NEWTOWN CREEK/GREENPOINT OIL SPILL STUDY BROOKLYN, NEW YORK

September 12, 2007

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Executive Summary

Section 1: Introduction, Legislative & Historical Background

A. Introduction: This study was compiled by a team of U.S. Environmental Protection Agency (EPA) scientists, biologists, engineers, hydrogeologists, geologists, risk assessors, attorneys and EPA contractor geologists and engineers. The study is based upon a review of both public and private sector organizations. Methodologies, models, sampling data, and other pertinent information from all discovered sources were reviewed and considered in making the recommendations of this study. In order to produce the study in a timely manner, EPA conducted no additional sampling. Instead, EPA focused on the reviews of existing documents and previously collected sampling data. A conscious decision was made to limit the scope of the study to the Newtown Creek oil spill and its petroleum based impacts on the Greenpoint community. Because of the more than 140+ years of heavy industry in the area of Newtown Creek, it would not be feasible in one year to evaluate potential health risks from a large number and wide variety of possible industrial contamination. The oil seepage into the Creek seems to be only one of many pollution issues impacting Newtown Creek. A potentially more significant issue that appears to be having a major effect on the Creek is the ongoing discharge from the New York City-Newtown Creek municipal wastewater treatment system, the combined sewer overflows and the consequent zero oxygen levels. This in concert with a stagnated water flow in the Creek will only exacerbate the Creek's future ability to recover. Plans to upgrade the New York City-Newtown Creek municipal wastewater treatment system to secondary treatment are currently underway pursuant to an enforcement agreement between the New York State Department of Environmental Conservation (NYSDEC) and the New York City Department of Environmental Protection (NYCDEP). In order to address the combined sewer overflow issues, a Watershed/Waterbody Facility Plan will be submitted by NYCDEP to NYSDEC shortly which will lay out the City's long term abatement program for managing the source of the contamination.

B. Legislative History: The Coast Guard and Maritime Transportation Act of 2006" (Public Law No. 109-241)" was signed by the President on July 11, 2006. Section 410 of the legislation set forth a requirement for EPA to conduct, within one year of enactment, a study of the public health and safety concerns relating to the Newtown Creek oil spill. Section 410 (originally introduced as H.R. 109-889, and referred to below as "H.R. 889") was authored by Representative Anthony Weiner (D-Brooklyn and Queens) and Representative Nydia Velazquez (D-Manhattan, Brooklyn and Queens). Newtown Creek and the Greenpoint community are part of their districts. [See "Conference Report on H.R. 889, Coast Guard and Maritime Transportation Act of 2006" (remarks by Representative Weiner), 152 Cong. Rec. H4527-28, June 26, 2006.]

> ***SEC. 410. NEWTOWN CREEK, NEW YORK CITY, NEW YORK.***
> ***(a) Study****- Of the amounts provided under section 1012 of the Oil Pollution Act of 1990 (33 U.S.C. 2712), the Administrator of the Environmental Protection Agency shall conduct a study of public health and safety concerns related to the pollution of Newtown Creek, New York*

City, New York, caused by seepage of oil into Newtown Creek from 17,000,000 gallons of underground oil spills in Greenpoint, Brooklyn, New York.

(b) Report- *Not later than one year after the date of enactment of this Act, the Administrator shall submit a report containing the results of the study to the Committee on Environment and Public Works and the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Transportation and Infrastructure of the House of Representatives.*

To meet this legislative mandate, EPA looked at the following main issues:

- Review of the 1979 USCG Report;
- Mitigation of seeps into Newtown Creek;
- Extent and mitigation of the free product plume;
- Extent and mitigation of the dissolved product plume;
- Possible vapor intrusion/indoor air problems; and
- Sediments/ecology of Newtown Creek.

Additionally, EPA has addressed in the study, as appropriate, the remarks of Representative Weiner from the House floor concerning H.R. 889. Response to, and discussion of, Representative Weiner's remarks have been included in the study's discussion of the six main issues outlined above.

Shortly after passage of H.R. 889, a Memorandum of Understanding (which had been in coordination for over a year) was signed between the USCG and EPA on July 21, 2006, which transferred response authority for this area by adjusting the jurisdictional boundary from the USCG to EPA.

C. Area Characterization and Spill History: The northeast area of Greenpoint, the northwestern-most community in Brooklyn, New York has been heavily industrialized and the site of various petroleum industries for more than 140 years. The industrial history of this section of Brooklyn dates back to the 1830s. Large quantity petroleum storage and refining were some of the predominant activities in this area in the 1860s. An 1844 map of the area shows where Newtown Creek had been partially filled, and much of the area that has been historically used for oil storage and refinery operations is located on this fill. Petroleum refining within the Greenpoint area began in approximately 1866. By 1870 more than 50 refineries were located along the banks of Newtown Creek. This tidal area of salt marshes along the creek was reportedly severely impacted and saturated by the waste discharges of the industries and refineries in the area in the late 1800s.

In 1892, the majority of the area refineries were purchased and consolidated into the Standard Oil Trust. Following the breakup of the Trust in 1911, ownership of the refinery property in Greenpoint reverted to the Standard Oil Company of New York (SOCONY), and these operations became the SOCONY Brooklyn Refinery. SOCONY later became Mobil Oil

Corporation, which later became Exxon/Mobil Corporation, referred to below as Exxon/Mobil. Refinery operations at the former Mobil Brooklyn Refinery ceased in 1966. The refinery was subsequently demolished, and significant portions of the refinery property were sold. Several of the subdivided lots were retained by Mobil Oil Corporation, while the other lots were sold to Amoco Oil Company and others. The lots retained by Mobil were utilized as a petroleum bulk storage terminal until 1993, when storage operations ceased at the property. Amoco Oil Company (currently BP, referred to below as BP/Amoco) constructed a bulk fuel storage terminal on its portion of the property that began operation in late 1969 and which continues in operation today. In addition to the petroleum facilities on the former Mobil site, the Paragon Oil Company occupied a portion of the site. Paragon Oil was a wholly-owned subsidiary of Texaco Oil, now Chevron Corporation (ChevronTexaco). Paragon operated an oil storage terminal at this location until approximately 1969, when Peerless Importers purchased the property and constructed a warehouse for its operations.

Prior to 1947, the ground water under Brooklyn was the sole source of the Brooklyn Municipal Water System. This system pumped huge quantities of water and caused a significant decline in ground water levels in that area. The pumping was so heavy that it created a large "cone of depression" (an area where the ground water levels are depressed due to pumping) in the ground water and is believed to have reversed the direction of flow of ground water away from Newtown Creek toward the pumping station. In the past 60 years since the pumping station closed down, the ground water levels have recovered and the direction of the flow has reversed back toward Newtown Creek. Since 1947 the ground water in Brooklyn has not been used as a source of public drinking water.

The U. S. Coast Guard first detected signs of an oil spill entering Newtown Creek in 1978. A subsequent investigation concluded that the area of the spill under the Greenpoint area was in excess of 52 acres, and the total spill volume, as estimated in 1979, was approximately 17 million gallons (Mgal) of petroleum product.

Petroleum product recovery operations are currently in place within four distinct areas, including the former Exxon/Mobil Brooklyn Terminal, the BP Brooklyn Terminal, the commercial/industrial/residential area southwest of the BP Terminal known as the Off-Site Area, and the site of the former Paragon Oil Terminal, which is currently the location of the Peerless Importers facility. Product recovery systems have been in place on both the terminal properties and in the Off-Site Area since 1979. In 1990, Mobil entered into two consent orders with NYSDEC and began upgrades to its recovery systems, including the design and construction of a new and expanded system to recover the free product from the Off-Site Area. Following the discovery of free product seepage through the facility's bulkhead, Mobil also began recovery activities at the Peerless Importers/former Paragon Oil site in 1990 and continued recovery activities until 2005 when Chevron took over that portion of the project.

Of the four petroleum product recovery operations, three separate free product recovery systems are currently operating in Greenpoint. These include the Exxon/Mobil Brooklyn Terminal Recovery and Containment System (RCS), the BP Brooklyn Terminal Recovery System, and the Exxon/Mobil Off-Site Free-Product Recovery System. Both Exxon/Mobil and

BP have recently completed upgrades to their terminal recovery systems to increase the free product recovery capacity and water treatment capabilities of their systems. Through these combined efforts, a total of approximately 8.8 Mgal of product, or about half of the amount estimated to have been spilled, has been recovered from the plume areas. (Much of this historical summary came from the NYSDEC website found at: http://www.dec.state.ny.us/website/der/projects/reg2/greenpoint.)

Depending on various estimates, approximately 17 to 30 millions of gallons of petroleum were spilled in the area. Although some major fires and explosions occurred historically in the storage areas, it is somewhat unclear:

- How much petroleum actually is on the ground water;
- Who are the responsible parties that caused the spill(s);
- Whether the petroleum on the ground water is from one or two events or the culmination of 140 years of spillage;
- Whether other smaller Aboveground Storage Tanks (AST's) and Underground Storage Tanks (UST's) in the area have contributed to the plume; and
- What apportionment of the spill should be allocated to the different potential responsible parties.

Circumstantial evidence points to Exxon/Mobil as the most likely responsible party based on hydrocarbon forensics analysis, product thickness on the ground water, the direction of ground water flow and the seeps originating at the bulkhead adjacent to their property. However, some analysis also suggests that BP/Amoco has contributed significantly as well. In addition, there have been many ASTs and USTs (both commercial and residential) historically in the area; it is unknown how many of those may have leaked over the years. To date, approximately 8.8 Mgal of the projected 17 Mgal on the ground water have been recovered. Comparison of product recovery volume of 8.8 Mgal to date with the original estimated 17 Mgal of product volume and the present size of the plume also suggests that the original volume estimate may have been low, or that recovery volumes may have been overestimated, or both.

D. Spill Related Health Effects: In general, EPA does not perform health effects studies; EPA does conduct risk assessments at certain sites (e.g., those on the National Priorities List) to estimate the potential health risks under current and future exposure scenarios assuming no remedial action will be taken. With respect to the Newtown Creek/Greenpoint oil spill, the determination that response actions are warranted has already been made, and these actions are ongoing.

In light of the ongoing spill response actions, EPA made a determination to focus the study on efforts to remediate and recover the petroleum products of the spill. EPA did, however, review the potential risk pathways related to the spill to evaluate whether or not these were being addressed. There are four possible primary public health exposure routes that are typically associated with petroleum spills:

- Vapor intrusion from the chemicals found in petroleum;

- Contaminated drinking water wells that provide a public drinking water source;
- Ingestion of fish from contaminated waters or food products made from or with the contaminated waters; and/or
- Dermal contact from seeps which transport the petroleum to either the surface soil or surface waters.

At the present time the greatest potential exposure pathway is possible vapor intrusion into the residential properties. The efforts to address this pathway are reviewed in Chapter 2 of this report.

Potable water is provided to the Greenpoint community by the City of New York, from water sources located in upstate New York, and is tested regularly to ensure that the quality meets all necessary federal and state requirements. Therefore the drinking water in this area is not impacted by the spill. Similarly, the ingestion pathway is limited due to the restricted nature of access for fishing in the Creek and the issuance of fish advisories by the NYSDOH in the East River and its tributaries.

The physical nature of the seeps entering Newtown Creek limits the possibility of dermal contact to a member of the public. The Creek is not easily accessed by the public because of the vertical nature of the Creek banks, the location of the seeps on private property, and the siting of industrial facilities along the length of the creek. Although there is access to the Creek via boats, the use of the Creek for recreational boating and/or swimming has not been reported. In the unlikely event of dermal contact by the public with the seeps, the health effects of exposure to the petroleum seeps would be minimal compared to those presented by exposure to sewage and contamination from other historical industrial sources found in the Creek. The sewage and other contamination not related to the oil spill are separate issues from the petroleum seeps and are not evaluated in this report.

Section 2: Summary of Response, Engineering and Analytical Contract (REAC) Report: As directed by Congress, EPA reviewed the Newtown Creek/Greenpoint oil spill report prepared by government contractor Geraghty & Miller for the U.S. Coast Guard in 1979. At EPA's request, EPA's Response, Engineering and Analytical Contract (REAC) contractor (Lockheed Martin) produced a document entitled "Newtown Creek Oil Spill: A Review of Remedial Progress (1979-2007) and Recommendations." This document, referred to as the "REAC Report," is found in this report to Congress at Chapter 1. The REAC Report is based on the review of the Geraghty & Miller report, as well as on the review and analysis of current technical issues regarding the oil spill. The REAC Report's findings and recommendations are summarized as follows:

A. **USCG's 1979 Report:** The 1979 USCG report focused mainly on the physical parameter of defining the spill and establishing booming/collection strategies along Newtown Creek. The report did not focus on extensive recommendations for a comprehensive response to the spill, but rather recommends that cleanup efforts should be based on a few recovery wells and then biodegradation techniques to finalize the recovery. The report projects a total recovery of up to 70% within four years.

This projected cleanup time has since been shown to be unrealistic, since the recovery wells have been operating for more than 25 years. The recovery wells, grout wall, booming and oil collection process did seem to minimize and contain the seeps along the creek. However, it has done little to remediate the plume of oil. It should be noted that the USCG study was based on 1979 technology, and many improvements to modeling, recovery and remediation have been made since then.

B. **Mitigation of Seeps into Newtown Creek:** Focusing the response and recovery on the mitigation of the seeps into the creek would be ineffective without addressing the source. While there are a number of systems currently in place which are property-specific stop gap measures, there is no coordinated effort to attack the spill as a whole. As such, what action one property undertakes to mitigate the seep can have an adverse impact on an adjoining property. An example of this is the grout wall that was installed along the Steel Equities property. This grout wall and its associated recovery wells located behind the wall help to prevent seeps from continuing to occur. Eventually these recovery wells will form a cone of depression which will draw more petroleum toward that area. When this happens the oil will collect and find its way around the end of the wall onto the adjacent property. Another example is the Peerless Recovery system which is currently preventing large seeps from going into the creek. However, this system has the potential to draw the free product plume across the property and may increase seepage in the creek.

C. **Extent & Mitigation of the Free Product Plume:** At present, the extent of the free-product plume is divided into four specific areas:

(1) the On-Site area which includes the Exxon/Mobil properties that overlie the northern portion of the plume, (2) the BP/Amoco terminal that borders Newtown Creek to the southeast of the Exxon/Mobil facility, (3) the Off-Site area which includes commercial and residential areas in the central and southern portion of the plume for which Exxon/Mobil has taken remedial responsibility, and (4) the former Paragon Oil Property (now Peerless Importers and Steel Equities facilities) bordering Newtown Creek, currently being remediated by Chevron/Texaco.

More than 200 monitor/observation wells and approximately 35 designated recovery wells have been installed in the project area since 1978. Until recently, approximately 23 recovery wells were active, including six monitor wells that have been converted to recovery wells. However, in early March 2007, ground water pumping from the On-Site and Off-Site recovery wells was suspended by Exxon/Mobil because of uncertainty about the status of the State discharge permits and because of impending law suits by the State and others concerning the discharge of the oil-stripped water into Newtown Creek. As such, the product recovery will apparently continue via suction of only the free product from recovery wells. This is a much more inefficient and much slower process to recover only the free product without collecting water as well. This will cause the cones of ground water depression developed around the recovery wells that help control product movement to dissipate with time. It is not presently known when ground water pumping will be reinstated.

Numerical modeling in 2001 has indicated that it may take up to 25 years to recover up to an estimated maximum of 70% of the free product in the Off-Site plume. No model estimate appears to be available for recovery time of the On-Site plume beneath the Exxon/Mobil facilities. The On-Site plume exhibits the greatest apparent free-product thickness but also appears to have the lowest recovery rate for the On-Site and Off-Site plume designations.

D. **Extent and Mitigation of the Dissolved Product Plume:** To date, very little data have been collected concerning the dissolved plume. Most of these data on the dissolved product plume have been collected around the margins of the free-product plume. As stated earlier, only about 70% of the petroleum on the ground water is recoverable. The other 30% potentially could contribute to a dissolved-phase plume and also could be a source of soil vapors.

Section 3: Vapor Intrusion Document:

High levels of methane gas concentrations have been found during vapor intrusion sampling in some commercial establishments. These levels were found to be above the Upper Explosive Limit (UEL). This methane has been found to be both biogenic (derived from the by-products of the petroleum spill) and thermogenic (from leaking KeySpan Energy's methane pipes in the area). Exxon/Mobil has established 3 pilot units to conduct vapor extraction and flaring of the methane and other petroleum vapors from above the groundwater. These pilot systems have been in place for the past few months and proved to significantly reduce these methane levels to acceptable levels. In instances when these systems have operated and the methane levels have not been reduced, sampling has then identified thermogenic methane. Once identified, KeySpan is notified and they repair the leaking piping.

As part of the ongoing investigation and remediation activities for the Greenpoint Remediation Project, the NYSDEC determined that an investigation of potential vapor intrusion into residential structures was warranted. The vapor intrusion pathway accounts for the migration of contaminants from one medium (i.e., ground water or soil) to a vapor phase that can collect underneath building foundations (e.g., sub-slab), and finally enter through building foundations into indoor air. This investigation began during the 2006-2007 winter heating season.

NYSDEC, in conjunction with the New York State Department of Health (NYSDOH), is continuing to assess the data that were collected from this investigation. To date, EPA has received analytic results from 45 properties. EPA is providing several recommendations in this report to assist the NYSDEC with this ongoing effort including: additional sampling of area homes to close existing data gaps, providing information to the community on how risk management decisions are being made, and a continued evaluation of ground water data to ensure that the vapor intrusion study provides full coverage of both free product and dissolved phase plume areas. The ability to close data gaps is dependent on obtaining access to residential properties. In spite of considerable outreach by the NYSDEC, participation in this program has been low. Access to homes for sampling purposes may continue to be an issue for the NYSDEC.

Section 4: Natural Resource Damages Assessment (NRDA) Document:

While EPA has a large role in protecting the environment, EPA is not a natural resource trustee. As a result, EPA does not have authority to assess the extent of natural resource damages, recover for lost or diminished natural resources, or restore the natural resources themselves. In matters such as the Newtown Creek/Greenpoint oil spill, EPA's regulatory role is to support the designated Federal natural resource trustee for coastal and marine resources, namely the National Oceanic and Atmospheric Administration (NOAA) and the designated State natural resource trustee, namely the NYSDEC through the New York State Department of Law (NYSDOL). In this matter, EPA has referred the natural resources issues with the site to NOAA which is the lead Federal trustee for coastal and marine resources. Coordination has taken place between NOAA and the Department of the Interior U.S. Fish and Wildlife Service (another Federal trustee), and it was decided that NOAA would retain the Federal trustee lead in this case.

In regard to the Newtown Creek/Greenpoint oil spill, the Federal and State Trustees have recently begun to focus on the extent of natural resource losses in this ecosystem and the relationship of such losses to the releases of petroleum in the Greenpoint community and the into the Creek.. It is anticipated in the next several years that the Federal and State trustees will conduct an assessment of the natural resources damaged by the release of petroleum into Newtown Creek and around the Greenpoint community.

Section 5: EPA Recommendations:

As noted above, EPA revisited the U.S. Coast Guard’s 1979 Geraghty & Miller report via EPA’s REAC contractor. Based on that review as well as a review of the actions taken to date and other technical issues regarding the oil spill, the following recommendations contained in the REAC Report have been concurred on and approved by EPA:

1. Review of 1979 USCG Report:

- The 1979 Geraghty & Miller report is fairly comprehensive for the relatively short period of investigation that led to this report. However, the northern portion of the plume was not entirely delineated because of the lack of monitoring well coverage. Additional monitoring wells need to be installed to delineate the northern portion of the plume.

2. Response and Recovery:

- A comprehensive area-wide feasibility study that includes coordination among all responsible parties is needed. NYSDEC appears to be working toward this goal, but competing interests among the multiple responsible parties hinder this effort.

- Other remedial technologies (e.g., injection of surfactants or biological remedial compounds, bioslurping, vacuum enhanced recovery, steam or hot water injection, and electrical heating) should be considered for recovering additional product once the bulk of free-product is recovered.

- Due to logistical and regulatory restrictions, the feasibility of specific recovery and/or remediation techniques should be determined prior to any in-depth analysis of their applicability to the spill. For instance, the presence of utilities, buildings and other constraints imposed by the urban setting may restrict recovery well placement to less than preferred locations. Furthermore, the use of injection wells and the re-injection or discharge of recovered ground water is subject to New York City, State, and Federal regulations and policies.

3. Seep Mitigation:

- It is recommended that the spill response focus more intensively on remediation of the source of the petroleum (i.e., the free product) to the extent technology allows, rather than on controlling or mitigating the seeps into the Creek.

- The present boom and well recovery system appears to be minimizing and containing product discharges into Newtown Creek from the Peerless property, but not remediating them completely. While we recommend an overall long term strategy of plume removal instead of plume containment (with its inherent weaknesses), we also recognize that interim measures may also be required. As an interim measure, the planned installation of recovery wells along the grout wall on the Peerless property should proceed, if the petroleum finds its way around the wall.

- A combined effort by all property owners is needed to develop an overall site-wide plume strategy. A coordinated effort will maximize recovery efforts while preventing unintended consequences in other areas.

- Background water levels need to be established to determine if the water table is actually increasing because of increased precipitation, the cessation of pumping in the 1940s, or other factors. Because monitoring wells within the plume area are likely to be affected by variations in the water table, an ongoing effort should be made to monitor an existing observation well and study the long term ground water levels. A rising water level could have a significant impact on the movement of the plume toward the Creek.

