PNG ENVIRONMENTAL, INC.

Confidential Memorandum

To: Michael Lilly, Attorney

From: Martin Acaster and Paul Ecker

Date: July 15, 2010

Subject: **Site Status Report – Remedial Alternative Screening**
Former Plaid Pantries Store #324
10645 16th Avenue SW
Seattle, Washington
Ecology Site ID #97464/LUST #592164

PNG Environmental, Inc. (PNG) prepared this memorandum to provide a status report for the Former Plaid Pantries #324 retail gasoline station, located at 10645 16th Avenue SW in Seattle, Washington (Figures 1 and 2). The primary focus of this report is to summarize the site setting and preliminary remedial technology screening for applicability at the site. A discussion of the recent pilot testing results and a summary of issues related to the right-of-way adjacent to the site are also included.

BACKGROUND

Based on site characterization performed to date (PNG May 18, 2009), soils located north and northeast of the former underground storage tank (UST) cavity are contaminated with gasoline and benzene at concentrations exceeding Ecology's Model Toxics Control Act (MTCA) Method A cleanup levels (Figure 3). Gasoline impacts may extend offsite into the right-of-way east of the property. Groundwater is present at depths of greater than 50 feet below ground surface. Based on the vertical extent of soil contamination identified at the site, groundwater is unlikely to be impacted by the release; however, PNG has not observed groundwater nor collected confirmatory groundwater samples at the site.

Based on the identified lateral and vertical extent of the impacted soil, PNG evaluated a scope and budgetary cost for on-site remedial excavation. Planning discussions with geotechnical engineers at two firms (KPFF and Terracon) indicated that shoring would be required prior to anticipated excavation to stabilize the adjoining 16th Avenue right-of-way. Some shallow excavation could be conducted without shoring although it would be unlikely to address the deeper on-site contamination. This scenario does not address likely offsite impacts extending beneath the adjacent right-of-way.

Because of the relatively high costs associated with shoring and remedial excavation and the uncertainties in scope related to (1) the contamination extending beneath the right-of-way and (2) whether Ecology will require evaluation of groundwater conditions at the site, PNG conducted pilot testing and remedial technology screening to evaluate alternate soil treatment options on a preliminary basis.

PNG performed initial soil vapor extraction pilot testing in July 2008. Results indicated generally poor site conditions with limited effectiveness for this remedial technology. PNG completed follow-up pilot testing in November 2009 to determine if soil vapor extraction or air (ozone) injection could be modified to improve effectiveness at this site. Results of this pilot testing are presented below.

NOVEMBER 2009 PILOT TESTING

On November 20, 2009, PNG performed a second phase of soil vapor extraction and air injection pilot testing at the site. The pilot testing included five separate short term soil vapor extraction tests, with each test using only one well for vapor extraction while vacuum influence monitoring was performed on the other site wells. For the pilot test, both air injection and soil vapor extraction tests were performed on wells B-13 and B-14 (Figure 3). The purpose of the testing was to evaluate whether air could be injected into the subsurface in order to evaluate certain technologies for possible use in site remediation.

In general, the results of the air injection and soil vapor extraction pilot testing are consistent with previous pilot testing results for the site (PNG October 1, 2008) and indicate soil conditions within the contaminated zone are not conducive to air injection or extraction technologies. The pilot testing activities are described further below.

A 1.0 horsepower Rotron DR404 blower was used to apply vacuum or pressure to each extraction/injection well. The extraction wellhead was connected to the blower using piping and quick-connect hoses plumbed to a vapor/water separator (condensate tank) equipped with a vacuum gauge and dilution inlet valve. The extracted vapors were routed from the blower to a carbon canister filled with vapor phase granular activated carbon prior to discharge to the atmosphere via a ten foot length of PVC pipe. The system was equipped with two monitoring ports located before the blower (pre-treatment) and after the carbon treatment canister.

During the pilot test, vacuum/pressure was measured at approximate ten-minute intervals using a set of magnehelic gauges with vacuum ranges capable of measuring from 0.01 to 50 inches of water. During the soil vapor extraction tests, a photo ionization detector (PID) was used to measure volatile organic vapor concentrations in the blower exhaust air stream.

