervening Public Properties study area. Based on the base plan from the Town of Hamden assessors map (revised April 2000), 303 properties were identified in the NPP study area (some adjacent properties with common ownership, if known, are counted as one). For ease of geographic reference, the city blocks are given the letters shown on Sheet 1. The NPP includes blocks A, C, E, F, H, J, K, L, M, N, P, Q, R, S, and T.

The Consent Order directs Olin to prepare a work plan to determine the extent and degree of soil, surface water, and ground water pollution resulting from the disposal of waste on the NPP study area as encompassed within the areas outlined on Figure 1-1 and Sheet 1. The Public Properties, which are also shown on the figure and sheets, are adjacent to the NPP, are the responsibility of others under the Consent Order, and are not subject to the scope of work described in the work plan.

The "Supplemental Investigation Work Plan, Non-Public Properties Study Area, Hamden, Connecticut" was conditionally approved by CTDEP on April 23, 2004. In accordance with the Consent Order and conditional approval letter, the work plan included the following required elements:

- Proposed sampling and analytical program, including the parameters to be tested, the sampling and analytical methods, and quality assurance/quality control procedures.
- Proposed locations and depths of groundwater monitoring wells and soil and surface water samples.
- Proposed schedule for conducting the investigation, including deliverable reports and dates of report submissions to the CTDEP.

1.2 PREVIOUS STUDIES

Several consultants and environmental regulatory agencies have conducted studies and/or limited interim remedies within the NPP study area. After sampling soil or fill at 76 properties during April 2001, USEPA conducted limited removal of surficial materials at 11 properties within the NPP study area between October 1, 2001 and May 1, 2002. Between December 2000 and November 2002, the CTDEP conducted investigations (soil/fill and groundwater) within the NPP study area. During this period, the Town of Hamden compiled background information on the site as part of a Phase I environmental site assessment. During September and October 2002, HRP Associates, Inc. completed environmental assessment reports on the properties at 425 and 449 Newhall Street. Loureiro Engineering Associates, Inc. completed a "Draft Phase II Subsurface Investigation Report" on these properties in March 2004. In the summer of 2002, Olin conducted a voluntary Initial Investigation on portions of the NPP study area. The results of Olin's Initial Investigation are summarized in the "Initial Investigation Findings Report, Newhall Street Residential Area, Hamden Connecticut", dated December 2002.

The Initial Investigation identified and described five geographically separate areas of fill within the NPP study area: Southwest Satellite Area, Morse Street Area, Newhall Street Area, Bryden Terrace Area, and Augur Street Area (Sheets 2 and 3). The Morse Street, Newhall Street, and Bryden Terrace Areas are contiguous to fill underlying the Public Properties to the north, which are the subject of investigations by others. The extent of filling on the site correlates with historical descriptions and photographs of filling in the record. Detailed descriptions of the history, extent, composition, chemistry, and current use of the fill areas are included in the following Conceptual Site Model, updated to include the information obtained from this supplemental investigation and March 2004 Loureiro report. Similar information on the filling of the Public Properties is included in this report only to the extent that the filling, due to its proximity, has a bearing on the Conceptual Site Model and affects the scope of work for the NPP study area.

Section 3.2.2 of the Supplemental Investigation Work Plan included a scope of work for an Isolated Fill Assessment. This section states that upon completion of the scope of work and following an initial evaluation of the results, an interim report and proposal for supplemental investigation, if warranted, will be made to the CTDEP. The reason for an interim report was because at the time of work plan preparation, the degree of isolated fill characterization was less than the degree of contiguous fill characterization. Therefore, a phased approach was required to increase the degree of isolated fill characterization so that a comprehensive final report could be prepared in accordance with the Data Quality Objectives. The isolated fill assessment began in June 2004 and, insofar as access was granted, was largely accomplished in accordance with the work plan by October 2004.

Malcolm Pirnie, Inc., on behalf of Olin Corp., prepared an "Interim Report on Isolated Fill, Non-Public Properties Study Area, Hamden, Connecticut." in November 2004. This interim report presents the initial evaluation of isolated fill and refined aspects of the conceptual site model regarding the presence and extent of isolated filling. Therefore, it included the following elements:

- Preliminary graphical presentation of the edge of contiguous fill (to better define what constitutes isolated fill).
- Tabular and graphical summaries of documentary, field, and historical data regarding isolated fill.
- Tabular presentation of field and laboratory analytical data.

These elements were evaluated together to prepare an updated conceptual site model regarding isolated fill. The interim report included a proposal for additional direct push borings primarily to further delineate and characterize known or suspected areas of isolated fill. CTDEP conditionally approved this report on January 11, 2005. This additional scope of work, insofar as access was granted and winter conditions permitted, was accomplished by February 9, 2005.

1.3 PROPERTY ACCESS

As a signatory to the Consent Order, the Town of Hamden granted access to perform work in public rights-of-way within the Study Area. Before entering a private property within the NPP Study Area to perform an investigation activity, permission was obtained from the property owner via a signed access agreement letter prepared by Olin. In April 2004, access agreement letters were mailed to the owners of 303 non-public properties. By the time field investigation activities began on June 7, 2004, access was granted to 133 properties (44%). Significant efforts and resources were continually used to obtain access to more properties. Activities included repeat mailings by certified mail with return receipt, numerous attempts to reach owners by phone, and many attempts to speak to owners face to face. By August 5, access was granted to 219 properties (72%); by September 7, the number was 260 properties (86%). At the conclusion of field investigation activities on February 10, 2005, access was obtained from 289 properties (95%).

Several obstacles were overcome to achieve this result:

- Inaccurate ownership information from the Hamden Assessor's office.
- Change of property owners before and during the investigation. On several occasions, gaining access was delayed pending closing of a property sale. Other times, ownership changed between conducting different phases of the investigation, which required securing multiple access agreements for the same property.
- Owners living out of town and out of state.
- Difficulty in finding owners to discuss the issue face to face.

Eight new groundwater monitoring wells were installed on 6 non-public properties. A different, more complex access agreement was required to allow for continued access for multiple sampling events before these wells could be installed. The process for obtaining access agreements for installation and monitoring of these wells took several months to complete.

Cooperation from the residents in the Study Area enabled the investigation to achieve nearly all its data quality objectives. Minor data gaps remain for the 14 properties where access was not obtained. These properties, highlighted in yellow on Sheet 1, are scattered throughout the Study Area. Wherever feasible, conclusions about these properties were inferred based on the results from neighboring properties. Sufficient data have been gathered from the Voluntary Initial Investigation and the Supplemental Investigation to support the conclusions stated later in this report.

1.4 DEFINITIONS

The following terms are strictly used in the work plan, interim report, and supplemental report as defined below. Any other term appearing in the CTDEP Remediation Standard Regulations (RSRs) (RCSA 22a-133k-1(a)) and not otherwise defined below is used in accordance with its RSR definition.

Soil

Unconsolidated, solid, subsurface material that was naturally placed (native) and is composed of geologic mineral and rock grains and/or natural organic matter. It does not include sediment as defined in the RSRs. Soil typically displays natural textural features such as varying grain size and/or composition sorted into laminations (<1/2-inch-thick) and layers (>1/2-inch-thick). Three types of soil occur in the site as defined by composition, texture, and mode of deposition: Fines, Sand, and Glacial Till.

Fines – Soil composed primarily of clay and silt sized mineral grains, with some very fine-grained sand and commonly including organic matter. Is typically dark colored (gray, brown, or black) and generally less permeable to groundwater than other soils. Deposited by slow-moving surface water in a restricted basin.

Sand - Soil composed primarily of sand sized mineral grains, with some gravel. Is typically pink or light red-brown colored and laminated or layered and generally more permeable to groundwater than other soil. Deposited by fast-flowing surface water in river channels.

Glacial Till - Soil composed of all grain sizes, including abundant cobbles and boulders, and completely non-sorted, typically red-brown colored, and exhibits no laminations or layers and with widely varying permeability to groundwater. Deposited by glacial ice.

Fill

Unconsolidated, solid, subsurface material that was artificially placed and/or disturbed. It is divided into three general types based on a bulk visual assessment of differing texture and composition: Disturbed Soil Fill, Refuse Fill, and Waste Fill.

Disturbed Soil Fill - Fill composed primarily of reworked natural soil. It may have been reworked locally or brought in from another location. It may contain minor or trace commingled proportions of brick, ceramics, concrete, asphalt paving fragments, and miscellaneous refuse such as wood debris, metal, or glass. This description is based on texture and the absence of other fill indicators, and does not imply that substance concentrations meet the RSR criteria in all cases.

Refuse Fill - Fill composed primarily of commingled articles such as wood (e.g. construction and demolition debris), metals, glass, ceramics, papers and cardboard, dishware, leather goods, bottles, cinders, paint chips, roof shingles, margarine containers and newspapers. Also may contain white to gray ash from the combustion of these articles and minor commingled proportions of reworked soil and rock, and ash, slag, and cinders. The key distinction is that it contains differing discarded and/or incinerated manufactured items but implies no specific source(s) for the items observed such as residential versus industrial/commercial. This type of fill is similar to municipal solid waste.

Waste Fill - Fill composed primarily of typically black ash, slag, cinders, coal and/or coke, or a discrete, identifiable waste product item in quantity (such as wood chips or batteries). It may contain a significant refuse fraction and/or minor commingled proportions of soil and rock. The key distinction is that it consists of materials disposed in quantity, indicative of a waste byproduct from a single source or source(s) that contributed loads, of discrete materials.

<u>Bedrock</u>
Consolidated or cemented, subsurface, solid material that was naturally placed and is composed of naturally produced mineral and rock grains. Bedrock contiguously underlies all soil and fill deposits and may outcrop at the ground surface such as at Mill Rock Ridge.

<u>Kettle</u>
A kettle is a natural, topographic basin formed where a block of glacial ice was buried by soil and then later melted. The melting of the ice causes the overlying and surrounding soil to collapse, leaving a depression with angle-of-repose side slopes and circular outlines. Larger ones are complexly segmented and typically contain surface water bodies.

<u>Logging</u>
The collection and description of small, representative portions of fill, soil, or bedrock for the purpose of visually identifying and describing these materials.

<u>Sampling</u>
The collection of representative portions of fill, soil, groundwater, or surface water for the purposes of field or laboratory analyses of the material and/or of substances within the material.

<u>Surficial</u>
That portion of fill or soil that is within 0.5 feet beneath the ground surface.

<u>Underlying</u>
That portion of fill or soil that is deeper than 0.5 feet beneath the ground surface.

1.5 STATEMENT OF THE PROBLEM

Environmental investigations, beginning in 1989 at the Hamden Middle School and expanding into the adjacent NPP, identified areas where wetlands formerly existed and/or where waste materials were historically placed. The investigations revealed that fill including, but not limited to, ash, slag, and coal waste, as well as other industrial and household waste is buried throughout the area in varying proportions and at various locations.

Soil and fill are potentially polluted with metals, polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and total petroleum hydrocarbons (TPH).

In accordance with the Consent Order, Olin shall perform all investigations that the CTDEP Commissioner deems necessary to determine the extent and degree of pollution of the NPP and perform the remediation of the NPP, in accordance with the Regulations of Connecticut State Agencies (RCSA), Sections 22a-133k-1 to k-3 ("Remediation Standard Regulations"). Because the Commissioner determined that Olin's Initial Investigation Report was incomplete, Olin submitted for the Commissioner's review and written approval a scope of study for a supplemental investigation on the portion of the site encompassed by the NPP to:

- Define the three-dimensional extent and the physical and chemical nature of fill materials.
- Determine the extent and degree of soil, surface water, and groundwater pollution resulting from such fill.

This required the development of a conceptual site model (CSM) describing and evaluating the information, whether generated by Olin, CTDEP, or other responsible parties, on the site's physical condition and history, particularly the:

- Location, extent, thickness, and types of fill.
- Chemical and physical characteristics of the fill and how they vary.
- Origin of the fill.
- Effect filling has on the quality of soil, groundwater, and surface water.

The evaluation also identifies the gaps in Olin's understanding of the extent and degree of pollution and provides a basis for the scope of work needed to collect the data necessary to fully characterize the pollution on the NPP.

1.6 SUBSTANCES OF CONCERN

The substances of concern (SOC) for the Supplemental Investigation were based on an evaluation of laboratory analytical data from the Initial Investigation and communications by CTDEP (Conditional Approval letter dated April 23, 2004; letter dated December 1, 2004).

The SOC include fifteen metals (antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, zinc), ETPH, and PAHs. In addition, semi-volatile organic compounds (SVOCs) are SOC for samples collected as part of the Isolated Fill Assessment, and PCBs and chlorinated pesticides are SOC primarily in areas where filling was known to occur after the mid-1930s. Volatile organic compounds (VOCs) are SOC for samples with field photoionization detector readings above background and asbestos is a substance of concern in samples containing demolition debris.

No site-specific data have been obtained for polychlorinated dibenzodioxins and polychlorinated dibenzofurans (D/F). Therefore a subset of samples for which PCBs or benzo(a)pyrene have been detected will be analyzed for D/F in accordance with Malcolm Pirnie's December 22, 2004 letter request, which was approved by CTDEP on February 25, 2005. The results will be evaluated, and reported in an addendum report later, to determine if these chemicals are substances of concern in the study area.

1.7 DATA GAPS

Several data gaps were identified in the Conceptual Site Model in the Supplemental Investigation Work Plan. Based on the findings from the Initial Investigation, the composition and approximate edge of the contiguous fill areas were delineated to a thickness of one foot. Delineation of the perimeter of fill for all contiguous fill areas was needed. In the Morse Street fill area, the extent and thickness of fill was uncertain in the properties from 259 to 321 Morse Street. Three elliptical shaped areas of contiguous filling were identified in blocks H, J, and L in the Southwest Satellite fill area. Verification of the maximum thickness and enhanced delineation of the perimeter of fill was needed in all 3 blocks plus in block M to the east. In the Newhall Street fill area a band of fill was identified in the western part of blocks E, P, and Q contiguous with Rochford Field to the north. Delineation of the perimeter of fill was needed to the east, south, and west across Newhall St. in blocks K and N. A rectangular mass of fill encompassing nearly all of blocks C and F and contiguous with filling in Mill Rock Park to the north was identified in the Bryden Terrace fill area. Delineation of the perimeter of fill was needed, particularly to the south in blocks R and S, and along the eastern edge of block E. In the Augur Street fill area an elliptical shaped area of filling was identified in the western section of block T. Delineation of the perimeter of fill was needed to the east and into the southern portion of block T extending to the Public Properties.

The Initial Investigation provided data on the analytical composition of the fill from each contiguous fill area. However, greater analytical characterization was needed of the surficial sand, surficial fill, fill at depth, and native soil beneath the fill for all SOCs in each contiguous fill area.

Based on historical information and limited sampling, CTDEP identified several properties containing small areas of isolated fill outside the contiguous fill areas. The extent and characterization of isolated fill areas in the NPP study area was identified as a data gap.

The dataset for groundwater quality within the NPP study area was limited to 1-time grab samples obtained from 25 borings during Olin's Initial Investigation and periodic samples from 4 wells installed by GZA GeoEnvironmental, Inc. for CTDEP. Lack of an adequate network of groundwater monitoring wells presented a data gap for determining the effects, if any, of fill materials on groundwater quality in the NPP study area.

1.8 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are qualitative and quantitative criteria used to determine when there are enough representative data of sufficient precision and accuracy to address the data gaps in the CSM presented in the Work Plan and Interim Report (see Section 2.0). The DQOs determine when, where, and how many samples to collect and analyze, and the desired level of confidence needed to make a decision. Like the CSM, the development of DQOs is an iterative process. Existing data and data gaps in the CSM are evaluated relative to the DQOs to determine what data gaps are significant. Then the sampling and analysis plan is developed or modified accordingly to address the significant data gaps.

Closing data gaps and verifying the CSM requires additional characterization, which includes determining where and how many samples to collect (described in detail in Section 3.2). Once the sample locations are selected, other DQOs address the analyses to perform, and the sampling procedures, analytical methods, and required accuracy of the analyses. The Work Plan (and additional work proposed in the interim report and requested by CTDEP during the supplemental investigation) was developed to ensure that the uncertainties in data accuracy are minimal, the database is of sufficient size, and the results are appropriate for comparison to RSR criteria. These procedures are discussed in the Quality Assurance Project Plan.

For the study area the primary DQOs are identifying and delineating actual and potential release areas (contiguous and isolated fill areas) and associated substances of concern (SOCs). In this case the data quality objective is spatial. The areas of contiguous fill are understood well enough to predict which parcels lay completely within them even if not previously investigated, but presumed fill thicknesses need to be verified. These DQOs were addressed through research into site history, interviews with knowledgeable individuals, historic maps, photographs, correspondence, reports, and field work. Only the edge of fill must be mapped on a parcel-specific scale so that the degree of contiguous fill at any given parcel can be predicted and remedial decisions can be made for each separately owned parcel of the study area. The same parcel-specific DQO is needed for finding and characterizing isolated fill areas because of the general absence of detailed historical documentation and their presumed smaller extent. This information is summarized in the following sections and was evaluated to determine if there is enough information of sufficient detail or quality to meet the objectives.

For evaluating SOCs, the DQOs required that the individual analyses have detection limits that are below remedial criteria and that the samples are representative of the materials potentially requiring remediation. The materials themselves are visually distinctive such that laboratory analyses are not needed to distinguish fill material from soil. Because the nature of the release was the placement of fill into low-lying areas, with the SOCs intrinsic to the fill when placed, the occurrence of SOCs was presumed to be coincident with the occurrence of fill and mobility within environmental media. The DQO was determining the range of SOC concentrations in fill and the occurrence and range of SOC concentrations in surrounding soil and groundwater. The ultimate goal was to obtain the ability to predict the presence or absence of SOC concentrations relative to remedial criteria. Samples were collected anywhere from within or around/outside the fill areas to meet this objective and determine remedial needs. However, given the scale of the study area features, a sizable database was needed to make reliable comparisons between the range of SOCs in fill and in the soil and to assess if and how the SOCs may have migrated out of the fill.

For groundwater characterization, the DQOs were both spatial and temporal. Reproducible sampling locations at representative points throughout the study area were needed to determine how groundwater flow and SOC concentrations vary in both space and time.

Aside from a few areas of the site where access was not granted or where field conditions did not allow data to be obtained, the CSM is considered largely complete and representative of conditions. Data from various sources are in agreement and successfully predict observed the conditions. The DQOs resolved the data gaps such that the problems can be logically explained to the stakeholders, and a remedial action plan can be developed. The remainder of this report presents the scope of work used to meet the DQOs and the updated CSM resulting from the supplemental investigation activities. The Remedial Action Plan (RAP) is presented as Section 5 of this report.

2.0 SUPPLEMENTAL INVESTIGATION SCOPE OF WORK

This section describes the scope of work conducted during the supplemental investigation in accordance with the work plan as modified by, the conditional approval letter, the approved Interim Report, and additional requests by CTDEP. Table 2-1 summarizes the investigation activities conducted on each parcel in the NPP study area.

2.1 CONTIGUOUS FILL ASSESSMENT

2.1.1 Extent Delineation

Approach and Procedures

To obtain a more precise delineation of the approximate edge of contiguous fill, investigations of every property along the edge (access permitting) were conducted via iterative, shallow subsurface borings. Table 2-1 lists the 95 non-public properties previously determined to be intersected by the edge of contiguous fill. One or more transects, of typically three borings each, were advanced across the inferred fill perimeter on these properties, as shown on Sheets 2 and 3. Because these 115 planned transects extended onto some adjacent properties, a total of 119 properties, listed in Table 2-1, were included in the contiguous fill extent delineation. Exact placement of the transect borings in the field followed these guidelines:

<u>Determination of Transect Location</u>

An initial visual reconnaissance inspection of the properties was conducted for the purpose of identifying potential filling. The inspection focused on any potential indication of filling that would guide the initial boring locations, including the following:

- Debris/waste visible at the ground surface.
- Differences in relief, apparent terracing or filled areas, especially along property lines.
- Areas of ground surface depressions.
- Hummocky or uneven terrain.

- Bare spots and/or stressed vegetation.

Based on the inspection, the investigation proceeded from within the fill to the outside or from native soil to the inside, depending on the material intersected by the first boring. Typically, three borings were advanced; more were drilled if necessary. The drilling program resulted in:

- Transects that are roughly perpendicular to the inferred fill perimeter.
- Borings along the transect that are spaced approximately 20 feet apart.

Wherever possible, borings were advanced using hydraulic direct push drilling equipment, supplemented by hand-operated direct push, when necessary, in sensitive or physically inaccessible areas. The direct-push method creates minimal disturbance to the ground surface. Incidental damage caused by the vehicle itself was rare, but any damage to lawns or pavement was repaired. Direct-push borings fully penetrated the fill materials and advanced into native soil. The borings were inspected and logged to confirm the absence and presence of fill or soil. The materials encountered were evaluated for color, odor, and texture and field screened for concentrations of volatile organics using a photoionization device. Based on the materials observed, the transect progressed in the direction necessary to determine the edge of fill by identifying the surrounding, undisturbed native soil. The number of points and their depth, and the degree that each technique was employed at any property depended on the physical circumstances such as access by the drilling rig, subsurface utilities, landscaping, paving or buildings.