4. Extent and Mitigation of Free Product Plume:

- The entire regional area, covering both the free-product and dissolved plume, should be evaluated using three-phase numerical modeling techniques. The term “three-phase modeling” refers to simulating the movement and interaction of water, oil, and vapor in a geologic medium. In addition, this model can better determine the length of time that will be required to recover free product from both the Off-Site and On-Site plumes. To date, there is only an estimated 25 to 30 years (from 2001) of product recovery time for the Off-Site plume (based on a 2001 numerical model). It is important that the modeling be approached as one unified effort, as opposed to individual models for each property or by each responsible party.

- Product thickness, as indicated on most maps presented in the various reports, should be considered only an approximation. True product thickness is often difficult to determine but is usually less than the apparent thickness measured in the wells. A reevaluation of remaining plume volume across the entire project area, using corrected product thickness values, is warranted.

- The original 17 Mgal product volume estimate should be used with caution. Comparison of the 8.8 Mgal product recovery volume with the apparent static size of the plume suggests that the original volume estimate may have been low, or that recovery volumes are optimistic, or both.

- Additional geologic investigation in the area of the Exxon/Mobil On-Site plume appears warranted. This area exhibits the thickest product accumulations, but also the lowest product recovery rates. This information is also necessary for construction of the numerical model.

- The continued use of dual-phase recovery as the primary remedial method is recommended. This has been used by most of the responsible parties through 2006 and appears to be the most efficient procedure at present, given the extent and volume of recoverable free product. However, these recovery systems were put on hold because of impending lawsuits concerning the extent to which the discharges of treated effluent are permitted by the State. (As of June 28, 2007, Exxon/Mobil has restarted both the On-Site and Off-Site groundwater pumping, recovery pumping and treatment systems. Preliminary feedback indicated that the pumping is operating between 150-220 gpm. The BP system is undergoing final systems checks and will initiate pumping soon. NYSDEC representatives have been present during the system startups and have sampled the discharges to ensure they have met the State Pollutant Discharge Elimination System (SPDES) Equivalents. Additional sampling and monitoring will occur over the near term.)

5. Extent and Mitigation of Dissolved Product Plume:

- NYSDEC should investigate, and collect additional data on, the extent of the dissolved plume. Very little data have been collected to date in reference to the dissolved phase of the plume.

6. Vapor Intrusion:

- NYSDEC should continue investigations based on results from houses with elevated subslab and indoor air concentrations along Meeker Avenue.

- NYSDEC has and should continue to attempt to get access to additional homes along

Kingsland Avenue, Van Dam Street, Meeker Avenue, and South of the Brooklyn Queens Expressway (BQE) for further subslab and indoor air sampling to close existing data gaps.

- NYSDEC should make readily available a decision matrix/flowchart for the Greenpoint community that clearly explains how data are being evaluated and how risk management decisions are being made regarding subslab, indoor, and ambient concentrations.

- NYSDEC should continue outreach to commercial facilities which are located within the residential areas (delicatessens, shops, etc.) to get access, so that vapor intrusion data can be collected.

- NYSDEC should continue to evaluate ground water data for both the free product plume and the dissolved phase plume to determine if boundaries of the vapor investigation should be revised.

- NYSDEC should evaluate its ambient air monitoring program to investigate potential confounding sources to indoor air.

- Naphthalene should be added to the analytical suite of subslab sampling data.

- NYSDEC should evaluate existing databases for background air concentrations in similar communities for comparison against the Greenpoint community.

7. Natural Resource Damages:

- EPA, as the co-chair of the Regional Response Team (RRT), should continue to monitor progress relating to the Newtown Creek/Greenpoint oil spill. EPA should also assist the natural resource damage trustees, as appropriate, under Federal laws and regulations.

Chapter 1

NEWTOWN CREEK OIL SPILL
A REVIEW OF REMEDIAL PROGRESS (1979-2007)
AND RECOMMENDATIONS
NEWTOWN CREEK OIL SPILL SITE
BROOKLYN, NEW YORK
MAY 2007

U. S. EPA Work Assignment No. 0-228
Lockheed Martin Work Order No. EAC00228
U. S. EPA Contract No. EP-C-04-032

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CHAPTER 1

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LIST OF ACRONYMS AND ABBREVIATIONS

AOC - Administrative Order on Consent
API - American Petroleum Institute
AST - above ground storage tank
Delta - Delta Environmental Consultants
E&E- Ecology and Environment
ERT - Environmental Response Team
IT - International Technology Corporation
LB&G - Leggette, Brashears & Graham, Inc.
MATF - Meeker Avenue Task Force
Mgal - million gallons
MTBE - methyl tertiary-butyl ether
NYSDEC - New York State Department of Environmental Conservation
PRP - Principal Responsible Party
REAC - Response Engineering Analytical Contract Roux- Roux Associates
SAIC - Science Applications International Corporation
SOCONY - Standard Oil of New York
SPDES - State Pollutant Discharge Elimination System
USCS - United States Coast Guard
U. S. EPA - Environmental Protection Agency
USGS - United States Geological Survey
VER - vacuum enhanced recovery WA - Work Assignment

SUMMARY

Under Work Assignment No. 0-228, the U. S. Environmental Protection Agency/Environmental Response Team (EPA/ERT) has requested personnel of the Response Engineering and Analytical Contract (REAC) to review industry reports pertaining to investigations undertaken for the Newtown Creek site located in the Greenpoint area of Brooklyn, New York (Figure 1-1). The site covers approximately 55 to 60 acres and is underlain by a plume of mostly petroleum distillates that rest on top of the groundwater column. The spill was first discovered in 1978 by a routine U. S. Coast Guard (USCG) patrol that observed a seep into Newtown Creek at the foot of Meeker Avenue (Figure1-2). The firm of Geraghty & Miller™ completed the initial investigation of the spill extent in 1979 for the USCG and produced the first map of the spill extent (Figure 1-3). They indicated that the minimum spill volume was probably about 17 million gallons (Mgal). Product recovery estimates and the present free-product extent suggest that the 1979 estimate may have been somewhat low. Smaller additional spills have occurred after the discovery of the Meeker Avenue seep and have been documented in various consulting reports (e.g., Delta Environmental Consultants, 2000).

Primarily in response to directives from the New York State Department of Environmental Conservation (NYSDEC), over 20 additional investigative studies have been completed and numerous work plans, progress reports, and information packages issued since 1979. Some of these investigations have resulted in periodic remapping of the plume extent and the apparent thickness (Figure 1-4). Approximately 35 product and groundwater recovery wells (Figure 1-5) and over 200 monitor or observation wells (Figure 1-6) have been installed since 1978. Parties to the investigations have included major petroleum companies that have operated terminals or other facilities in the area for several decades, both before and after the spill discovery.

At present, the extent of the free-product plume is divided into four specific areas of responsibility (Figure 1-2): (1) the "On-Site" area which includes the ExxonMobil™ properties that overlie the northern portion of the plume, (2) the BP Amoco™ terminal that borders Newtown Creek to the southeast of the Exxon/Mobil facility (3) the "off-site" area which includes commercial and residential areas in the central and southern portion of the plume for which Exxon/Mobil has taken remedial responsibility, and (4) the former Paragon Oil™ Property (now Peerless Importers™ and Steel Equities™ facilities) bordering Newtown Creek, now being remediated by Chevron Texaco™. Over 200 monitor/observation wells and approximately 35 designated recovery wells have been installed in the project area since 1978. Until recently, approximately 23 recovery wells were active, including six monitor wells that have been converted to recovery wells. However, in early March 2007, groundwater pumping from the On-Site and off-site dual phase (ground water and product) recovery wells was suspended by the principal responsible party (PRP). Product recovery will apparently continue, but the cones of groundwater depression developed around the recovery wells (Figure 1-7) that help control product movement will dissipate with time. It is not presently known when groundwater pumping will be reinstated.

Numerical modeling has indicated that it may take up to approximately 25 years (from 2001) to recover up to an estimated maximum of about 70 percent (%) of the free product in the off-site

plume. No model estimate appears to be available for recovery time of the On-Site plume beneath the Exxon/Mobil facilities. The On-Site plume exhibits the greatest apparent free-product thickness but also appears to have the lowest apparent recovery rate for the On-Site and off-site plume designations.

In addition to the general document review, specific goals of the study were: (1) review the 1979 Geraghty & Miller U. S. Coast Guard report for conclusions and recommendations, (2) assess the extent of the free-product plume, (3) determine the presence and extent of a dissolved product plume outside of the area underlain by the free-product plume, (4) determine the adequacy of current remedial measures, both for recovering product in the subsurface and for preventing seeps into Newtown Creek, and (5) present recommendations for enhancing or accelerating product recovery. Findings included the following:

- The 1979 Geraghty & Miller report can be considered fairly comprehensive for the relatively short period of investigation that led to this report. However, the northern portion of the plume (Figure1-3) was not entirely delineated because of the lack of monitor well coverage. Later investigations (Figure1-4) indicate that the northern extent of the plume was larger than originally mapped in 1979. The thickness of the original free-product plume, as mapped by Geraghty & Miller, was also based on uncorrected product thickness as measured in monitor wells. Using uncorrected thickness would normally give larger than actual plume volumes. However, because the spatial extent of free product was not entirely defined, the free-product volume estimate may have been low. Comparison of product recovery volume (8.8 Mgal) to date with the original 17 Mgal estimate of product volume and to the present size of the plume also suggests that the original volume estimate may have been low, or that recovery volumes are optimistic, or both.

- The Geraghty & Miller report focuses largely on defining the geology, spill extent, and source area but does not include extensive recommendations for a comprehensive response to the spill. The report recommends recovery wells should be installed initially at three sites with two years of pumping projected for a free-product recovery of approximately 50 percent (%). Pumping would then be followed by two years of biodegradation techniques for a total product removal of approximately 70 %. This projected clean-up time has since been shown to be overly optimistic as discussed above, although the report indicated that additional recovery wells might be required. Also, additional techniques for recovery or remediation of petroleum-contaminated sites have been developed or improved since 1979.

- The present boom and well recovery system appears to be minimizing and containing product discharges into Newtown Creek from the Peerless property, but not remediating them completely. The recently installed grout wall along the Creek should help prevent further seeps in the short term, although it is too early to judge its long-term effectiveness. In the long-term, it is likely to be a temporary containment measure. It is possible that product will eventually find a path around the end of the grout wall until product can be permanently removed, or induced to flow away from the creek by additional recovery wells.

- Until recently, product beneath Peerless Importers, bordering Newtown Creek, was considered to be separate from the larger main free-product plume and had been recovered by vacuum trucks or skimming methods, rather than by water-level depression. This prevented the recovery of unwanted creek water and the initiation of product movement beneath Peerless Importers towards Newtown Creek, but provided no control of groundwater levels in the immediate vicinity of the recovery wells. The main free-product plume has since been shown to be contiguous with the product beneath the Peerless facility (SAIC, 2007) and, therefore, remains a continuing source of potential seeps. Moreover, following the completion of the grout wall, dual-phase extraction pumps were installed in the Peerless recovery wells. These wells have the potential to accelerate product movement beneath Peerless, and therefore, their effect on migration of the off-site plume should be assessed.

- The present extent of free product is generally well mapped (Figure 1-4), given present monitor well coverage (Figure1-6) and additional wells that are planned for installation in 2007. Variations in plume extent, however, can be expected over time as remediation continues. Minor differences in plume extent (and thickness) among various reports can also be expected depending on the time of field measurements and the specific mapping procedures employed. Product thickness, as indicated on most maps presented in the various reports, should be considered only an approximation. True product thickness, as measured in monitor wells, is often difficult to consistently determine but is usually greater than actual thickness for reasons related to differences in density between the ground water and product.

- The greatest apparent (uncorrected) product thickness, approximately 15 to 20 feet, underlies the Exxon/Mobil North Henry Street Terminal. It is possible that confined hydrologic conditions and/or fine-grained soils are exaggerating product thickness, a common phenomena affecting measurements made in monitor wells. Recovery well yields in this area appear to be less than might intuitively be expected and product thickness has not appeared to decrease significantly. In particular, recovery well RW-20, located in this area (Figure1-5) pumps little product. Exxon/Mobil is apparently replacing neighboring recovery well RW-19 that appears to be pumping approximately 25 gallons of product per day, but no plans are indicated for RW-20. Numerical modeling methods, similar to those completed for the off-site area (Roux, 2003) are recommended to better determine true free-product thickness in the Exxon/Mobil On-Site area.

- The primary remedial method used by most parties through 2006 was wells with dual pumping systems that lower water levels and recover water and product in separate systems. This method continues to be effective at the moment, given the extent and volume of recoverable free product. Synthesis from various reports indicates that approximately 8.8 million gallons of product have been recovered.

- An estimate derived from a numerical model of approximately 25 to 30 additional years (from 2001) to recover free product from the off-site plume appears reasonable based on the present approach of using dual-phase recovery wells (Roux, 2003). Recently proposed additional recovery wells, not included in the model, may shorten this time. This is the most aggressive and technically feasible method to recover the bulk of free product. No estimate of product recovery time appears to be available which incorporates both the On-Site and off-site free-product volume. However, as more product is recovered, the recovered volume will decrease, therefore increasing recovery time. Not all product can be recovered without a large scale removal action. A removal action of this scale that would be logistically and economically unfeasible. Ultimately, up to perhaps 70% of the total volume of the plume may be recovered by wells. The impact of the remaining product is difficult to predict with certainty. The remaining product would potentially contribute to a dissolved-phase plume and could also remain a potential source of soil vapors.

- Other remedial technologies may be applicable for recovering additional product once the bulk of free-product has been recovered. These include injection of surfactants or biological remedial compounds, bioslurping, vacuum enhanced recovery, steam or hot water injection, and electrical heating. All of these methods would require detailed study prior to implementation and their use will be constrained by the urban setting and infrastructure. Injection methods using chemicals, for example, generally require an organized grid of wells and have the potential to move product outside of the project area. No significant discussion of other remedial methods and their potential application or rejection was found in those reports, mainly produced by or for principal responsible parties, and made available to REAC.

- Some data on the dissolved product plume are available (Figure 1-8) just outside the margins of the free-product plume and indicate concentrations of primary gasoline compounds in groundwater are orders of magnitude lower than groundwater samples from within the free-product plume.

- Remedial activities for the various areas of responsibility on the Newtown Creek site have been carried out independently by multiple responsible parties with no apparent coordination. A site-wide feasibility study is needed that addresses issues such as the total effect of recovery wells on site-wide plume movement, evaluates all potential remedial options, and recommends site-wide long-term remedial plans. NYSDEC efforts in this direction may be hindered by statutory limitations and the presence of multiple responsible parties.

- Both present recovery techniques and those indicated in this report as possible alternatives will be affected to various degrees by both logistical and administrative restrictions. For instance, the presence of utilities, buildings and other constraints imposed by the urban setting may limit recovery well placement to less than preferred locations. The use of injection wells and the re-injection or discharge of recovered groundwater are subject to State and Federal regulations or policies. Thus, targeted feasibility studies are necessary before the applicability of specific techniques can be determined.

1.0 INTRODUCTION

1.1 Purpose

This report is provided under Work Assignment (WA) No. 0-228, issued by the staff of the Environmental Protection Agency/Environmental Response Team (EPA/ERT) to personnel of the Response Engineering and Analytical Contract (REAC). The WA was issued in response to a congressional-mandated study by EPA of an historic oil spill adjacent to Newtown Creek in the Greenpoint section of Brooklyn, New York. Elements of the study that were considered to meet the congressional directive in this report include (1) reviewing the 1979 Geraghty & Miller U. S. Coast Guard report for conclusions and recommendations, (2) assessing the extent of the free-product plume, (3) determining the presence and extent of a dissolved product plume outside of the area underlain by the free-product plume, (4) determining the adequacy of current remedial measures, both for recovering product in the subsurface and for preventing seeps into Newtown Creek, and (5) recommending ways to enhance or accelerate mitigation measures for free product and the seeps into Newtown Creek. The study was carried out through a general review of existing documents generated by the principal responsible parties (PRPs) and their consultants as provided by the NYSDEC through EPA to REAC.

1.2 Background

1.2.1 Spill Discovery

The Newtown Creek oil spill was discovered in September 1978 by a United States Coast Guard (USCG) routine patrol (Geraghty & Miller, 1979; Delta Environmental Consultants™ [Delta], 2000). Oil was observed on Newtown Creek that on further investigation was found to be seeping from a bulkhead at the foot of Meeker Avenue (Figure 1-2). Preliminary investigations were conducted by the USCG, the City of New York, and various companies with properties adjacent to the spill area, including several major oil companies. In early 1979, an industry advisory committee was established with technical assistance and advice provided by the American Petroleum Institute (API). The advisory committee included representatives from local government and state agencies, the U. S. Geological Survey (USGS), and the firms of Amoco (now BP Amoco), Exxon (now Exxon/Mobil), Gulf, Mobil (now Exxon/Mobil), Shell, Texaco (now Chevron Texaco), and Buckeye Pipeline™. In August 1979, the USCG withdrew from active participation in cleaning up the spill, based on the premise that the State oil spill program fund was established in April 1978, after the spill occurred. Subsequently, the Meeker Avenue Task Force (MATF) was formed that included the participation of the City of New York, Amoco, Mobil, Texaco, and other local and state regulatory agencies (Delta Environmental Consultants, Inc™ [Delta], 2000; Science Applications International Corporation™ [SAIC], 2006). The MATF recovered nearly 230,000 gallons of product by recovery wells installed near the foot of Meeker Avenue before being disbanded in 1990 (Delta, 2000). In February 1990, Mobil agreed to remediate the "On-Site" free- phase plume under an Administrative Order on Consent (AOC), and in June 1990 also agreed to remediate the "off-site" portion of the plume. The "On-Site" plume includes that portion of the free-product plume beneath the existing Exxon/Mobil facilities (Figure 1-2), whereas the term "off-site", refers to the remaining portion of the plume, except that beneath the BP Amoco facilities. These terms are used in this report in order to be consistent with the terminology consistently used in the reports of the various responsible parties or their consultants. It should be noted that the entire "off-site" study area, as defined by Roux (1991), encompasses approximately 14 acres and extends from the North Henry Street Terminal on the north, Newtown Creek to the east, Lombardy Street to the south, and Kingsland Avenue to the west (Figure 1-2).

Early in the initial investigations, the USCG employed the firm of Geraghty & Miller to conduct an investigation into the extent, thickness, and source of the free-product plume. Their work resulted in a July 1979 report that outlined the extent of free product (Figure 1-3) and formed much of the basis for later work by other consulting firms. Based on analysis by various petroleum companies involved in the investigation, Geraghty & Miller concluded that the product was comprised of the various distillates including naptha, fuel oil, and a small percentage of gasoline. They also estimated the total free-product volume to be approximately 17 million gallons (Mgal), although they acknowledged that the estimate might be low. The greatest apparent product thickness, about 20 feet, occurred along Kingsland Avenue at the Mobil North Henry Street Terminal in what was mapped by Geraghty & Miller as a separate plume. A second, more extensive free-product plume, with a maximum apparent thickness of about six feet, extended beneath the property now owned by BP Amoco to just south of Meeker Avenue and was identified by Geraghty & Miller as the source of the discharge to Newtown Creek. The Geraghty & Miller report indicated that the source of both spills was probably leaking product storage tanks or leaking pipelines on the former Mobil refinery. At the time, no connection was established between the two sources. Later work, as discussed in the sections following, has indicated that the two plumes described in the Geraghty & Miller report are indeed a single plume.

It should be noted that hydrocarbon accumulations were being detected throughout the Greenpoint area as early as the 1950s (Delta, 2000), generally incidental to construction projects. Also, Leggette, Brashears & Graham, Inc.™ (LB&G) conducted an extent of product investigation beneath the Mobil North Henry Street Terminal in 1972 (LB&G, 1990) and had installed 85 observations wells between 1972 and 1979 to monitor product accumulation. This effort also included the installation of one recovery well (Mobil RW-1) and two well-point systems to recover product. Since 1978, smaller releases of various petroleum products have occurred on the properties of Exxon/Mobil and BP Amoco and from Buckeye Pipeline which served the Amoco terminal. These spills are listed in detail by Delta (2000).

1.2.2 Historical Land Use and Property Ownership

The Greenpoint area has a history of oil refining or ownership by petroleum companies dating back as early as 1834 (SAIC, 2006). The SAIC report provides a particularly detailed history of land ownership in the area, in some cases by individual blocks or lot, and presents a graphical time line of historic property uses.

In the early 1900s, Standard Oil of New York (SOCONY) operated a major refinery that included an area of approximately 79 acres, extending along Newtown Creek from approximately Apollo Street, west beyond Kingsland Avenue, and north again to Newtown Creek (SAIC, 2006). The refinery produced fuel oils, gasoline, kerosene and solvents. Naptha and gas oil, secondary products, were also stored in the refinery area. SOCONY later became Mobil, the predecessor to Exxon/Mobil, and also operated a refinery on approximately 55 acres that constitutes the present area of investigation.

Mobil ceased operations in 1965 when the property was subdivided and sold. Ten acres of the original refinery were purchased by Amoco (Figure 12) which constructed a bulk storage facility on the property, whereas the remaining lots were purchased by other non-petroleum businesses. Mobil retained the North Henry Street 15 acre parcel. In addition, Paragon Oil Company, owned by Texaco, operated a terminal just south of the Amoco Property until approximately 1964. Peerless Importers, a liquor distributor, then purchased the former Paragon facility and presently operates a warehouse and distribution facility there (Figure1-2). The area along Newtown Creek, adjacent to the Peerless property, is the location of present day product seeps.