The test design included measuring air velocity through each extraction/injection well using an anemometer, and estimating airflow to/from selected wellheads by attaching a one-liter tedlar bag to the wellheads and measuring the time to evacuate/fill the bag.

The results of the vacuum influence measurements were inconsistent, with slight vacuums measured in some wells and slight positive pressure measured in other wells during the vacuum tests. No measurable air flow was induced at the surrounding monitoring points during the application of vacuum at either B-13 or B-14. The radial distance between the extraction points and the monitoring points ranged from approximately three to ten feet.

The July 2008 pilot testing results indicated that some minimal air flow was generated during pilot testing in the summer (dry months). Conversely, the November 2009 pilot testing results represent conditions during the rainy seasons where soil moisture contents are greater and consequently further restrict air flow through the limited soil pore space. Pilot testing during these conditions indicated no measurable air flow was generated by the application of vacuum or pressure to either of the wells which were tested. These additional data further indicate that site soil conditions are not conducive to either vapor extraction or air injection.

RIGHT-OF-WAY CONTINGENCY PLANNING

Because site characterization data identified impacted soil near the property boundary with the adjacent 16th Avenue right-of-way, PNG considers it likely that impacted soil extends offsite beneath the right-of-way. Consequently, if future road expansion, re-paving, or utility work were performed along the right-of-way, impacted soil may be encountered. Plaid should develop an approach for future characterization of possible gasoline impacts extending into the right-of-way, as well as other response actions that may be required.

As part of this planning effort, Plaid requested that PNG conduct preliminary research regarding current and planned future right-of-way construction/development activities. PNG contacted city and county agencies as well as each of the identified private utility companies that have buried lines in the vicinity of the former Plaid Pantries #324 site. Agencies and companies PNG attempted to contact included:

- City of Seattle Public Utilities – Water
- Southwest Suburban Sewer District
- King County Roads
- City of Seattle
- Puget Sound Energy – Gas and Electric
- Qwest Local Network
- Comcast Cable
- Seattle City Light

PNG's communications with these agencies and companies indicated that no excavation in the right-of-way adjacent to the site is planned for the foreseeable future. Traffic control device infrastructure will be installed in intersections along the 16th Avenue right-of-way; however, excavation for this installation project will reportedly be limited to the upper one foot below the right-of-way. Impacted soil at the Plaid site extends between approximately three to twelve feet in depth and therefore shallow impacts (one foot deep) associated with Plaid's operations are not expected at the right-of-way or near the specified intersection.

ALTERNATE REMEDIAL TECHNOLOGY SCREENING

Based on the pilot testing results, PNG compiled and evaluated information for other possible remedial technologies. These alternate remedial technologies are presented in Tables 1 and 2. Many of the screened technologies are not recommended for further evaluation because of unreasonable cost, limited applicability at the site, or limited availability of the technology in the Pacific Northwest (Table 2). PNG can further evaluate a subset of the more promising technologies for application at this site at Plaid's direction. Future considerations would incorporate Plaid's strategy and timing for site remediation and whether or not the adjacent right-or-way is to be included in the overall cleanup evaluation.

Attachments: Table 1 – Remedial Alternative Screening Table
Table 2 – Remedial Alternative Screening Table (Rejected Alternatives)
Figure 1 – Site Location Map
Figure 2 – Site Features
Figure 3 – Gasoline and Benzene in Soil

TABLES

Table 1
Alternate Remedial Technology Screening Table
Plaid Pantry #324
Seattle, Washington