In transects that straddled the edge of fill, one sample was collected from undisturbed native soil from the boring located closest to the outside edge of fill. The soil sample was collected from the same depth horizon of the fill found in the adjacent borings. In transects where the edge of fill could not be determined, e.g. the transect extended to the edge of the study area or to a property where access was not granted, a native soil sample may have been collected from beneath the thinnest fill found in the transect. Each native soil sample was analyzed in the field with an x-ray fluorescence (XRF) device for the metals (Appendix E). The XRF instrument was used as a field screening tool for identifying lead in soil samples. For every three native soil samples collected, the one with the highest XRF lead concentration was submitted for laboratory analysis. The analyses were used to document the concentrations of substances of concern outside the fill from transects that lie approximately every 150 feet along the inferred fill perimeter. The soil samples were analyzed by a certified laboratory for the following substances reasonably expected to be found in the contiguous fill:

- Total and SPLP metals by methods 6010B/7470A and 1312
- ETPH by method CTETPH
- PAHs by method 8270C
- Pest/PCBs by method 8081 (only in areas where filling may have postdated the mid 1930s as described in the Conceptual Site Model)

If ETPH concentrations in samples from around fill pre-dating the mid-1930s were elevated, then these samples were also analyzed for pesticides and PCBs.

At CTDEP's request any additional soil sample with XRF lead concentration exceeding 200 mg/kg was submitted for laboratory analysis of total lead and arsenic.

The locations of the borings and the subsequent delineation of the edge of fill were plotted on plans by measuring their distance from permanent landmarks. The overall delineation of the edge of fill compiled from the individual property investigations was added to the site plan (Sheets 2 and 3).

Contiguous Fill Extent Delineation Summary	
Contiguous Fill Borings	408
Transects	118
Properties Included in Extent Delineation	119
Native Soil Samples Analyzed by XRF	149
Native Soil Samples Analyzed by Laboratory	60

2.1.2 Bare Spot Characterization

Approach and Procedures

A visual inspection of 162 of the Non-Public Properties within, and on the edge of, the known contiguous fill areas was performed to identify the presence of any bare spots. When and where appropriate, this inspection coincided with, and in certain instances guided, the Extent Delineation activities described above. The bare spots were mapped on each property, including places where vegetation has been worn away or is stressed due to:

- Frequent animal or pedestrian activities.
- Proximity to outdoor structures such as swing sets and picnic tables.
- Absence of direct sunlight limiting the growth of vegetation.

Samples were collected at each property exhibiting bare spots. One surface sample was collected at a depth of 0 to 6 inches from each bare spot observed. All samples were analyzed in the field with an XRF device for metals. The sample with the highest XRF lead results from each property was sent to a certified laboratory for the following analyses:

- Total and SPLP SOC metals by methods 6010B/7470A and 1312.
- PAHs by method 8270C.

At CTDEP's request, any additional bare spot samples with XRF lead concentration exceeding 200 mg/kg, were submitted for laboratory analysis of total lead and arsenic.

The locations of all bare spots and sampling points were pin flagged, photographed, and plotted on site maps by measuring distances from permanent landmarks.

Bare Spot Characterization Summary	
Properties Inspected	162
Properties with Bare Spots	86
Samples Analyzed by XRF	167
Samples Analyzed by Laboratory	115

2.1.3 Additional Characterization

Approach and Procedures

A data gap identified by the CSM was the need for additional characterization of the bulk of the contiguous fill material and of native soil underlying fill. This data gap was addressed by collecting samples from the borings drilled for the installation of monitoring wells within the thickest parts of the fill areas. These borings were also used to confirm the thickness of fill in each area.

One 2-foot long split-spoon sample of fill was collected for laboratory analysis from each 5-foot fill thickness interval. One sample of native soil immediately underlying fill was also collected from each well boring that penetrated fill, additional contiguous fill samples from the Augur Street Area were collected from transect borings to augment characterization of this area. The samples were analyzed for SOC metals (total & SPLP), PAHs, ETPH, PCBs, and pesticides.

Additional Contiguous Fill Characterization Summary

Boring	Fill Thickness (ft)	Fill Samples	Native Samples
	Southwest Satellite Area		
H2002S	19	4	1
H2002D	19	4	1
J2001S	10	4	0
L2001S	14	3	1
L2001D	14	3	1
	Newhall Street Area		
E2002D	10.6	2	1
Q2002S	10.2	2	1
Q2002D	10.2	2	1
	Bryden Terrace Area		
C2001D	11	3	1
F2001S	2	1	1
F2001D	2	0	0
F2002S	10.5	2	1
	Augur Street Area		
T2002S	2.8	1	1
T2003S	12	2	0
T1075	5.4	1	0
T1077	2	1*	0
T1079	4	1	0
T1080	4	1	0
	TOTAL:	**37**	**11**

*****Fill sample was analyzed for total lead and arsenic only.

2.2 ISOLATED FILL ASSESSMENT

2.2.1 Isolated Fill Investigation

Approach and Procedures

Concurrent with the boring program described below, a visual reconnaissance inspection of 124 properties outside the known contiguous fill portion of the NPP study area was conducted for the purpose of identifying potentially smaller, isolated areas of filling. The inspection focused on any potential indication of filling, including the following:

- Debris/waste visible at the ground surface.
- Differences in relief, apparent terracing or filled areas, especially along property lines.
- Areas of ground surface depressions.
- Hummocky or uneven terrain.
- Bare spots and/or stressed vegetation.

The bare spots were mapped for each property, including places where vegetation has been worn away or is stressed due to:

- Frequent animal or pedestrian activities.
- Proximity to outdoor structures such as swing sets and picnic tables.
- Absence of direct sunlight limiting the growth of vegetation.

When possible, anecdotal information was gathered from property owners or residents.

2.2.2 Isolated Fill Borings

Approach and Procedures

An initial sampling program was conducted at 50 selected properties outside the currently inferred perimeter of contiguous filling based on the following criteria:

- Properties whose owners reported the presence of debris or potential indicators of fill and that have not been previously investigated.
- Properties adjacent to the 6 properties where CTDEP already identified isolated fill.

- Properties adjacent to fill found by CTDEP rights-of-way borings and that have not been previously investigated.
- Properties not otherwise selected, but which provide additional geographic coverage of the NPP study area.

Boring locations were established in the field and may differ from the proposed locations due to access issues, physical constraints, utility clearance, and the findings of an initial inspection of these properties (as described above).

The Interim Report on Isolated Fill presented the results of the borings drilled at the original 50 properties and the initial inspections performed on the 124 properties outside the known contiguous fill areas. Most isolated fill areas were identified by one boring with the closest surrounding borings typically on the order of 100 feet away. Historical data, interviews with residents, and inspection data also did not indicate isolated fill areas larger than this distance. Therefore, the Interim Report included a proposal for additional direct push borings at 65 properties primarily to further delineate and characterize known or suspected areas of isolated fill identified. This additional work was performed in January and February 2005.

Four borings were typically drilled around and approximately 20 feet away from a boring where isolated fill was identified. This was an iterative process to better delineate the extent of each area of isolated fill. If fill was found in one boring, additional borings were drilled in a manner similar to that for transects (described in Section 2.2.1) until the isolated fill area was delineated. Not all isolated fill areas were completely delineated on all sides because some areas were not accessible to the direct push rig or access to an adjacent property was not granted.

Two other potential indicators of fill were also investigated. One is reports of "debris", abnormal soil color, or burn pits observed by residents or during property inspections conducted for this investigation. Sixteen borings were drilled on 13 properties to investigate these reports. Fill was found on 7 of these properties. The investigation was not completed on 4 additional properties due to the inaccessibility of the direct push rig. Hand operated direct-push drilling could not be used in the frozen ground. In addition, borings were proposed in a representative number of observed surface depressions to investigate if these features are indicators of filling. Ten surface depressions were investigated outside the area of known contiguous fill. Isolated fill was found in 4 of them. Due to the presence of significant snow cover, these features could not be identified at all proposed locations.

Wherever possible, borings were advanced using hydraulic direct push drilling equipment, supplemented by hand-operated direct push, when necessary, in sensitive or physically inaccessible areas. The direct-push method creates minimal disturbance to the ground surface. Incidental damage caused by the vehicle itself was rare, but any damage to lawns or pavement was repaired. Due to frozen ground up to 1.5 feet thick in January and February, the hand driven direct push alternative was not feasible during the additional isolated fill investigation.

Direct-push borings fully penetrated any fill materials and were advanced into native soil. The borings were inspected and logged to confirm the absence or presence of fill or soil. The materials encountered were evaluated for color, odor, and texture and field screened for concentrations of volatile organics using a photoionization device. Subsequent to the physical characterization of the materials, a determination was made whether any fill encountered is of limited extent and potentially attributable to on-site residential activities or alternatively, potentially attributable to and contemporaneous with other filling within the area. The locations of any isolated fill and any sampling points were plotted on site maps by measuring distances from permanent landmarks. The occurrence of any isolated fill was added to the site plan.

Fill samples were collected from each boring where fill was encountered. All samples were analyzed in the field for metals with an XRF device. If fill was found in more than one boring on the same property, the sample with the highest XRF lead concentration was submitted to a certified laboratory for analysis of the following substances:

- Total and SPLP metals, ETPH, SVOCs, and, in areas where filling may have post-dated the mid 1930s, pesticides/PCBs.

Any other fill samples with XRF lead concentrations greater than 200 mg/kg were submitted to a certified laboratory for total lead and arsenic analysis.

If fill was not observed in a boring, a native soil sample was collected and analyzed in the field for metals by XRF. During the additional isolated fill investigation conducted in

January and February 2005, the native soil sample with the highest XRF lead concentration detected for that property was submitted to a certified laboratory for analysis of the following substances:

Total and SPLP metals, ETPH, PAHs, and, in areas where filling may have post-dated the mid 1930s, pesticides/PCBs.

In addition, any other native soil samples with XRF lead concentrations greater than 200 mg/kg were submitted to a certified laboratory for total lead and arsenic analysis.

Bare spots were identified coincident with isolated fill on 6 properties. In December 2004, CTDEP requested that bare spots overlying isolated fill areas also be sampled and analyzed in the field by XRF. Samples with XRF lead concentrations greater than 200 mg/kg were to be submitted to a certified laboratory for total and SPLP lead and arsenic analysis. Due to snow cover and frozen ground, bare spot samples were not collected at 4 properties.

Isolated Fill Delineation Summary	
Isolated Fill Borings	322
Properties Included in Isolated Fill Delineation	75
Isolate Fill Samples Analyzed by XRF	138
Native Soil Samples Analyzed by XRF	176
Isolated Fill Samples Analyzed by Laboratory	83
Native Soil Samples Analyzed by Laboratory	37

2.3 GROUNDWATER INVESTIGATION

Malcolm Pirnie, Inc. installed 29 monitoring wells in accordance with the rationale presented in the work plan. Some of the proposed locations were modified and approved by CTDEP because of field constraints. As a result, proposed wells P2002S and P2002D were relocated across Marlboro Street from their original location and therefore were redesignated as Q2002S and Q2002D. Four existing shallow monitoring wells were incorporated into the monitoring plan in accordance with the work plan (BT-113-MW, WIN-1067-MW, MS-109-MW, NH-499-MW). Water level measurements were also obtained from two wells in the Public Properties study area (HA-108-MW, HA-109-MW).

Most monitoring well borings penetrated sand and thus were drilled using 8-inch-diameter hollow-stem augers. However, where glacial till and bedrock were encountered, which was not originally expected, 4-inch-diameter steel casing was driven and cleared out using a roller bit until refusal at bedrock. Bedrock was cored if necessary using a 3-inch diameter core barrel. Monitoring well boring logs and construction details are presented in Appendix D. A summary of the monitoring well network is included in Table 2-2.

Each new monitoring well was constructed in accordance with the draft CTDEP Water Management Bureau February 1990 guidelines. Typical water table and deeper monitoring well details are shown in the Quality Assurance Project Plan. The 10-foot-long screens and attached riser pipes consist of 2-inch inside-diameter, schedule 40 PVC placed to the bottom of the borehole. To aid in minimizing groundwater sample turbidity, the screens have 0.010-inch-wide slots, the minimum slot size commercially available. A clean sand pack was placed around and two feet above the top of the screen. About two feet of bentonite was placed above the sand pack to prevent migration of materials down the outside of the well casing to the well screen. The remainder of the borehole was filled with a bentonite/cement grout to grade. Each well was finished with an 8-inch-diameter curb box mounted flush with grade. A locking expansion plug was placed on each well riser pipe.

Following installation, each well was developed to remove cuttings and drilling water from the well, sand pack, and surrounding formation until the groundwater was relatively sediment-free. Depending on well yield, development was accomplished with pumps and/or bailers. After development, the wells were left undisturbed for one to two weeks to allow hydraulic and chemical conditions around the well to equilibrate prior to sampling. Well development purge wastewater was containerized for proper off-site treatment/disposal.

The top of each PVC riser pipe and the ground surface adjacent to each well was surveyed to the nearest 0.01 foot relative to on-site benchmarks. To be consistent with the topography depicted on the base maps obtained from the Town of Hamden, the wells were located relative to the following standards:

- Horizontal location: CT State Plane coordinates, NAD 1983.
- Vertical elevation: North American Vertical Datum (NAVD) 1988.

A total of 31 wells (29 new wells and 2 existing wells) were sampled as part of the groundwater investigation. Due to access issues four of these wells, C2001D, E2002D, H2002S, and H2002D, were not installed in time for the first round of quarterly groundwater sampling conducted November 16-19. All 31 wells were sampled during the second round of quarterly groundwater monitoring February 7-10. All of the wells were sampled in accordance with the QAPP with the exception of E2002D. This well is screened in bedrock and exhibited a very slow recharge rate and substantial draw-down during low-flow purging. Filtering of the metals sample from E2002D was necessary due to the low yield of the well and resulting high turbidity. Two existing wells (MS-109-MW and WIN-1067-MW) could not be sampled in accordance with the QAPP because they contained insufficient standing water.

Before sampling groundwater, water levels were measured in all monitoring wells concurrent with measurements at the Public Properties by the other Respondents. The monitoring wells were sampled in accordance with CTDEP standards using low-flow (<300 milliliters/minute) submersible pumps to minimize sample turbidity with the goal of achieving less than five NTUs and less than one-foot of water level drawdown. During well purging and sampling, the groundwater was analyzed in the field for turbidity, pH, temperature, and specific conductance. All well sampling purge wastewater was containerized for proper off-site treatment/disposal.

2.4 DATA VALIDATION

The purpose of the data validation review is to determine the usability of the data generated by the laboratory by evaluating specific quality assurance and quality control (QA/QC) parameters. All laboratory analytical data generated for Olin during the

Supplemental Investigation (June 2004 – February 2005) were reviewed by an independent, third-party and evaluated in accordance with the project QAPP, and with guidance from the USEPA CLP National Functional Guidelines for Organic and Inorganic Data Review. This report does not comment on the validity of data collected by other investigators. The data validation reports completed to date are included on CD in Appendix I. The specific QA/QC parameters are:

- Chain-of-Custody Documentation
- Laboratory Narrative Discussion
- Holding Times
- Field, Trip, and Method Blank Contamination
- Surrogate Compound Recoveries
- Sample Matrix Spike/Duplicate Recoveries and Correlations
- Laboratory Control Sample (LCS) Spike Recoveries
- Field Duplicate Correlations
- ICP Interference Check Samples

This evaluation indicates the accuracy and precision of the sample results reported by the laboratory. If standard QA/QC parameters were found to lie outside validation action limits, results for those analytes may be qualified (list of qualifiers may be found in Appendix I) or rejected. For example, matrix interferences can affect surrogate recoveries for analysis of organic compounds, which may indicate a high bias in the detected values. As a result of the validation, the associated results would be considered estimated and flagged accordingly ("J" flag).

According to the data validator, "In summary, the organic and inorganic analyses were performed acceptably and the data quality is good. There does not appear to be a significant sample matrix effect on [SOC] recoveries, and most results are usable as reported, or usable with minor qualification of reported results as estimated in value. Some low level analyte detections are considered external contamination." Results for the principal SOCs (arsenic, lead, SPLP lead, PAHs, and ETPH) were not significantly qualified with one exception. Benzo(b)fluoranthene and benzo(k)fluoranthene were reported as a combined value as benzo(b)fluoranthene in several samples, due to the matrix effect on resolving the analytes. This creates a falsely high result for the former and falsely low result for the latter. Therefore, the results for those two compounds in the affected samples are considered as estimated ("J"), with those stated biases. The CTDEP

RSR criteria are more strict for benzo(b)fluoranthene, so the reported bias occurs in a more conservative direction. The combined values reported as benzo(b)fluoranthene in some of the affected samples exceed the RSR criteria, whereas they may not have been if the compounds had resolved.

The data validation reports confirm that the QA/QC procedures for the Supplemental Investigation followed during field sampling and in the laboratory produced reliable results according to the data quality objectives established in the work plan. None of the qualified data affect the findings presented in this report. Data generated by other investigators are presented in this report for information only. No assumption is made as to the validity or quality of those data. However, given the magnitude of data collected as a result of the Initial and Supplemental Investigations, there are no significant data gaps that affect the overall conclusions and recommendations of this report.

3.0 CONCEPTUAL SITE MODEL

3.1 SOURCES OF INFORMATION

Malcolm Pirnie evaluated available data from multiple sources in formulating a conceptual site model (CSM) for the NPP study area. Appendix B summarizes most of the historical information and contains a list of documents and aerial photographs that provided the best historic information regarding chronology of filling at the site. In addition to Olin's 2002 Initial Investigation, the results from other investigations of the site (see Section 1.2), especially maps, boring and test pit logs, well completion logs, field notes, cross-sections, groundwater level measurements, and other field observations provided additional physical and analytical information supporting the CSM. Malcolm Pirnie has assembled physical and analytical data from the following numbers of borings, wells, and test pits within the NPP:

Total number of borings:	931
Olin Supplemental Investigation:	759
Transect borings:	408
Isolated fill borings:	322
Well borings:	29
Olin Initial Investigation:	78
CTDEP:	51 (mostly in rights-of-way)
Louriero Engineering Associates:	20 (425-431 and 449 Newhall Street)
HRP Associates:	9 (425-431 and 449 Newhall Street)
Haley & Aldrich:	9 (geotechnical in Blocks C, E & F)
Leggette, Brashears & Graham:	5 (bordering the Public Properties)
Total number of monitoring wells:	33
Olin Supplemental Investigation:	29
Haley & Aldrich:	4 (Blocks C, E & F)
Total number of test pits (CTDEP):	11 (6 properties)

To facilitate the evaluation and interpretation of the stratigraphic and analytical information from the various studies, these data were compiled into electronic databases and combined with digital maps using geographic information software (GIS) to display the information in 3-D space. Stratigraphic data and the location of the source information for these representations are summarized in Appendix C. Monitoring well logs are included in Appendix D.

Laboratory analytical data pertaining to the NPP study area that were made available electronically to Olin by December 15, 2003 have been included in an Access software database file. Paper copies of analytical data that were unavailable electronically were reviewed and because of the volume of data only certain SOCs typical of the fill material (arsenic, lead, SPLP lead, benzo(a)pyrene, and ETPH) were manually added to the database to enhance the GIS maps and data summary tables. These include:

- CTDEP Surface Soil Screening Reports.
- HRP and Loureiro Engineering Associates, Inc. subsurface investigations at the Christian Tabernacle Baptist Church at 425 and 449 Newhall Street.

Appendix G is a summary table of the 839 soil/fill sample analyses. The soil/fill analytical database (Appendix H) contains 54,328 individual records of laboratory analyses of substances. The groundwater analytical database contains 20,929 individual records of laboratory analyses from 87 samples.

3.2 SITE DESCRIPTION

Geography

As shown on Figure 1-1 and Sheet 1, the approximately 100-acre site, located in the southern portion of Hamden, Connecticut, east of Dixwell Avenue and just north of the border with New Haven, consists of two study areas. The 36-acre Public Properties study area consists of:

- Hamden Middle School, 550-560 Newhall Street (formerly the Michael J. Whalen Junior High School).
- Hamden Community Center, 496 Newhall Street (formerly the Newhall Street School).
- Rochford Field.
- Mill Rock Park (a.k.a. Rochford Field Annex).

- Two Hamden Housing Authority properties, 249-251 and 253-255 Morse Street.
- The sewage pump station, 1099 Winchester Avenue.

The NPP study area consists of 18 city blocks occupied by residential, light commercial/industrial, and religious institutional development. Based on the base plan from the Town of Hamden assessors map revised April 2000, 302 properties were identified in the NPP (some adjacent properties with common ownership, if known, are counted as one).

The approximately 64-acre NPP has two portions, a smaller approximately 5.6-acre portion lying north of, and a larger approximately 58.4-acre portion lying south of, the intervening Public Properties study area.

The smaller portion of the NPP study area encompasses 32 properties between Newhall Street and New Haven Water Company land on the east and west, respectively, and between 698 Newhall Street and Mill Rock Road Extension on the north and south, respectively. The southern boundary of this portion of the NPP study area is a portion of the northern boundary of the Public Properties study area. This portion of the NPP study area includes all properties along Remington Street (f.k.a. Central Lane) and Harris Street.