2.0 GERAGHTY & MILLER 1979 REPORT

The Geraghty & Miller report, prepared for the USCG, was the first report dealing with the spill. The work was carried out over approximately ten months and included mapping the extent of the spill, calculating the spill volume, describing the geology of the spill area, determining the travel time of the product and determining the probable source. Except for the mapping of the northern portion of the free product plume, which the report depicted as two smaller separate plumes, the Geraghty & Miller work has remained basically sound. The bulk of the report is descriptive but includes some recommendations for product recovery in the “Meeker spill area.” The Meeker spill area of Geraghty & Miller presently corresponds to the Exxon/Mobil off-site area. An initial pilot recovery system consisting of one dual-phase well was recommended in the Meeker Avenue area, based on aquifer characteristics obtained from pump tests in observation wells. One well would pump only ground water and lower the water level, and an adjacent well would recover product from the top of the groundwater column. This is essentially the same technique used by the dual-pump systems installed in the present day recovery wells. The Geraghty & Miller pilot program would then be followed by at least three other well pairs, with the implication that more well pairs may be needed. The location of six possible recovery sites were shown in the report, based on plume thickness and accessibility. Existing off-site recovery well locations are close to five of the original recommended locations and BP Amoco Recovery Well 5 (ARW-5) is near the remaining location. Differences in the original recommended locations and existing locations are probably due to changes in site availability and plume thickness. During the initial spill investigation, New York City also ordered a recovery system to be installed on the (then) Amoco property. Although the New York City order is mentioned in the Geraghty & Miller report, no specific recommendations for the installation of the system are provided except that its performance should be monitored.

Geraghty & Miller estimated that a maximum of 50% of initial product volume could be recovered by wells. Table1-1 suggests that indeed this amount has been recovered, assuming the original product volume estimate was correct. Water flooding and biodegradation techniques were suggested as methods to increase product recovery to 70% once the product thickness had been reduced so that recovery by water-level depression was no longer efficient. Geraghty & Miller also indicated that recovered ground water could be discharged to the storm sewer system, or alternatively to Newtown Creek. Nevertheless, their cost estimate for a Meeker spill area recovery system contains a line item for “re-injection of pumped water.” There is no discussion of this item in the text of their report, or in any later reports reviewed in this study, but it is assumed that the reference is to re-injection of water into the aquifer.

There are no additional recommendations in the Geraghty & Miller 1979 report. Other recommendations were made by LB&G in 1981 for installation of additional monitor wells in the North Henry Street Terminal and in 1987 for various operational parameters of the existing recovery wells. Five additional monitor wells were installed in 1982 (LB&G, 1990) in keeping with the 1981 recommendation.

3.0 NEWTOWN CREEK SEEPS

3.1 Seep Areas

In 1978, when seepage of oil was first discovered in Newtown Creek, the primary discharge point was around the bulkhead at the base of Meeker Avenue. Identification of the former Mobil refinery property by Geraghty & Miller in 1979 as the source of the product was based on hydrocarbon forensics analysis, free-product thickness in the subsurface, and groundwater flow directions deduced from existing monitor wells.

Between 1979 and 1991, apparently no seepage was occurring off Peerless Importers. However, in 1991, free-product seepage was discovered off the

Peerless waterfront. From 1991 to 2002, Exxon/Mobil contained and recovered the product and in 2002 a steel sheeting bulkhead, approximately 650 feet long, was installed on the Peerless property along the Newtown Creek shoreline (Figure 1-1, Appendix 1-A) . Another 500 feet of older concrete and wooden bulkhead is present to the east of the steel bulkhead. In 2004, Exxon/Mobil conducted a site investigation and concluded that the product seeping into the waterway off the Peerless property was not related to Exxon/Mobil's larger 55-acre free-product plume. This conclusion, however, may be questioned as discussed in later sections of this report. At present, seepage continues into Newtown Creek along a portion of the steel bulkhead.

3.2 Present Recovery Techniques and Effectiveness

From 1993 through mid-2005, Exxon/Mobil collected approximately 29,000 gallons of free product from Newtown Creek, primarily through the use of containment booms and free-product skimmers. Diagrams of the containment booms from SAIC (2006) are provided in Appendix1-A. In addition, the Meeker Avenue seep recovery system that operated through 1998, collected another approximately 800,000 gallons of free product from the north end of Meeker Avenue.

Since 2005, Texaco, Inc., (SAIC, 2006) has taken over the remedial activities at the Peerless site, and has been conducting both site characterization and free product recovery activities. Remedial activities have involved seep containment using (1) a boom system and (2) product removal by extraction from several monitoring wells immediately landside of the steel bulkhead, initially using vacuum trucks.

In July 2005, the containment boom system on the creek at the current seep area was upgraded to reduce sheen bypassing the boom due to wake spillage. The new hard containment boom (a globe boom) was installed and stabilized (using a series of I-beams and stabilizer bars) approximately 2-feet away from the bulkhead. The new globe boom is comprised of a continuous PVC coated conveyor belt with molded high-density polyethylene float shells filled with foam. This boom has twelve inches of free board (portion above the water) and twelve inches of draft (portion below the water surface). The globe boom has underwater ballasts to keep it upright in order to provide a greater degree of product containment. Two rows of soft adsorbent booms are presently in place within the "globe boom" and help collect product sheen and droplets. The globe boom and the soft booms are attached to the steel bulkhead at the east end but extend onto the Steel Equities property at the west end.

In March 2006, a product sheen was noticed seeping into Newtown Creek west of the hard globe boom, behind the Steel Equities property at 110-120 Apollo Street. In response, Texaco, Inc. installed an additional 100 feet of hard and soft booms to contain this seep.

In June 2006, an additional hard containment boom (a fence boom) was installed 10 to 20 feet farther away from the steel bulkhead to provide secondary containment for the product seep. The fence boom consists of an impermeable polyester-polyurethane composite fabric with extra wide outrigger floatation supports. The fence boom has 24 inches of free board and 24 inches of underwater draft. A row of soft adsorbent boom is presently in place to capture sheens that spill over the globe boom system. At present, approximately 1,750 feet of soft adsorbent boom is apparently being replaced every two weeks. Since July 2005, when the weekly vacuum extraction of free product was initiated, the amount of free product seeping into the Creek off the former Paragon Oil facility has apparently been reduced to sheens and discrete droplets.

3.3 Technology Advances

As discussed below, Texaco, Inc. has replaced the periodic vacuum extraction from selected monitor wells located immediately behind the bulkhead with a total fluids recovery system which collects both ground water and product. The primary objective of this system is to intercept and collect free product before it seeps into Newtown Creek. In addition, a grout wall was completed in November 2006 immediately landside of the entire bulkhead frontage (Figure 1-2) to impede the migration of product into Newtown Creek.

The product and ground water extracted from the subsurface behind the bulkhead is first treated by an oil water separator. Product from the oil water separator is temporarily stored in a 1,000-gallon above ground storage tank (AST) before it is transported off-site for disposal or recycling. The water from the oil water separator is transferred to a 6,500-gallon insulated above ground storage tank (AST). This water is then transferred to the existing Exxon/Mobil treatment plant on Meeker Avenue for treatment.

3.4 Data Acquisition and Deficiencies

In recent years, SAIC on behalf of Texaco, Inc., has collected a significant amount of site characterization data for the Peerless property and adjacent areas. Based on its findings, SAIC (2006) indicates that the free product that was originally mapped at the steel bulkhead (primarily on the western portion of the Peerless property and on the 110-120 Apollo Street properties) as two separate plumes, now in fact appears to be one plume that is contiguous with the much larger off-site plume. REAC believes it is necessary to determine how the recently installed total-fluids extraction system would impact the movement of the off-site plume. The new remedial system extracts both ground water and product and thus induces a cone of depression in the groundwater system that would move product beneath the Peerless facility and towards Newtown Creek. The analysis could best be done with a multi-phase numerical model although field pumping tests and analytical methods might also provide good estimates.

No definitive data is presently available on the relationship of the free-product plume and the seep at the Steel Equities property. However, in January 2007 the NYSDEC issued a work assignment to Ecology and Environment™ (E&E) for a remedial investigation at this property. The work is expected to address this issue and is scheduled for completion in late 2007.

3.5 Recommendations and Conclusions

Based on the review of data and reports available to date, the following conclusions can be drawn with respect to the seepage along Newtown Creek:

3.5.1 Peerless Recovery System

The present containment and recovery system appears to be preventing gross contamination of Newtown Creek. However, the total-fluids well recovery system now in use on the Peerless property has the potential to induce migration of free product from the larger off-site plume across the Peerless property, thereby increasing the potential for continued seepage into Newtown Creek.

3.5.2 Grout Wall Performance

The extended grout wall should provide short term benefit by slowing down the migration of free product into Newtown Creek. However, the presence of the seeps suggests a northerly net groundwater flow pattern towards Newtown Creek, even though this is not apparent in the generalized groundwater level data for May 2006 (Figure1-7), derived from the most recent site-wide map available. Data for February 2006, (SAIC, 2006) more definitively suggests a northerly flow. Small differences in direction of groundwater flow along Newtown Creek as indicated by various data sets, probably depend on the tidal cycle when measurements were taken. SAIC (2006) indicates that during high tides ground water along Newtown Creek flows south, away from the stream but a northerly flow towards the Creek develops during mid to low tide. Free-product may therefore eventually find its way around the grout wall to an alternate seepage point, unless intercepted by additional recovery wells. Indeed, seepage apparently continues at the adjacent Steel Equities property (Figure 1-2).

3.5.3 Additional Recovery Wells

Apparent proposals to install additional recovery wells along Bridgewater Street in front of the Peerless facility (Remedial Engineering and Roux Associates, 2007b) are timely, and, if implemented, will likely capture product moving northeasterly beneath Peerless.

4.0 FREE-PRODUCT PLUME

4.1 Plume Extent

As previously stated, the original extent of free product (Figure1-3) was outlined in the 1979 Geraghty & Miller report to the USCG, based upon measurements in over 100 monitor wells installed during the initial investigations. The extent and shape of the plume has gradually been refined through investigations by a number of other consultants employed by the various responsible parties involved in remedial activities. LB&G (1991) mapped free-product thickness in the shallow aquifer underlying the North Henry Street Terminal and also outlined the free-product plume extent in the deeper regional aquifer. A silt unit separates the two water-bearing units beneath the North Henry Street Terminal area and acts as a confining layer for the lower regional aquifer. The pathway by which product migrated into the regional aquifer is uncertain. Geraghty & Miller (1979) allude to a nearby industrial well in the regional aquifer that may have caused product migration. In addition, more recent work has indicated that the silt layer is not continuous across the project area.

Roux, in a 1991 report for Mobil, mapped the extent of free product in the off-site area south of the Amoco property, whereas the free-product plume beneath the Amoco facility was defined by International Technology Corporation (IT) in a 1993 report. The plume underlying the (now) BP Amoco property was remapped by Delta in a 2002 report for BP Amoco. In the same report, Delta also mapped the extent and thickness of the entire free-product plume.

The extent and thickness of the entire free-product plume was also mapped by Roux in a 2003 report for Exxon/Mobil and again in 2005 (draft) and 2006. The 2003 report shows the plume superimposed on a historic map of the Greenpoint area but details are difficult to discern because of the relatively small scale of the map. However, the 2005 and 2006 reports shows the free-product extent superimposed on a recent map of the area for November 2005 and February 2006 respectively. The 2006 SAIC Site Characterization Report for the former Paragon Oil Terminal also includes a map of the extent of free product in July 2005 which is nearly identical to that of the Roux maps.

The Roux November 2005 map, with modifications taken from the Roux February 2006 map and September 2006 SAIC data, is presented here as Figure 1-4. The major free-product plume is apparent with smaller separate thin plumes at (1) the north end of Meeker Avenue, and (2) just east of the intersection of Bridgewater Street and Kingsland Avenue. The plume at the north end of Meeker Avenue is probably a remnant of the main plume, resulting from a hydraulic divide formed between recovery wells RW-E and RW-F (Figure 1-5) and recovery wells located further to the southwest. The small product accumulation to the north, along Kingsland Avenue, may also be a remnant of the main On-Site plume and was mapped for the first time by Roux in 2005. A comparison of the Roux maps with the earlier Delta 2001 plume maps shows some significant differences in plume extent and thickness. Compared to the Roux mapping, Delta indicates an expanded plume in the northwestern portion of the project area along Kingsland Avenue and at the southern end of the plume along the Brooklyn Queens Expressway. The reason for the difference is uncertain but is possibly a consequence of what may be a computer generated Delta map as opposed to a manually- drawn map. Computer generated maps often require manual editing, based on professional judgment, to better represent actual field conditions.

The relationship of the Peerless free-product plume to the off-site plume was initially not entirely clear. Based on the absence of product in monitor wells MW76 and MW-77 (Figure 1-6), Roux (2005 draft) believed that the off-site plume and the plume beneath the Peerless property were separate and therefore the main plume was not the source of seeps into Newtown Creek. However, the Roux February 2006 product thickness map shows detectable product thickness in these latter two monitor wells. Moreover, the shape of the off-site plume in the Roux 2005 and 2006 plume map, and more recent data by SAIC (2006, 2007) indicates that the product beneath the Peerless property is contiguous with the off-site plume and plume beneath the BP Amoco terminal.

The shape of the free-product plume (but not necessarily the extent) as mapped by Geraghty & Miller, is generally similar to that in all of the later consulting reports, with the exception that Geraghty & Miller depicted a large plume, generally corresponding to the present off-site plume and that beneath a portion of BP Amoco, and two smaller separate plumes beneath the Exxon/Mobil (Figure1-3). The western portion of the plume as shown in later reports is somewhat expanded from the original Geraghty & Miller mapping and the eastern portion appears to be moving across the former Paragon property as discussed previously. The extent of free-product should be well defined, given the present monitor well coverage (Figure 1-6) and additional installations planned in 2007.

4.2 Plume Thickness

The original thickness of the entire free-product plume, as mapped by Geraghty & Miller (Figure 1-3) for their 1979 report, was based upon measurements of product thickness in existing monitor wells. Free-product thickness in monitor wells is usually greater than the actual thickness in the aquifer. The difference between measured and actual thickness varies, depending on the formation material, the degree of aquifer confinement (e.g., water table or confined) and fluid densities. A correction formula (dePastrovich et al.,1979) was applied by LB&G (1991) to measured product thicknesses in their calculation of plume thickness beneath the Mobil Kingsland Avenue Yard. Roux (1991), in a numerical modeling approach to determine the effect of recovery wells on the aquifer, indicated that the measured product thickness exceeded the actual product thickness by a factor of 3.85. They subsequently used this correction factor in modeling the off-site spill volume. No correction appears to have been applied in the Geraghty & Miller 1979 report, a procedure which would normally over-estimate product volume. However, the extent of the northern section of the free-product plume was not completely defined by Geraghty & Miller. This may compensate to some degree for the use of uncorrected thickness measurements.

The thickest free product according to Geraghty & Miller was along Kingsland Avenue at the North Henry Street Terminal, with uncorrected thicknesses reaching 20 feet (Figure 1-3). However, because the plume at this location appears to be confined or semi-confined, the apparent product thickness in wells is much greater than actual thicknesses. Apparent maximum product accumulation in the larger plume, located further to the south (now the "off-site" and BP Amoco plume), was approximately six feet.

Both Delta (2002) and Roux (2005) present maps indicating that the greatest apparent product thickness is in the northern portion of the plume area, beneath the Exxon/Mobil property. The Delta map is included in this report as Appendix 1-B whereas the Roux map is shown as Figure1-4. There is a significant difference, however, in uncorrected product thickness as shown on each of the two maps. Roux indicates a maximum apparent thickness of slightly over 15 feet whereas the earlier Delta map indicates a maximum thickness of only about seven feet. The reason for the apparent difference is unknown. Free-product thicknesses in the central portion of the plume beneath the BP Amoco Terminal appears to be two to four feet less on the 2006 Roux map than on the Delta map and on the Geraghty & Miller map, suggesting removal of product by recovery wells. The Roux 2006 map was also reproduced by SAIC in their 2006 Site Characterization Report for the former Paragon Oil Site.

4.3 Plume Volume

The most common method of determining free-product volume involves measuring product thickness in observation wells, contouring the thickness over the plume area, and then calculating the volume of product contained within the plume area based on a given porosity. As indicated above, without correcting for true product thickness in the formation, the volume estimate will likely be high, assuming a reasonable porosity is used in the calculations. A more accurate estimate of plume volume requires knowledge of several physical parameters of both the formation and fluids. Because of their spatial variability, these parameters are generally not known precisely so are often estimated and/or averaged across the plume area. Except for the Geraghty & Miller 1979 report, no calculations of total plume volume could be found in the documents available for the REAC review. However, Roux (2003) indicates that various estimates have placed the free-product volume between 10 Mgal and 17 Mgal, depending on the assumptions made and the understanding of subsurface multiphase fluid behavior.

Estimates have been made by various consulting groups for different portions of the plume. For example, LB&G (1991) estimated the volume of the On-Site plume beneath the present Exxon/Mobil facility to be approximately 1.6 to 2.5 Mgal (Table1-1), based on corrected product thickness. This appears to agree with the Geraghty & Miller estimate of approximately 1.9 Mgal for the same area, even though Geraghty & Miller envisioned only two isolated plumes beneath the (then) Mobil property.

The free-product volume beneath BP Amoco was calculated by Geraghty & Miller to be 0.1 Mgal but IT (1993) estimated it to be approximately 1 Mgal, using a hydrocarbon density of 0.75 grams/cubic centimeter (gr/cm^3) and a formation porosity of 30 percent (%). Using the numerical model SPILLVOL™, Roux (1991) concluded that the off-site product volume was between approximately 2.8 Mgal and 4 Mgal. These figures were revised by Roux in 2003, based on the use of the BIOSLURP™ multi-phase flow model that indicated approximately 5.3 Mgal of free product remained in the off-site plume. The Roux 2003 estimate appears to be based on more recently measured and estimated soil and fluid properties, and is therefore probably the most accurate estimate of the off-site plume volume. No estimates have been made of product volume beneath the Peerless or Steel Equities properties. Product thickness is relatively thin beneath these properties and the volume is not expected to be significant compared to that of the overall plume volume. Thus, the total probable maximum free-product volume remaining in approximately 2003 appears to be slightly less than 9 Mgal (Table 1-1).

4.4 Recovery/Mitigation Techniques

4.4.1 History

The bulk of product recovered to date has been based almost exclusively on the use of dual-phase pumping systems. In this system, a lower pump withdraws ground water, creating a cone of depression in the groundwater system; a second pump, placed at a shallower depth in the well, removes the induced product that is floating on top of the water column. Because both water and product are recovered from a dual-pump system, treatment and/or disposal is necessary for both fluids. Figure 1-5 shows the location of both active and inactive recovery wells in the Greenpoint area. Table 1-2 indicates the free-product yield of the recovery wells, where known, as extracted from various reports.

The initial remedial efforts began in September 1978 with the installation of two sumps at the foot of Meeker Avenue to intercept the seep into Newtown Creek. By December 1978, two additional sumps had been installed along or near Meeker Avenue. The first three sumps consisted of perforated drums that were installed with a backhoe, whereas the fourth sump was a large diameter shallow well with torched slots in the casing. By 1979, Mobil had also installed six recovery wells at the North Henry Street Terminal and by 1981 had ten recovery wells in operation (LB&G, 1990). Up to 20 recovery wells have subsequently been installed in the On-Site plume by Exxon/Mobil with the latest wells (RW-19, RW-20) installed in October 2005 (Table1-2). However, many of the earliest wells are not in active service, mainly because of the lack of sufficient free-product thickness to support recovery. Until recently, dual-pump systems were used in all of the On-Site recovery wells. In June 2005, Xitech™ product-only skimmer recovery systems were installed in recovery wells RW-19 and RW-20 and have continued to operate through 2006 (Remedial Engineering, 2006a). Product-only systems skim oil from the top of the water table and thus do not remove ground water which must usually be treated before disposal. Remedial Engineering and Roux (2007a) indicate that recovery well RW-19 will be replaced and, to increase the efficiency, a dual-pump system will be installed in the replacement well. A dual-pump system usually increases the capture area of the recovery well compared to a skimmer-only system.

Eight recovery wells have been installed on the BP Amoco property and seven recovery wells have been installed in the off-site plume in the vicinity of Meeker Avenue. Three of the BP Amoco wells and one of the off-site wells do not appear to be active because of insufficient free product. Up until August 2005, all of these recovery wells appeared to also operate using a dual-pump system. Exxon/Mobil, with excess groundwater treatment capacity, has agreed to treat the ground water recovered from its remedial systems and from the BP Amoco system. In return, BP Amoco stores and disposes of the product recovered from the systems of both companies (Delta, 2006). The ground water is treated On-Site using an oil-water separator, an air stripper, and carbon adsorption units before being discharged to Newtown Creek. The vapor phase is further processed through a catalytic oxidizer unit, which according to Remedial Engineering and Roux Associates (2007b) achieves complete destruction of volatile compounds.

In August 2005, Exxon/Mobil initiated a pilot study with a SpillBuster™ product-only recovery system in off-site recovery well RW-B (Remedial Engineering, 2006b). The study was later expanded to include a portable system in four additional monitor wells located near recovery wells RW-E and RW-F (Figure 1-5). Remedial Engineering (2007b) also indicates that locations have been selected for up to 10 additional recovery wells in the Exxon/Mobil off-site area (Figure 1-5). Exxon/Mobil is reportedly negotiating with property owners for access to and use of their property for these wells. Installation is expected in 2007 with start-up in 2008.