Remedial Technology	Methodology Basics	Advantageous Conditions	Limiting Conditions	Anticipated Costs
Remedial Soil Excavation	Impacted soil is excavated and transported offsite for disposal.	Remedial soil excavation is best suited for impacted areas that are not obstructed by surface features, where impacted soil is present at a relatively shallow depth to minimize the amount of overburden that must be removed to access and excavate impacted soil, does not extend offsite, and does not extend to great depths below the water table to minimize the need for dewatering activities.	Surface obstructions, shallow water table, utility corridors within the impacted area, and impacted soil extending beyond the boundaries of the subject property.	Site-specific and depends in part on the hydrogeology, type and amount of contaminants, and whether shoring is required to protect either site infrastructure or infrastructure on neighboring properties. Estimated between $100 to $600 per cubic yard.
Soil Mixing w/ Soil Vapor Extraction[a]	Contaminated soil is mixed ambient or heated air using augers to volatilize VOCs. VOC effluent is collected in a shroud covering the treatment area and VOC effluent is commonly treated by carbon adsorption or catalytic oxidation unit.	Soil mixing with SVE is well suited to heterogeneous soils or relatively low permeability soils since the mixing provides greater opportunity for volatilization of the VOCs and collection of the effluent. Soil mixing with SVE is a mature technology, and several vendors are capable of implementing the technology. Most cost-effective when treatment depths are relatively shallow (i.e., less than 30 to 40 ft.).	Requires use of vendors with specialized equipment for mixing soil (large diameter augers) and shroud for collection of soil vapors. Does not extract SVOCs. Off-gas treatment costs can be high. Cannot overcome inadequate characterization or design. Shallow groundwater will restrict applicability.	Site-specific and depends in part on the hydrogeology, depth of contamination/treatment zone, type and amount of contaminants, and whether the off-gas requires treatment. Estimated between $100 to $500 per cubic yard.
Soil Mixing w/ In Situ Chemical Oxidation[a]	Contaminated soil is mixed with ambient air that contains mist of diluted hydrogen peroxide or injection of other oxidant compounds using augers or specialized excavator arm to oxidize VOCs.	Soil mixing with in-situ chemical oxidation SVE is well suited to heterogeneous soils or relatively low permeability soils since the mixing provides greater opportunity for chemical oxidant contact and reaction with contaminants. Soil mixing with chemical oxidation is an evolving technology, and several vendors are capable of implementing the technology. However, regionally there may be limited vendors or contractors with the specialized equipment and/or substantial experience. Most cost-effective when treatment depths are relatively shallow (i.e., less than 30 to 40 ft.).	Requires use of vendors or contractors with specialized equipment for soil mixing and simultaneous introduction of the chemical oxidant. Soil with high organic carbon content are more difficult to treat. High organic carbon content soils require greater amounts of oxidant with corresponding greater treatment time frames and costs. Implementation often requires Underground Injection Control permitting and/or regulatory approval, as well as greater safety precautions with handling strong oxidants.	Site-specific and depends in part on the hydrogeology, depth of contamination/treatment zone, availability of experienced contractor and specialized equipment, and type and amount of contaminants. Estimated between $100 to $500 per cubic yard.
In Situ Chemical Oxidation	Contaminated soil is treated in-situ through injection of a chemical oxidant to oxidize contaminants. Oxidant injections are completed using either temporary or more permanent injection wells/points.	In-situ chemical oxidation is an effective treatment technology for a wide variety of contaminants. In addition, treatment time frames are relatively short. In-situ chemical oxidation is a rapidly evolving technology with proven effectiveness and a relatively large number of vendors capable of implementation.	Low permeability soil or heterogeneous soil with high organic carbon content and/or a wide range of petroleum hydrocarbons are more difficult to treat. Low permeability and heterogeneous soils present challenges to effective distribution of the oxidant within the subsurface treatment zone. High organic carbon content soils require greater amounts of oxidant with corresponding greater treatment time frames and costs. Implementation often requires Underground Injection Control permitting and/or regulatory approval, as well as greater safety precautions with handling strong oxidants.	Site-specific and depends in part on the hydrogeology, depth of contamination/treatment zone, availability of experienced contractor and specialized equipment, and type and amount of contaminants. Estimated between $50 to $200 per cubic yard.

Notes:

[a] In cases where SVE is a component of other remedial technologies, the effectiveness of those technologies may be reduced as indicated in Table 2.