The larger portion of the NPP study area encompasses the remaining 270 non-public properties. It is bordered on the south by the section of Goodrich Street between St. Mary Street on the west and Prospect Lane on the east. St. Mary Street forms the western boundary. The eastern boundary consists of most of Wadsworth Street, the eastern property lines of 96 Morse Street and 44 Prospect Lane, and most of Prospect Lane. The northern boundary of the NPP study area is also the southern boundary of the Public Properties study area and consists of:

- A section of Morse Street between St. Mary Street and 319-21 Morse Street.
- The western property line of 319-21 Morse Street.
- The northern property lines of 319-21 to 259 Morse Street (odd numbers only).
- The eastern property line of 259 Morse Street.
- The section of Morse Street between 259 Morse Street and Newhall Street.
- The section of Newhall Street between Morse Street and Newbury Street.

- Newbury Street.
- The section of Winchester Avenue parallel to the western property lines of 1061, 1067, and 1071 Winchester Avenue.
- The northern property lines of 1071 Winchester Avenue, 99 to 131 Bryden Terrace (odd numbers only), and 60 Wadsworth Street.

Where the study area is bounded by streets, the actual boundary lies in the center of these streets.

For ease of geographic reference, the city blocks or large properties within the site, are given the letters shown on Sheet 1. The NPP includes blocks A, C, E, F, H, J, K, L, M, N, P, Q, R, S, and T. Block T collectively refers to the four small blocks in the Augur-Remington-Harris northern portion. The public properties include blocks B, D, and G. The Letters I and O are not used to avoid confusion with the numbers 1 and 0. Principle property features, such as major buildings, fences, and property lines are from the Town of Hamden April 2000 assessor's map. The accuracy of these features shown on maps in this report has not been verified. Outside structures and improvements, inspection features, and previous and Supplemental Investigation features were added by Olin and are approximate.

Current Topography and Drainage

The site lies within the Central Lowland geographic province of Connecticut, a north-northeast-oriented series of wide, flat valleys and narrow ridges that is 20 miles wide at the Massachusetts border but only 4 miles wide at New Haven Harbor. As shown on Figure 1-1, the site area lies in the western part of the lowlands within a flat valley extending south-southeast into western New Haven. The area has a generally flat topography with typical elevations between about 50 to 65 feet above mean sea level (MSL). To the immediate east is the northwestern flank of Prospect Hill, a 1.6-mile-long, 0.5-mile wide NNE-SSW trending hill with a summit over elevation 200 feet MSL. Forming a "T" at the northern toe of Prospect Hill is Mill Rock Ridge, a 0.8-mile-long, east-west trending ridge that rises abruptly to about elevation 150 feet MSL immediately northeast of the site.

Because of the regional valley's generally flat topography and the presence of local highlands to the northeast, east and southeast, surface water drainage from the site is to the north via a small stream and associated wetland. This unnamed stream lies in a small north-tending, 1,500-foot long, 200-foot-wide, flat-bottomed valley with an elevation of about 38 feet. This stream drains into the series of kettle ponds at Pine Swamp, with water surface elevations of approximately 36.6 feet, which in turn drains into Lake Whitney. This reservoir has an outlet on the east end of Mill Rock Ridge on the eastern side of Prospect Hill from the site with a spillway elevation of approximately 36 feet. There are no ponds or streams within the site; all of the site's surface water runoff is conveyed northward to the unnamed stream via catch basins and underground drain pipes. The only other permanent, natural surface water bodies in the area are the ponds at Beaver Ponds Park, located about 0.5 miles to the southwest.

Locally, there are some subdued but noteworthy topographic variations within the site. The athletic fields west of the school in block G occupy a large, flat area at elevation 48 to 53 feet, with 4 to 9-foot-high scarps along the northern, western, and southern boundaries. The school itself lies on slightly higher ground than the fields, but drops down to about elevation 44 feet along Newhall Street. The Hamden Community Center is situated on a triangular terrace at elevation 60.5 feet.

The parks east of Newhall (blocks B and D) have elevations of 45 to 49 feet (increasing eastward) and the elevation of the developed areas south of Mill Rock Park within blocks C and F are also about 48 to 50 feet, with a local low of 47.5 feet along Bryden Terrace. A low, 1 to 2-foot-high slope grades up to properties east of blocks C, D, and F parallels the eastern edge of Wadsworth Street. The western to northwestern slopes of Prospect Hill lie east of blocks C, D, and F.

Low topography continues south of block F into blocks R and S that occupy a low-lying area saddled between the western slope of Prospect Hill and the north-trending local high along Winchester Avenue. The bottom of this area lies at elevation 45 feet where North Sheffield Street intersects Morse Street. An approximately 5-foot-high escarpment sloping up to Block F is situated along the northern edge of this depressed part of Morse Street. To the south, North Sheffield Street slopes upward to elevation 53 at Goodrich Street and follows the path of historic surface drainage into the former wetlands to the north. A closed, triangular depression below elevation 48 feet is present in the north-central part of Block S and may have been the historic location of an ephemeral pond.

The south-central part of the site is a typically higher elevation than those blocks just described, with elevations of around 58 to 60 feet. In particular, a north-trending local high up to elevation 60 feet lies along Winchester Avenue, terminating to the north at some retaining walls at its southwestern corner at Newbury Street. The flanks of this local high occupy the very southwestern corner of block F, the western edge of block R, and the eastern parts of blocks E, P, and Q.

The western parts of these latter three blocks have variable, but lower elevations than the eastern parts. From the highest ground in the western center of block P at elevation 57 feet, western block E slopes gradually down to Rochford Field at elevation 47 feet, and to the south, in southwestern block Q, is a local depression, which is partly occupied by the parking lot of Christian Tabernacle Baptist Church. This parking lot, at elevation 52 to 53 feet, is bordered to the north by an approximately 7-foot-high escarpment sloping up to elevation 60 feet within properties along Marlboro Street and a 3-foot high escarpment sloping down to elevation 50.5 feet within properties to the east. To the west it slopes gradually up to the 60-foot-high elevation of Newhall Street.

The highest terrain in the southern portion of the NPP study area includes block A and the area southwest of the intersection of Newhall and Morse, typically around elevation 63 to over 64 feet. As Newhall Street descends northward from Marlboro Street, there is an escarpment along its western side that is only about two feet high along the western edge of block K, but which increases to over 10 feet high at the southeastern corner of block G. However, there are local depressions down to:

- Elevation 58.7 feet in the center of block H.
- Elevation 61.2 feet in the center of block J.
- Elevation 59.6 feet in the center of block L.
- Elevation 56.6 feet at the east end of block K.

Block T, the portion of the NPP study area north of the Public Properties, is a terrace with upper elevations of 60 to 69 feet. It is sandwiched on the east and west by the very steep scarps leading up to Mill Rock Ridge and down to the flat-floored wetland, respectively.

A local, southwest-draining swale lies along its northern edge, and the southern part of the block slopes gradually down to Mill Rock Road Extension at about elevation 45 to 50 feet.

Water Quality Classifications

Groundwater quality beneath most of the site and the area to the north encompassing Pine Swamp and Lake Whitney is classified by the CTDEP as “GAA impaired” (see Sheet 1). This classification indicates that the groundwater in the area is tributary to a public water supply reservoir but that its quality is degraded. The extreme southwestern corner of the site (St. Mary and Goodrich Streets) lies in the abutting GB classification. The GB classification indicates that the groundwater is known or presumed to be unsuitable for direct human consumption without treatment. The site area is served by public water supplies.

The local surface water bodies have different classifications. The unnamed stream leading north to Pine Swamp is class A, as are the Beaver Ponds to the southwest of the site. CTDEP designates Class A water as habitat, potential drinking water supply, recreation, and navigation. Pine Swamp is class AA and Lake Whitney is class B/AA. CTDEP designates Class AA water as existing or proposed drinking water supply, as well as habitat, recreation, and navigation. The B/AA designation for Lake Whitney indicates that the water quality is not meeting the class AA water quality goals.

3.3 AREAS OF KNOWN CONTIGUOUS FILLING

General Site-Wide History of Filling

According to historical records, the study area was part of the “Highwood” district developed in the late 1800s to early 1900s. A large hog farm was reported in the area in 1899. In 1909, the New Haven Water Co. planned to extend a water main to Highwood in order to encourage development in the area. The earliest available records indicate that wet, low-lying parts of the site were being filled in the early 20th century, mainly to eliminate public health threats and later to provide more dry land for development. A typhoid epidemic (22 cases) reported in Highwood in 1912 was blamed on poor sanitary conditions. Public dumping in the streets and control of malarial mosquitoes were perennial issues in the area. Historically, and continuing well into the mid to late 1900s, it was a well accepted and customary practice throughout the state to eliminate wetlands and low-lying areas that were considered to be mosquito breeding areas in order to protect the public from mosquito borne diseases (e.g., malaria and yellow fever).

To that end, in 1913 the Town of Hamden health officer reported, "Steps are being taken toward the abolishing of mosquito breeding places" and the Town permitted and regulated the filling of wetlands in the Highwood Area for the common public good. (This was in addition to the use of other mosquito controls, such as spraying of oil and lead arsenate pesticides (Conn. Agricultural Experiment Station Bulletin, 1926).) As early as 1915, Hamden public officials encouraged homeowners and local industries to dump their waste in these areas to fill the swamps. In some instances the town would operate public dumps on these properties. When filled and the public health concerns eliminated, the properties would be developed by their owners. Historic records show that the Town of Hamden established at least three public dumps within or near the site. It was permissible to dump "rubbish", e.g. bottles, cans, and paper, but not "garbage, carcasses of dead animals, and decaying vegetables." Furnace ash, from household and industrial coal and/or coke-fired furnaces, was also discarded in these dumps. Manufacturers in the area disposed of large quantities of ash and other manufacturing wastes over several decades.

As swamplands were filled, they were developed for other uses, including homes, parks, and a school. With the mosquitoes under control, malaria was removed as a public health threat. It was not until environmental investigations in the area revealed that soils were polluted with metals, organic compounds, and other substances that public health concerns were raised about the materials used to fill the swamps.

<u>Identification of Fill Areas</u>

Olin identified and described five geographically separate areas of contiguous filling within the NPP study area as shown on Sheets 2 and 3. For convenience of reference, they have been given the following names:

- Morse Street Area.
- Southwest Satellite Area.

- Newhall Street Area.
- Bryden Terrace Area.
- Augur Street Area.

Appendix B contains a detailed interpretation of historic aerial photographs taken between 1934 and 1980, both as annotations on the photographs and text descriptions. These photographs, as well as historic topographic quadrangle maps dating back to the late 19th century, show that most of the public properties and at least two portions of the NPP study area consisted of contiguous, low-lying areas (kettles, many of them with standing water) that were gradually filled in until the late 1970s. Besides the filling and other topographic modifications to the Public Properties study area, aerial photographs document two fill areas within the NPP study area within the blocks on the north and south sides of Bryden Terrace (C and F) and on the east side of Newhall Street (E and Q). These fill areas are contiguous with fill underlying the public properties to the north, which are the subject of investigations by others.

Other sources of information, such as historic documents and local property maps, shed more light on the filling at the Bryden Terrace and Newhall Street Areas and described other changes to topography and potential filling. This lead to field work that identified at least three additional contiguous fill areas in the NPP study area: the Southwest Satellite Area in blocks H, J, and L; the Morse Street Area in block A, and the Augur Street Area in block T. It also showed that the Newhall Street Area is contiguous across the western part of blocks E, P, and Q. These three areas, and block E, were already filled and almost completely developed by the 1934 aerial photographs and were not resolved by the 20-foot contour interval of the early topographic quadrangle maps.

Areas of isolated filling were not evident on the aerial photographs, but may have occurred locally before 1934, or were of limited extent and short duration, and thus cannot be distinguished by subsequent photographs. Most post-1934 changes to land outside the contiguous fill areas are due to land development, particularly in blocks R, S, and the eastern portion of E. Any filling associated with this activity is apparently very local and thin and obscured by structures and landscaping.

The edges of the contiguous and isolated fill areas are delineated by a green edge of fill line on Sheets 2 and 3 and are based on interpolation between boring logs and are in agreement with interpretation of historic aerial photographs, site topography and other physical features where such information is available or relevant. Cross-sections on Sheets 8 and 9 further illustrate the typical shape of fill areas. For each fill area in the NPP, and to a lesser degree the adjacent filling on the Public Properties, the detailed history of known filling activities, and physical and analytical characteristics are provided in the following sections. Fill volume calculations are presented in Appendix F.

Laboratory analyses for soil and fill samples and the resulting analytical data from the complete Olin database for the NPP study area are presented in Appendices G and H, respectively. Analytical data summaries for each SOC analyzed, detected, and/or exceeding RSR criteria are presented in Tables 3-1 to 3-5 for each fill area and in Table 3-6 for the isolated fill areas. The samples are categorized into those in fill less than 4 feet deep, fill greater than 4 feet deep, soil underlying fill, and soil adjacent to fill, which is defined as within 25 feet of the edge of fill. Samples more than 25 feet from a mapped fill area are categorized as ambient samples and are summarized in Table 3-7. The adjacent and ambient soil samples are mostly surficial (0 to 0.5 feet deep) or shallow (0 to 2 feet deep) sand and typically incorporate surficial topsoil. These samples characterize the presence of SOCs that may migrate to or accumulate within the topsoil from any number of potential sources besides filling.

Inspection of these tables shows that the principal SOCs are the most common substances exceeding RSR criteria and essentially define the scope of the non-compliance. Table 3-8 is a summary of the samples that are non-compliant with RSR criteria for SOCs other than the principal ones. These include 14 fill samples (only 7 when the PAHs other than benzo(a)pyrene are excluded) and 7 sand samples with substances such as pesticides and a few SPLP metals exceeding GAPMC.

Figures 3-2 to 3-15 (Sheets 4 and 5) are maps displaying the locations and concentrations in fill and soil of the principal SOCs arsenic, lead, SPLP (and TCLP) lead, benzo(a)pyrene (representative of PAHs), and ETPH (and TPH), as well as overall compliance with the RDEC and GAPMC for any substance.

3.3.1 MORSE STREET AREA

3.3.1.1 History

Fill in the Morse Street Area underlies the northern portions of all but two properties (275 and 279) on the north side of Morse Street and bounded to the north by the Hamden Middle School playing fields. The largest and thickest (just over 10 feet) portion underlies the three easternmost properties (259 to 267) and the very eastern edge of 271. Assessor records show that the homes within block A were built in 1920, which is consistent with the development shown on the 1924 Sanborn map. The 1934 aerial photographs show level, landscaped backyards for the homes in block A, with the land to the north consisting of irregular, vegetated slopes descending into the low-lying wetland in a partially filled kettle complex to the north. There was an apparent fill slope along the north sides of properties 283 to 311 Morse Street descending into local depressions in the vegetated slopes that is best visible in the 1964 aerial photographs. Fill on these lots apparently predated, and initially was not physically connected to, the fill on the municipal parcel to the north. By 1980, the wetland and wooded slopes were covered with fill and a denuded, six-foot-high escarpment (down to the athletic fields) was created along the northern boundary of these properties obliterating the original topography.

In April 2001, USEPA initiated characterization of surface material for arsenic, lead, mercury, and SVOCs at 76 residential properties in the vicinity of the Hamden Middle School. As a result of this investigation, USEPA identified 3 properties in the Morse Street Area for interim removal action. Between October and December 2001, the top 18 inches of soil exceeding USEPA's 1,200 mg/kg lead concentration action level were excavated and replaced with clean fill.

3.3.1.2 Physical Characteristics

The specific shape and thickness of the known fill area is based on borings as the filling predates aerial photographs and was apparently too small and thin to appear on the 1892 or 1914 topographic maps, if in fact it existed at those times. As shown on Figure 3-1, the distribution of fill and the mostly northward increase in thickness within this block matches that seen in the 1964 aerials. A local hill was present north of 315-17 and 319-

21 and consequently the filling in the adjacent backyards is deepest about 30 feet south of the property line. The semi-circular shape and increasing fill thickness to the north indicate that the fill was placed northward in deepening swales. The low-lying topography in the backyards of 275 and 279 Morse St. correlate with the absence of fill at these properties.

Most of the fill in the eastern portion of block A, underlying 259 to 267 Morse St., consists of mixed refuse and waste fill comprised primarily of sand, ash, slag, cinders, glass, metal, brick, wood, and peat with disturbed soil fill near the southern edge of fill boundary. Most of the fill in the rest of this area, underlying the northern portions of 283 to 319-21 Morse St., is disturbed soil fill, comprised primarily of asphalt sub base and/or reworked sand and top soil mixed with pieces of coal, ash, and brick. The volume of all types of fill in block A is approximately 3,900 cubic yards.

Beneath and around the fill areas is light-brown to reddish-brown sand containing minimal silt and gravel typically covered by a surface layer approximately 0.25 to 1.5 foot thick of light brown to brown organic topsoil. The water table is within the sand at least 15 feet below the base of the fill.

3.3.1.3 Analytical Characteristics

34 Morse Street Fill Area samples were analyzed for one or more of the principal SOCs, mostly from the thicker eastern portion of the fill. 13 fill samples exceed the arsenic and/or lead RDECs of 10 and 400 mg/kg, respectively, including the 1 sample A1018S1 in the western part of the fill area. 27 fill samples exceed the SPLP lead GAPMC of 15 ug/l. Three fill samples exceed the benzo(a)pyrene RDEC and GAPMC of 1,000 ug/kg, and 1 exceeds the ETPH RDEC and GAPMC of 500 mg/kg. These data show that both the shallow (<4 feet) and deeper (>4 feet) fill is non-compliant with RSR criteria.

The 2 samples of native sand underlying the fill are compliant with criteria, however, some adjacent and nearby soil samples are non-compliant for lead and SPLP lead. Five soil samples adjacent to the eastern part of the fill area beneath 259 to 271 Morse Street have lead and/or SPLP lead exceeding criteria, especially CTDEP sample 263MORSE-HA8-S1 with a lead concentration of 23,100 mg/kg and also a non-compliant arsenic concentration of 13 mg/kg. These findings suggest some local source or localized surficial migration outside the fill boundary. Four soil samples adjacent to the western part of the fill area are also non-compliant for lead and/or SPLP lead. However, nine other ambient soil samples within the rest of Block A are also non-compliant for these two SOCs, indicating another potential ambient source of lead.

3.3.1.4 Data Gaps

The extent and thickness of fill within all of block A is delineated. Additional analytical characterization of the surficial sand, surficial fill, and native soil beneath the fill for all SOCs was obtained. Therefore, no additional investigation of this area is warranted.

3.3.2 SOUTHWEST SATELLITE AREA

3.3.2.1 History

The Southwest Satellite Area lies principally within blocks H, J, and L. The name derives from the observation that it is not contiguous with the other fill areas found in the NPP or Public Properties. Various historic documents generally refer to filling in this area but its extent was determined through fieldwork as there are no aerial photographs or historic topographic maps depicting it.

The historic topographic maps included in Appendix B show that the streets transecting or bordering the Southwest Satellite Area (with the exception of Butler Street) were already in place by 1889, long before any filling described below occurred. A few structures are shown along the both sides of Edwards Street, with additional development along Edwards and St. Mary Streets by 1914. Note that these small-scale maps have a generalized (manually generated) 20-foot contour interval and do not show any topographic depressions in the area. The maps indicate that they were either less than 20 feet deep, or if greater, the area below that depth was small.

Written documents post-dating the maps indicate that these three blocks were fill areas. A long-time resident describes “marshy ground of perhaps four acres” present in 1914 at a location consistent with the Southwest Satellite Area, which was a mosquito breeding ground. In the 1916 Hamden Annual Report, Health Officer G. H. Joslin reported that, “The very large [mosquito] breeding place on the corner of St. Mary and Morse Streets is nearly filled in.” Although the exact corner of those streets was not specified, independent historical research done in the 1970s noted that during World War One, the block bordered by Morse, Edward, Goodrich and St. Mary Streets, was raised 15 feet and a skating pond existed there until 1917. Town records also show that by 1917 a public dump was established in Highwood on Shelton Avenue between Goodrich and Morse streets. Residents were permitted to dump "rubbish, tin cans, etc.", but disposal of "garbage, carcasses of dead animals, decaying vegetables, etc." was prohibited. [1917 Hamden Annual Report, pg. 36]. A smaller third block (L), located between Shelton Avenue and Butler, Goodrich, and Marlboro Streets, is referred to as containing a "coke lot". The New Haven Water Co. reported in its December 1, 1917 Monthly Report that a surface water drain was installed at the corner of St. Mary and Goodrich Streets that discharged to the far corner of Newhall St. swamp (to the northeast). In 1919, St. Mary, Morse and Edwards Streets were raised and a storm drain was completed.

The depiction in the historic research paper and topographic maps of homes immediately adjacent to the streets indicates that the depressions must have been principally between the roads. Based on assessor records most homes in this area were built between 1900 and 1930. Based on home construction dates, filling here was most likely completed by 1920. Sanborn maps show development of these blocks to be virtually complete by 1924. In several places, assessor cards record construction dates later than shown on the 1924 Sanborn maps indicating that older homes were replaced with newer construction.