In addition to the operation of the dual-pumping system recovery wells, six monitor wells (Table1-2, Figure 1-5) had been used at the Peerless Importers facility for product recovery until October 1, 2006. Up to several times each week, a vacuum truck was used to remove product from four wells, whereas pneumatic pumps appeared to be used in the same manner on two other monitor wells. The cone of depression induced by water-level depression methods would likely intercept Newtown Creek, drawing in surface water and limiting the extent of the cone in the groundwater system. Roux (1995) discussed the use of removing product only on the Peerless property and indicated that significant free product could accumulate at low tide and be most efficiently removed by skimming methods. Roux likewise concluded that the use of a groundwater depression method at this location would be inefficient because of the existing hydraulic continuity between Newtown Creek and the location of these wells directly behind the Peerless bulkhead. However in November 2006, the grout wall landside of the existing bulkhead was completed and a total fluids extraction system was installed in the wells, replacing vacuum extraction. The new system became operational on November 20, 2006 (SAIC, 2006 [sic]).

All of the recovery systems discussed above have been in various stages of operation through early March 2007. However, on March 9, 2007, in a letter to the NYSDEC, Exxon/Mobil indicated they were no longer going to recover ground water from either their On-Site or off-site recovery systems. The action was based on the revocation of the discharge permits issued by the NYSDEC to Exxon/Mobil and a subsequent notice of intent to sue. Exxon/Mobil treats ground water for BP Amoco, and therefore the shut-down would likely affect the recovery systems at BP Amoco as well. The duration of the shut-down is unknown. If the shut-down continues any appreciable time (e.g., several weeks), the cone of depression developed around the recovery wells will dissipate and control on free-product movement will be lost.

4.4.2 Effectiveness of Recovery

To assess the general effectiveness of the recovery efforts, REAC sought to determine the amount of the estimated spill volume of approximately 17 Mgal that had been recovered. Recovered volumes of product are given in various reports for each of the separate recovery systems, but no report provides a site-wide estimate of total volume recovered. A site-wide compilation of the product recovered through approximately December 2006 is therefore provided in Table 1-1. The largest volume, 3.8 Mgal, has been recovered from the off-site plume as reflected by the relatively high product yields of recovery wells RW-A, RW-C, and RW-D. The approximate total volume recovered from all portions of the plume appears to be 9.4 Mgal. A comparison of this volume to the estimated 17.0 Mgal in the original plume suggests that approximately 7.6 Mgal should be remaining in the subsurface at the end of 2006. The latest product volume calculations, made from 1991 to 1993 (Table1-1), indicate that approximately 8.8 Mgal remained in 1993, suggesting that only about 1.2 Mgal was recovered between 1993 and 2006. However, the actual volume recovered between 1993 and December 2006 appears to be on the order of 5.9 Mgal. These calculations, and the maximum plume thicknesses remaining, particularly in the North Henry Street Terminal area, suggest that previous volume estimates may have been somewhat low, or that recovery rates may be reported too high, or both. Although Geraghty & Miller, used uncorrected thickness measurements in calculating free-product volume, they did not have the data at the time to map the complete plume extent.

Nevertheless, free-product thickness as mapped by Geraghty & Miller has decreased noticeably when compared to the more recent product thickness maps of Roux (2006), shown here as Figure 1-4. In the thick free-product section underlying the North Henry Street Terminal for instance, apparent product thickness has decreased by about five feet (from 20 feet to 15 feet) since 1979. Beneath the BP Amoco property and the off-site areas, apparent free-product thickness appears to have decreased by approximately two to four feet in the center of the plume (not necessarily in the thickest plume section) since 1979. Also, along Meeker Avenue, a small thin plume has separated from the main plume with no apparent free product between the two areas, and along the western side of the BP Amoco property a semicircular area of no free product is apparent on the Roux map. Again, such comparisons should be considered only estimates because of the uncertainties in using uncorrected product thicknesses.

The configuration of the local groundwater levels (in areas not affected by large tidal variations) may also be an indication of the effectiveness of the recovery systems in preventing the migration of product. Ideally, cones of depression developed by individual wells should prevent product from migrating off site without creating excessive drawdown. Excessive drawdown may produce a large smear zone or limit recovery of product. A May 2006 groundwater elevation contour map by SAIC (2006) shows cones of depressions that have developed around some recovery wells. The largest cone appears to be centered around off-site recovery well RW- A (Figure 17) and measures approximately 500 feet by 350 feet. Smaller cones are also evident around off-site recovery wells RW-D and RW-E. Exxon/Mobil On-Site recovery well RW-14 also shows a distinct cone of depression measuring approximately 200 by 100 feet. On-Site recovery well RW-18 appears to be producing a large asymmetric but shallow groundwater cone with an aerial extent of approximately 500 feet by 200 feet.

The size of the groundwater cone of depression is not necessarily indicative of the extent of the free product cone which, because of the differences in fluid properties, is usually more shallow and limited in extent than the groundwater cone. Delta (2002) mapped the corrected product elevation for May 2001 and showed distinct cones of depression in the free product around off-site recovery wells RW-A, RW-B, and RW-D. The extent and shape of the cones suggested that the wells were effective in controlling the off-site plume at its southern end. Recovery well performance could also be assessed by plotting cumulative recovery amounts with time. A significant decrease in cumulative recovery volumes suggests either fouling of the well screen or that product thickness has been reduced to the point where the well is no longer effective.

4.4.3 Mitigation/Recovery Time

The first definitive attempt to determine the probable free-product recovery time was by Roux (2003) in which they used the BIOSLURP model to estimate recovery times for the off-site plume. The results indicated that under the optimum arrangement of recovery wells, it would take approximately 25 to 30 years (from 2001) to recover product to the point where a free-product gradient, and therefore recovery, could no longer be sustained. The modeling results assumed, and also suggested, the installation of one to three additional recovery wells. At the time of the study, four off-site wells were in operation. The report also suggested that recovery could be optimized in existing wells by (1) increasing the groundwater pumping rates or (2) shortening the screen lengths in the wells to increase drawdown. These two alternatives were not necessarily simulated by the model and specific predictions as to their effect are not available. Roux indicates that shortening the recovery well screen length would provide the same effect as increasing the pumping rate, but without producing more ground water that would need treatment and disposal. Although acknowledged in the report, the effect of recovery efforts at BP Amoco and the Exxon/Mobil On-Site area were not considered in the model simulations. The 10 additional off-site recovery wells that have since been proposed should shorten recovery time, but a detailed analysis is apparently yet to be completed.

The time predicted by the 2003 Roux modeling effort is not necessarily the time for complete site remediation. Once the free product is removed to where it can no longer be efficiently recovered by wells, the remaining thin product volume must be handled by other methods as indicated in the following *Recommendations and Conclusions* section. In addition, a spatially broad smear zone caused by recovery of groundwater levels since 1947, and possible a more localized smear zone due to tidal effects in Newtown Creek may also have to be remediated.

4.5 Data Deficiencies

The extent of the free-product plume appears to be well-defined with the existing network of over 200 monitor wells which includes 25 additional monitor wells that were added to the Exxon/Mobil On-Site network in 2006 (Remedial Engineering, 2006b, 2007a) and 42 additional wells that were installed at the Peerless and Steel Equities properties in 2005 and 2006 (SAIC, 2006).

As previously discussed, plume thickness determinations, in most cases, are based on uncorrected product thickness measurements in monitor wells, and thus probably overestimates the actual product thickness in the formation. This fact is recognized in the various reports reviewed by REAC. Comparing uncorrected thickness maps of various dates, however, provides an indication of relative changes in product thickness and is therefore a useful exercise. Nevertheless, a better estimate of product thickness beneath the North Henry Street Terminal seems especially warranted, given the apparent thick section of product but relatively low product recovery from recovery well RW-20 located in this area (Figure 1-5).

Except for some of the earlier Exxon/Mobil recovery wells, there appears to be little or no information in the reviewed reports on screen settings for the recovery wells. Knowledge of screened settings would be most helpful in those recovery wells exhibiting poor performance to determine if the screened interval remains optimum for product recovery.

4.6 Recommendations and Conclusions

Overall, the documents reviewed are concerned mainly with the near-term operation of dual-pump systems. Roux (1991) discusses the use of dual-pump systems as an aggressive approach to control product migration through the development of cones of depression in the aquifer. This appears to be the most appropriate method to date, given the apparent mass of product still unrecovered. However, with the exception of a brief mention of other technologies by Geraghty & Miller and the Roux (1995) discussion on skimming methods in use at the Peerless property, there is little discussion in the reports reviewed by REAC concerning the use of other remedial technologies. Other technologies may indeed have been considered, but updated documentation or discussion is needed concerning their applicability or rejection. In particular, long-term plans are needed for final recovery methods once recovery wells are no longer efficient. Other possible technologies that could have limited application, once the bulk of mobile free-product has been removed, include those discussed in the next section and are summarized in Table1-3. Without feasibility studies in specific areas of the site, it is not possible to determine which of these methods might be most applicable. Variables affecting the success of any one method include the geology, above ground space available, nature and thickness of remaining product, depth of target zone, presence of underground utilities, and cost. REAC recognizes that the logistics presented by the urban environment are formidable and may limit the use of some technologies, such as:

4.6.1 Well Redevelopment

LB&G (1991), in work for Mobil, redeveloped several existing recovery wells and reported significant improvements in yield. There is no indication that any recovery wells have been redeveloped since that time. Wells with low yields but with sufficient product thickness for continued operation may benefit from redevelopment to remediate possible fouling of well screens.

4.6.2 Re-injection of Treated Water

Until recently, recovered groundwater was presently treated and discharged back to Newtown Creek under a State Pollutant Discharge Elimination System (SPDES) permit. As discussed in Section 4.4.1, Exxon/Mobil has since indicated that as of early March 2007, they were no longer going to pump and treat ground water from either their On-Site or off-site recovery system. If groundwater pumping is reinstated, consideration should be given to re-injection of this water in selected areas where product recovery might be enhanced by increasing hydraulic gradients, or where hydraulic barriers might be useful in preventing migration of the free-product plume. The most efficient method would be to reinject the recovered water directly after separation from the product. Technically, treatment should not be necessary because the same water is being returned to the aquifer. However, State and Federal policy may require treatment. During injection, it may be possible to add surfactants or biological remedial compounds to promote product release and/or breakdown. It is critical that product not be moved to areas beyond the present plume extent or outside the control of recovery wells. Optimal areas for injection and their effects on hydraulic gradients can best be determined by computer modeling methods.

4.6.3 Additional Recovery Wells

Additional recovery wells were considered by Roux (1993) in their numerical modeling study of product recovery in the off-site plume; one to two additional off-site wells were recommended as a result of the study. As indicated previously, Remedial Engineering and Roux (2007b) has recently proposed locations for 10 additional off-site recovery wells. Two of these wells are located along Bridgewater Street which would potentially intercept product moving northeast towards Peerless.

The thick section of free product beneath the Exxon/Mobil North Henry Street Terminal is also an area where additional recovery is needed. On-Site recovery wells RW-19 and RW-20 were recently installed by Exxon/Mobil in this area (Figure 5) but recovery well RW-20, in particular, shows relatively poor product recovery in what appears to be the thickest portion of free product. This suggests that (1) actual product thickness is not sufficient to support water-table depression recovery methods, (2) the geologic formation is too fine-grained to allow efficient product movement, or (3) a problem exists with well construction. An additional effort, such as numerical modeling may be necessary to determine true product thickness and resolve the problem. Updating the Roux Bioslurp model, to include a study of optimum recovery well locations and performance across the entire project area is recommended. The various companies within the project area generally confine their investigations to the properties for which they have assumed responsibility, and therefore the mechanism for a coordinated site-wide study is yet to be determined.

Additional recovery wells will enhance free-product recovery and are necessary to help control seeps, but the extent to which this option can be used is limited. Wells that are spaced too closely to each other may create overlapping cones of depression and lower groundwater levels excessively. This in turn reduces the amount of product recovered by each well and also creates a smear zone that has the potential to become a continuing source of groundwater contamination. Likewise, increasing pumping rates does not necessarily improve long-term product recovery. An excessively high pumping rate produces the same results as recovery wells that are spaced too closely. Thus, the installation and operation of additional recovery wells, and the selection of pumping rates must be carefully considered. Recovery wells also need additional space or corridors for transporting recovered fluids and must be accessible for maintenance. Again, a site-wide numerical model that includes all existing and proposed recovery wells would ensure that optimum well locations were selected, and that changes in locations necessitated by logistical problems could be rapidly assessed.

Not all product can be removed by recovery well and a certain amount of residual product will remain trapped in the soil pore spaces. The residual product cannot be mobilized by pumping because the small individual oil pockets are held in place by capillary pressure and no longer connected. Remediation must therefore be completed with other technologies as suggested in the current section of this report.

4.6.4 Bioslurping/Vacuum Enhanced Recovery

Bioslurping, a dual-or multi-phase extraction technique, recovers both liquids and vapors at the same time using a single vacuum pump with the drop tube set at the air/product interface. Place and others (2001), in a review of bioslurping performance, indicate that the product recovery rate with bioslurping is significantly greater than with dual-phase drawdown pumping but that less ground water is recovered, thus lowering groundwater treatment costs. Smear zones are also reduced as compared with the water-level depression method now in use.

Proper placement of the drop tube and well screen is generally critical to the operation of a bioslurping system. Significantly fluctuating water levels, such as tidal variations also impair system operations. The effect of tidal influence from Newtown Creek on groundwater levels has been documented in a number of reports. A tidal study by Roux (2005 draft) for the Peerless property indicates a tidal range of approximately four feet in monitor wells directly behind the bulkhead. The tidal influence decreases to approximately 0.1 feet at Bridgewater Street, about 470 feet south. SAIC (2006) shows much the same results but with additional detail showing that the tidal fluctuation is considerably less than one foot at a distance of about 100 feet south of Newtown Creek.

In the vacuum enhanced recovery (VER) system, a dual or single pumping system recovers both product and ground water but a vacuum is also applied to the well which causes upwelling of the product/water interface. Bioslurping and VER appear to have potential across portions of the study area and may be most efficient after much of the product has been removed and there is no longer a major need to control hydraulic gradients. However, capital costs are high and it is usually necessary to treat recovered vapors. Additional maintenance, permits, and space for trenching and piping will be required. Pilot studies can be conducted using mobile systems.

4.6.5 Steam / Hot Water Injection

Steam or hot water flushing has been an experimental technology in the environmental field (Newell and others, 1995), but in the last few years some small scale or pilot remedial projects have been attempted (e.g. Kemper and others, 2005). Most work to date has been concerned with relatively high viscosity products but there may be limited application to selected portions of the plume in the Greenpoint area. The objectives would be to (1) reduce the viscosity of any remaining movable free product by raising the temperature, and (2) enhance phase transfer to the water and vapor phases which are more easily recovered. Hot water injection is probably the more preferred method because of lower temperatures and operating costs than steam injection. Both steam and hot water systems require injection and recovery wells to be located in a fairly specific pattern for best efficiency. This may be logistically difficult in the project area. As with groundwater injection, similar precautions are necessary to ensure that product remains On-Site. Again, this technology may be more applicable once existing recovery wells can no longer operate efficiently.

4.6.6 Electrical Heating

Electrical heating methods might best be applied to selected small areas underlain by low permeability soils that resist more conventional treatment. The method would be impractical for the large area of the site-wide free-product plume. Soils are heated by a low frequency electrical current that is applied through a grid of electrodes. Reduction of product viscosity and also partitioning of product into the water and vapor occurs, similar to the effects produced by steam or hot water injection. Accompanying vapors and free product can be extracted by recovery wells that are co-located with the electrodes. Lower temperature electrical heating, between 30^{0} and 40^{0} centigrade (C), may also enhance biodegradation and would not require treatment of vapors.

4.6.7 Bioremediation

Bioremediation techniques would be most applicable after the bulk of free-product was removed. Geraghty & Miller briefly mention biodegradation as a means of remediating “residual oil absorbed in sediments” and include a line item for the technique in their proposed clean-up budget. In active bioremediation, nutrients are added to either the soil above the water table by infiltration galleries or to the underlying aquifer though injection wells depending on the amount and location of residual contamination. Supplying sufficient oxygen to support the growth of microbes is also essential. Below the water table this can be done though air injection wells or by lowering the water table with extraction wells that allows air to circulate through the denatured area. The use of extraction wells also may call for groundwater treatment facilities and satisfying permit requirements for discharge or re-injection of the treated water.

5.0 DISSOLVED PRODUCT PLUME

5.1 Data Acquisition and Deficiencies

Nearly all of the work in the project area has focused on characterizing the composition and extent of the free product and composition of the ground water from within the plume area. A limited amount of data, generally within a few hundred feet of the margins of the free-product plume, are available on the dissolved phase plume and have been plotted by Roux (*in* Remedial Engineering and Roux Associates, 2006). The Roux map is included here as Figure 1-8. Concentrations of primary gasoline compounds in groundwater samples from outside the extent of the free-product plume range from non-detect to orders of magnitude lower than for groundwater samples within the free-product plume. However, the gasoline additive methyl tertiary-butyl ether (MTBE), which was not used until the 1990's, was found in most samples, both within and outside of the free-product plume. Higher concentrations, particularly within the BP Amoco property, suggest more recent releases. Because of the prevalence of MTBE in ground water, especially in urban areas, it is not possible to attribute a source to the relatively low concentrations of the compound found outside of the free-product plume.

Remedial Engineering and Roux (2007b) refer to sampling ground water "upgradient" of the off-site plume and indicate that they plan a "full evaluation of the groundwater quality in the Off-Site Area" in 2007. It is unclear how far the investigation will extend beyond the margins of the free-phase product. The extent and composition of a dissolved-phase plume is important in assessing the threat to possible groundwater supply wells located outside of the project area and in determining the potential for vapor intrusion.

A dissolved-phase plume will migrate in the direction of groundwater flow. The more recent groundwater data (e.g. Roux, 2005; SAIC, 2006) indicate that ground water generally flows into the project area from the south and western portions of the area (Figure 1-7). However, groundwater elevation maps compiled by Cartwright (2002) indicate that groundwater flow was formerly towards a center of municipal pumping, located approximately 1.5 miles to the southwest of the Greenpoint area. The southwesterly flow apparently persisted until about the early 1970s, despite the cessation of pumping in 1947. By the mid-1970s, groundwater levels had recovered to those observed in 1903 with ground water flowing generally northerly and easterly towards the Greenpoint area and Newtown Creek.

Remedial Engineering and Roux (2007a) indicate that a shallow ground water component presently leaves the site to the northeast, north, and northwest. The groundwater flow regime in the deeper regional aquifer is altered by the active recovery wells but a component of flow is probably also discharging to Newtown Creek along the northeast side of the site. This is not immediately evident on Figure 1-7 which represents an approximation of ground water levels at a given time; however, the tidal range in Newtown Creek near the site has been measured at approximately five feet (Roux, 2005). A regional aquifer flow component leaving the northwestern portion of the site was also indicated by Roux (in Remedial Engineering and Roux, 2007a) and has been depicted on Figure 1-6 of this report. The potential for ground water in the regional aquifer to migrate beneath Newtown Creek is unknown and depends on groundwater levels on the opposite side of the Creek.

5.2 Recommendations and Conclusions

Determining the extent of a dissolved-phase plume is needed to assess the potential for vapor intrusion adjacent to the free-phase plume and for possible threats to other wells. However, given the urban setting of the area, it may be difficult to determine the source of dissolved constituents at any appreciable distance from the site. Oil and chemical fingerprinting and/or isotopic analyses may be necessary to identify compounds that can be statistically related to the spill area or portions of the area.

Because of permit requirements and the logistics involved, an inordinate amount of time may also be required to install enough wells to provide statistically significant coverage. Soil gas analyses and/or the installation of temporary borings in conjunction with in-hole groundwater collection techniques may be the most rapid and viable methods for obtaining preliminary data on a dissolved plume.

6.0 CONCLUSIONS

- The 1979 Geraghty & Miller report provided a firm historic and hydrogeologic basis for further work, but was largely investigative in scope and did not set forth substantial long-term recommendations for remediating the plume.

- The reports provided by the various consulting groups working for the potentially responsible parties appeared to be effective in exchanging technical information. However, there is no evidence of a coordinated approach for product recovery efforts. Because investigations on both the On-Site and off-site free-product plume are being conducted for Exxon/Mobil by the same firm (Roux Associates), there may indeed be internal coordination for these two phases of the remedial efforts but documentation is lacking.

- The existing remedial measures along the Peerless Importers waterfront, including booms, a grout wall, and recovery wells, appear to be minimizing, but not completely remediating, discharges to Newtown Creek. The lasting effect of the grout wall remains to be assessed. However, the potential for seeps will remain until the free-product plume is remediated or controlled by reversing the net hydraulic gradient towards Newtown Creek.

- The extent of the free-product plume is fairly well-defined; however, the thickness of the plume is uncertain because of the use of uncorrected thickness measurements. This may lead to large errors in estimating plume volume, particularly in thicker areas of product. Determining corrected (true) free-product thickness is difficult because of the number of physical parameters that must be known or the number of tests that must be made. Because of the area involved in the Greenpoint spill, even corrected product thickness should probably be considered as only an approximation.