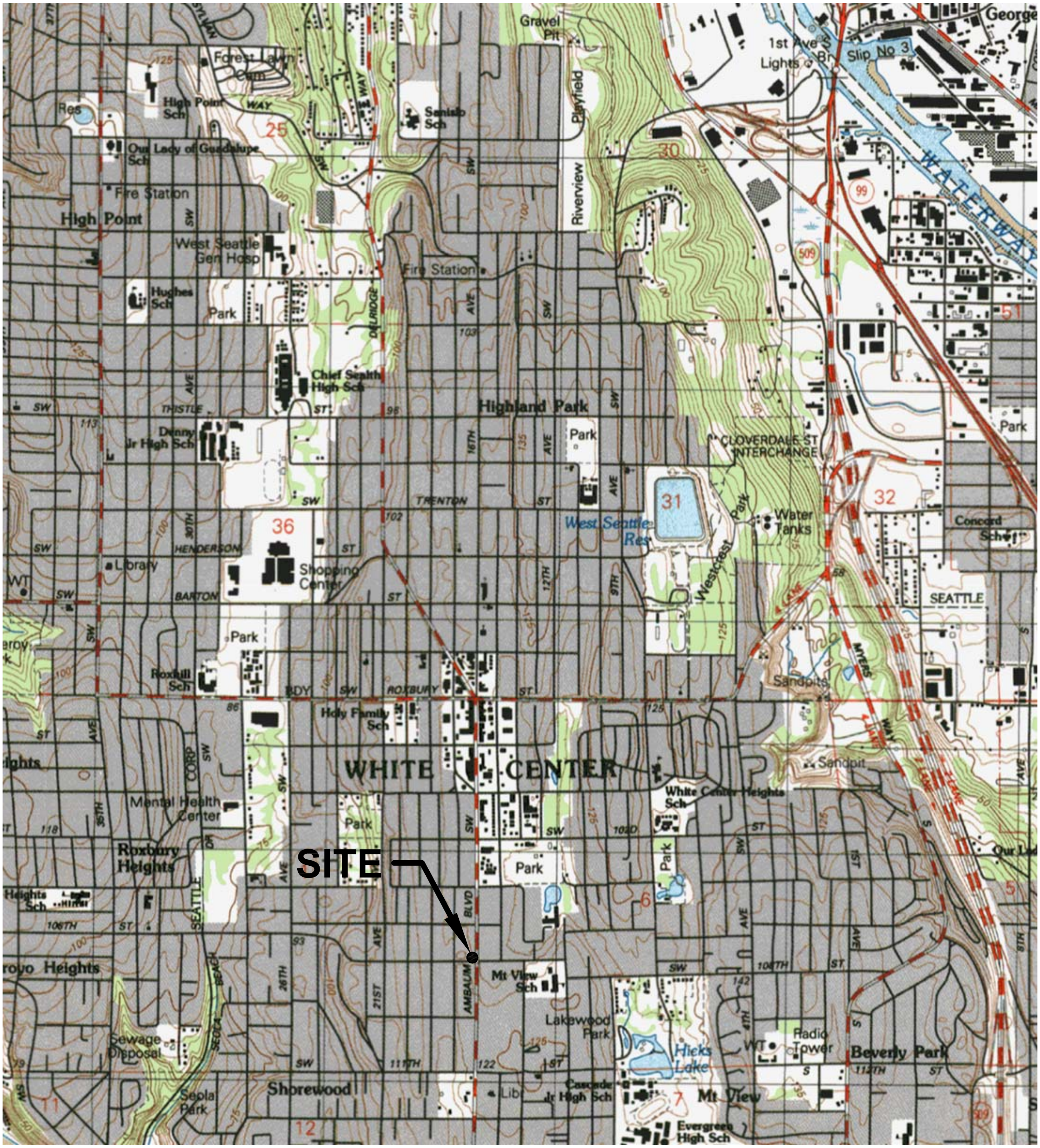
Table 2
Alternate Remedial Technology Screening Table (Rejected Alternatives)
Plaid Pantry #324
Seattle, Washington