In all aerial photos from 1934 and afterward, the site topography and development appears essentially as it does today, so no evidence of later filling is apparent from these sources. The "coke lot" within block L is unpaved in 1934 and appears flat or very slightly depressed, which it still is today, even after the construction of the factory in 1965.

3.3.2.2 Physical Characteristics

<u>Thickness and extent</u>

The actual thickness and extent of the filling in this area comes from borings and test pits completed by Olin and by other investigators. The explorations revealed three roughly elliptical deposits of fill within former topographic depressions within blocks H, J, and L as shown on Sheet 3, with the deepest parts of the fill underlying the center of the blocks.

The edges were defined by interpolation between previous and supplemental investigation transect borings. Minor topographic swales locally modify the shape of the fill areas, with two minor former depressions just over four feet deep situated on the east side of Butler Street. The overall shape and orientation of the former depressions, and the alignment of Shelton, Edwards, and Butler Streets between them, indicates that the road network was established before filling, which is consistent with the historical record. The depths of the former depressions are just over 20 feet, which is also consistent with the generalized 1889 topography. Their gentle regular slopes, rounded edges, and spatial clustering indicate their origin as kettles. Their generally level current surfaces with slight topographic depression in their centers, is also consistent with the historical record. Total volume of fill in the Southwest Satellite Area is approximately 130,000 cubic yards.

The base of fill in the center of blocks H, J, and K is five to ten feet above the water table in the underlying sand as established by the monitoring wells installed there (see cross-sections on Sheet 8). Historical descriptions of these depressions refer to surface water, however, fines were encountered beneath the fill in only one boring, located in the northwest section of the fill lobe in block H. The current depth to the water table suggests that this surface water was seasonal and/or ephemeral.

Composition

Most of the fill has the appearance of black, fine-grained sand. Mineralogical and chemical analysis determined that this material is waste fill composed of:

- >50 % glass grains (ash - primarily oxides of silica, aluminum, and iron).
- 25% anisotropic coke.
- 10% uncoked coal, including anthracite.
- lesser amounts of spinel, mullite, inertinite, and quartz.

Other materials found in the fill include cinders, slag, brick, and wood chips. In other words, the black material is waste fill as defined in Section 1.4, primarily coal or coke-fired furnace ash.

A very different type of fill was found in the middle of block J. It consists of light gray ash with slag, glass, and wood. A CTDEP test pit, dug over 7 feet deep in the same area of gray ash, revealed numerous glass bottles and jars, broken ceramic dishes and pottery, newspaper fragments, three “D” size dry cell batteries, jar lids, a few pieces of slag, and part of a leather shoe. On one jar was a Hellmans label. Dates were embossed on the bottom of 2 jars: “PAT FEB 10 03” and “PATENTED JUN 9 03 JUNE 23, 03”. The composition of the material found is indicative of refuse fill, as defined in Section 1.4.

Test pits dug in the middle of block H revealed a mix of both waste and refuse fill. A newspaper fragment contained text, “..h 8, 1879” and written on the side of one small round, clear glass bottle with a cork stopper, containing a small amount of orange liquid was, “DAVID’S Quality ESTABLISHED 1825”. On the bottom of the same bottle was embosssed, “Patent 1886”. Other items found included saw dust, wood chips, bullets and bullet casings, broken pane and safety glass, bricks, oyster shells, leather shoes, numerous bottles (including a bottle with “BROMO SELTZER EMERSON DRUG CO BALTIMORE”), several pieces of wood, paper, and electronic vacuum tubes.

These articles of refuse are also consistent with the historical references regarding the type and timing of filling in this area. Most of the fill in the eastern portion of this area, located in the mid-western section of block M, consists of shallow disturbed soil fill.

3.3.2.3 Analytical Characteristics

128 Southwest Satellite Fill Area samples were analyzed for one or more of the principal SOCs. 88 fill samples exceed the arsenic and/or lead RDECs of 10 and 400 mg/kg. 60 fill samples of SPLP lead exceed the GAPMC of 15 ug/l. 25 fill samples exceed the benzo(a)pyrene RDEC and GAPMC of 1,000 ug/kg, and 22 exceed the ETPH RDEC and GAPMC of 500 mg/kg. These data show that both the shallow (<4 feet) and deeper (>4 feet) fill is non-compliant with RSR criteria.

A few adjacent soil samples are non-compliant for arsenic (1 sample), lead (3 samples), and benzo(a)pyrene (2 samples). Also, 12 adjacent soil samples with concentrations of SPLP lead up to 390 ug/l exceed the lead GAPMC. Some of these samples are very close to the edge of fill and others are bare spot samples up to 25 feet away. Given their shallow depth, the origin of these concentrations may be mechanical/airborne migration of fill matrix along the ground surface or accumulation from other unknown ambient sources that are also mobile.

The majority of the underlying soil samples are compliant with RSR criteria. One of 23 lead analyses and 2 of 12 SPLP lead analyses exceed the RDEC and GAPMC, respectively.

3.3.2.4 Data Gaps

Verification of the maximum thickness and enhanced delineation of the perimeter of fill is complete. In addition, greater analytical characterization was obtained from the surficial sand around the perimeter, waste fill, and native soil beneath the fill for all SOCs, including SPLP metals, pesticides and PCBs. No additional characterization is warranted.

3.3.3 NEWHALL STREET AREA

3.3.3.1 History

The Newhall Street Area lies within blocks E, P, and Q along the east side of Newhall Street. The 1892 topographic map shows blocks P and Q defined by existing streets and several buildings in block P. The 1892 and 1914 topographic maps show blocks E and B as one block, without Newbury Street. A closed, circular contour line, with vegetation indicated on the 1914 map, lies in the eastern part of block E, indicating the historic presence of the current high ground there, with a topographic low immediately to the west along Newhall Street. The historic presence of this depression, and another at the western end of block Q, suggests that the fill area was once a contiguous, northward-sloping swale, but not deep enough to be resolved by the 20-foot contour interval of these old topographic maps. The Newhall Street Area appears to be contiguous with the fill found in the Public Properties to the north (block B).

Included in the Town of Hamden Phase I ESA Report are anecdotal reports from an “old timer” who lived in the neighborhood in the 1920s and 1930s. He states that filling occurred in “the area from Marlboro Street to Mill Rock Road bordering on Winchester Ave. on the east side to Newhall Street on the west side.” Exceptions were properties along the east (Winchester Ave.) side of these blocks. Videotaped interviews of other knowledgeable residents conducted by CTDEP suggest that this area may have once been a sand quarry.

Filling and subsequent development of this area apparently started in the western end of block P and northwestern-most part of block Q, with homes there dating from 1924. By the first aerial photographs in 1934 this block is already filled and developed; however, depressions still existed to the immediate north and south.

To the north, filling in the western part of block E began before 1934 and apparently ended by 1943. In 1934, the western part of the block is slightly lower than Newhall Street and the gray tones and patterns seen on the aerial photographs suggest that the western part of this block has also been filled. By 1943, the western part of this block has been brought up to surrounding road level, and the ground is covered with shrubs. Development of this part of the fill area began in 1944 with the home at 499 Newhall Street and was completed by 1957.

The aerial photos show that the eastern part of block E has always been high ground (up to elevation 59), mostly vacant and heavily wooded until gradually developed during the 1930s to 1963. The high ground slopes down to the north from Morse St. In 1934 what is now Newbury Street is shown as an unpaved path cut into the toe of this slope. Aerial photographs from 1943 onward show topography that is consistent with current topography. A low retaining wall is present along the south side of the eastern part of Newbury and around the corner along Winchester where these roads were cut into the toe of the sloping hill.

The depression at about elevation 50 feet in the southwestern part of block Q was vacant in 1934, similar to the topography to the east of this parcel and sloping very steeply up to Newhall St. to the west. In 1941 what is now the rectory at the Christian Tabernacle Baptist Church was constructed, with some local filling of the depression under and around the building. Additional filling of the depression apparently took place when the rest of the church was built in 1975, with about 3 to 5 feet of fill added up to the rear property line. A 2 to 3-foot-high escarpment remains along the southern and eastern property lines.

Throughout the period of aerial photographs, the topography and degree of development on the west side of Newhall Street is consistent with today’s appearance. Therefore, if some filling took place on the west side of the street, then the historical record does not document it.

3.3.3.2 Physical Characteristics

<u>Thickness and extent</u>

The actual thickness and extent of the filling in this area comes from borings and test pits completed by Malcolm Pirnie and other investigators and from field observations of topographic features. These explorations reveal fill in the western sections of blocks E, P, and Q extending from Goodrich Street in the south into block B to the north, consistent with the historical record. Numerous small topographic depressions are found throughout this fill area. Aside from the church parcels, which are not completely filled up to surrounding grade, most of this fill area has a known or inferred maximum thickness of just over 10 feet (Sheet 2). The thickest fill encountered, 13 feet, was near the northwest corner of the house at 499 Newhall St. Another filled depression at least 12 feet deep was discovered in a parcel at 34 Marlboro St. just north of the church. The base of the fill is approximately 3 to 12 feet above the water table. The fill area has a rectangular shape paralleling Newhall Street, a steep western edge along this road and merging with thin fill under it, and a generally constant thickness. These regular, geometric features suggest that the original depression was not a former stream channel or kettles, but produced by local sand quarrying. The western boundary is coincident with Newhall Street, which has a cut escarpment along its western edge that increases in height as the road drops in elevation to the north. Only sand was found underlying the fill; there are no fines to suggest the potential presence of former wetlands in this depression.

To the east, the boundary is well defined by borings and is slightly irregular, with the maximum width of the fill area located just north of the Baptist church. Historically high and heavily wooded ground underlies the eastern part of blocks E, P, and Q, where borings found only native sand at the surface and small topographic depressions are largely absent. Retaining walls are present along the northeastern corner of block E where Winchester Avenue and Newbury Street were cut into this high ground. Fill is likely present under Newbury Street, separating a small area where fill is absent at the southeastern corner of Rochford Field from the rest of the historic high ground south of

Newbury. Total volume of fill in the Newhall Street Area is estimated to be about 50,000 cubic yards.

Composition

The composition of the fill in the Newhall St. area varies with location. Most of the deeper fill (>4 feet) in blocks E and P appears to be waste fill, with some refuse fill also evident in block E. Sand, gravel, slag, cinders, and peat are also present in the fill. The shallow fill (<4 feet) along the eastern edge of the contiguous fill area and in most of block Q consists primarily of disturbed soil fill composed of brown sand with traces of gravel, wood fragments, coal, concrete, and brick.

Test pits dug to a depth of approximately 7 feet in the western part of block E revealed several red and white bricks, chunks of black tar or asphalt, slag, wood chips, tools, and pieces of metal amidst the predominantly fine to medium-grained black ash material. Molded onto several of the red bricks was the word “STILES”. Test pits dug about 6 feet deep in the western part of block P revealed some material similar to that found in the block E test pits. Other material is more representative of refuse fill, including large chunks of slag, a silvery slag material, pieces of broken pottery and safety glass, bottles, carbon battery cell rods, paper that appeared to be packing slips, cardboard fragments imprinted with the word “shells”, and newspaper fragments with Italian writing. One fragment was dated 1920. Although the fill materials found in both blocks and in the northwestern part of block Q just north of the church is typically waste fill, the variability in the type of waste found indicates more than one potential source.

3.3.3.3 Analytical Characteristics

115 Newhall Street Fill Area samples were analyzed for one or more of the principal SOCs. 44 fill samples exceed the arsenic and/or lead RDECs of 10 and 400 mg/kg. 32 fill samples exceed the SPLP lead GAPMC of 15 ug/l. 23 fill samples exceed the benzo(a)pyrene RDEC and GAPMC of 1,000 ug/kg, and 12 exceed the ETPH RDEC and GAPMC of 500 mg/kg. These data show that both the shallow (<4 feet) and deeper (>4 feet) fill is non-compliant with RSR criteria. The figures also show that in the area of the Christian Tabernacle Baptist Church in Block Q, most of the non-compliant arsenic, lead, and SPLP lead concentrations are clustered within the fill around 449 Newhall Street,

which was apparently filled in 1941. The rest of the fill around 425-431 Newhall, which was filled in the 1970s, has a lower proportion of SOC concentrations exceeding criteria.

Two adjacent soil samples (P1002S1 and P1021S1) have SPLP lead concentrations of 72 and 32 ug/l, respectively, which exceed the GAPMC. These samples are located in the right-of-way in front of 17 Marlboro Street. Given their shallow depth, the origin of these concentrations may be mechanical/airborne migration of fill matrix along the ground surface or accumulation from other unknown ambient sources that are also mobile.

The majority of underlying soil samples is compliant with RSR criteria. Only 1 of 14 underlying soil samples is non-compliant with the arsenic RDEC.

3.3.3.4 Data Gaps

Delineation of the perimeter of this fill area is complete. In addition, greater analytical characterization was obtained for the surficial sand, surficial fill, and native soil beneath the fill for all SOCs, including SPLP metals. No additional characterization is warranted.

3.3.4 BRYDEN TERRACE AREA

3.3.4.1 History

The Bryden Terrace Area underlies blocks C and F and is contiguous with fill underlying Rochford Field (block B) and Mill Rock Park (block D) in the Public Properties study area. The 1892 and 1914 topographic maps show this area as a wooded depression.

Various historic documents refer to the filling activities east of Winchester Avenue. Long time area resident John J. Carbrey reported in the December 15, 2000 *New Haven Register* that the town dump was located on the east side of Winchester Avenue from Morse Street to Mill Rock Road and part way up towards Prospect Street. The area east of Winchester Ave. between Morse and Goodrich Streets (blocks R and S) was solid ground and had been a golf course. Because most of the filling took place after 1934, the most detailed historic information comes from aerial photographs.

The 1934 aerial photo shows this area as mostly wetland undergoing filling from the northwest, southwest, and south. No homes are present and Winchester is an unpaved path that does not extend north past what will be the western extension of Bryden

Terrace. A black area interpreted to be water occupies the central and northwestern part of the blocks and merges with a channel leading westward through what will be Rochford Field (block B). Based on relationships to the west and the western drainage pattern, the water is inferred to be at about elevation 38 feet.

Land just west of Wadsworth St. (an unpaved road) is mostly dark gray wetland vegetation with some ditching that grades into the central black area, and thus has elevations sloping up from 38 feet to less than about 45 feet. Wadsworth St. itself consists of a level path between a low escarpment on the east (cut into higher ground) and an embankment on the west (fill spoils deposited in the lower wetlands). It appears to be at the same elevation as it is today (50 to 54 feet).

Gray, sharp-edged lobes of fill occupy the southern and western sides of block F and terminate at Winchester Ave., Morse, and Wadsworth streets. These fill lobes are at or slightly above the adjacent road elevations and post-date the roads. Given that their upper surfaces appear to be at about the same elevation as today (48 to 51 feet), and assuming that the wetland under them sloped upward toward Morse to about elevation 48, then these fill lobes are about 0 to 11 feet thick.

No filling is apparent immediately west of Winchester Ave. (block E), east of Wadsworth St., or south of Morse (blocks R and S), where there are fields, homes, and wooded areas with the same topography as today. Another unpaved path extends northeastward from the intersection of Winchester and Morse into the water. This path and Winchester Ave. are shown on the 1892 and 1914 topographic maps as extending north to Mill Rock Road; however their northern portions were underwater on the early spring date of the 1934 aerials.

The 1939 oblique aerial photo shows the future residential parcels as vacant land, indicating that filling is largely complete. This aerial shows the Mill Rock Park parcel as very light-toned, suggesting filling and disturbance rather than wetland/swamps. The 1939 oblique taken from the top of Mill Rock shows an active fill area within the future Bryden Terrace Area, with a smoke plume from a fire at the southern edge of the fill area. The future Mill Rock Park (block D) area is obscured by trees, but both areas are seen in the 1943 vertical and 1946 oblique photographs as completely filled and graded to road level.

The 1949 topography of the land east and south of the fill area is consistent with today's and includes a heavy, continuous cover of large trees and consistent gray-tone. These topographic relationships and other features suggest that filling contiguous with that on Rochford Field and Mill Rock Park covers most of these parcels, but does not appear to extend past Wadsworth to the east and Morse on the south. Assuming that the center of the former underlying wetland area was at or above elevation 38, the underlying fill in the vicinity of Bryden Terrace (elevation 48) is inferred to be up to about 10 feet thick. The highest ground within these blocks lies at the southwest corner (elev. 56), which is just across Winchester Ave. from the natural-appearing high ground on block E. The lowest ground is at the south-central border of block F along Morse St. (elev. 48), although this elevation is higher than on Morse St. (elev. 46). Ground to the east across Wadsworth St. is higher; in fact, the photos show Wadsworth St. under construction with escarpments cut into the higher ground all along the east side of this road.

Residential development occurred during the late 1940s to late 1950s. In the 1949 aerials, the western extension of Bryden Terrace between blocks C and F did not exist and the fill area was undeveloped except for 10 homes along the southern edge and corners (12 Wadsworth, 95-135 Morse, 1019-1027 Winchester). In 1951 blocks D and F appear similar to 1949, except that leafed out shrubs and small trees obscure the surface details. By 1957, Bryden Terrace extended westward through the fill area to Winchester Avenue, and by 1959 all of the homes present there today are visible in this and subsequent photos.

3.3.4.2 Physical Characteristics

<u>Thickness and extent</u>

While the extent of filling is clear from the aerial photographs, and thickness can be inferred from stereo photographs, the actual thickness presented herein and subsequent volume calculations are based upon fieldwork completed by Olin and other investigators. These explorations revealed that the majority of blocks C and F are underlain by fill up to 11 feet thick (see Sheets 2 and 8). The thickest fill is present within a northwest-trending swath from the center of block F to the west end of block C, consistent with the black area of standing water seen in the 1934 aerial photographs and the presence of the water table within the fill. The fill pinches out along the higher ground at blocks E, R, and S to the southwest and south, where no fill was encountered, except for a thin, narrow, southward extension into the intersection of Morse Street and North Sheffield Street and adjacent 116 Morse Street. This southward extension is coaxial with the downward sloping grade of North Sheffield Street and the thickest part of the fill under Blocks F and C to the north. Together these three features comprise the historic surface water drainage channel that led into former wetlands under Rochford Field to the northwest. Total volume of fill in the Bryden Terrace Area is estimated to be about 100,000 cubic yards.

Most of the fill in Bryden Terrace Area is underlain by a layer of fines, including peat consistent with the former presence of wetlands. Sand mostly underlies the fines, with glacial till beneath the sand.

<u>Composition</u>

Most of the fill in this area is composed of brown to black sand with varying amounts of gravel, gray ash, coal, brick, glass, wood, cinders, ceramic, concrete, asphalt, and assorted refuse. In addition to the material described, the EPA removals and CTDEP test pits in this area uncovered glass bottles and jars, broken pottery, cardboard, seashells, leather shoes, a bicycle tire, a bed frame and a toilet bowl. These materials are consistent with refuse fill and the reported historical use of this area as a town dump. Filling under Wadsworth Street is different, consisting mostly of disturbed soil fill, consistent with its 1934 appearance as a pathway cut into natural high ground. Overall, the Bryden Terrace Area fill consists of about 57% refuse, 26% disturbed soil, and 17% waste.

3.3.4.3 Analytical Characteristics

161 Bryden Terrace Fill Area samples were analyzed for one or more of the principal SOCs. 82 fill samples exceed the arsenic and/or lead RDECs of 10 and 400 mg/kg, respectively. 115 fill samples exceed the SPLP/TCLP lead GAPMC of 15 ug/l. 78 fill samples exceed the benzo(a)pyrene RDEC and GAPMC of 1,000 ug/kg, and 26 exceed the ETPH RDEC and GAPMC of 500 mg/kg. The comparatively large number of samples exceeding benzo(a)pyrene and other PAH criteria in this area relative to the

other contiguous fill areas is apparently related to the burning of refuse that occurred here. These data show that both the shallow (<4 feet) and deeper (>4 feet) fill is non-compliant with RSR criteria.

The adjacent soil samples are compliant for all substances except SPLP lead in sample R1020S1 (26 ug/l). This sample is from the right-of-way in front of 126 Morse Street. Given its shallow depth, the origin of this lead may be mechanical/airborne migration of fill matrix along the ground surface or accumulation from other unknown ambient sources that are mobile. Two ambient samples also across Morse Street (126-MS and S1003S1) exceed RSR criteria for benzo(a)pyrene and ETPH. However, these right-of-way samples may be affected by asphalt particles from the adjacent roadway.

The majority of underlying soil samples are compliant with RSR criteria. Only 1 of 5 samples analyzed for SPLP lead exceeds the GAPMC.

3.3.4.4 Data Gaps

Delineation of the perimeter of fill is complete and additional analytical characterization was obtained for the surficial sand around the perimeter, surficial fill, and native soil beneath the fill for all SOCs, including SPLP metals, particularly in the interior portions of the blocks. No additional characterization is warranted.