- Groundwater depression, using recovery wells with both water and oil recovery pumps (dual-extraction system) has been the major technique to capture free product. This appears to be the most efficient recovery method at the moment, given the extent and apparent thickness of free product and the urban working environment with its inherent limitations. However, as free product thickness declines, recovery by wells will become less efficient and other remedial methods may be needed. To date, there has been no apparent discussion of the viability of other methods, except for product skimming.

- The presence and extent of a dissolved product plume, extending beyond the perimeter of the free-product plume has only been partially determined. Assessing the extent and composition of a dissolved plume is important in determining the potential for vapor intrusion.

- The installation of a product-only recovery system in recovery well B and its possible use in other off-site recovery wells will reduce the amount of ground water that needs to be treated. However, this needs to be weighed against the reduction in the radius of influence of these wells.

- The present cessation of the groundwater off-site and On-Site recovery systems will lead to a decay in the cones of depression developed around the recovery wells and to a possible loss of hydraulic heads that have acted to some degree to contain free-product.

- The Roux (2003) estimate of approximately 25 to 30 years (from 2001) to complete recovery of the off-site plume by pumping techniques appears to be reasonable for the scenarios proposed in the Roux report. Physical limitations are imposed on recovery techniques by the geology, fluid characteristics and the general behavior of fluids in subsurface environments. However, the addition of up to 10 proposed new recovery wells is expected to decrease the recovery time.

New pumping scenarios that include the proposed wells should be tested by means of additional numerical modeling techniques.

- It will not be possible to recover all of the free product, both because of logistical limitations imposed by the urban setting and physical limitations imposed by capillary forces which trap free product within the soil matrix. This residual product cannot be moved by recovery wells. Also, portions of a probable smear zone that likewise cannot be treated efficiently by pumping may continue to act as a source of ground water contamination in the future. For instance, the American Petroleum Institute (2002) indicates that 40% to 80% of a product spill may be retained in soils as residual product. Phase transfer technologies, which would convert free-product from a liquid to a vapor-phase, or into the water phase, may then be necessary in the final stages of remediation, depending on costs, accessibility, and clean-up guidelines. Such methods may include steam or hot water injection and electrical heating.

- Final clean-up goals do not appear to have been discussed or set forth in any of the reports available to REAC.

7.0 RECOMMENDATIONS

o • A reevaluation of remaining plume volume across the entire project area, using corrected product thickness values, appears warranted, particularly in the North Henry Street Terminal area, where much of the free product is under confined conditions. In particular, the apparent discrepancy between product thickness in the North Henry Street Terminal area and the relatively low recovery of product by recovery wells RW-19 and RW-20 should be resolved.

- Installation of one or more additional recovery wells is recommended along Bridgewater Street, southwest of the Peerless facility, to control what appears to be product gradually moving northeast beneath the Peerless and Steel equities properties. At least two additional recovery wells have been proposed by Roux (2007) for this area, and if installed, should meet this recommendation.

- The effect of the Peerless total fluids recovery system on the migration of the off-site and/or the free-product plume beneath the BP Amoco property towards the Peerless property should be assessed. The main plume will remain a potential source of seeps if it migrates beneath the Peerless facility.

- Once recovery wells become inefficient because of declining free-product thickness, other recovery methods may be necessary. These methods may include re-injection of recovered ground water, bioslurping or vacuum enhanced recovery, steam or hot water injection, or electrical heating. The use of some methods, such as direct re-injection of ground water without treatment, may be infeasible because of logistical and/or policy limitations. In any case, detailed feasibility studies would be necessary to determine the most viable method.

- No numerical modeling of the On-Site free product thickness and recovery time is documented in the report made available for this review. A site-wide model that includes a corrected product thickness estimate and a product recovery time projection, incorporating all existing and proposed recovery wells is recommended.

- A long-term comprehensive site-wide feasibility study that includes coordination among all responsible parties is needed. NYSDEC appears to be working towards this goal but statutory limitations and multiple PRPs hinder this effort. Such an approach does not necessarily mean that actual remedial objectives will be achieved faster than the current 25-year estimate, due to uncertainty in the data. It would, however, ensure that recovery efforts by one party enhances, or at least does not hinder, efforts by other parties.

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APPENDIX A

DIAGRAMS SHOWING CONTAINMENT BOOMS,
BULKHEAD, AND GROUT WALL (SAIC; 2006, 2007)
NEWTOWN CREEK SITE
BROOKLYN, NEW YORK

Diagram of Current Seep Containment System

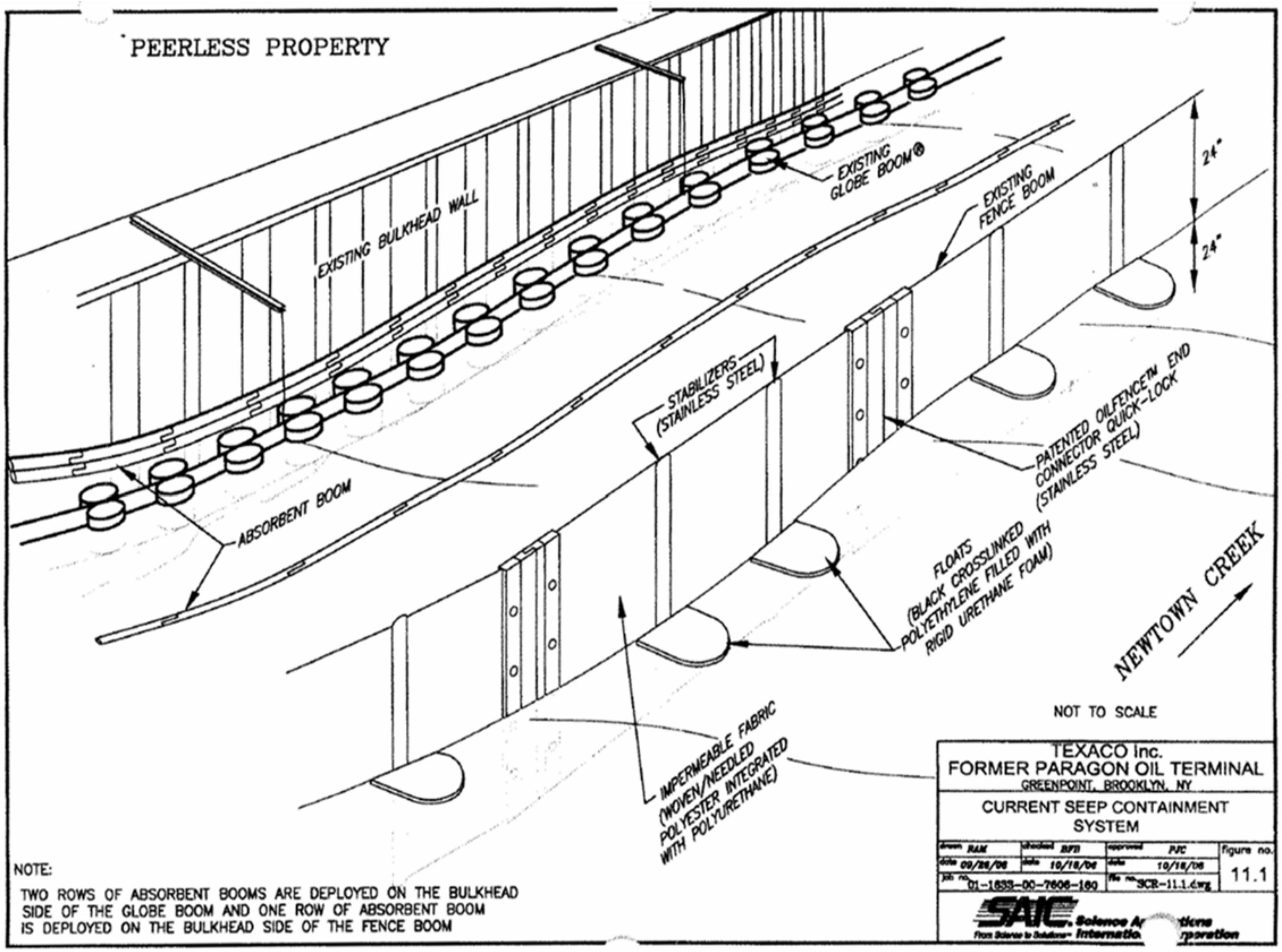
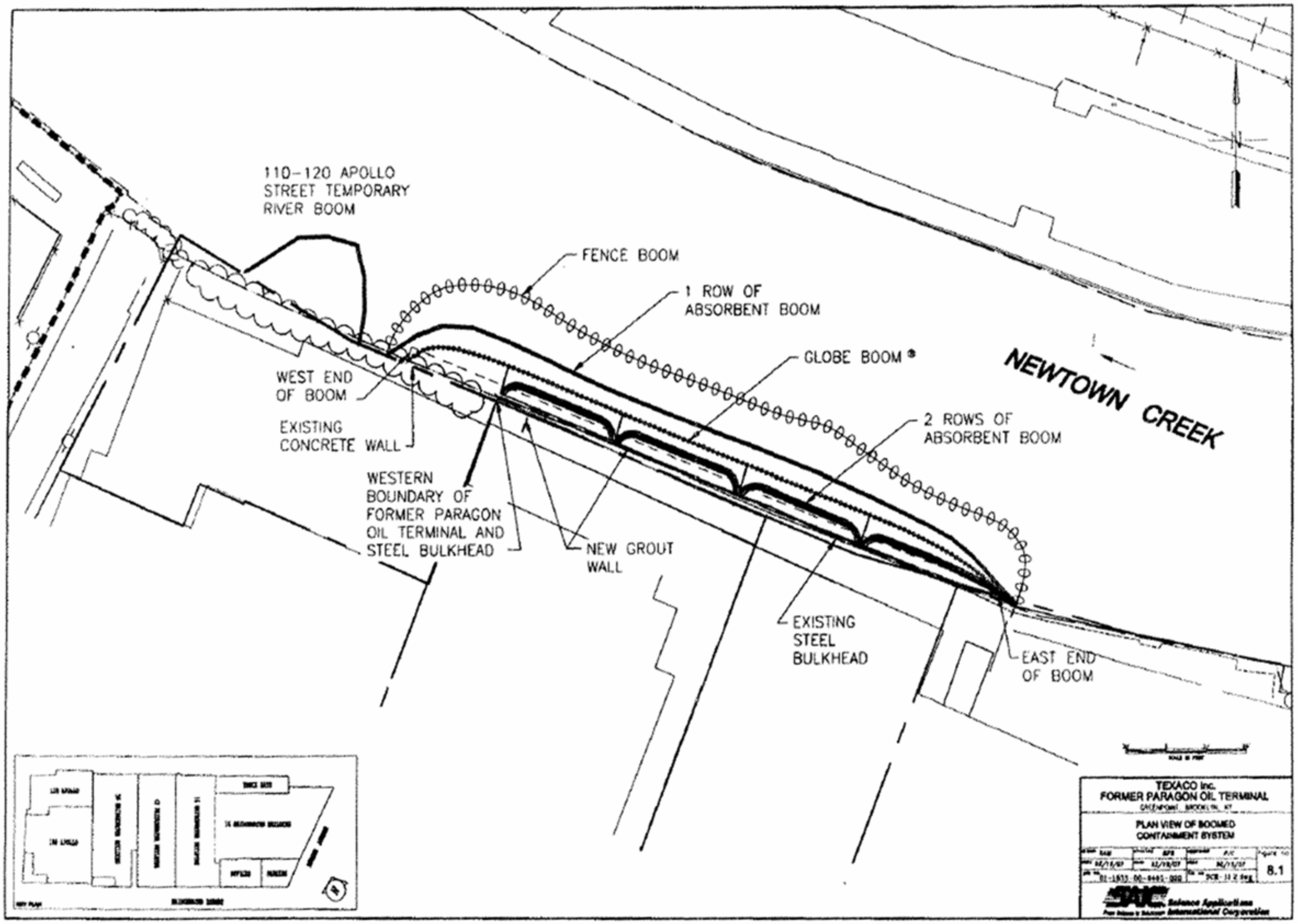


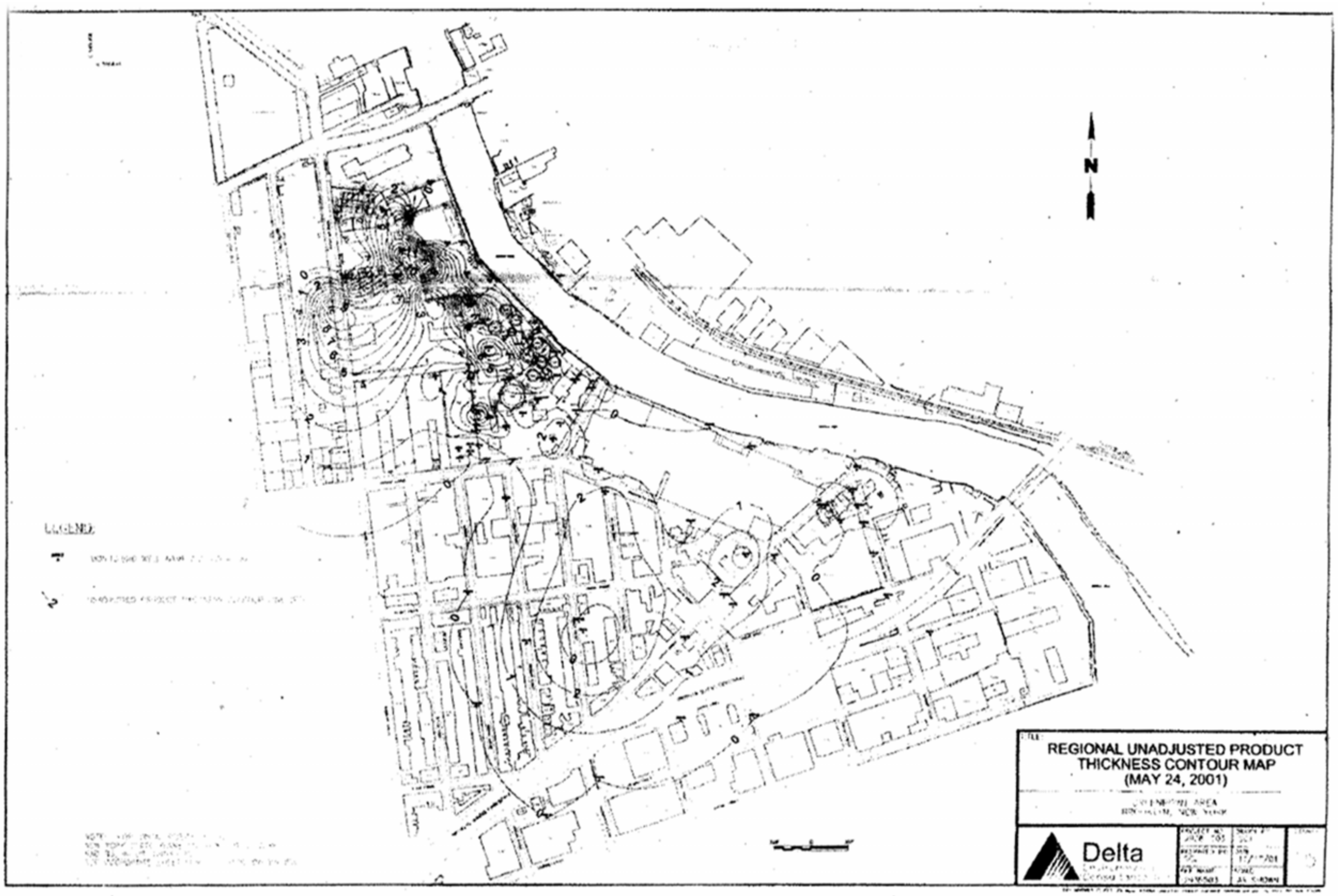
Diagram of Historical Booming on Newtown Creek



APPENDIX B

FREE-PRODUCT THICKNESS (DELTA, 2002)
NEWTOWN CREEK SITE
BROOKLYN, NEW YORK

Unadjusted Product Thickness Contour Map



Tables

TABLE 1-1
PRODUCT VOLUME AND RECOVERY ESTIMATES
NEWTOWN CREEK SITE
BROOKLYN, NEW YORK

REMAINING VOLUME ESTIMATES (Mgal) - REGIONAL AQUIFER						
Off-Site Plume (Exxon/Mobil)			On-Site Plume (Exxon/Mobil)		BP Amoco	
Roux 5/91	3.4		LB&G 8/81	1.4 to 2.4	IT 6/93	1.0
Roux 10/91	3.1	*	LB&G 6/91	1.6 to 2.5*		
Roux 1/03	5.3	*				
Approximate Total remaining January 1993: (5.3 + 2.5 +1.0) = 8.8 Mgal (maximum)						

PRODUCT RECOVERY ESTIMATES				
Off-Site Plume (EM)	MATF	On-Site Plume (Exxon/Mobil)	BP Amoco	Former Paragon
Roux 10/06 3.8	Roux 1/05 0.7	RE 1/07 1.7	Delta 1/07 3.19	SAIC 1/07 0.013
Approximate total recovered from start-up to December 31, 2006 (3.8 + 0.7 + 1.7 + 3.19 + 0.013)= 9.4 Mgal				
Approximate total recovered from January 1, 2003 to December 31, 2006 = 5.9 Mgal				
Approximate volume remaining (8.8 - 5.9) = 2.8 Mgal				

Mgal = million gallons
IT = International Technology Corp.
LB&G = Leggette Brashears & Graham
MATF = Meeker Avenue Task Force
RE = Remedial Engineering
Dates refer to the report providing the indicated data.
* recalculation based on new data

TABLE 1-2
RECOVERY WELL STATUS
NEWTOWN CREEK SITE
BROOKLYN, NEW YORK

Well No.	Aquifer	Status		F. P. Yield GPD	Screen Setting	Comments
Mobil Onsite						
ARW-1	Shallow	I	(Insufficient free product)	NA		Installed 1979
ARW-2	Shallow	I	(Insufficient free product)	NA		Installed 1979
ARW-3	Sallow/Regional	I	(Insufficient free product)	NA	0 to 38 ft bgs	Installed 1979
ARW-4R	Regional	I	(Insufficient free product)	NA		Installed 1988
ARW-5	Shallow	I	(Insufficient free product)	NA		no record
ARW-6	Shallow	I	(Insufficient free product)	NA		Installed 1979
ARW-7		I	(Insufficient free product)	NA		no record
ARW-8	Shallow	I	(Insufficient free product)	NA	0 to 18 ft bgs (?)	Installed 1980
ARW-9	Shallow	I	(Insufficient free product)	NA	0.5 to 12 ft bgs	no record
ARW-10	Shallow	I	(Insufficient free product)	NA	0 to 12 ft bgs	Removed from service 1981
ARW-11	Shallow	I	(Insufficient free product)	NA	0 to 15.5 ft bgs	24-inch diam., installed 1980
ARW-12	Shallow/Regional	I		NA		Installed 1982
ARW-13	Shallow/Regional	I		NA		Installed 1982
ARW-14	Regional	A		~20		Installed 1985
ARW-15		A				Installed 1988
ARW-16		I		NA		Installed 1993
ARW-17		A		~55		Installed Nov. 2004
ARW-18		A		~185		Installed Nov. 2004
ARW-19		A		~27		Installed Oct. 2005
ARW-20		A	Low Yield	>1		Installed Oct. 2005
Mobil Offsite						
ARW-A	Regional	A		~575 - 600		10-inch diam. steel
ARW-B	Regional	A		~6		10-inch diam. steel
ARW-C	Regional	A		~ 80 -105		10-inch diam. steel
ARW-D	Regional	A		~185		10-inch diam. steel
ARW-E	Regional	A		~21 - 23		10-inch diam. steel
ARW-F	Regional	A	(negligible free product)	NA		10-inch diam. steel
ARW-G	Regional	I	(Insufficient free product)	NA		12-inch diam, steel

TABLE 1-2 (continued)
RECOVERY WELL STATUS
NEWTOWN CREEK SITE
BROOKLYN, NEW YORK

Well No.	Aquifer	Status		F. P. Yield GPD	Screen Setting	Comments
BP Amoco						
ARW-1	Regional	A		51*		
ARW-2	Regional	I	(Insufficient free product)	NA		24-inch diam. steel -34 ft deep
ARW-3	Regional	A		~ 1*		4-inch diam. steel - 35 ft deep
ARW-4	Regional	A		6*		14-inch diam. steel -35 ft deep
ARW-5	Regional	A		110*		10-inch diam., installed June 2004
ARW-6	Regional	A		153*		10-inch diam., installed June 2004
ARW-7	Regional	I	insufficient free product**	NA		10-inch diam., installed June 2004
ARW-8	Regional	I	insufficient free product**	NA		10-inch diam., installed June 2004
Peerless Importers (Formerly Paragon Oil)						
"Lower Bulkhead Wells"						
MW-68	Shallow	A		4.4 (stressed)	5 to 20 ft bgs	periodic vacuum extraction
MW-69	Shallow	A		6.9 (stressed)	5 to 20 ft bgs	periodic vacuum extraction
MW-70	Shallow	A		9.5 (stressed)	5 to 20 ft bgs	periodic vacuum extraction
"Upper Bulkhead Wells"						
MW-73	Shallow	A		11.3 (stressed)	4 to 14 ft bgs	total fluids extraction
MW-74	Shallow	A		56.5 (stressed)	5 to 17 ft bgs	total fluids extraction
MW-75	Shallow	A		33.5 (stressed)	5 to 20 ft bgs	total fluids extraction