Remedial Technology	Methodology Basics	Advantageous Conditions	Limiting Conditions	Anticipated Costs
Soil Vapor Extraction	Soil vapor is extracted through vertical extraction points or horizontal extraction trenches by inducing a vacuum with an aboveground blower. Effluent is commonly treated by carbon extraction.	SVE is bested suited in well-drained high-permeability soil or heterogeneous soil with low organic carbon content. SVE is a mature, widely used technology, and many vendors are capable of implementing the technology. In addition, the technology introduces oxygen into the subsurface that may promote additional biological degradation of residual contamination.	Low permeability soil or heterogeneous soil with high carbon content are more difficult to treat with SVE and often require amendments such as pneumatic or hydraulic fracturing. Soil must be permeable to air. Does not extract SVOCs. Off-gas treatment costs can be high. Cannot overcome inadequate characterization or design. Shallow groundwater will restrict applicability.	Site-specific and depends in part on the hydrogeology, type and amount of contaminants, and whether the off-gas requires treatment. Estimated between $10 to $60 per cubic yard.
Soil Flushing	Soil flushing involves flooding a zone of contamination with an appropriate solution to remove the contaminant from the soil. After passing through the contamination zone the contaminant-bearing fluid is collected and brought to the surface for disposal or recirculation.	Flushing is most efficient in relatively homogenous and permeable soil. Flushing of relatively homogenous but lower permeability soil is possible, but it requires a high-induced gradient to move the agent, while greatly increasing the remediation time. Due to its use in oil field applications, soil flushing is considered a mature technology; however it has found limited application at environmental sites.	Heterogeneous soil reduces the efficiency of the flood sweep and may prevent optimum contact between the agents and the target contamination. Other soil factors that may adversely affect efficiency are high CEC, high buffering capacity, high organic soil content, and pH. Circulation of water-based solutions through the soil may increase contaminant mobility and necessitate treatment of underlying groundwater.	Site-specific depends on waste type and quantity to be treated. Estimated between $65 to $300 per cubic yard.
Bioremediation	Bioremediation is aerobic or anaerobic and intrinsic or enhanced. Intrinsic bioremediation depends on indigenous microorganisms while enhanced bioremediation is facilitated by manipulating the microbial environment by supplying amendments (air, substrates, nutrients, and other chemicals).	Bioremediation is more effective when conditions that promote microbial activity are present. Factors that will promote microbial activity include: presence of nutrients, absence of predators and parasites, low competition, mobility of bacteria, elevated contaminant concentrations, moderate temperature ranges.	Most failures at bioremediation are due to failure of introduced organisms to thrive in the natural environment or a failure to access the contaminant. This could be due to: lack of nutrients, predation or parasitism, competition, immobility of introduced bacteria, contaminant concentrations below threshold for organism survival, presence of alternate substrates. Soil matrix may prohibit contaminant-microorganism contact. Preferential colonization by microbes may occur causing clogging of nutrient and water injection wells. High concentrations of heavy metals, chlorinated organics, long chain hydrocarbons, or inorganic salts likely toxic to microorganisms.	Typical costs for enhanced bioremediation range from $20 to $80 per cubic yard of soil. Factors that affect cost include the soil type and chemistry, type and quantity of amendments used, and type and extent of contamination.
Bioventing	Bioventing involves the injection of a gas (typically oxygen for aerobic) into the subsurface to enhance the biodegradation of a contaminant. The gas can be used to keep the subsurface aerobic or anaerobic, or to provide a substrate that enables co-metabolic degradation to occur. Aerobic bioventing has a robust track record in treating aerobically degradable contaminates such as fuels.	Contaminant must be biodegradable by aerobic bacteria in the soil if not adding oxygen will have no effect. Oxygen must currently be limited in the contaminated area. If sufficient oxygen is present adding more won't help. Under proper operating and site conditions no off-gas treatment is needed reducing cost. Some contaminants that are not very volatile and cannot be efficiently removed by SVE are aerobically biodegradable and can potentially be removed by biodegradation.	Limitations include the ability to deliver oxygen to contaminated soil, soil with high moisture content may be difficult to biovent due to reduced soil gas permeability. Low permeability soils limit the ability to distribute air. Shallow contamination poses a problem related to system design to minimize environmental release. Bioventing also will not enhance bioremediation if sufficient oxygen is already present. If aerobic conditions are correct but bioremediation remains inhibited other factors (see above) may be limiting the microbial activity.	The total cost for in situ bioremediation using bioventing technology ranges from $10 to $60 per cubic yard. At sites with over 10,000 cubic yards of contaminated soil, costs of less than $10 per cubic yard are achievable. Higher unit costs are associated with smaller sites.