3.3.5 AUGUR STREET AREA

3.3.5.1 History

The Augur Street Area lies within block T. There is no direct historical information on filling within this area, just maps depicting gradual residential development. The 1892 topographic map does not show any development of roads or buildings in this area west of Newhall Street, but the 1914 map shows a westward extension of Augur Street and the presence of Harris Street as far west as the future Remington Street. The 1924 Sanborn map shows homes built on nearly every parcel in this area. From 1934 and afterward, the topography and degree of development in this parcel is consistent with today’s appearance. The 1934 aerial photos show disturbance from the installation of the sewer pipe located along the west side of the block, within and parallel to the slope to the wetland. A tornado in 1989 destroyed several homes and scattered debris throughout this area. Some debris reportedly was buried in place during clean up/reconstruction efforts after the storm.

Some filling took place at the southern boundary of the block abutting the Hamden Middle School. Until 1963, a swale separated 20 Harris St. and 596 Newhall St. from fill in the adjacent school parcel to the south. By 1963, the swale was filled and an unpaved road (Mill Rock Road Extension) continuing westward from Newhall St., which became a paved road leading to the rear of the school by 1964. Subsequent development of the building at 596 Newhall Street in the early 1970s may have locally dispersed some of this fill material. Parcels to the north are at a higher elevation (up to elevation 68 feet) than the filling at Mill Rock Road Extension and the school; thus do not appear to be contiguous with fill in the Public Properties.

3.3.5.2 Physical Characteristics

Thickness and extent

Because there is no specific information in the historical record or aerial photographs, the actual thickness and extent of the filling in this area comes from fieldwork completed by Olin and other investigators. The contiguous fill area consists of a series of connected fill areas west of Remington Street and northward and southward extensions of that street across Augur Street and Harris Street, respectively, and merging with fill along Mill Rock Road Extension at the study area boundary. Most of the fill area north of Augur Street is just over four feet thick, with a steep eastern boundary at the east edge of 331 Augur Street. A similarly configured area to the south at 334 Augur Street suggests filling of two former excavations. The fill area at 13, 17, and 20 Harris Street appears to represent filling over the original westward sloping topography and is up to 12 feet thick at boring T2003S at the west end of this street. This fill merges with thin fill found within the western backyards of 606 to 618 Newhall Street.

Filling of the former swale trending east-west along Mill Rock Road increases in thickness to the west and along the southern edge of the study area as expected from former surface topography visible on aerial photographs. It is only present under the southernmost edge of 20 Harris Street and 596 Newhall.

The volume of fill is estimated to be about 14,000 cubic yards.

Native sand underlies and surrounds fill in the Augur Street Area. The fill does not intersect the water table.

Composition

The fill encountered in block T consists primarily of sand and gravel with only trace amounts of wood, concrete, brick, glass, and ash. This is consistent with the definition of disturbed soil fill. Thin lenses of refuse fill were found at 16 Harris St., along part of the right-of-way of Harris St., at 337 Augur St., and in a few other isolated borings. Thin lenses of waste fill and asphalt material were found sandwiched between layers of sand in the borings along Mill Rock Road Extension, indicating commingling of waste fill with disturbed soil fill during the road construction.

3.3.5.3 Analytical Characteristics

16 Augur Street Fill Area samples were analyzed for one or more of the principal SOCs. Only fill sample T1080S1 (10.6 mg/kg) exceeds the arsenic RDEC of 10 mg/kg. This fill sample and 4 others exceed the lead RDEC of 400 mg/kg. Eight fill samples exceed the SPLP lead GAPMC of 15 ug/l, 4 fill samples exceed the benzo(a)pyrene RDEC and GAPMC of 1,000 ug/kg, and 2 fill samples exceed the ETPH RDEC and GAPMC of 500 mg/kg. These data show that both the shallow (<4 feet) and deeper (>4 feet) fill is non-compliant with RSR criteria.

The 12 samples of surrounding and underlying soil are compliant with RSR criteria.

3.3.5.4 Data Gaps

Delineation of the perimeter of fill is complete and additional analytical characterization was obtained for the surrounding surficial sand, surficial fill, and native soil beneath the fill for all SOCs, including SPLP metals. No additional characterization is warranted.

3.4 AREAS OF ISOLATED FILL

The Initial Investigation was the first widespread effort at investigating Non-Public Properties. Based on available information, the Initial Investigation study area was limited to where there was historic information (documents and aerial photographs) of systematic, large-scale, contiguous filling.

The Consent Order expanded the NPP study area to include more properties outside the boundaries of the Initial Investigation study area, where potentially smaller, isolated areas of filling may be present.

These potential fill areas are undocumented in the record and either were too small or of limited duration to be seen on aerial photographs or may have been placed before the first aerials were taken in 1934. Small isolated, fill is less likely to be solely the result of institutional filling by a municipality or industry than the large scale, contiguous fill areas. Small, isolated fill may also be due to localized property development needs or individual resident waste disposal activities. The Initial Investigation discovered remnants of burn furnaces, which were identified by homeowners as places where residents burned their household trash. Tables 3-9 and 3-10 presents summaries of the resident information on the potential presence of isolated fill and descriptions of the isolated fill material encountered by borings. The vast majority of isolated fill observed in the borings consists of disturbed soil fill less than two feet thick, underlain by native sands. Specifically, the composition is typically reworked sand with minor or trace amounts of rock, ash, slag, glass, coal, ceramic, concrete, and/or brick; or processed sand and gravel (traprock), especially in the rights-of-way. Most of the “debris” reported by owners/tenants also consists of these materials. In a few instances the fill was deeper than 2 feet and/or consisted of refuse or waste fill. Fill found under roads may be associated with road building/grading and utility installation rather than an extension of fill from the adjacent properties.

Areas and volumes are based on the presumed boundaries shown on Sheets 2 and 3, include which areas are not well bounded primarily to due lack of data (due to frozen ground or no access granted). Appendix F presents calculations of the volume for each isolated fill area. The minimum total area of isolated fill areas is approximately 3 acres. Minimum total volume is approximately 8,500 yd^3 with an average fill depth of 1.8 feet (based on borings penetrating fill). Isolated fill areas were not found in blocks A, C, F, J, and L.

Laboratory analyses for soil and fill samples and the resulting analytical data from the complete Olin database for the NPP study area are presented in Appendices G and H.

Analytical data summaries for each SOC analyzed, detected, and/or exceeding RSR criteria are presented in Table 3-6 for the isolated fill areas. The samples are categorized into those in fill, soil underlying fill, and soil adjacent to fill, which is defined as within 25 feet of the edge of fill. Samples more than 25 feet from a mapped fill area are categorized as ambient samples and are summarized in Table 3-7. The adjacent and ambient soil samples are mostly surficial (0 to 0.5 feet deep) or shallow (0 to 2 feet deep) sand and typically incorporate surficial topsoil. These samples characterize the presence of SOCs that may migrate to or accumulate within the topsoil from any number of potential sources besides filling.

Figures 3-2 to 3-15 (Sheets 4 and 5) are maps displaying the locations and concentrations in fill and soil of the principal SOCs arsenic, lead, SPLP (including TCLP) lead, benzo(a)pyrene (representative of PAHs), and ETPH (including TPH), as well as overall compliance with the RDEC and GAPMC for any substance. Inspection of the tables and figures shows that the principal SOCs are the most common substances exceeding RSR criteria and essentially define the scope of the non-compliance. Overall, the most widespread non-compliant SOCs are lead and SPLP lead, with 44 of 98 and 37 of 54 analyses, respectively, exceeding RDEC and/or GAPMC. Adjacent soil samples are mostly affected by SPLP lead (6 of 39 analyses exceed GAPMC), with a few total lead and arsenic, SPLP antimony and arsenic, and PAHs also exceeding RSR criteria. These same SOCs are common in ambient soil samples as well.

Descriptions of individual isolated fill areas are presented below. The ambient samples on Table 3-7 include 3 samples apparently of disturbed soil fill collected by CTDEP from rights-of-way (borings 158-MOR, 303-MS, and 304-MS). Malcolm Pirnie drilled borings very close to these locations to confirm and/or delineate the extent of fill but only found fill of very limited extent near one boring, 158-MOR. The findings suggest that localized deposits of disturbed soil fill occur as a result of filling/grading for road construction sub-base. Occasional detections of these materials in the rights-of-way in close proximity to the roadways cannot be inferred to be contiguous.

Block E

Two isolated fill deposits were found in Block E designated E01 and E02 and are discussed separately below.

E01

Isolated fill area E01 is located in the central portion of block E. It is located behind the garage at the rear of 165-167 Morse Street and potentially extends into the rear of properties located at 171-173 Morse Street, 18 Newbury Street, and 1032 Winchester Avenue. It is delineated to the east by a boring within 20 feet, however, borings to the west, north, and south are approximately 40 feet away. This fill area covers approximately 2,700 ft^2 and contains an estimated 140 yd^3 of fill, based on an average thickness of 1.4 feet. The maximum fill thickness (1.7 feet) was at boring E1056 where 1.2 feet of disturbed soil fill was found to overly 0.5 feet of waste fill. This was the only boring in this fill area to penetrate waste fill. The other two borings located in E01 penetrated disturbed soil fill that was composed of sand mixed with traces of white ash, black ash, and coal.

Two samples were analyzed for SOCs and both exceed the lead RDEC of 400 mg/kg (E1055S1 447 mg/kg and E1034S1 3,040 mg/kg) and the latter sample (52.9 ug/l) exceeds the SPLP lead GAPMC of 15 ug/l. Two adjacent soil samples (E1005S1 22.6 ug/l and E1057S1 18.3 ug/l) also exceed the SPLP lead GAPMC.

E02

Isolated fill area E02 is located in the central portion of block E just southeast of isolated fill area E01 and underlies the rear of the property at 1030 Winchester Avenue. E02 is delineated in all four cardinal directions by borings within 20 feet. This fill area covers approximately 1,300 ft2 and contains an estimated 65 yd3 of fill, based on an average thickness of 1.4 feet. Boring E1035 penetrated a maximum fill thickness of 2.1 feet. The three borings penetrated disturbed soil fill composed mostly of sand with traces of ash, brick, and coal.

Two samples were analyzed for SOCs. One sample exceeds the lead RDEC of 400 mg/kg (E1050S1 475 mg/kg) and both exceed the SPLP lead GAPMC of 15 ug/l

(E1035S1 100 ug/l and E1050S1 91 ug/l). One adjacent soil sample (E1057S1 18.3 ug/l), which lies between this fill area and area E01 also exceeds the SPLP lead GAPMC.

Block H

One isolated fill deposit found in Block H designated H01 is discussed below.

H01

Isolated fill area H01 is located in the southern portion of block H. It underlies the southeastern corner of 17-19 St. Mary St. and potentially extends into 319 and 321 Goodrich to the south and 303 Edwards to the east. It is delineated to the north and west by borings within 20 feet, however, borings to the east and south are farther away (>40 feet). This fill area covers approximately 1,300 ft^2 and contains an estimated 53 yd^3 of fill, based on an average thickness of 1.1 feet. The maximum depth of fill is 1.8 feet at boring H1069. The three borings located in H01 penetrated disturbed soil fill that is composed of dark brown topsoil with traces of coal. A small surface depression and bare spot area are located in this fill area. A larger surface depression is located outside of the fill area to the north.

Five samples from this fill area were analyzed for SOCs. Three samples exceed the lead RDEC of 400 mg/kg (up to 932 mg/kg), sample H1072S1 99.6 ug/l exceeds the SPLP lead GAPMC of 15 ug/l, and 2 samples exceed the benzo(a)pyrene RDEC and GAPMC of 1,000 ug/l (up to 1,900 ug/kg).

Two adjacent soil samples just to the west also exceed these criteria.

Block K

Six confirmed or potential isolated fill deposits were found in Block K designated K01 to K06 and are discussed separately below.

K01

Isolated fill area K01 is located in the northern portion of K block and is the largest isolated fill area in the study area. K01 is estimated to overly properties between the eastern edge of 266 Morse Street, the western portions of 474 to 484-486 Morse Street and the northern parts of the properties at 69 and 73 Marlboro Street. K01 is approximately 31,000 ft^2 and contains an estimated 1,800 yd^3 of fill, based on an average thickness of 1.6 feet. The thickest amount of fill penetrated was at boring K1075, which has 6.3 feet of primarily waste fill with some disturbed soil fill. This fill area is bounded by the study area line (which coincides with Morse Street) to the north and borings within 20 feet to the west and south. On the eastern edge of this fill area, the fill line is not as clearly delineated. However, only thin amounts of disturbed soil fill occur near the eastern edge that appears to coincide with the topography surrounding the large depression to the southeast. Fill in K01 is predominantly composed of disturbed soil fill and localized deposits of waste fill consisting of ash, slag, coal, glass, sand, and gravel.

20 samples from this fill area were analyzed for SOCs. 3 samples exceed the arsenic RDEC of 10 mg/kg (up to 12 mg/kg) and 12 samples exceed the lead RDEC of 400 mg/kg (up to 2,920 mg/kg). Seven samples exceed the SPLP lead GAPMC of 15 ug/l, only 1 sample (K1023S1) exceeds the benzo(a)pyrene RDEC and GAPMC of 1,000 ug/l (2,300 ug/kg).

Two adjacent soil samples (214MORSE-S3 and 214MORSE-S3B) exceed the lead RDEC and two other samples (K1064S1 and K1038S1) exceed the SPLP lead GAPMC.

K02

Isolated fill area K02 is located southwest of isolated fill area K01. It underlies a portion of the southern parking lot at 266 Morse Street, and at least parts of 83 to 91 Marlboro Street. Borings to the north, west, and south are within 20 feet of the edge of fill line. The eastern edge is undetermined because the owner of 79 Marlboro Street has not granted access, but the distribution of fill so far mapped suggests that it extends onto this property. This fill area covers approximately 13,000 ft^2 and contains an estimated 780 yd^3 of fill, based on an average thickness of 1.6 feet. This fill area has a maximum depth of 7 feet at boring K1070 (87 Marlboro Street), which is composed entirely of waste fill, however, most borings penetrated disturbed soil fill. Localized deposits of waste fill are present in the southwest and center.

12 samples were analyzed for SOCs. Five samples exceed the arsenic RDEC of 10 mg/kg (up to 35 mg/kg), 6 samples exceed the lead RDEC of 400 mg/kg (up to 1,830 mg/kg), and 3 samples exceeds the SPLP lead GAPMC of 15 ug/l (up to 149 ug/l).

Adjacent and underlying soil samples are compliant with RSR criteria.

K03

Isolated fill area K03 is a small area of disturbed soil fill located in a section of the eastern parking lot at 266 Morse Street west of isolated fill area K01 and north of isolated fill area K02. The area is bound to the north, east, and south by borings within 20 feet and to the west by the building. This fill area covers approximately 490 ft^2 and contains an estimated 23 yd^3 of fill, based on the thickness of 1.3 feet penetrated by the one boring K1008S1.

The SOC concentrations from the one sample (K1008S1) within and the one sample (K1056S1) adjacent to K03 are compliant with RSR criteria.

K04

Isolated fill area K04 is located southeast of isolated fill area K01 and west of Newhall Street. It underlies portions of 466 and 468 Newhall Street as well as 61 Marlboro. The extent of this fill area to the west is uncertain because of physical access issues with the direct push rig at 69 Marlboro. Borings to the north, east, and south are within 20 feet of the edge of fill line. This fill area covers approximately 5,300 ft^2 and contains an estimated 310 yd^3 of fill, based on an average thickness of 1.6 feet. This fill area has a maximum depth of 5 feet at boring K1078 where a former sinkhole was covered with clean fill in May 2004 by Loureiro Engineering Associates, Inc. Rusted scrap metal, wood and glass bottles were observed in the fill when the sinkhole was collapsed and covered. Most of the other borings in this fill area penetrated disturbed soil fill composed of sand mixed with trace amounts of black and gray ash, coal, slag, and brick. Boring K1111 penetrated an 8-inch thick layer of waste fill consisting of coal and brick.

Seven samples from this fill area were analyzed for SOCs. One sample (466NH-HA5-S1) exceeds the arsenic RDEC of 10 mg/kg, 6 samples exceed the lead RDEC of 400 mg/kg (up to 2,200 mg/kg), and 3 samples exceed the SPLP lead GAPMC of 15 ug/l (up to 219 ug/l).

The lead concentration of 5,600 mg/kg in adjacent soil sample 266NH-HA8-S1 exceeds the lead RDEC. Other adjacent samples are compliant with RSR criteria.

K05

Area K05 is marked with a question on Sheet 2 because the presence and/or extent of fill has not been confirmed. A CTDEP boring in the right-of-way at the eastern corner of Morse St. and Shelton Ave. in January 2001 found disturbed soil fill to a depth of 1 foot. Fill was not found in a boring approximately 20 feet to the south at 274 Morse St. Snow piles in the right-of-ways prevented further investigation during the supplemental investigation in time for this report. Because this potential isolated fill area has not been confirmed or sufficiently delineated, no fill volume was estimated. The fill may be associated with roadway construction.

K06

This area is also marked with a question on Sheet 2. A CTDEP investigation in December 2001 at 115 Marlboro St. found a trace amount of ash between the garage and swimming pool. No fill was observed in borings to the north, east, south, and west, but because the CTDEP borings did not extend beyond 6 inches deep, CTDEP does not consider the area to be sufficiently delineated. Due to physical access issues and frozen soil, additional investigation could not be completed during the supplemental investigation in time for this report. Because this potential isolated fill area has not been confirmed or sufficiently delineated, no fill volume was estimated.

Block M

Two isolated fill deposits were found in Block M designated M01 and M02 and are discussed separately below.

M01

Isolated fill area M01 is located at 150 Shepard Street. This fill area is bordered to the east by Shepard Street and to the west by the house at 150 Shepard. Borings to the north and south are within 20 feet of the edge of fill line. This fill area covers approximately 2,000 ft^2 and contains an estimated 240 yd^3 of fill, based on an average thickness of 3.2 feet. It has a maximum depth of 5 feet at boring M1037. Most borings penetrated disturbed soil fill composed of sand with traces of ash, coal, and glass. Boring M1038 penetrated waste fill to a depth of 1.9 feet in the right-of-way, which may be associated with roadway construction.

Two samples from this fill area were analyzed for SOCs. Only sample M1026S1 exceeds any RSR criteria, in this case the SPLP lead concentration of 40.7 exceeds the GAPMC of 15 ug/l.

Adjacent soil sample M1035S1 just to the south is compliant with criteria.

M02

Area M02 is marked with a question on Sheet 2 because the presence of fill has not been sufficiently delineated. This area is located in the rear of the property at 80 Marlboro Street. Disturbed soil fill composed of sand with traces of ash, coal and glass was found to a depth of 1.6 feet. Because this isolated fill area has not been sufficiently delineated, no fill volume was estimated.

Block N

Four confirmed or potential isolated fill deposits were found in Block N designated N01 to N04 and are discussed separately below.

N01

Isolated fill area N01 is located at the parking areas for 424 Newhall and 197 Goodrich Streets and may extend west into the yard at 197 Goodrich Street. Access to the yard was not possible with the hydraulic direct push rig and frozen ground prevented the use of the manual direct push in time for this report. This fill area is bordered to the east by Newhall Street and by borings approximately 30 feet to the north and south. This fill area covers at least approximately 3,400 ft^2 and contains an estimated 130 yd^3 of fill, based on an average thickness of 1.0 feet. This fill area has a maximum depth of 1.7 feet at boring N1011. Borings penetrated disturbed soil fill composed of silty sand with traces of ash, coal, and glass.

Two fill samples were analyzed for SOCs, and only the benzo(a)pyrene concentration of 3,600 ug/l in sample N1006S1 was exceeds RSR criteria. The presence of this substance may be associated with parking lot construction.

Adjacent soil samples are compliant with RSR criteria.

N02

Isolated fill area N02 is located at 432-434 Newhall Street and was penetrated by one boring, N1014, where disturbed soil fill 1.0 foot thick was found. Borings to the north, east, and west are within 20 feet of the edge of fill line. Borings to the south are >20 feet from the edge of fill line. This fill area covers approximately 260 ft^2 and contains an estimated 10 yd^3 of fill, based on an average thickness of 1.0 feet.

No samples of the small fill area were analyzed because when drilled this fill was thought to be part of the Newhall Street contiguous fill.

Two soil samples adjacent to it on the east and west were analyzed for SOCs and are compliant with RSR criteria.

N03

Isolated fill area N03 is located in the rear (north) of properties at 199 and 203 Goodrich Street. The extent of this fill is unknown on 3 sides. Access was not granted to the property to the northwest. The hydraulic direct push rig could not access the properties to the east and west and frozen ground prevented the use of the manual direct push in time for this report. Borings to the south are within 20 feet of the observed fill. This fill area covers approximately 1,800 ft^2 although this area is questionable given the data, and contains an estimated 110 yd^3 of fill, based on an average thickness of 1.7 feet. It has a maximum depth of 1.9 feet at boring N1024. Most borings penetrated disturbed soil fill. One boring, N1024, penetrated a layer of waste fill composed of sand with some coal, glass, and slag.

Three samples from this fill area were analyzed for SOCs and the SPLP lead concentration of 24.4 ug/l in sample N1018S1, which exceeds the GAPMC of 15 ug/l. In underlying soil sample N1018S2, the lead concentration of 685 mg/kg exceeds RDEC of 400 mg/kg. Aside from the absence of artificial materials or coal, the description of this soil and that of the overlying fill are very similar, therefore the lower sample may also be fill given the lead concentration.