A = Active
bgs = below ground surface
I = Inactive
FP = Free Product
GPD = gallons/day
NA = not applicable
LB&G = Leggette Brashears & Graham
~ approximately
* average from August 2005 through September 2006 ** contingency well

TABLE 1-3
FREE-PRODUCT POTENTIAL REMEDIAL METHODS
NEWTOWN CREEK SITE
BROOKLYN, NEW YORK

METHOD	APPLICATION	DISADVANTAGES
Recovery Well Redevelopment	Relatively inexpensive, no additional construction or support facilities required. Review of well performance history necessary.	Results not always certain
Treated Ground Water Re-injection	Increases hydraulic gradient to improve product capture; opportunity for addition of surfactants.	May need space for grid of wells; product movement needs to be controlled by optimal placement of recovery wells. Permits usually required for injection; uniform and moderate to high formation permeability needed.
Additional Recovery Wells	Aggressive method to increase product capture rate in thick sections of free-product. A dual-phase system (water and product) creates ground water cone of depression, thus increasing radius of capture zone.	Efficiency deceases as free-product thickness decreases. Requires collection and/or treatment facilities for recovered fluids; usually produces smear zone.
Bioslurping/Vacuum Enhanced Recovery	Multi-phase extraction with relatively high free-product recovery rate. Minimizes smear zone.	High capital costs; treatment usually necessary for recovered ground water and vapors, thus requiring permits.
Steam/Hot Water Injection	Reduces product viscosity, promotes phase transfer where water and vapor phases are more easily recovered.	A pilot technology; space needed for grid of injection and recovery wells; need to maintain control of product in urban area.
Electrical Heating	Relatively fast method with product capture enhanced by phase transfer.	Relatively high cost, best applied to small areas; space needed for electrode grid.
Bioremediation	Most applicable as a polishing step after	Both injection and extraction wells may be
	bulk of free product has been removed.	needed; treatment facilities may be required. Low permeability soils limits effectiveness

FIGURES

Figure 1 - Index Map

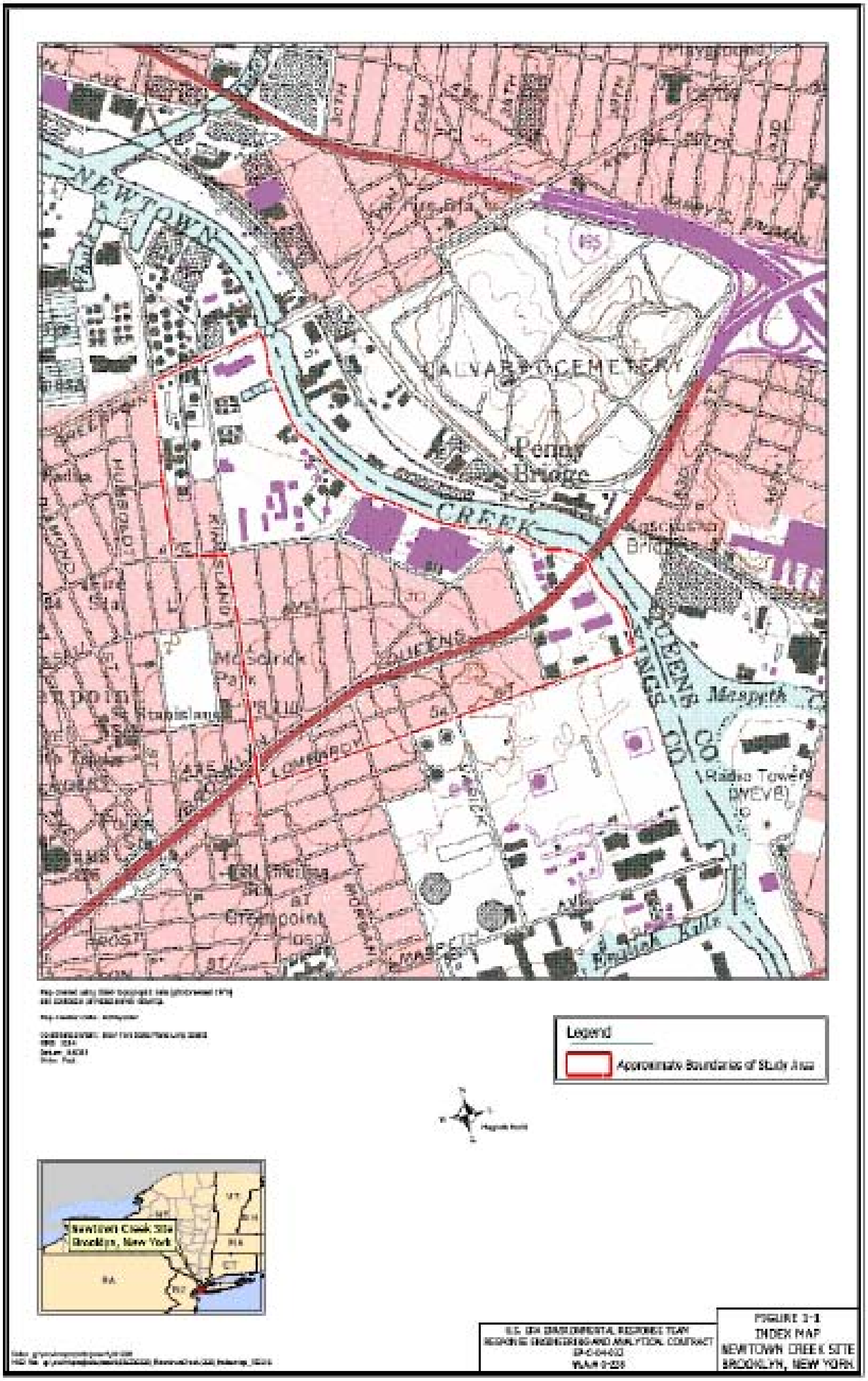


Figure 2 - Property and Seep Locations

Figure 3 - Product Extent and Thickness

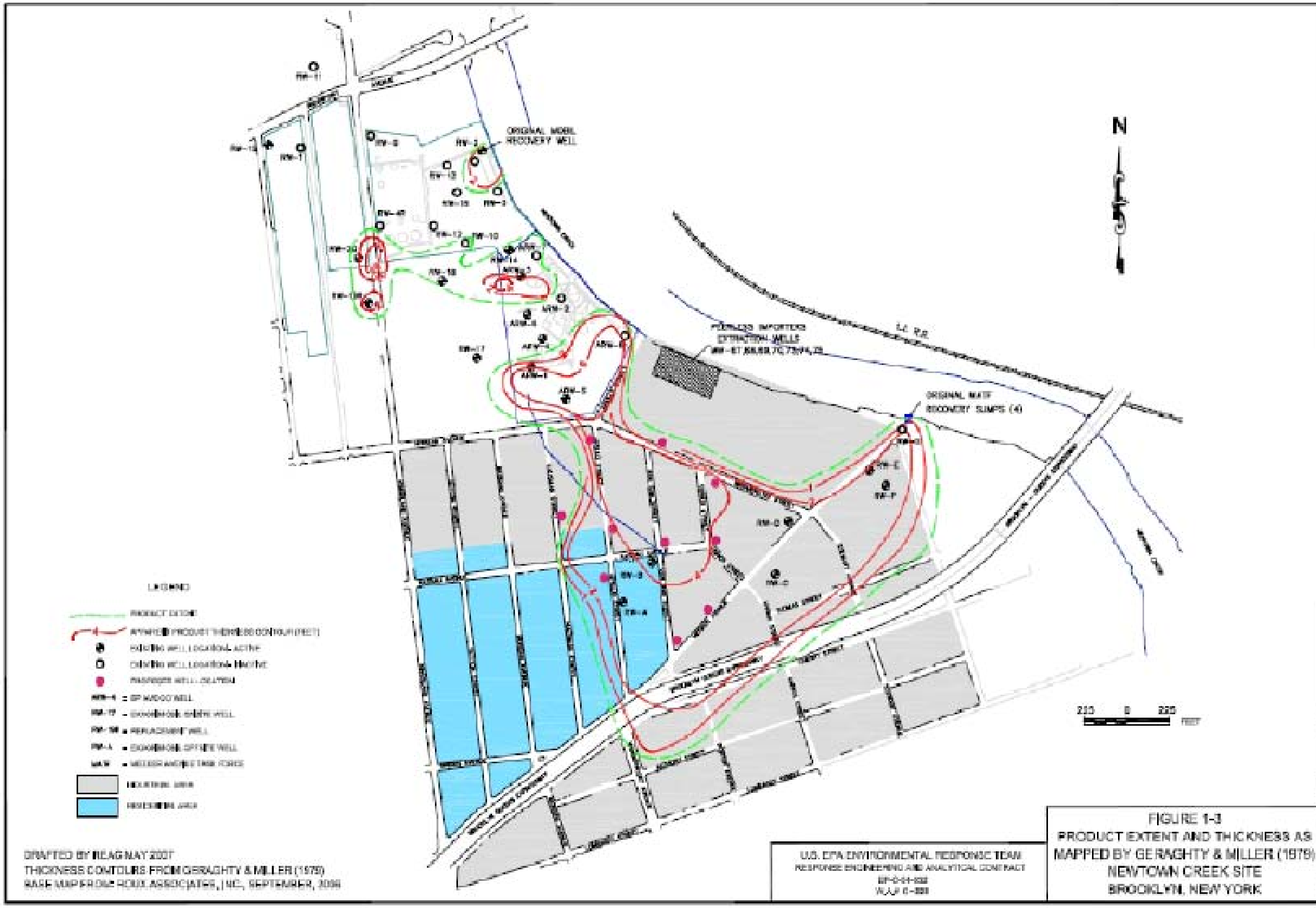


Figure 4 - Apparent Free-Product Thickness

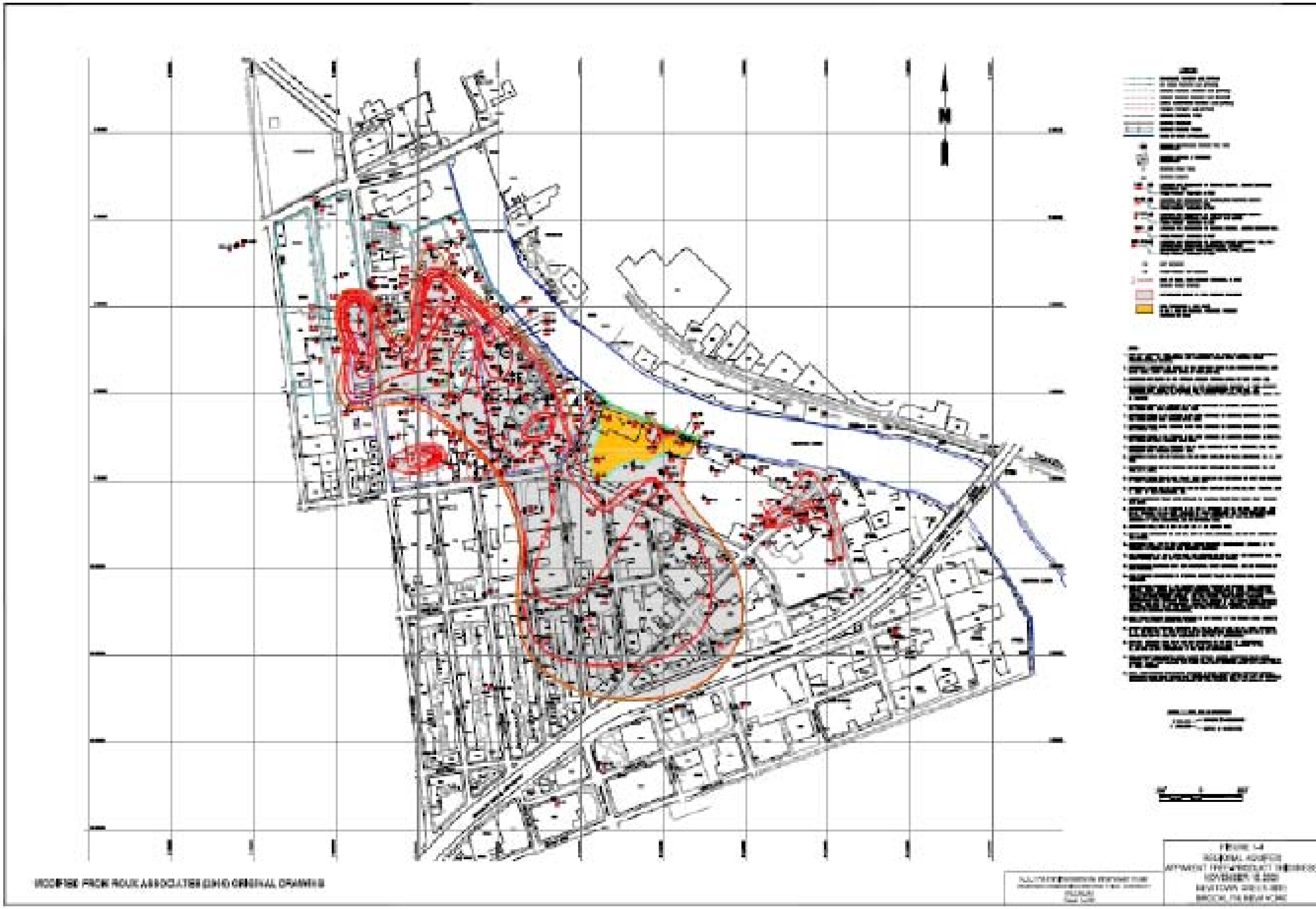


Figure 5 - Recovery Well Locations

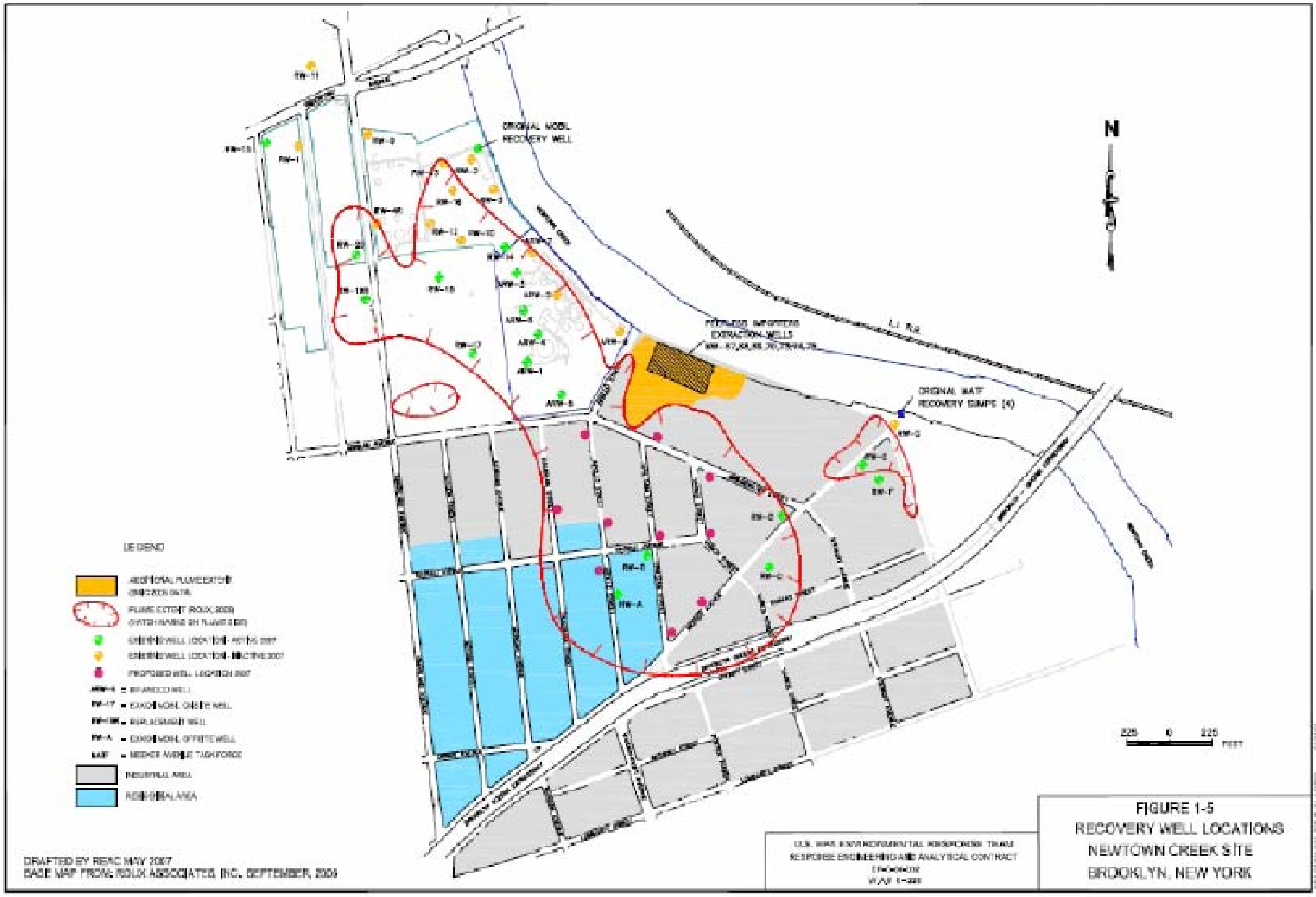


Figure 6 - Monitoring Well Locations

Figure 7 - Generalized Groundwater Flow Direction Map

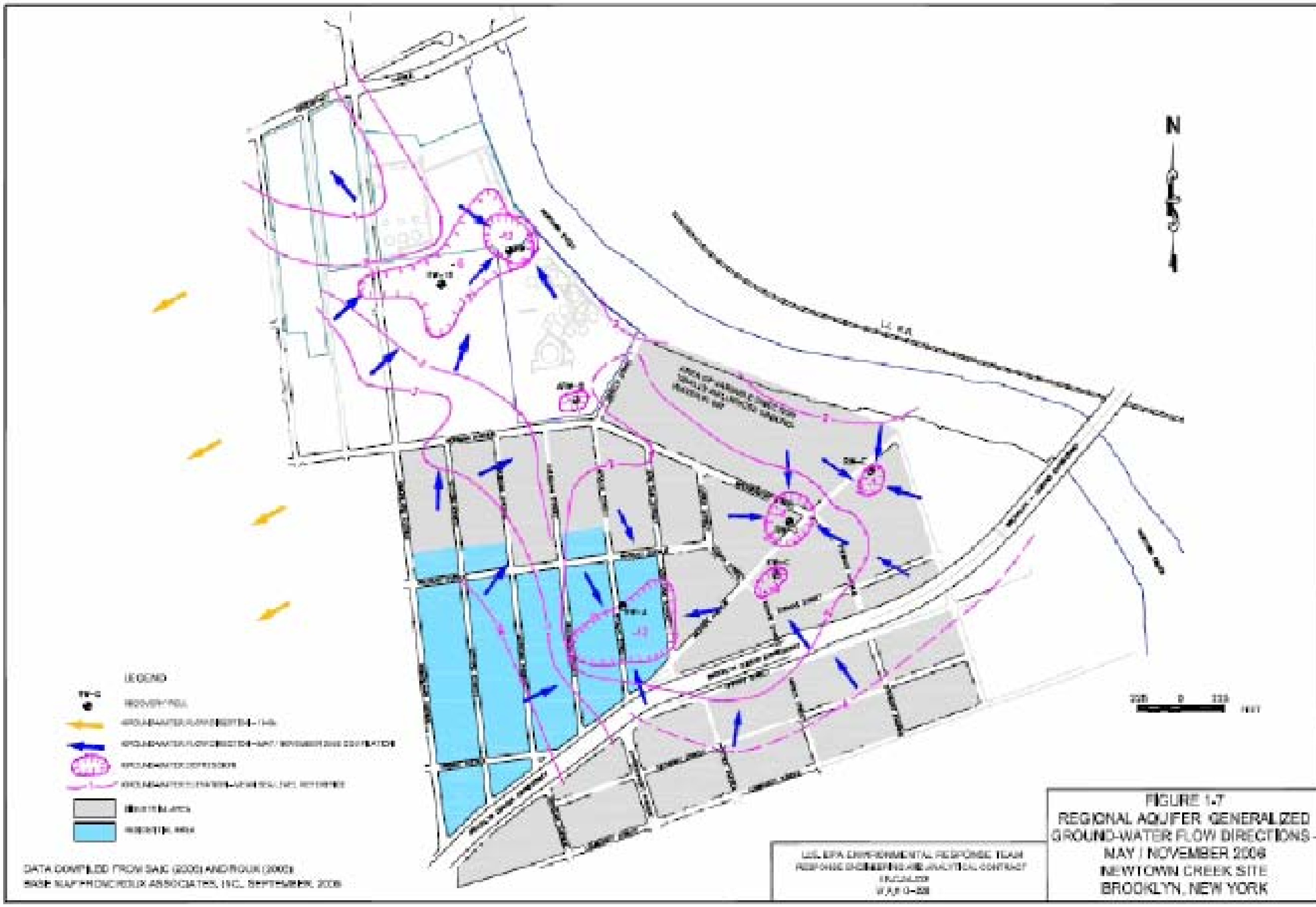
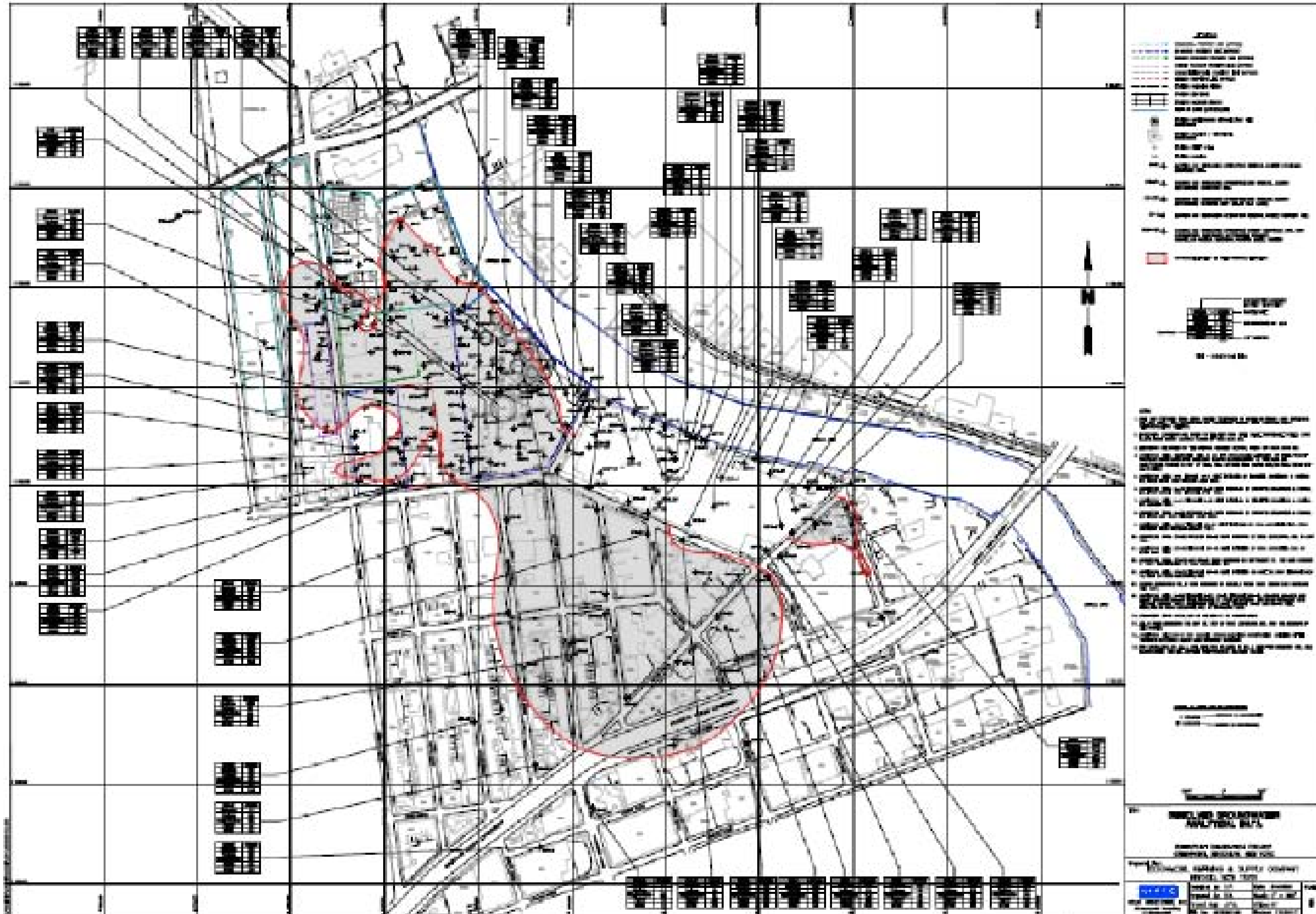