Table 2
Alternate Remedial Technology Screening Table (Rejected Alternatives)
Plaid Pantry #324
Seattle, Washington

Remedial Technology	Methodology Basics	Advantageous Conditions	Limiting Conditions	Anticipated Costs
Electrical Resistivity Heating	Electrical resistivity heating involves passing electrical current through moisture in the soil between an array of electrodes.	ERH systems can be deployed to any depth and used in both vadose and saturated zone. If used in the vadose zone only water should be added at the electrodes to maintain the moisture content and flow of electricity. Volatilization and steam stripping with SVE-capture are the predominant removal mechanisms.	Soil with a high natural organic carbon content will slow or prevent the recovery of some organic contaminants.	Cost is largely dependent on electrode spacing. More electrodes = more cost but lower operating time. Cost estimate is installation (up to $200,000) plus $40 to $70 per cubic yard.
Steam Injection and Extraction	Steam injection and extraction involves injection of steam into injection wells and the recovery of mobilized groundwater, contaminants, and vapor from the recovery wells.	The applicability of steam injection to a particular site is determined by permeability of the soil, the depth at which the contaminants reside and the type and degree of heterogeneity, and the contaminant type. Soil permeability must be high enough to allow steam to be injected. Injection pressures cannot exceed 1.65 psi per meter of depth or the overburden pressure will be exceeded.	Shallow treatment areas are difficult to treat with steam. Low permeability soils many not allow steam to move through it at an economical rate or may require unsupportable injection pressures. Highly reactive soil (clays and organic rich soil) bind the contaminants and prevent their removal by steam.	The technology is mature and well established, however few vendors use it for environmental remediation. The most significant factor affecting cost is the time of treatment or treatment rate. Treatment rate is influenced primarily by the soil type, waste type, and on-line efficiency. On average, the cost ranges from $100 to $300 per cubic yard based on a 70 percent on-line efficiency.
Conductive Heating	Conductive heating uses either an array of vertical heater/vacuum wells or surface heater blankets (when the treatment area is within six inches of the ground surface). Typical deployment consist of a hexagonal group of heater wells with an extraction well in the center of the hexagon.	Conductive heating operates best in unsaturated soil, however, it does find application in saturated soil with low hydraulic conductivity. Drying soils, especially fine-grained silt and clay at high temperatures can result in shrinkage and cracking that will promote the removal of organics contained within them.	In soil with high hydraulic conductivities the influx of water to replace that boiling off may be sufficient to prevent the soil from exceeding the boiling point of water and target temperatures may not be met. If the treatment area contains saturated high hydraulic conductivity soil, then a dewatering system should be considered. Conductive heating systems can consume large quantities of power.	Cost estimates range from $75 to $350 per cubic yard depending on volume and type of contamination. TerraTherm has an exclusive license in the US to offer this technology for remediation.
Radiofrequency Heating	Radio-frequency heating uses a high frequency alternating electric field for in situ heating of soils. The technique depends on the presence of dielectric materials with unevenly distributed electrical charges.	The main advantage of the RF treatment technology is that it is considerably less dependent on either the soil type or the contaminant type. RF technology will probably be applied only in selected parts of the contaminated site, for example in contamination 'hot spot' areas, hard to reach areas and within tightly compacted soils.	Clean sand is non-polar and heating in sand must rely on impurities present. The drier a soil becomes the more difficult it is to move organic gas through it. Conversely too much water becomes a heat sink. In saturated conditions, RF treatment boils the water in the immediate vicinity of the electrode and does not heat the treatment zone to a useful temperature. If the water table is shallow dewatering is necessary.	The primary cost driver is soil type, which determines soil permeability. For thermal treatment, soils of lower permeability (silts/silty-clays) are less expensive to remediate as they require less gas flow. The secondary cost drivers are depth to the top and thickness of the contaminated zone. A deeper and thicker region of contaminated soil has higher remedial cost. Cost estimates range from $30 to $75 per cubic yard.