Two adjacent soil samples located to the south and east are compliant with RSR criteria.

N04

Area N04 located in the southwestern corner of 199 Goodrich is marked with a question on Sheet 2 because the presence of fill has not been confirmed or sufficiently delineated in time for this report due to physical access problems and frozen ground. Only CTDEP surficial hand auger sample HA-2, which found disturbed soil fill described as "red-brown sand, slag & glass", currently defines this area. Because this isolated fill area has not been sufficiently delineated, no fill volume was estimated. No samples were analyzed from within or adjacent to this fill area.

Block P

Two isolated fill deposits were found in Block P designated P01 and P02 and are discussed separately below.

P01

Isolated fill area P01 is located in the rear of the property at 17 Marlboro Street coincident with an area of reported debris. The area is bounded to the north, south, and east by borings within 20 feet, but may extend westward into the northeast corner of 21 Marlboro Street. Most of the fill encountered is refuse fill composed of sand mixed with white ash, coal, glass, and wood, which is consistent with an old backyard trash/burn area. This fill area covers approximately 1,500 ft^2 and contains an estimated 100 yd^3 of fill, based on an average thickness of 1.9 feet. This fill area has a maximum depth of 2.0 feet at boring P1034.

Three samples were analyzed for SOCs. The arsenic concentration of 10.1 mg/kg in sample P1030S1 exceeds the RDEC of 10 mg/kg and the lead concentrations (up to 826 mg/kg) in all three samples exceed the lead RDEC of 400 mg/kg. The SPLP lead concentration of 76.2 ug/l in sample P1034S1 exceeds the SPLP lead GAPMC of 15 ug/l. One adjacent soil sample P1032S1 is compliant with RSR criteria.

P02

Isolated fill area P02 is located approximately 20 feet northeast of P01 at the rear of the properties at 164 Morse St. and 1002 Winchester Avenue. The area is bound by borings in all four cardinal directions, underlies approximately 1,000 ft^2, and contains an estimated 52 yd^3 of fill, based on an average thickness of 1.4 feet. It has a maximum depth of 1.7 feet at boring P1039. The two borings in this fill area penetrated disturbed soil fill composed of sand with trace of coal, glass, and slag.

Two samples were analyzed for SOCs. In sample P1039S1, the arsenic concentration of 13 mg/kg exceeds the RDEC of 10 mg/kg and the SPLP lead concentration of 36 ug/l exceeds the SPLP lead GAPMC of 15 ug/l.

Two adjacent soil samples to the north are compliant with RSR criteria.

Block Q

Three isolated fill deposits were found in Block Q designated Q01 to Q03 and are discussed separately below.

Q01

Isolated fill area Q01 is located at 976 Winchester Avenue in the northeastern portion of block Q. It is located on the eastern edge of the property at 976 Winchester Avenue. It is delineated to the west, south, and east by borings within 20 feet, but not to the north. This fill area underlies a minimum of approximately 110 ft^2 and contains a minimum estimated 6 yd^3 of fill, based the 1.5-foot thickness of disturbed soil fill in boring Q1018, consisting of sand with a piece of glass, slag, and gravel.

The SPLP lead concentration of 29 ug/l in the one sample from this boring, Q1018S1, is non-compliant with the GAPMC of 15 ug/l.

Adjacent soil sample Q1042S1 is compliant with RSR criteria.

Q02

Area Q02 in the rear of the property at 976 Winchester Avenue is marked with a question on Sheet 2 because the extent of fill has not been sufficiently delineated in time for this report due to physical access problems and frozen ground. Disturbed soil fill was found in boring Q1031 consisting of sand with white ash and coal to a depth of 1.4 feet. No samples were analyzed from within or adjacent to this fill area.

Q03

Area Q03 is marked with a question on Sheet 2 because the extent of fill has not been sufficiently delineated in time for this report due to physical access problems and frozen ground. Disturbed soil fill consisting of sand with some coal to a depth of 0.8 feet was found in boring Q1034 at a reported debris location behind the garage at 155 Goodrich Street.

The SPLP lead concentration of 61 ug/l in the one sample from this boring, Q1034S1, is non-compliant with the GAPMC of 15 ug/l.

No samples were analyzed from soil adjacent to this fill area.

Block R

Three isolated fill deposits were found in Block R designated R01 to R03 and are discussed separately below.

R01

Isolated fill area R01 is located in the southern portion of block R. It is located at the rear of the properties at 10 North Sheffield St. and 959-957 Winchester Avenue. This isolated fill area is undefined to the north, although no fill was found nearby at 18 N. Sheffield St. It is delineated to the west, south, and east by borings within 20 feet. The delineated fill area covers approximately 1,700 ft^2 and contains an estimated 97 yd^3 of fill, based on an average thickness of 1.5 feet. The maximum depth of fill of 1.8 feet is at boring R1043, which is located in the north of this isolated fill area. One of the five borings penetrated a thin (0.4’) layer of waste fill and the other four penetrated disturbed soil fill that consists of sand with trace coal, glass, white ash, and slag.

Three samples from this fill area were analyzed for SOCs. The lead concentration of 581 mg/kg in sample R1019S1 exceeds the RDEC of 400 mg/kg. The SPLP lead concentration of 26 ug/l in sample R1031S1 exceeds the GAPMC of 15 ug/l. The benzo(a)pyrene concentration in this sample also exceeds the RDEC.

Adjacent soil sample R1033S1 located to the west is compliant with RSR criteria.

R02

Isolated fill area R02 is located in the front portion of the property at 973 Winchester Avenue. This fill area is delineated to the east, south, and north by borings within 20 feet and to the west by a boring across the street. This fill area covers approximately 1,400 ft^2 and contains an estimated 110 yd^3 of fill, based on an average thickness of 1.5 feet. The maximum depth of fill of 3 feet is at boring R1007. All five borings penetrated disturbed soil fill that consists of sand with some coal, white ash, and slag.

The SPLP lead concentration of 35 ug/l in the one sample from this fill area, R1007S1, is non-compliant with the GAPMC of 15 ug/l.

Adjacent soil sample R1030S1, located to the south, is also non-compliant with the SPLP lead criterion.

R03

Isolated fill area R03 is located at 981-979 and 985 Winchester Avenue. This fill area is delineated to the west, east, and north by borings within 20 feet. Boring to the south are greater than 20 feet away. This fill area covers approximately 6,400 ft^2 and contains an estimated 340 yd^3 of fill, based on an average thickness of 1.5 feet. Three borings plus additional hand augers done by the CTDEP were used to characterize this isolated fill area. These hand augers, which are located in the eastern portion of this fill area, did not fully penetrate the fill. The maximum depth of fill of 2.5 feet is at boring R1032. Disturbed soil fill containing sand with some coal, black ash, white ash, and glass was found at this isolated fill area.

The SPLP lead concentrations of 41 and 82 ug/l in the two samples from this fill area, R1041S1 and R1036S1, respectively, are non-compliant with the GAPMC of 15 ug/l.

Adjacent soil samples R1040S1 and R1042S1, located to the east and west, respectively, are compliant with RSR criteria.

Block S

Six isolated fill deposits were found in Block S designated S01 to S06 and are discussed separately below.

S01

Isolated fill area S01 is located in the front yards of 92 and 98 Morse Street. This fill area is delineated in all four cardinal directions by borings within 20 to 30 feet. It underlies approximately 2,000 ft^2 and contains an estimated 180 yd^3 of fill, based on an average thickness of 2.5 feet. It has a maximum depth of 4.0 feet at boring S1056. This isolated fill area is characterized by disturbed soil fill containing sand with some gravel, ash, and slag, with localized deposits of waste fill.

The lead and SPLP lead concentrations of 2,490 mg/kg and 68 ug/l, respectively, in one of the two samples from this fill area, S1058S1, are non-compliant with the RDEC of 400 mg/kg and the GAPMC of 15 ug/l.

Adjacent soil samples are compliant with RSR criteria.

S02

Isolated fill area S02 is located in the rear of the property at 92 Morse Street coincident with reported debris. This fill area is delineated to the west, south, and north by borings within 20 feet. There are no borings to the east because this fill area intersects the study area boundary. It underlies approximately 2,800 ft^2 and contains an estimated 210 yd^3 of fill, based on an average thickness of 2.0 feet. It has a maximum depth of 2.3 feet at boring S1051. This isolated fill area is characterized by disturbed soil fill containing sand with some gravel, coal, and white ash, with a localized deposit of waste fill.

The lead concentrations of 989 and 1,030 mg/kg in the two samples from this fill area, S1050S1 and S1051S1, respectively, are non-compliant with the RDEC of 400 mg/kg.

Adjacent soil sample S1049, located to the west, is compliant with RSR criteria.

S03

Isolated fill area S03 is located in a small portion of the front yard of 28 Prospect Lane. This fill area is delineated to the west, south, and north by borings within 20 feet. There are no borings to the east because this fill area intersects the study area boundary. This fill area covers approximately 1,200 ft^2 and contains an estimated 210 yd^3 of fill, based on an average thickness of 4.5 feet. This fill area has a maximum depth of 4.8 feet at boring S1022. This isolated fill area is characterized by disturbed soil fill containing sand with some coal and ash.

The two samples analyzed from this area are compliant with RSR criteria.

S04

Isolated fill area S04 is located in the southeast corner of 14 Prospect Lane and may extend to the northeast corner of 99 Goodrich Street. This fill area is delineated to the west and north by borings within 20 feet. There are no borings to the east because this fill area intersects the road and study area boundary and borings to the south are greater than 40 feet away. This fill area underlies approximately 1,100 ft^2 and contains an estimated 60 yd^3 of fill, based on an average thickness of 1.4 feet. It has a maximum depth of 1.8 feet at boring S1073 and is characterized by disturbed soil fill containing sand with some brick, coal, and ash.

The SPLP lead and benzo(a)pyrene concentrations of 86 ug/l and 1,200 ug/kg, respectively, in the sample from this fill area, S1070S1, are non-compliant with the RSR criteria.

Adjacent soil sample S1071S1, located to the west, is compliant with criteria.

S05

Isolated fill area S05 is located in the center of block S in large, shallow topographic depression and sections of the fill boundary closely match the existing topographic contour lines. S05 includes portions of back yards extending from 28 Prospect Lane and 29 N. Sheffield St. in the south, to 41 N. Sheffield St. in the north. This fill area is delineated on most sides, but may also extend onto 40 Prospect Lane and 49 N. Sheffield St. to the north and east. It underlies a minimum of approximately 13,000 ft^2 and contains an estimated 1,200 $yards^3$ of fill, based on an average thickness of 2.6 feet. This fill area contains two deposits that are greater than 4 feet thick and reaches a maximum depth of 6.0 feet at boring S1020. It is characterized by disturbed soil fill containing sand with some brick, coal, white ash, black ash, and glass. Boring S1044 penetrated a thin layer of waste fill.

Eight samples were analyzed for SOCs. The lead concentrations of 2,100 and 517 mg/kg, in the samples from the 2 thickest parts of the fill area, S1033S1 and S1039S1, respectively, exceed the RDEC of 400 mg/kg. The SPLP lead concentrations of 109 and

56 ug/l, in the samples S1039S1 and S1041S1, respectively, exceed the GAPMC of 15 ug/l.

Surrounding samples are compliant with criteria except for the SPLP lead concentration of 25 ug/l in sample S1032S1.

S06

Isolated fill area S06 is located at 40 Prospect Lane. This fill area is delineated to the west and north by borings within 20 feet. There are no borings to the south because this fill area intersects the road and study area boundary. The extent of fill is uncertain to the east and may extend onto the property at 44 Prospect Lane. This fill area covers approximately 5,900 ft^2 and contains an estimated 460 yd^3 of fill, based on an average thickness of 2.1 feet. It has a maximum depth of 4.1 feet at boring S1062. This boring is located near debris and a bare spot. This isolated fill area is characterized by disturbed soil fill containing sand with some ash and coal. Boring S1016 penetrated a thin layer of waste fill.

The arsenic, lead, SPLP lead, and benzo(a)pyrene concentrations in the waste fill of sample S1016S1 exceed their respective criteria.

Adjacent samples are compliant with criteria except for the benzo(a)pyrene concentration of 1,400 mg/kg in sample S1015S1, located just southwest of boring S1016 and on the uphill side of a small retaining wall. Although no fill was mapped at this location, the boring had only 2 feet of recovery and hit a “black stone”. This description, combined with the benzo(a)pyrene concentration and the local topography suggest that this boring also may have penetrated some surficial fill.

Block T

Four isolated fill deposits were found in Block T designated T01 to T04 and are discussed separately below.

T01

Isolated fill area T01 is located in the northeastern portion of block T. It includes portions of properties 670 to 678 Newhall St. and 323 to 329 Augur St. Homes in this area were severely damaged by a tornado in 1989. This fill area is delineated to the east, south and west by borings within 20 feet. There are no borings to the north because this fill area intersects the study area boundary. This fill area underlies approximately 19,000 ft^2 and contains an estimated 1,100 yd^3 of fill, based on an average thickness of 1.5 feet. This fill area has a maximum depth of 4.0 feet at boring T1079. It is characterized by disturbed soil fill containing sand with some white ash, coal, and wood.

Five samples were analyzed for SOCs. The arsenic concentration of 18.3 mg/kg in sample T1079S1 exceeds the RDEC of 10 mg/kg. The lead concentrations of 457 and 1,320 mg/kg in samples T1077S1 and T1079S1, respectively, exceed the RDEC of 400 mg/kg. The SPLP lead concentrations of 199 ug/l in sample T1079S1 exceeds the GAPMC of 15 ug/l.

Two adjacent soil samples are compliant with RSR criteria.

T02

Isolated fill area T02 is located to the south of isolated fill area T01. It is located on the northern portion of properties at 642 Newhall Street and 322 Augur Street. This fill area is bounded to the north and west by Augur and Remington Streets and to the east and south by borings within 20 feet. This fill area underlies approximately 6,400 ft^2 and contains an estimated 440 $yards^3$ of fill, based on an average thickness of 1.9 feet. This fill area has a maximum depth of 4.0 feet at boring T1020. It is characterized by disturbed soil fill containing sand with white ash, black ash, coal, and ceramic, with localized deposits of waste fill.

Two samples were analyzed for SOCs. Both the lead and SPLP lead concentrations of 2,680 mg/kg and 85 ug/l in sample T1082S1, respectively, exceed the RDEC of 400 mg/kg and GAPMC of 15 ug/l.

Adjacent soil sample T1066S1, located to the southeast, is compliant with RSR criteria.

T03

Isolated fill area T03 is located in the southeastern corner of block T. This fill area is delineated to the east and north by borings within 20 feet. There are no borings to the east and south because this fill area intersects the study area boundary at Newhall Street and Mill Rock Road Extension. It underlies approximately 2,100 ft^2 and contains an estimated 250 yd^3 of fill, based on an average thickness of 3.2 feet. The maximum depth of fill penetrated is 4.3 feet at boring T1047. This isolated fill area is characterized by disturbed soil fill with a localized deposit of waste fill.

Two samples were analyzed for SOCs. Both samples T1046S1 and 596-NS are non-compliant for arsenic and SPLP lead. The arsenic concentration in sample T1046S1 is 17.3 mg/kg, and the SPLP lead concentrations in these samples are 19.1 and 30 ug/l, respectively.

There are no adjacent soil samples.

T04

Isolated fill area T04 is located in the northern portion of the property at 634 Newhall Street. This fill area is delineated to the west and north by borings within 20 feet. There are no borings to the south within 20 feet. The area is bounded to the east by a retaining wall. It underlies approximately 680 ft^2 and contains an estimated 43 $yards^3$ of fill, based on an average thickness of 1.7 feet. Disturbed soil fill consisting of sand and glass was penetrated in one boring, T1027, which is 1.7 feet deep.

The one sample T1027S1 from this small fill area is compliant with RSR criteria.

There are no adjacent soil samples.

Summary

Overall the isolated fill areas have a lower percentage of non-compliant samples than the contiguous fill areas, which correlates with their disturbed soil composition. Very small isolated fill areas with 1 or 2 samples exhibit SOC concentrations compliant with the RSRs even though the fill appears similar to other areas with some non-compliant samples. Some of these fill areas may extend onto properties that could not be characterized in time for this report either because access was not granted or because frozen ground prevented sampling using hand operated direct push. Consequently, based on the study-area wide analytical findings, even fill in the small areas is considered to be non-compliant given the heterogeneity intrinsic to fill material and the isolated fill is presumed to extend across a property boundary where there is an absence of data to the contrary. Additional data will be obtained from these properties when conditions permit.

We will report the results of the additional data in the follow-up report with the balance of the outstanding data from this investigation.

3.5 GEOLOGY

The geology of the area is dominated by the regionally extensive and thick glacial Lake Connecticut deltaic sand deposit that underlies the southern Hamden/western New Haven area from upper Lake Whitney to Long Island Sound (see Hydrogeologic Maps and Cross-Sections on Sheets 6 through 9). The regional sand deposit pinches out against Prospect Hill to the east and Mill Rock Ridge to the north but is reportedly up to 300 feet thick under and southwest of the Southwest Satellite Area (Surficial Materials Map of Connecticut, Stone et al, 1992 and Quaternary Geologic Map of Connecticut and Long Island Sound Basin, Stone et al, 1998). The sand is typically fine to coarse-grained, with local, subordinate amounts of silt and gravel. Although it is mostly composed of quartz and some feldspar grains, it typically has a pink to red color due to the incorporation of local brownstone bedrock fragments. Glacial meltwater delta sand deposits of this kind typically exhibit laminations and layers of differing grain size and composition that is lost if the soil is disturbed. This characteristic provides a simple visual method of differentiating native, undisturbed sand from disturbed soil fill, and along with the light color, from the typically much darker waste/refuse fill.

Kettles, which are natural depressions caused by the melting of isolated blocks of glacial ice, are common within the sand deposit. They are often in clusters and hold surface water, as at the Pine Swamp Area north of the site, and at Lake Whitney. The former wetland depressions within the Public Properties/Bryden Terrace Area and the Southwest Satellite Area were probably kettles.

Numerous borings within the site show that a layer of fines up to about 8 feet thick is present between the fill and the sand in the Bryden Terrace Area and the adjacent Public Properties where wetlands were prevalent before that part of the site was filled. The fines are composed primarily of clay and silt sized mineral grains, with some very fine-grained sand and commonly including organic matter and peat. It is typically dark colored (gray, brown, or black), generally less permeable to groundwater than other soils, and indicates deposition by slow-moving surface water in a restricted basin. The presence of the fines in the Bryden Terrace Area and the adjacent Public Properties is consistent with the distribution of wetlands seen on historic aerial photographs. The absence of fines under fill in the Morse Street, Southwest Satellite, Newhall Street, and Augur Street fill areas suggests that the bottom of these former topographic depressions were not perennially wet, although the Southwest Satellite Area has been described as containing a marsh and ice skating pond.

The sand and fines pinch out against the flanks of Prospect Hill and Mill Rock Ridge, which were never submerged by the glacial meltwater delta. They were, however, once under an ice cap, and so thin (approximately 5 feet) deposits of glacial till mantle the sedimentary New Haven Arkose and basaltic West Rock Diabase bedrock that underlie Prospect Hill and Mill Rock Ridge, respectively. Composed of all grain sizes, including abundant cobbles and boulders, completely non-sorted, and typically red-brown colored, glacial till exhibits no laminations or layers and has widely varying permeability to groundwater. In the NPP borings typically found it to be very dense and silty. Sheets 6 and 7 includes elevation contours of the glacial till surface found under the eastern part of the NPP during the supplemental investigation. This surface represents the original ground surface immediately after the glacial ice retreated upon which the delta sand was subsequently deposited. There is a completely buried till-mantled bedrock hill up to elevation 40 feet (about 20 feet below grade) centered at well cluster E2001, coincident with high topography. The buried hill plunges to the northwest, north and northeast under former wetlands in those directions. Its eastern flank joins the western subsurface flank of Prospect Hill to form a buried valley that is aligned with the north-sloping surface topography along North Sheffield Street leading to the former wetlands under Blocks F and C. The till is thickest at the crest of the buried hill (18 feet) and thins along the flanks such that it is absent at well cluster Q2002.

Bedrock consists of the New Haven Arkose formation and is present directly beneath the till, or directly beneath the sand at well cluster Q2002. This formation consists of a well-cemented red-brown sandstone (aka brownstone) that underlies the entire NPP study area. Generally, the bedrock surface mimics the glacial till surface.

3.6 HYDROGEOLOGY

The topography and drainage pattern in the site area and the underlying geology control the groundwater flow directions. Because of the surrounding valley's flat topography and the presence of local highlands (Mill Rock Ridge and Prospect Hill) to the northeast, east and southeast, surface water drainage from the site is to the north via a small stream and associated wetland west of the Augur Street Area. This unnamed stream lies in a north-tending, 1,500-foot long, 200-foot-wide, flat-bottomed valley with an elevation of about 38 feet above high sea level. This stream drains into the series of ponds at Pine Swamp with a surface water elevation of approximately 36.6 feet, which in turn drains into Lake Whitney. This reservoir has an outlet with a spillway elevation of approximately 36 feet on the east end of Mill Rock on the eastern side of Prospect Hill from the site. There are no ponds or streams within the site; all of the site's surface water runoff is conveyed northward to the unnamed stream via catch basins and storm drains. The only other permanent, natural surface water bodies in the area are the ponds at Beaver Ponds Park, located about 0.5 miles to the southwest. Consequently, the general groundwater flow should be away from the highlands (west) and towards the surface water features (north around the west end of Mill Rock and southwest towards the Beaver Ponds).