Figure 8 - Dissolved Groundwater Analytical Data Map



Chapter 2

Vapor Intrusion Investigation - Greenpoint Petroleum Remediation Project

Background

As part of the ongoing investigation and remediation activities for the Greenpoint Remediation Project, the New York State Department of Environmental Conservation (NYSDEC) determined that an investigation of potential vapor intrusion into residential structures was warranted. The vapor intrusion pathway accounts for the migration of contaminants from one medium (i.e., groundwater or soil) to a vapor phase that can collect underneath building foundations (e.g., sub-slab), and finally enter through building foundations into indoor air (Figure 1).

The decision to conduct residential vapor intrusion sampling was based, in part, on soil gas sampling performed in the area by Exxon/Mobil Refining & Supply Company ("Exxon/Mobil"). Exxon/Mobil sampled soil gas in the Greenpoint Area around the Off-Site product plume (Figure 2). The goal of the sampling was to determine if vapors from the product plume were attenuating before impacting indoor air as believed from some earlier investigations. This investigation was conducted in 2005, and a report was finalized in February 2006 and made available to the public through the NYSDEC's Greenpoint website at www.NYSDEC.state.ny.us/website/der/projects/greenpoint.

The soil vapor investigation conducted by Exxon/Mobil in 2005 concluded that the free-product plume was not contributing to concentrations of contaminants in residential indoor air. According to the report the depth of the contamination allowing for biodegradation and presence of a clay/silt layer to prevent migration are factors supporting this conclusion. The NYSDEC reviewed the data and agreed that it supported Exxon/Mobil's conclusions, however, NYSDEC concluded that a residential vapor intrusion/indoor air investigation to collect the data necessary to verify or refute this conceptual model was needed. This work is described below.

Since the 2005 investigation indicated that further work was needed to delineate the areal and vertical extent of potential soil vapor exceeding the screening criteria in the commercial and industrial areas, Exxon/Mobil continued investigating soil vapor, especially methane and benzene, in non-residential areas in 2006 (see Figure 3 and 4). The screening criterion for benzene was 170,000 parts per billion volume in soil vapor beneath commercial areas. The screening criterion for methane in soil vapor was set at 50,000 parts per million volume. Exxon/Mobil concluded that the findings of this investigation were consistent with the earlier 2005 investigation; the presence of silt/clay layers when combined with increased depth restricted the upward migration of soil vapor.

Biannual soil vapor sampling is conducted by Exxon/Mobil in both the residential and commercial/industrial areas. This sampling is not the same as the residential vapor intrusion study performed by the NYSDEC. Exxon/Mobil is not sampling the subslab and indoor air in the residential area, rather it is sampling discrete locations which are part of a soil vapor monitoring network. These monitoring points are generally located under area sidewalks. There are twenty nested monitoring points, containing both a deep (7 - 8 feet below land surface) and a shallow (2 - 3 feet below land surface) sampling point, for a total of forty points in the commercial/industrial area and ten deep (7 - 8 feet below land surface) monitoring points in the residential area. The most recent sampling round was conducted from January to March 2007, and results are presented in a March 30, 2007 letter report to the NYSDEC. Benzene and methane results from this latest sampling round are presented in Figures 5 and 6. It should be noted that there may be multiple sources of methane in the area, such as leaks of natural gas from subsurface pipelines, which may be contributing to the methane detections reported in soil vapor.

Another investigation into soil vapor in the area included work performed on behalf of Chevron-Texaco at a warehouse located on the former Paragon Oil Terminal (currently Peerless Importers). This investigation included the installation of ground water monitoring wells inside the warehouse in July 2005. Air monitoring was conducted primarily to assess worker health and safety issues and as such has limited application to the residential vapor intrusion study conducted by the NYSDEC.

Residential Vapor Intrusion Investigation

Although Exxon/Mobil was willing to perform an investigation of the vapor intrusion pathway at the site, it had difficulty securing access from property owners. Therefore, NYSDEC opted to conduct the study using NYSDEC personnel and contractors. The NYSDEC study targeted residential structures over the current and historical free product plume (see Figure 7). Investigation of residences over the dissolved phase plume was deferred pending the results of the initial free product plume investigation. NYSDEC began soliciting participation from the public in November 2006.

Methodology

To investigate vapor intrusion NYSDEC developed an initial work plan that was distributed to both EPA and the public at an Information Session held on September 27, 2006. Key tasks identified in the work plan included: 1) obtaining access, 2) conducting a building survey, 3) conducting a product inventory within the structure for potential sources of indoor air contamination, and 4) the collection and analysis of subslab, indoor air and outdoor (ambient) air samples. This last task was conducted in accordance with the New York State Department of Health ("DOH") "Guidance for Evaluating Soil Vapor Intrusion in the State of New York."

1. Access

   Extensive outreach was conducted by the NYSDEC to obtain as many access agreements as was possible. This outreach consisted of two public information sessions held during the fall and winter of 2006 - 07. In addition, NYSDEC mailed 387 letters in English, Spanish and Polish to area residents requesting their participation in the study. Positive responses have been somewhat low. NYSDEC reports having 59 volunteers as of March 2007, possibly because of potential litigation.

2. Building Surveys

NYSDEC contractors visited each property to be tested prior to actual sampling. A building survey was conducted. This consisted of evaluating the building type, floor layout, air flow/air flow patterns and the physical condition of the building.

3. Product Inventory

One of the factors that significantly affects indoor air sampling is the presence of products within the residence that contain volatile organic compounds (VOCs). These products may contain the same chemicals that are the focus of the investigation. Even when unopened, containers with these compounds can result in detectable concentrations of volatile chemicals in indoor air. To evaluate this, the NYSDEC contractors conducted an inventory of products in each residence to be tested. This inventory lists the product name, its chemical composition (when known) and the readings from this product obtained using a sensitive handheld VOC monitor. These readings were then recorded in the field notes.

4. Sample Collection and Analysis

Sample collection was conducted during the winter of 2006 - 2007. Samples were collected from beneath the building foundation (sub-slab samples), the basement, the first floor and the outdoor air. Samples were collected using Summa canisters, a sampling vessel designed to collect air samples, over a 24-hour sampling period. Analysis was conducted using EPA Method TO-15 for VOCs, and EPA Method TO-3 for methane.

EPA reviewed and provided comments on the initial Work Plan to NYSDEC in November 2006. In December 2006 NYSDEC provided EPA with two supplementary documents: "Standard Operating Procedures: Soil Vapor Intrusion Investigation in New York State" and "Verification and Validation of Chemical Analytical Data." A revised Work Plan was provided to EPA in January 2007. In addition, NYSDEC provided EPA with a response to EPA's November comments. EPA reviewed the Standard Operating Procedures and provided comments to NYSDEC in February 2007.

Results

To date, EPA has received analytic results from 45 properties. Samples were collected at each home from beneath the slab and in the basement (when available) and first floor living space (when available). In addition, outdoor (ambient) air was collected at 44 of the 45 residences. Typically, when vapor intrusion is occurring at a site, the concentrations in the subslab are highest, with decreasing concentrations as samples are collected in higher levels of a home; outdoor (ambient) concentrations are usually quite low so that they would not serve as an influence to vapors that are detected indoors. A review of the data collected by the NYSDEC shows that, in general, chemicals were detected at all locations in each home, but not in a pattern that would typically represent a vapor intrusion phenomenon. Chemicals were detected at concentrations in the subslab soil gas and the indoor air (both the basement and the first floor living space) but usually at concentrations that are consistent with outdoor (ambient) air results. This pattern suggests that outdoor (ambient) air may be contributing to vapors that are detected indoors. Data collected from a few residences do not follow this pattern and additional investigation may be warranted to more fully understand how the vapors are migrating. NYSDEC, in conjunction with the DOH, reviews the analytic results and DOH transmits the data with an explanatory letter to the homeowners. This effort is ongoing.

Recommendations

As previously noted, NYSDEC in conjunction with the DOH, is continuing to assess the data that were collected from this investigation. The following recommendations are provided to assist with this effort.

- Further investigate results from homes with elevated subslab and indoor air concentrations along Meeker Avenue.

- Based on existing information, data gaps exist. Continue to attempt to gain access to additional homes along Kingsland Avenue, Van Dam Street, Meeker Avenue, and South of the Brooklyn Queens Expressway. Access issues may interfere with the NYSDEC's ability to close these data gaps.

- Provide decision matrix/flowchart for community that clearly explains how data are being evaluated and how risk management Decisions are being made regarding subslab, indoor, and ambient concentrations.

- Outreach to commercial facilities which are located within the residential areas (delicatessens, shops, etc.) to get access so that vapor intrusion data can be collected. These can be used to assess potential distribution across the plume.

- Continue to evaluate ground water data for both the free product plume and the dissolved phase plume to determine if boundaries of the vapor investigation should be revised.

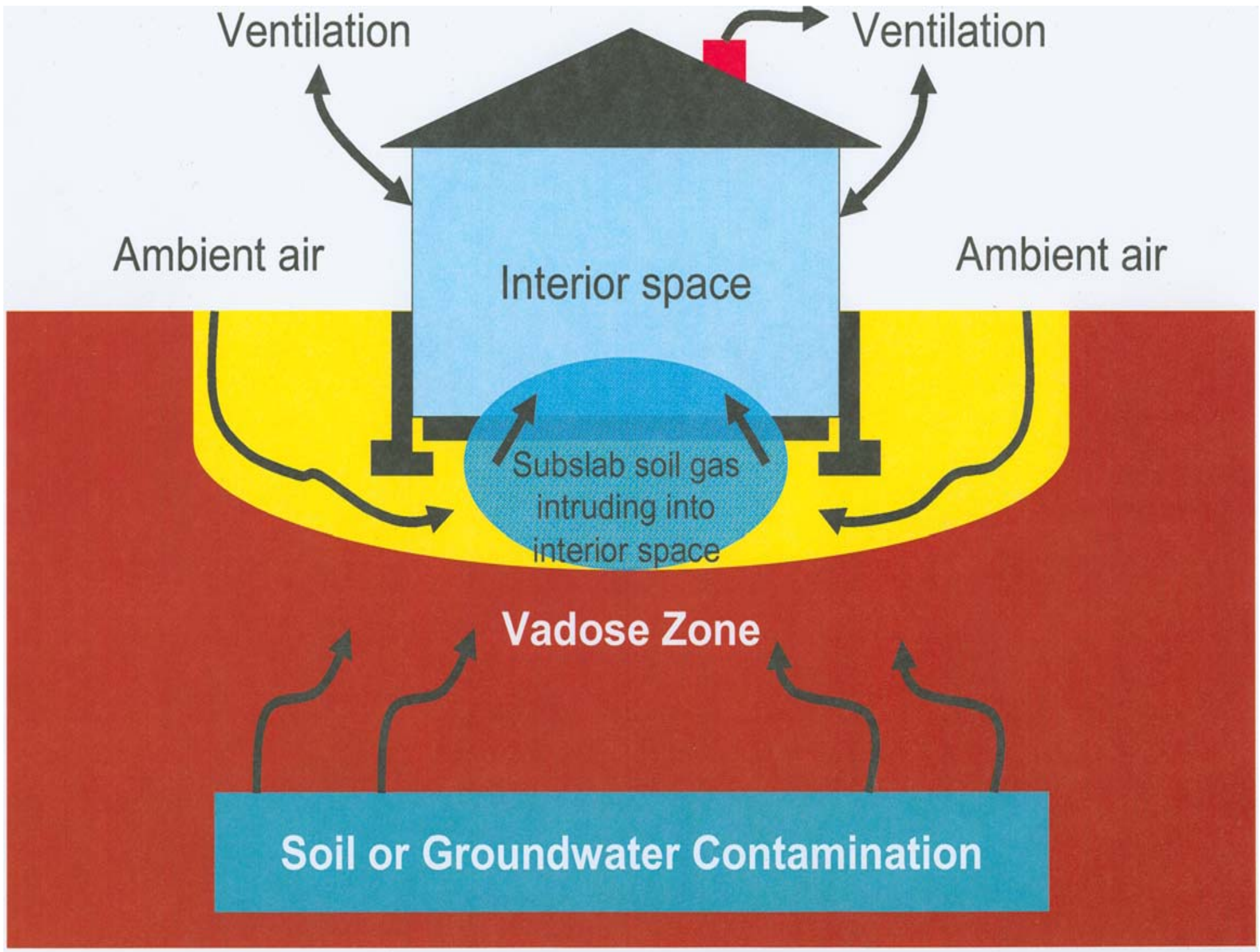
- Develop ambient air monitoring program to investigate potential confounding sources to indoor air.

- Include naphthalene in the analytical suite.

- Evaluate any potential existing databases for background air concentrations in similar communities for comparison with

Chapter 2 Figures

Figure 1 - Vapor Pathways Into Buildings



Vapor Pathway into Buildings

Figure 2 - Site Plan

(Source - Exxon/Mobil Soil Vapor Investigation Feb. 2006)

Figure 3 - Benzene Concentrations in Soil Vapor

(Source - Preliminary Phase IV Commercial Soil Vapor Results)

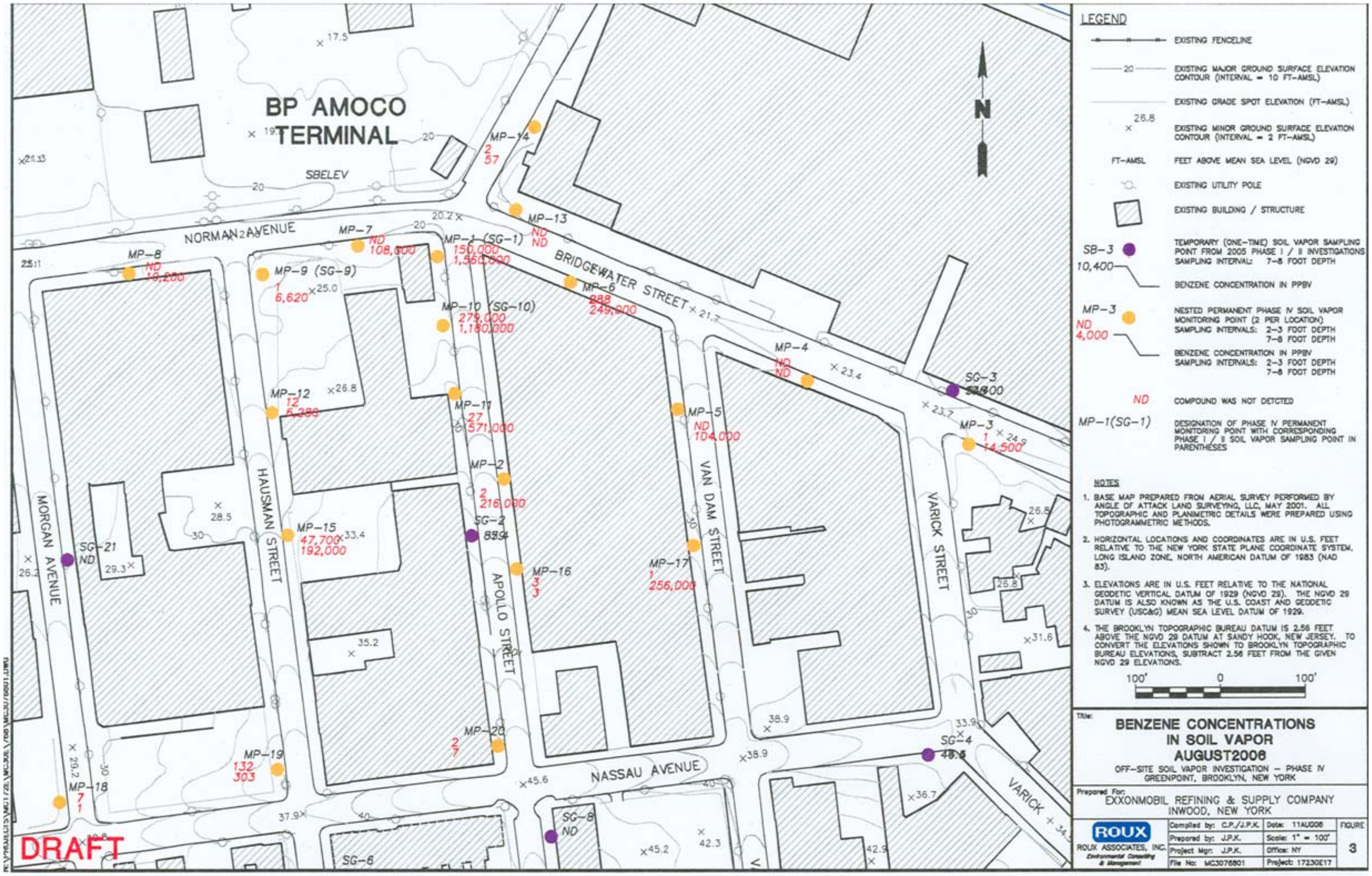


Figure 4 - Methane Concentrations in Soil Vapor

(Source - Preliminary Phase IV Commercial Soil Vapor Results, August 2006)

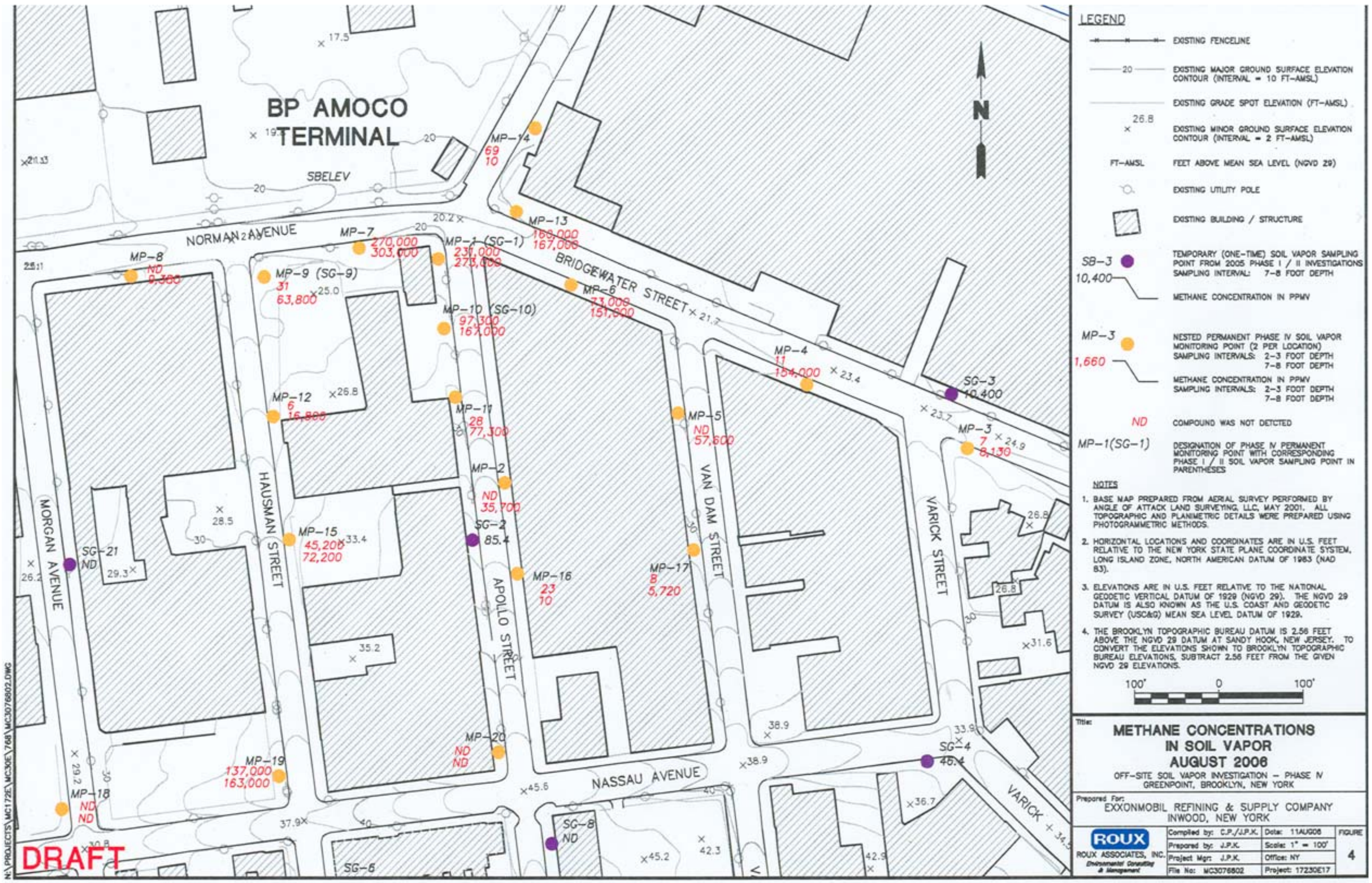


Figure 5 - Benzene Concentrations in Soil Vapor

(Source - January 2007 Soil Vapor Report Exxon/Mobil)

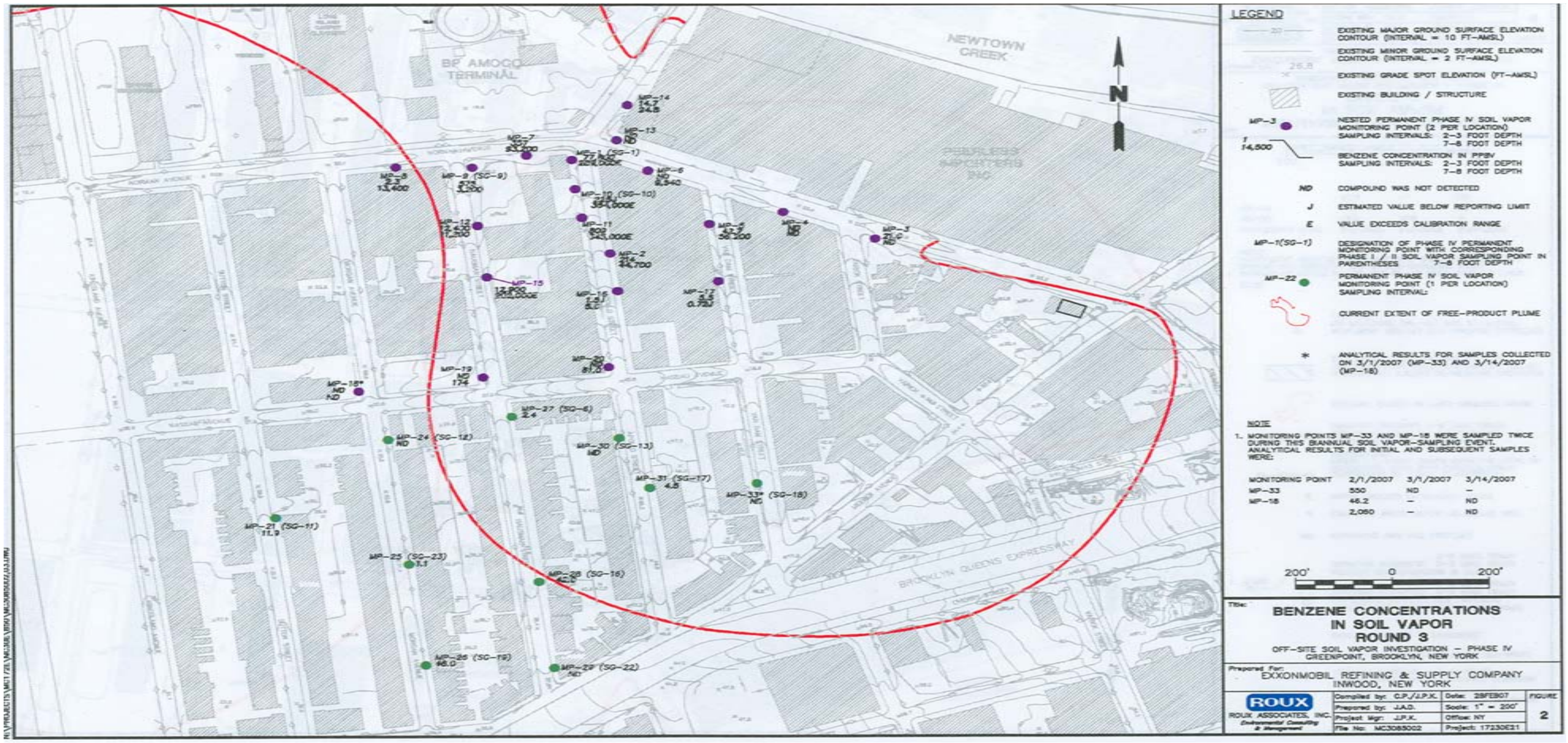


Figure 6 - Methane Concentrations in Soil Vapor

(Source - January 2007 Soil Vapor Report Exxon/Mobil)

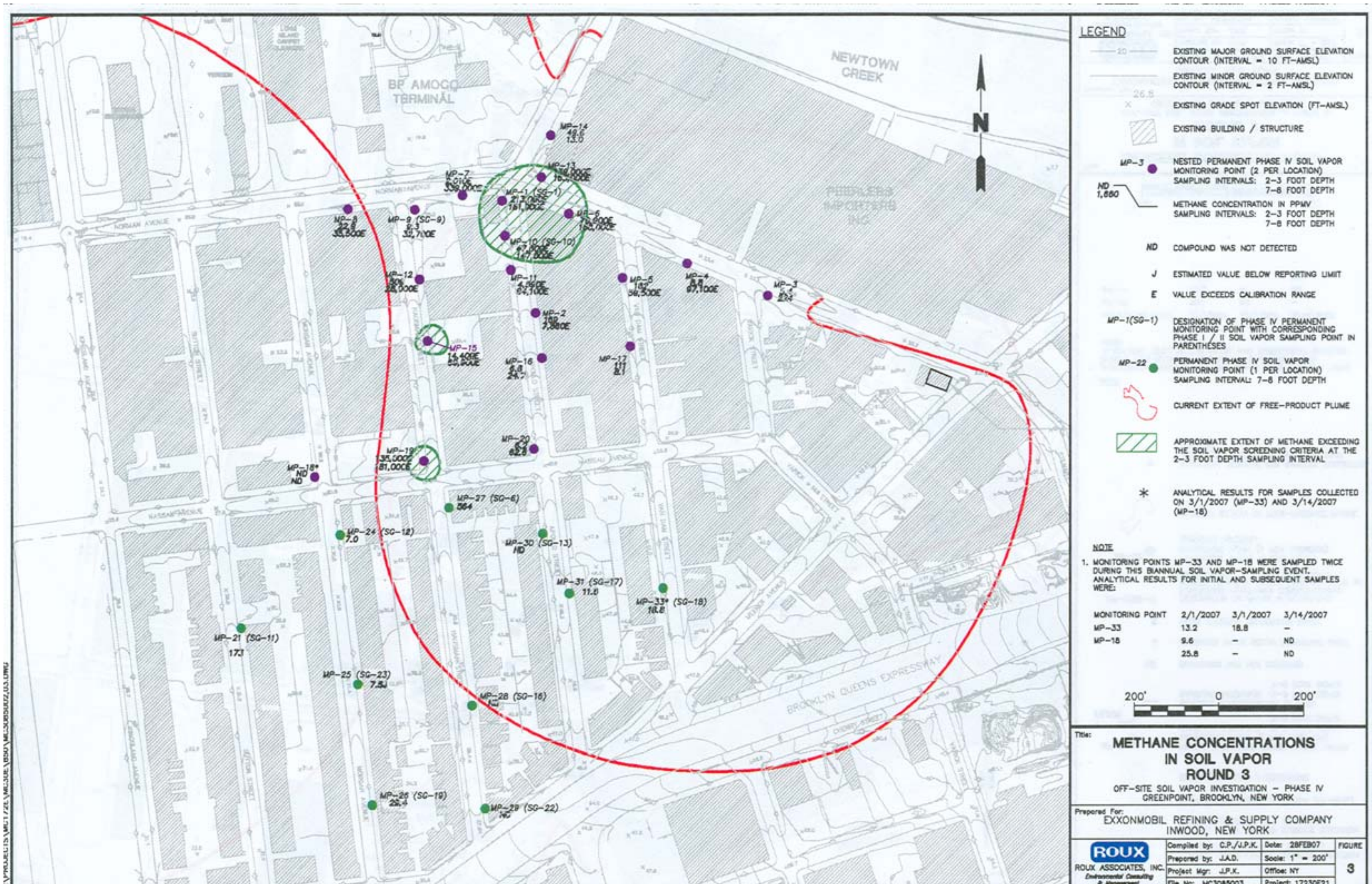
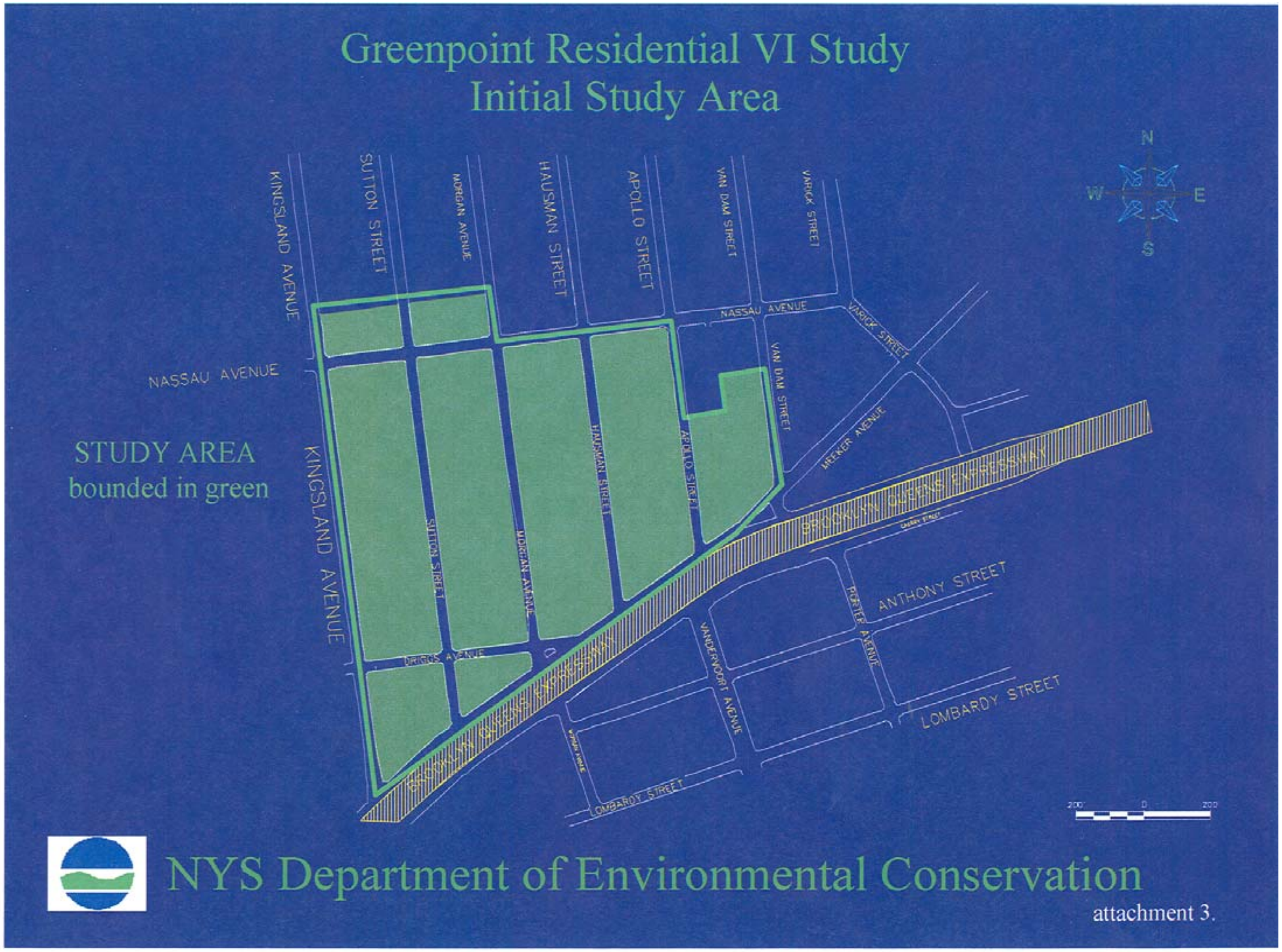


Figure 7 - Greenpoint Residential Vapor Intrusion Study

(Source - New York State Department of Environmental Conservation)



Chapter 3

Natural Resource Damages Assessment - Greenpoint Petroleum Remediation Project

Background

As noted above, the legislative history of H.R. 889 is largely contained in remarks made by Representative Anthony Weiner (D-NY) in the Congressional Record of June 26, 2006. In Representative Weiner's remarks, he stated that in preparing the Newtown Creek/Greenpoint oil spill study, EPA was to revisit the findings of the U.S. Coast Guard's July 1979 report entitled "Investigation of Underground Accumulation of Hydrocarbons along Newtown Creek," and more specifically, address the "extent to which the Spill has affected aquatic species in the Creek and Harbor, and methods to prevent further harm."

The July 1979 report prepared for the U.S. Coast Guard made no findings concerning potential natural resource impacts in the Greenpoint area and Newtown Creek caused by the oil spill. Since 1979, however, a comprehensive framework for studying, assessing, recovering for, and restoring lost or degraded natural resources has developed through Federal statutes and regulations, case law, and science. This framework now includes the Oil Pollution Act (OPA90), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and their regulations (particularly the National Contingency Plan, or NCP).

EPA is not a Federal natural resource trustee. Two other Federal departments, namely the Department of Commerce through the National Oceanic and Atmospheric Administration, and the Department of the Interior through the U.S. Fish and Wildlife Service, have been designated by the President as the leads in addressing most damaged natural resources for the Federal government. The Departments of Defense, Agriculture, and Energy also have Federal trustee status for various natural resources. Similarly, State and Tribal governments have been given prominent roles by Congress in the Federal statutes and regulations that address the restoration of and compensation for damaged natural resources.

The State of New York has led the response to this spill since the 1980's, when the USCG determined under its authorities that the State was equipped to perform an adequate response. After receiving the Federal spill response lead in 2006 from the USCG under OPA90, EPA has served in a supporting role to the State, and has also commenced the study called for by H.R.889. At this time, EPA believes that the State continues to have the capability to perform, and is in fact performing, an adequate response to the spill. As discussed further below, among the response actions planned by the State with respect to the spill is to perform, in conjunction with NOAA, an expedited natural resource damage assessment of Newtown Creek.

EPA's Limited Role in Addressing Natural Resource Damages

Even when EPA has been designated under OPA90 as the lead Federal response agency for an onshore oil spill such as the Newtown Creek/Greenpoint spill, its involvement with natural resource damages is limited. Section 1011 of OPA90 provides that the President "shall consult with the affected trustees...on the appropriate removal action to be taken in connection with any discharge of oil." 33 U.S.C. § 2711. Section 300.305(e) of the NCP provides that the EPA On-Scene Coordinator "shall ensure that the natural resource trustees are promptly notified in the event of any discharge of oil." Promptly after assuming the Federal lead for the spill from the U.S. Coast Guard on July 21, 2006, EPA's On-Scene Coordinator for the spill notified his counterparts within NOAA and the State of New York of the discharge of oil in the Greenpoint community and into Newtown Creek. (Again, EPA made the determination in July of 2006 that the response to the spill was being adequately managed by the State of New York; EPA does not foresee taking a more active role in the spill response at this time.) Section 300.305(e) of the NCP also provides that the "OSC and the trustees shall coordinate assessments, evaluations, investigations, and planning with respect to appropriate removal actions," and that the OSC "shall consult with the affected trustees on the appropriate removal action to be taken." Since EPA's assumption of the Federal lead for the spill response, EPA's OSC and other EPA personnel have coordinated and consulted with the affected trustees, in particular the State of New York, concerning most aspects of EPA's involvement with the spill.

Designation of Federal and State Trustees

OPA90's and CERCLA's natural resource damage provisions are similar in most respects. CERCLA pre-dated OPA90, and therefore many of OPA90's natural resource damage provisions are based on those in CERCLA. Given that the Newtown Creek/Greenpoint oil spill is being addressed under OPA90, however, the H.R. 889 Report focuses on OPA90's natural resource damage provisions. Under OPA90, the responsibility for protection of natural resources rests in Federal, State, and Tribal trustees. Federal law in the U.S. incorporates the English common law principle that natural resources are held in trust for the public by the resources' trustees.

OPA90 requires the President to designate through the NCP the Federal officials who act on behalf of the public as trustees for natural resources. OPA90 § 1006, 33 U.S.C. § 2706. The President has not designated any EPA officials as Federal trustees under OPA90 or any Federal statute.

Instead, the President has designated Secretaries of Commerce, Interior, Defense, Agriculture, and Energy to act as Federal trustees for the nation's natural resources. In the case of the Newtown Creek/Greenpoint oil spill, the Secretary of Commerce through the Administrator of the National Oceanic and Atmospheric Administration is the lead Federal natural resource trustee because of the coastal and marine resources of the Creek.

Specifically, the Secretary of Commerce is by regulation the Federal trustee for "natural resources managed or controlled by [the Department of Commerce] and for natural resources managed or controlled by other Federal agencies and that are found in, under, or using waters navigable by deep draft vessels, tidally influenced waters, or waters of the contiguous zone, the exclusive economic zone, and the outer continental shelf." 40 C.F.R. Part 300.600(b)(1). The regulations authorize the Secretary to pursue a claim for damages "when there is injury to, destruction of, loss of, or threat to natural resources, including their supporting ecosystems, as a result of a release of a hazardous substance or a discharge of oil." 40 C.F.R. Part 300.600(b). Through a further delegation from the Secretary of Commerce, the trustee responsibility for the natural resources found in our nation's coastal and marine environments rests in the NOAA Administrator. Newtown Creek is part of the New York Harbor estuary system, a coastal and marine environment.

The governor of each State appoints the trustee of natural resources. OPA90 § 1006(b)(3); 40 C.F.R. Part 300.605. The governor of New York has appointed the Commissioner of the New York State Department of Environmental Conservation (NYSDEC) to serve as trustee of the State's natural resources. For certain resources, the State trustee role can run concurrently with Federal and Tribal trustee roles. In the case of Newtown Creek, both the Federal and State governments have expressed their respective trustee interests in the natural resources relating to the Creek.

Status of Natural Resource Actions Regarding Newtown Creek

In 2006, NYSDEC referred the State's potential natural resource damages claim for the Creek to the New York State Department of Law (NYSDOL). Since then, NYSDOL has been actively engaged in discussions with NOAA (in its role as Federal trustee), and Phelps Dodge Corporation regarding a possible claim related to the effects of contamination from the former Phelps Dodge facility on Newtown Creek. The former facility, located on the north side of Newtown Creek immediately east of the Kosciusko Bridge, was the subject of an extensive remediation under the State's hazardous waste site remediation program. NYSDOL has also sought to enter into settlement negotiations with Exxon/Mobil. Such negotiations have reportedly been unsuccessful.

Other than the sampling undertaken by Phelps Dodge in the sections of the Creek closest to its facility, there has been very little sampling of conditions in the Creek, including surface waters, sediments, and biota. No identification has been made of the natural resources in the Creek damaged by discharges of petroleum products or hazardous substances. Accordingly, there has been no assessment of such damages. NYSDOL and NOAA have entered into discussions with Phelps Dodge regarding the performance of an expedited natural resource damages assessment for the Creek. Such an expedited assessment would be similar to one that the State performed recently for Lake Ontario.