Table 3-11 summarizes the monitoring well water level measurements obtained from the NPP on November 16, 2004 and February 7, 2005. Water level measurements from two wells in the Public Properties Study Area (HA-B108-MW and HA-B109-MW) area are also included. Sheets 6 and 7 shows water table elevation contours based on these measurements. Note that wells C2001D, E2002D, H2002S, and H2002D were not yet installed during the November 2004 round. However, enough measurements were available from other wells to complete a November contour map and, except for an increase in groundwater elevations of about one foot between November and February, the overall flow patterns are the same. Cross-sections on Sheets 8 and 9 show generalized groundwater flow directions in the vertical plane. To the extent that the two data sets overlap (primarily north of Morse Street), groundwater flow directions based on the new water table contour maps are consistent with earlier data. These data include maps generated by investigators working in the Public Properties in 2002 and from approximate water table elevations obtained from direct push borings in the NPP during the Initial Investigation in August and September 2002.

In the southern part of the NPP, beneath the eastern part of block F and all of block S, the water table slopes steeply to the west down the flank of the till mantled bedrock of Prospect Hill. Prospect Hill is therefore upgradient of the NPP and as expected downward flow gradients are also found in this portion of the NPP. As the water table crosses into the fill, fines, and sand under blocks C, F, and R, the horizontal and vertical flow gradients lessen due to the presence of these porous materials. However, as the groundwater flow reaches the flanks of the buried till-mantled hill centered at well cluster E2002, it is retarded by this less permeable material. Consequently, the water table is nearly flat just east of the buried hill's crest, which acts as a dam, and the westward groundwater flow is diverted over and around the crest. Groundwater flow under block E is diverted slightly north of west into the southern part of the Public Properties. Where the depth to the till is greater, such as at block C, the groundwater gradients and flow directions are unaffected and are consistently westward also into the Public Properties. In a manner similar to that exhibited on the west flank of Prospect Hill, the groundwater gradients west of the buried hill are moderately steep and downward to the west as the till surface plunges. Once the till surface is sufficiently deep west of Shepard Street and the Hamden Community Center, the horizontal gradient is very flat within the extensive and porous sand deposit and the vertical gradient is minimal. The three-dimensional groundwater flow is essentially horizontal within the extensive sand deposit underlying the valley and the horizontal flow direction also shifts to the southwest toward the direction of Beaver Ponds. These ponds are located about one-half mile away and are the closest location of presumed groundwater discharge from the southern part of the NPP and Public Properties to surface water.

Locally, the water table is situated in the lower part of the fill, especially in the Bryden Terrace Area, adjacent Rochford Field and Mill Rock Park, and in the western part of the Hamden Middle School parcel, or in the fines underlying the fill in these areas. This is consistent with the presence of standing water (wetlands) there as seen in historical aerial photographs. The absence of fines under fill in the Morse Street, Southwest Satellite, Newhall Street, and Augur Street fill areas suggests that the bottom of these former topographic depressions were not wetlands. The water levels obtained from wells in these areas show that the water table is in the underlying sand, as shown in the cross-sections.

Within block T, the groundwater flow direction was expected to be westward toward the unnamed, north-flowing stream, based on the difference in topography. Water table elevations from the three wells in this block actually show a very slight southerly gradient during both rounds and the cross-sections show that the water table is below the elevation of the adjacent stream valley. Therefore, it appears that groundwater beneath this part of the NPP does not discharge to the stream to the west and, therefore, that this stream may be a losing stream.

3.7 GROUNDWATER QUALITY

Based upon the evaluation of the first two rounds of groundwater samples from the NPP in November 2004 and February 2005, the groundwater quality appears to be only slightly degraded relative to upgradient wells. The data are very similar to that obtained from grab samples during the initial investigation. Despite numerous detections of SPLP lead above GAPMC in the fill, lead in groundwater is below groundwater protection criteria (GWPC) of the RSR. It was detected only at low, qualified concentrations in a few wells. Tables 3-12 and 3-13 summarize the groundwater analytical data. The February groundwater data is currently being validated and is included in this report. When the validation is completed, it will be submitted by addendum. Table 3-14 summarizes groundwater analytical data from five wells within the Public Properties study area that are situated north and upgradient of Block A (obtained by LBG in December 2004 and February 2005). The following SOCs were found in the groundwater above RSR criteria:

- Two trihalomethanes (bromodichloromethane and chloroform) were detected, and they exceed the GWPC at 9 wells. Chloroform exceeds its residential groundwater volatilization criterion (RGWVC) at 4 of these wells. These concentrations do not exceed surface water protection criteria (SWPC).

- Extractable total petroleum hydrocarbons (ETPH) were detected and exceed GWPC at 8 wells, all situated within different contiguous fill areas. There is no SWPC for ETPH.
- Semi-volatile organic compounds (SVOCs) were either non-detect or detected at very low concentrations that are flagged as estimated. None exceeds criteria. Three PAHs exceed GWPC in well H2003S and phenanthrene concentrations of 0.1 to 0.4 ug/l exceed the SWPC in 4 wells, including 2 downgradient wells H2002D and H2003S, during the February round. The phenanthrene SWPC is 0.077 ug/l, which is below the method detection limit of 0.1 ug/l. The February groundwater data is currently being validated and will be submitted by addendum.
- Several pesticides were detected (mostly at low estimated values), particularly at well NH-499-MW and at wells in blocks Q, R, and S in the southeast. Chlordane and dieldrin exceed GWPC where detected, and both pesticides exceed SWPC in the upgradient well S2001S (screened in bedrock).
- The only metal concentration exceeding any criterion is zinc. The zinc concentration at well BT-113 in the Bryden Terrace contiguous fill area exceeds SWPC during both rounds. This well is screened within the saturated lower portion of this fill.

The overall groundwater quality appears to be consistent with both the GB and GAA Impaired CTDEP groundwater classifications. The GAA classification area for most of the study area was established some time ago absent any groundwater gradient information from the study area. It presumably was established under the assumption that groundwater flow mimics the general surficial drainage flow, northward toward Pine Swamp and Lake Whitney reservoir. However, the actual groundwater flow direction is southwestward away from those water bodies toward other areas of GB classification and surface waters of B classification, the ponds at Beaver Pond Park. The most recent study area specific data suggest that the GAA classification for the study area is unnecessary.

Regarding surface water quality, only the SWPC are appropriate for assessing potential adverse effects of groundwater discharge to adjacent surface water. Therefore, of the substances exceeding criteria detailed above, only the phenanthrene, chlordane, dieldrin, and zinc concentrations at 5 wells suggest a potential need to monitor surface water quality. Two of these wells (BT-113 and S2001S) are not situated at the downgradient edge of the study area or adjacent to the discharge zone. Zinc in the groundwater at well BT-113-MW and phenanthrene at F2002S and NH-499-MW in the Bryden Terrace area overall must migrate through the rest of the Non-Public Property study area before reaching any discharge zone. Chlordane and dieldrin at well S2001S is the farthest location any well in the study area can be from any presumed discharge zone. Other monitoring wells already installed downgradient of these locations (in blocks H through N) are more appropriate for evaluating the need for surface water quality assessment. Zinc and dieldrin concentrations at these downgradient wells are compliant with SWPC. Only phenanthrene exceeds SWPC in downgradient wells H2002D and H2003S near the southwest corner of the study area in the February round. However, these concentrations were not detected in the November round, are just above the detection limit in the February round, and have not been validated.

4.0 CONCLUSIONS

The Supplemental Investigation accomplishes all the objectives set forth in the Work Plan and the study area is considered sufficiently characterized to support remedial decisions and remedial design. No additional work is required other than the two remaining groundwater rounds and investigations at potentially 3 properties where access was denied to Olin but where CTDEP is negotiating access.

With data gathered from 95% of the properties who granted access, the CSM is considered complete and representative of actual conditions. Conclusions for properties with no access were inferred from the results from neighboring properties. Data from various sources are in agreement, successfully predicting the presumed conditions, and the results are appropriate for comparison to RSR criteria. The DQOs resolved the data gaps such that conditions can be logically explained to the stakeholders, and a remedial action plan can be chosen.

The nature and extent of the fill material has been established. With regard to nature, the analytical results indicate that the contiguous fill and most of the isolated fill areas have substance concentrations exceeding RSR criteria, including both RDEC and GAPMC. Non-compliant concentrations are found throughout the fill volume indicating that any portion has the potential to exceed RSR criteria. The principal SOCs (arsenic, lead, SPLP lead, PAHs, and ETPH) are indicators for non-compliance for the fill because only 7 samples of fill out of 839 samples are non-compliant only for other SOCs. The principal SOCs are intrinsic to the fill matrix and occur in all other fill areas and in all three fill types.

With regard to extent (quantity and configuration), the five major contiguous fill areas have been mapped in enough detail to locate the edge on any property within about 20 feet and estimate the area, which is approximately 29 acres. The thickness is understood well enough to estimate the volume, which is approximately 300,000 cubic yards.

Thirty-three isolated fill areas were found and most have been mapped to the same precision as the contiguous fill. The minimum total area of isolated fill areas is approximately 3 acres with an average fill thickness of 1.8 feet. Minimum total volume is approximately 8,500 yd^3.

Therefore, a thorough review of all the data furnished by the agencies, the other party's investigations, and Olin's Initial Voluntary Investigation and Supplemental Investigation, identifies the contaminated fill at approximately 310,000 cubic yards in the NPP area. About 225 properties are at least partially underlain by this widespread fill. Later, in section 5.0, the RAP will discuss how much of this total needs to be remediated, by excavation or covering, in order to achieve compliance with the RSR.

Evaluation of Groundwater

Shallow and deeper groundwater flow is westward near Prospect Hill to southwestward under the Southwest Satellite Fill Area and southward at Block T. The groundwater quality appears to be only slightly degraded relative to upgradient wells. Despite numerous detections of SPLP lead above GAPMC in the fill, lead in groundwater is below RSR criteria. The following few non-compliant SOCs were found in the groundwater:

- Chloroform exceeds groundwater protection criteria (GWPC) in 9 wells and exceeds residential groundwater volatilization criterion (RGWVC) at 4 wells. It is not an SOC associated with fill.
- Extractable total petroleum hydrocarbons (ETPH) were detected at different contiguous fill areas and exceed GWPC at 8 wells.
- Chlordane and dieldrin exceed GWPC where detected, and the concentrations at upgradient well S2001S exceeds their SWPC. The zinc concentration at well BT-113 in the Bryden Terrace contiguous fill area exceeds SWPC. Neither location is near the downgradient edge of the site.
- Unvalidated PAH concentrations in 4 wells, including 2 downgradient wells, slightly exceed their SWPC and detection limit.

The overall groundwater quality appears to be consistent with both the GB and GAA Impaired CTDEP groundwater classifications. However, the actual flow directions are away from the reservoir indicating that the GAA classification for this area is unnecessary.

Only phenanthrene exceeds SWPC in downgradient wells near the southwest corner of the study area. However, these concentrations were not detected in the first round, are just above the detection limit, and have not been validated. Given the preliminary nature of the data, the low concentrations, the great distance (1/2-mile) to the closest presumed discharge zone (ponds at Beaver Pond Park), and the numerous other intervening potential sources of this SOC to those ponds, a surface water quality assessment is not recommended.

5.0 REMEDIAL ACTION PLAN

5.1 PURPOSE

This section presents an evaluation of potential remediation alternatives and a recommended remedial action plan (RAP). The goal of the RAP is to provide an environmentally protective and compliant remedy that can be implemented in the least disruptive and most cost efficient and expeditious manner.

The feasibility of potential remedial technologies, associated costs, and schedules were evaluated to determine what options are available for addressing the non-compliant fill located within the Non-public Properties study area. Potential technologies were screened and those that were found to be applicable were further evaluated for feasibility. While several different remedial options are available, the ultimate decision to select a specific technology will have to address not only the cost and technical feasibility, but also the impact to the specific homeowners whose properties fall within the fill areas, plus the community as a whole. The recommended RAP will most likely incorporate a combination of the technologies described in the following sections.

The costs presented are realistic based on best engineering practice and experience, but are not intended to be used for funding or construction purposes. The costs are sufficiently accurate to rank alternatives for planning and decision making purposes.

5.2 OBJECTIVES

The primary remedial objectives for the study area are to comply with the terms of the Consent Order # SRD-128. Specific remedial objectives include:

- Remediation of the study area in accordance with the applicable Connecticut Department of Environmental Protection (CTDEP) Remediation Standard Regulations (RCSA 22a-122k) (RSR) as well as any other laws and regulations that may apply. As detailed in previous sections, the primary concern is fill that exceeds RDEC for metals (primarily lead), PAHs and ETPH, and GAPMC for metals.

- Select a cost-effective remedial technology(ies) that addresses the remedial needs and is generally acceptable to the community.

5.3 REMEDIAL TECHNOLOGY ALTERNATIVES

A brief description of the remedial technology alternatives evaluated for the non-compliant fill material is presented in this section. Also presented are a review of the effectiveness and the potential for successfully implementing each alternative and assuring its long-term integrity, the means by which each alternative addresses the direct exposure criteria (DEC) and pollutant mobility criteria (PMC), and the costs of the various alternatives.

An initial screening of remedial technologies was performed to determine which technologies are and are not potentially applicable. The following technologies were not included in the detailed evaluation because of the indicated shortcomings.

- Incineration/Thermal Treatment
  - Does not eliminate contaminant toxicity/direct exposure potential for metals.
  - Residual material may still require landfilling or further treatment.
  - Does not address material under structures.
- In-Situ Solidification/Stabilization
  - Limited by varied composition and size of the fill materials.
  - Cannot guarantee complete contact of the solidification agent with the fill.
  - Does not eliminate contaminant toxicity/direct exposure potential for metals.
  - Likely will increase volume of material treated, raising grades or requiring excavation and removal of excess material from the NPP study area for disposal.
  - Does not address material under structures
- In-Situ Bioremediation
  - Does not eliminate contaminant toxicity/direct exposure potential for metals.

The technologies that were considered potential alternatives for remediating the study area were divided into two categories based on the depth of fill. In areas where non-compliant fill is present at depths shallower than four feet below the ground surface (bgs), removing the fill and replacing it with clean fill was the only alternative considered (Alternative 1). This remedy satisfies both DEC and PMC criteria, allows for restoration of the property with minimal disruption to the residents, and places no restrictions on the property owner regarding future land use. In addition, a significant number of properties that fall into this category contain fill material at depths shallower than four feet or have only small areas of fill on the property.

Several of the remedial alternatives presented below include provisions for the requesting of certain variances which are allowed by the CTDEP regulations. These variances could include some or all of the following: widespread polluted fill; establishing alternative PMC; and reclassification of the groundwater quality to GB. It is recognized that the granting of these variances by the CTDEP is subject to rigorous technical scrutiny; must be consistent with applicable laws, regulations, and policies; and is taken at the discretion of the Commissioner after obtaining public input. The granting of these variances by the Commissioner is not presumed. However, based upon the extensive information developed from this and the earlier investigation, it is the best professional judgment of the investigator, that sound technical and regulatory bases exist for the alternatives recommended.

Where non-compliant fill is present at depths less than four feet bgs, the following alternative was evaluated:

- *Alternative 1: Removing and Replacing Fill*

Where non-compliant fill is present at depths greater than approximately four feet bgs, the following alternatives were evaluated:

- *Alternative 2A: Removing and Replacing the Top Four Feet of Fill Material, Obtaining a Widespread Polluted Fill Variance with or without the Reclassification of Groundwater Quality, and Obtaining an ELUR*
- *Alternative 2B: Removing and Replacing the Top Four Feet of Fill Material, Obtaining Alternative Pollutant Mobility Criteria with or without the Reclassification of Groundwater Quality, and Obtaining an ELUR*
- *Alternative 3A: Removing and Replacing the Top Two Feet of Fill Material, Constructing a DEC Control Measure, Obtaining a Widespread Polluted Fill Variance with or without the Reclassification of Groundwater Quality, Providing for Long-term O&M, and Obtaining an ELUR*
- *Alternative 3B: Removing and Replacing the Top Two Feet of Fill Material, Constructing a DEC Control Measure, Obtaining Alternative Pollutant*

Mobility Criteria with or without the Reclassification of Groundwater Quality, Providing for Long-term O&M, and Obtaining an ELUR

- *Alternative 4: Removing and Replacing the Top Two Feet of Fill Material, Constructing an Engineering Control, Providing for Long-term O&M, and Obtaining an ELUR*
- *Alternative 5: Acquisition and Demolition of Homes, Construction of an Engineering Control, Providing for Long-term O&M, and Obtaining an ELUR.*
- *Alternative 6: Acquisition and Demolition of Homes, Excavation and Disposal of Non-compliant Fill Material, and Replacement with Clean Fill.*

5.4 METHODOLOGY AND APPROACH

The following approach was applied to each alternative:

- All fill that is removed will either be consolidated on the Hamden Middle School property (referred to as "onsite disposal") in compliance with all applicable regulations and/or disposed of at an offsite landfill. Costs for each disposal option are included in the cost analysis for each remedial alternative. Based on existing data, the fill is not a characteristic hazardous waste and could be disposed of in bulk at a permitted landfill.
- All fill within the contiguous fill areas is assumed to be non-compliant. Each isolated fill area has been tested for compliance with the RSRs. All non-compliant isolated fill areas will be included in the RAP.

For the purpose of comparing alternatives, a preliminary opinion of probable costs was calculated for each of the remedial alternatives. Sources used as the basis for costs include quotes from individual contractors, 2005 RS Means Heavy Construction Cost Data 19th Annual Edition, and cost data from professional experience from similar remediation projects in the Northeast. Costs were generally produced by calculating the cost for remediating a single parcel of average size for the alternatives described below. Unit costs are based on work performed concurrently with several properties and not on one property at a time. Remediation costs include:

- Access agreement acquisition – this includes negotiations with the homeowner and will determine the level of property restoration required upon completion of any remedial activities. This will be done before any work is started. Photos will also be taken to document the pre-remediation status of each property.

- Excavation and disposal of fill – this includes transportation, tipping fees, and handling of material at its final destination.
- Backfilling of excavation with clean fill material – this unit cost includes compaction and grading of fill material based on similar project cost and standard engineering sources.
- Volume calculations were based on an average parcel size of 7,000 square feet for Alternative 1 and 8,200 square feet for Alternatives 2 - 6.
- Restoration of property subject to the remedy – this may include repair or replacement of utilities, curbs, drive and walk ways, topsoil and grass, fences, and landscaping. Mature specimen trees will be handled on a case-by-case basis; costs do not include provision for replacement in kind.
- Installation of a DEC control measure or an engineering control as specified by the remedial alternative. The DEC control measures consist of a 4-inch thick binder course of asphaltic concrete pavement, gravel, and clean fill. The engineering control consists of a flexible membrane liner with a geocomposite drainage layer that meets the meets the requirements set forth in the CTDEP RSRs.
- The cost of obtaining an ELUR includes attorneys' fees, an A-2 property survey, filing costs, public notice, and other associated expenses.

Additional unit costs are provided in the cost summary tables for the various alternatives (see Tables 5-1 to 5-8). The cost for remediating a single property was multiplied by the total number of properties included in the remedial alternative. Disposal costs are provided for both onsite disposal of fill behind the Hamden Middle School (HMS) and for offsite disposal (landfilling).

Based on existing grade and a known maximum final elevation specified in the Consent Order, there is approximately 175,000 yd^3 of capacity at the HMS for the onsite disposal of fill material. Onsite disposal costs include transportation, placement, and compaction of the material at the school property, but do not include cap construction or other site restoration activities because these costs will be incurred by others regardless of placement of additional fill at the school.

Costs for landfilling of material were provided by Cycle Chem, Inc. and include transportation to and disposal at EQ of Detroit, Inc. in Detroit, Michigan. Other offsite disposal options, such as beneficial reuse and recycling, may exist at the time of the remedy. However, their availability is generally dependent on a specific market or location and volume of material to be disposed. Beneficial reuse and recycle facilities (e.g., landfill cover material, asphalt batching) generally have limited capacity, variable site-specific acceptance criteria, and cannot be assumed to handle the large volumes of material (50,000 to 300,000 cubic yards) addressed by this RAP. Consequently, landfilling is the only offsite disposal option for the volumes requiring disposal that can be reliably assumed to be available when the remedy is implemented.

The cost for additional technical services pertaining to implementation of the remedy, contractor mobilization and demobilization, and a contingency are also included in the total cost. Remedial design costs (which include activities such as writing a QAPP, HASP, and Workplan) are not included in the total cost presented.

Expenses for post-excavation sampling and analyses are not included in the cost estimate for alternatives entailing complete excavation of the fill material. The extensive characterization database has shown that non-compliant SOC concentrations are substantially confined to the fill material. The substances are relatively immobile in the environment and the fill material is readily discriminated from the surrounding native materials. QA/QC during the remedy implementation will verify that all surfaces at the limit of excavation consist of clean natural materials and are backfilled and restored using fill materials from approved sources.

Operation and Maintenance (O&M) costs for both the DEC control measure and the engineering control alternatives have been identified at the bottom of each table, where applicable, but are not included in the total cost of each alternative. O&M costs include activities such as maintenance, monthly inspections, groundwater monitoring, an annual bench mark survey, and various technical services including reviews of monitoring and settlement data.

5.5 ALTERNATIVES 1-6

Alternative 1: Removing and Replacing Fill

Fill that exceeds DEC or PMC and is at depths shallower than approximately four feet bgs can be addressed by completely removing the material and replacing it with clean fill.

Excavation can be accomplished with over the road equipment, capable of working in the yard areas, with minimal shoring or sheeting requirements and minimal threat to structures. Because the fill material is visually distinct from the native soil and quality control oversight of the excavation will verify that all fill material is removed, and the underlying native soils have been adequately characterized and are substantially compliant with the RSRs. post-excavation sampling is not considered necessary.

This approach removes all impacted material from the property and therefore fully addresses the RSRs. Alternative 1 also does not require an Environmental Land Use Restriction (ELUR) on the property and no long-term institutional controls or O&M are needed to monitor the integrity of the remedy. Properties will be restored to conditions agreed upon by the homeowner during the access agreement acquisition phase. Temporarily relocation of residents may be necessary during the scheduled remediation of their properties.

ALTERNATIVE 1	
ADVANTAGES	**DISADVANTAGES**
• Complete removal of all fill material • Allows for complete restoration of the property • No ELUR • No long-term O&M • Meets DEC and PMC criteria	• Access agreement acquisition • Temporary disruption and possible dislocation of residents • Potential temporary disruption and reconstruction of utility services

Cost: This alternative would be implemented at those properties with less than four feet of fill and would include the isolated fill areas and the properties located along the edges of the contiguous fill (~131 properties). Unit costs developed for this alternative are shown in Table 5-1. Restoration costs do not include replacement in kind of mature specimen trees which would be handled on a case-by-case basis during implementation of the remedy. Assuming this technology would be used on 131 properties, the preliminary opinion of probable costs ranges from $7.8 million (onsite disposal) to $23.6 million (offsite disposal). The range is due to the potential costs associated with disposing of the fill material at an offsite disposal facility.

Alternative 2A: Removing and Replacing the Top Four Feet of Fill Material, Obtaining a Widespread Polluted Fill Variance with or without the Reclassification

of Groundwater Quality, and Obtaining an ELUR

This alternative would address the DEC through the excavation of fill to a depth of four feet bgs and the placement of clean backfill in the excavated areas to render the remaining fill inaccessible. The considerations relative to excavation and backfill to a relatively shallow depth of four feet are similar to those presented in Alternative 1. To address the PMC, a request will be submitted to the CTDEP by the current property owners, or through an alternative mechanism acceptable to the Commissioner, to receive a widespread polluted fill variance. The success of this alternative is based on the properties meeting the requirements described in the CTDEP RSRs and subsequent review and approval by the Commissioner. The historical records, as well as the environmental characterization of the study area, indicate that the material meets the RSR definition of widespread polluted fill. The fill is not polluted with volatile organic substances and does not affect the quality of an existing or potential public or private water supply. The placement of fill was not prohibited by law at the time of placement. An ELUR would be recorded on the land records to prohibit disturbance of the fill at depths below four feet without appropriate protective or remedial measures. A post-remedial groundwater monitoring program may be required.

ALTERNATIVE 2A	
ADVANTAGES	**DISADVANTAGES**
• Allows for complete restoration of the property, minimal intrusion upon residents' use of property • Addresses DEC and PMC requirements • Property purchases not required • Maintains the neighborhood • No long-term O&M needed to ensure integrity of a structural remedy	• Need to obtain Widespread Polluted Fill variance • ELUR required limiting excavation • Temporary access agreement acquisition • Temporary relocation of residents during remedy implementation may be necessary • Groundwater monitoring program may be Required • May need to obtain groundwater quality reclassification

<u>Cost:</u> This alternative would be implemented at those properties with greater than four feet of fill (~90 properties). Unit costs developed for this alternative are shown in Table 5-2. Assuming this remedy will be used on all 90 properties, the preliminary opinion of probable costs range from $14.3 million (on-site disposal) to $46.5 million (off-site disposal). These costs do not include the costs of implementing a groundwater

monitoring program. The range in cost is due to the potential costs associated with disposing of the fill material at an offsite disposal facility.

Alternative 2B: Removing and Replacing the Top Four Feet of Fill Material and Obtaining Alternative Pollutant Mobility Criteria with or without the Reclassification of Groundwater Quality, and Obtaining an ELUR

This alternative would address the DEC through the excavation of fill to a depth of four feet bgs and the placement of clean backfill in the excavated areas to render the remaining fill inaccessible. The considerations relative to excavation and backfill to a relatively shallow depth of four feet are similar to those presented in Alternative 1. To address the PMC, a further investigation of the fill material (a laboratory bench test) and hydrologic modeling would be conducted to obtain an alternative PMC. This investigation would include activities such as a leachate column study. In addition, an analysis of the watershed hydrology would be completed to determine available site dilution factor and the appropriate groundwater classification for the watershed. The required demonstrations to establish an alternative PMC are highly technical and the outcome is uncertain until they are performed.

The hydrology data suggest that the primary direction of groundwater flow is to the southwest toward an area of GB classification and is not tributary to the Lake Whitney watershed recharge. Consequently, a request would be made to reclassify the groundwater from GAA Impaired to GB. GB classification for the site is apparently consistent with the surrounding area and Connecticut Water Quality Standards. Reclassification would allow the characterization data to be compared to GBPMC, which are less stringent than the PMC criteria for a GA area. An ELUR would be recorded on the land records to prohibit disturbance of the fill at depths below four feet without appropriate protective or remedial measures. A post-remedial groundwater monitoring program may be required.

ALTERNATIVE 2B	
ADVANTAGES	**DISADVANTAGES**
• Allows for complete restoration of the property, minimal intrusion on residents' use of property • Addresses DEC and PMC requirements • No long-term O&M needed to ensure remedy integrity • Property purchases not required • Maintains the neighborhood	• Need to obtain alternative Pollutant Mobility Criteria. • Potential need to reclassify GW quality, success uncertain • ELUR required limiting excavation • Temporary relocation of residents during remedy implementation may be necessary • Temporary access agreement acquisition • Groundwater monitoring program may be required

<u>Cost:</u> This alternative would be implemented at those properties with greater than four feet of fill (~90 properties). Unit costs were developed for this alternative are shown in Table 5-3. Assuming this technology would be used on all 90 properties, the preliminary opinion of probable costs range from $14.5 million (on-site disposal) to $46.8 million (off-site disposal). These costs do not include the costs of implementing a groundwater monitoring program. The range in cost is due to the potential costs associated with disposing of the fill material at an offsite disposal facility.

Alternative 3A: Removing and Replacing the Top Two Feet of Fill Material, Constructing a DEC Control Measure, Obtaining a Widespread Polluted Fill Variance with or without the Reclassification of Groundwater Quality, Providing for Long-term O&M, and Obtaining an ELUR

This alternative would address the DEC through the excavation of fill to a depth of two feet bgs and the placement of a DEC control measure to render the remaining fill inaccessible. The considerations relative to excavation and backfill to a relatively shallow depth of two feet are similar to those presented in Alternative 1, but further mitigated by the shallower depth. The volume of fill material to be handled and disposed of would be nominally halved relative to alternatives entailing four feet of excavation. The control measure would consist of a paved surface, sub-base, and clean backfill that has a combined minimum thickness of two feet. The paved surface would require installation of yard drains that would be connected to the existing storm sewers. The increase in surface water runoff may overload the existing stormwater drainage system necessitating replacement of drains and/or the construction of storm water management facilities. The paved surface would significantly restrict the residents' options for landscaping and use of the property. Any landscaping would be in raised beds or planters elevated above the paved surface.

To address the PMC, the same procedures would be followed as described in Alternative 2A. An ELUR would be recorded on the land records to prohibit disturbance of the fill at depths below four feet without appropriate protective or remedial measures. To monitor that the DEC control measure remains intact, maintenance of the control measure would continue indefinitely. This will require a financial assurance mechanism that would cover all O&M costs that may be incurred. A groundwater monitoring program would be required to demonstrate the effectiveness of the remediation in preventing migration of SOCs to groundwater.

ALTERNATIVE 3A	
ADVANTAGES	**DISADVANTAGES**
• Addresses DEC and PMC requirements • Less fill material to be removed • Property purchases not required • Maintains the neighborhood	• Need to obtain Widespread Polluted Fill variance • Major impacts to homeowners' use of property (loss of lawns, vegetation, etc.) • Stormwater management and grading issues • ELUR required • Requires maintenance indefinitely • Financial assurance mechanism required • Temporary/Permanent access agreement acquisition • Temporary relocation of residents during remedy implementation may be required • Groundwater monitoring program required

<u>Cost:</u> This alternative would be implemented at those properties with greater than four feet of fill (~90 properties). Unit costs developed for this alternative are shown in Table 5-4. Assuming this technology would be used on all 90 properties, the preliminary opinion of probable costs range from $13.4 million (on-site disposal) to $29.5 million (off-site disposal). These costs do not include the costs of implementing town storm sewer improvements, a groundwater monitoring program, and the O&M costs associated with maintaining the DEC control measure. The range in cost is due to the potential costs associated with disposing of the fill material at an offsite disposal facility.

Alternative 3B: Removing and Replacing the Top Two Feet of Fill Material, Constructing a DEC Control Measure, Obtaining Alternative Pollutant Mobility Criteria with or without the Reclassification of Groundwater Quality, Providing for Long-term O&M, and Obtaining an ELUR

This alternative would address the DEC through the excavation of fill to a depth of two feet bgs and the placement of a DEC control measure to render the remaining fill inaccessible. The considerations and issues presented by this alternative are similar to those presented by the previous Alternative 3A. The primary difference is the mechanism employed to achieve compliance with PMC. This control measure would consist of a paved surface, sub-base, and clean backfill that has a minimum thickness of two feet. The paved surface would require installation of yard drains which would be connected to the existing storm sewers. The increase in surface water runoff may overload the existing stormwater drainage system.

To address the PMC, the same procedures would be followed as described in Alternative 2B entailing the same considerations and issues. An ELUR would be recorded on the land records to prohibit disturbance of the fill at depths below four feet without appropriate protective or remedial measures. To monitor that the DEC control measure remains intact, maintenance of the control measure would continue indefinitely. This will require a financial assurance mechanism that would cover all O&M costs that may be incurred. A groundwater monitoring program would be required to demonstrate to demonstrate the effectiveness of the remediation in preventing migration of SOCs to groundwater.

ALTERNATIVE 3B	
ADVANTAGES	**DISADVANTAGES**
• Addresses DEC and PMC requirements • Less fill material to be removed • Property purchases not required • Maintains the neighborhood	• Need to obtain alternative Pollutant Mobility Criteria • Potential need to reclassify GW quality • Major impacts to homeowners' use of property (loss of lawns, vegetation, etc.) • Stormwater management and grading issues • ELUR required • Requires maintenance indefinitely • Financial assurance mechanism required • Temporary/Permanent access agreement acquisition • Temporary relocation of residents during remedy implementation may be required

Cost: This alternative would be implemented at those properties with greater than four feet of fill (~90 properties). Unit costs developed for this alternative are shown on Table 5-5. Assuming this technology would be used on all 90 properties, the preliminary opinion of probable costs range from $13.5 million (on-site disposal) to $29.6 million (off-site disposal). These costs do not include the costs of implementing town storm sewer improvements, a groundwater monitoring program, and the O&M costs associated with maintaining the DEC control measure. The range in cost is due to the potential costs associated with disposing of the fill material at an offsite disposal facility.

Alternative 4: Removing and Replacing the Top Two Feet of Fill Material, Constructing an Engineering Control, Providing for Long-term O&M, and Obtaining an ELUR

This alternative would address the DEC and PMC through the excavation of fill to a depth of two feet bgs and the placement of an engineering control to physically and environmentally isolate the fill material and minimize the migration of water through the fill. The engineering control would be an engineered cap (a geocomposite drainage layer and flexible membrane liner) that meets the requirements set forth in the CTDEP RSRs. Additional backfill would be required to install a properly sloped sub-drainage system, which would be connected to the existing storm sewers. The existence of the membrane and drainage layer at shallow depth would restrict the residents' use of the property; specifically any excavation, plantings, structures or hardscape items which would require foundations below frost penetration. Extreme care would be required to ensure the integrity of the cap joint with foundations and at utility service penetrations.

An ELUR would be recorded on the land records to prohibit disturbance of the fill at depths below four feet without appropriate protective or remedial measures. To monitor that the engineering control remains intact, maintenance of the control measure would continue indefinitely. This would require a financial assurance mechanism that would cover all potential O&M costs. A groundwater monitoring program would be required to demonstrate the effectiveness of the engineering control in preventing migration of SOCs to groundwater.

ALTERNATIVE 4	
ADVANTAGES	**DISADVANTAGES**
• Addresses DEC and PMC requirements • Less fill material to be removed • No discretionary exemptions or variances required • Property purchases not required • Maintains the neighborhood	• Constructability (maintain current grades, integrate cap into foundations, utility service penetrations, stormwater and internal drainage) • Infringement on the landowners enjoyment of the property • Land-use restrictions will include no trees, no penetration of the cap • ELUR required • Requires maintenance indefinitely • Financial assurance mechanism required • Temporary/Permanent access agreement acquisition • Temporary relocation of residents may be required during remedy implementation • Groundwater monitoring program required

<u>Cost:</u> This alternative would be implemented at those properties with greater than four feet of fill (~90 properties). Unit costs developed for this alternative are shown in Table 5-6. Assuming this technology would be used on all 90 properties, the preliminary opinion of probable costs range from $21.6 million (on-site disposal) to $37.7 million (off-site disposal). These costs do not include the costs of implementing a groundwater monitoring program and the O&M costs associated with maintaining the engineering control. The range in cost is due to the potential costs associated with disposing of the fill material at an offsite disposal facility.

Alternative 5: Acquisition and Demolition of Homes, Construction of an Engineering Control, Providing for Long-term O&M, and Obtaining an ELUR.

This alternative would address the DEC and PMC through the placement of a substantially continuous engineering control to physically and environmentally isolate the fill material and minimize the migration of water through the fill. To accomplish this, all homes located within the project boundary would be acquired. Acquisition and demolition of the homes technically simplifies construction of the engineering control. Numerous constraints on site grading are eliminated since removal of the structures allows expansive, continuous surfaces. Similarly the numerous joints, seams and utility penetrations required to accommodate the many structures are also avoided. Constructability and long-term integrity of the control would be significantly enhanced relative to Alternative 4. The engineering control would be an engineered cap (a geocomposite drainage layer and flexible membrane liner) that meets the requirements set forth in the CTDEP RSRs.

Prior to the installation of the cap, all structures, site improvements, and vegetation located within the boundary of the cap would be demolished and removed. The cap area would be regraded to form regular, gently sloped surfaces and easily integrated surface and sub-drainage systems, which will be connected to the existing storm sewers. The absence of structures would allow fill material to be regraded onsite as needed to achieve the desired regular and continuous surface slopes eliminating the need for removing fill from the project area. The capped area would be left as a grass surface and fenced to minimize the prospect of damage to the cap. Once the cap is in place, the consolidated properties represent an opportunity for redevelopment in a manner consistent with the presence of the cap. However, any potential economic benefit from future redevelopment is not included within the cost analysis.

An ELUR would be recorded on the land records to prohibit disturbance of the fill at depths below four feet without appropriate protective or remedial measures. To monitor that the engineering control remains intact, maintenance of the control measure would continue indefinitely. This will require a financial assurance mechanism that would cover all potential O&M costs. A groundwater monitoring program would be required to demonstrate the effectiveness of the engineering control in preventing migration of SOCs to groundwater.

ALTERNATIVE 5	
ADVANTAGES	**DISADVANTAGES**
• Addresses DEC and PMC requirements • No fill material will need to be removed • State will own properties, can issue ELUR	• Destruction of neighborhood/Resident relocation • Decreased property tax income to Town • Security fencing of 17 acres • Stormwater management issues • Requires maintenance indefinitely • Financial assurance mechanism required • Requires restoration and maintenance of road system through the remedy area • Groundwater monitoring program required

Cost: This alternative would be implemented at those properties with greater than four feet of fill (~90 properties). Unit costs developed for this alternative are shown in Table 5-7. Average home acquisition costs are approximate and are based on the latest available Hamden appraised values (October 2000) adjusted to reflect estimated current market value and assumed transaction expenses. Assuming this technology would be used on all 90 properties, the preliminary opinion of probable cost of implementation would be approximately $31.2 million. These costs do not include the costs of implementing a groundwater monitoring program and the O&M costs associated with maintaining the engineering control.

Alternative 6: Acquisition and Demolition of Homes, Excavation and Disposal of Non-compliant Fill Material, and Replacement with Clean Fill.

This alternative would address the DEC and PMC through the complete removal of non-compliant fill material. To accomplish this, all affected properties located within the project boundary (the area to be excavated) would be acquired. Following the acquisition, the entire area would be cleared of structures, site improvements, and vegetation. The fill would than be excavated and replaced with clean backfill back to the pre-remediation grade. This approach removes all non-compliant fill from the properties and would not require an ELUR on the property.

ALTERNATIVE 6	
ADVANTAGES	**DISADVANTAGES**
• Complete removal of all fill material • Meets DEC and PMC numeric criteria • Remediated areas could be redeveloped for unrestricted future uses	• Requires the purchase of homes • Destruction of neighborhood/Resident relocation • Temporary decreased property tax income to Town • Significant disruption to abutting properties during material excavation • Large volume of material generated for offsite disposal and equivalent volume of backfill • Significant traffic associated with waste and backfill hauling • Volume of waste fill generated exceeds onsite disposal capacity. Significant additional disposal cost • Requires restoration and maintenance of road system through the remedy area

Cost: This alternative would be implemented at those properties with greater than four feet of fill (~90 properties). Unit costs developed for this alternative are shown in Table 5-8. Average home costs are approximate and are based on the latest available Hamden appraised values (October 2000) adjusted to reflect estimated current market value and assumed transaction expenses. Assuming this technology would be used on all 90 properties, the preliminary opinion of probable costs range from $90 million (partial on-site disposal) to $148.6 million (all off-site disposal). The range in cost is due to the potential costs associated with disposing of the fill material at an offsite disposal facility.

5.6 PREFERRED REMEDIAL APPROACH

Table 5-9 provides a summary of the various remedial alternatives and the costs associated with each alternative.

Based on this evaluation of alternative remedial technologies, Alternative 1 plus Alternative 2A with onsite disposal is the recommended remedial approach for the NPP study area. These alternatives achieve the desired goals of the RAP, meet CTDEP remediation standards for both DEC and PMC, pose the least disruption of the neighborhood and least long-term infringement on property use, can be practically implemented, and do not require long-term operation and maintenance. These alternatives avoid the risk regarding the long-term effectiveness of a control measure or engineered control, and do not require the acquisition of properties. The school site has capacity for the estimated 150,000 cubic yards of fill to be excavated. In addition, onsite disposal will facilitate use of smaller trucks than can be practically used for offsite disposal, which is safer, less polluting, and less disruptive to the residents.

Alternative 2A is preferred over 2B because the data supporting a Widespread Polluted Fill Variance have already been collected. The work required to complete a column study will take several months to complete and the results are not certain. Alternatives 3 through 6 are not practical for the reasons cited in the above discussions. The total remediation costs for implementing Alternatives 1 and 2A are estimated to be $22.1 million. These alternatives are cost effective only with disposal of the fill at the school property. If offsite disposal is required, all alternatives requiring excavation increase in cost significantly. The next least costly alternative is Alternative 5, *Acquisition and Demolition of Homes, Construction of an Engineering Control, Providing for Long-term O&M, and obtaining an ELUR*. This alternative would destroy the present fabric of a significant and vital portion of the neighborhood.

5.7 SCHEDULE

As shown in Table 5-9, the estimated time to complete the recommended remedies is 4 years. The times shown are from mobilization of construction crews to the site and are based on 125 available work days per year with a 25% contingency. Because the recommended alternatives presume disposal of the fill at the school site, excavation can commence no sooner than when the HMS is closed and the area becomes available. The Town estimates that this will occur no sooner than September 2006.

Pre-construction activities are not included in the schedule shown in Table 5-9. Several issues need to be resolved before a remedy can be implemented. First, the RAP must gain approval of CTDEP. Access agreements need to be obtained from owners of all affected properties. Funding needs to be secured and a contracting mechanism agreed upon. After these issues are resolved, 1 year will be needed to prepare a remedial design, obtain approval from the CTDEP and secure contracts for the work to be performed. In addition, coordination of the NPP remedy with remedial plans for the public properties is imperative. The RAP for the public properties has not yet been developed.