FIGURES

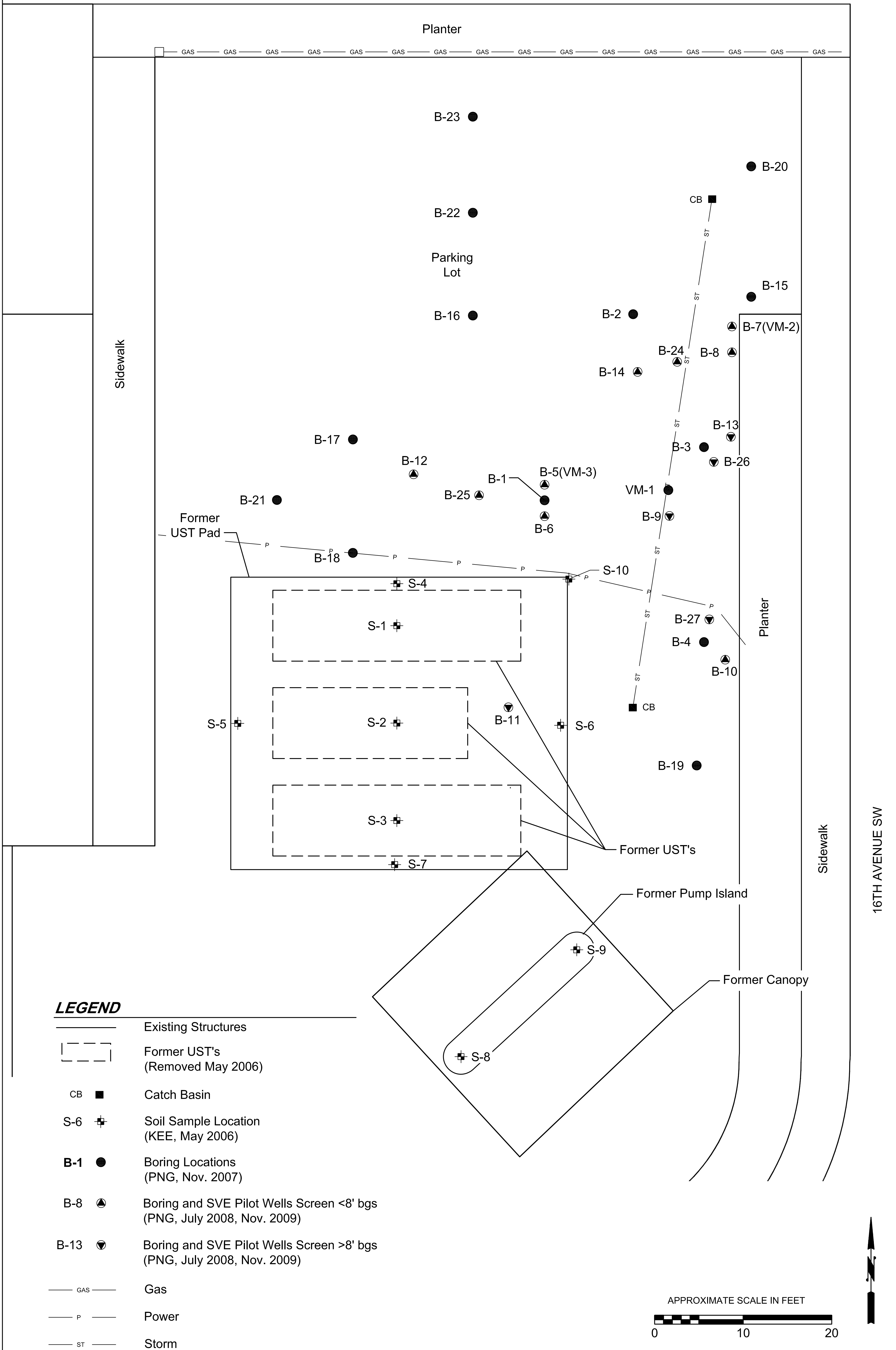


APPROXIMATE SCALE IN FEET

0 1000 2000 4000

NOTE: USGS, Seattle South Quadrangle
Washington - Snohomish Co.
7.5 x 15 Minute Quadrangle, 1983.
Base map provided by MapTech.

PNG ENVIRONMENTAL, INC. 1339 Commerce Avenue, Suite 313 TEL (360) 414-0669 Longview, Washington 98632 FAX (360) 414-0663	DATE: 10-5-07 FILE NAME: 1133-01 DRAWN BY: JJT APPROVED BY:	PLAID PANTRY #324 10645 16TH AVE. SW SEATTLE, WASHINGTON	SITE LOCATION MAP	Project No. 1133-01 Figure No. 1



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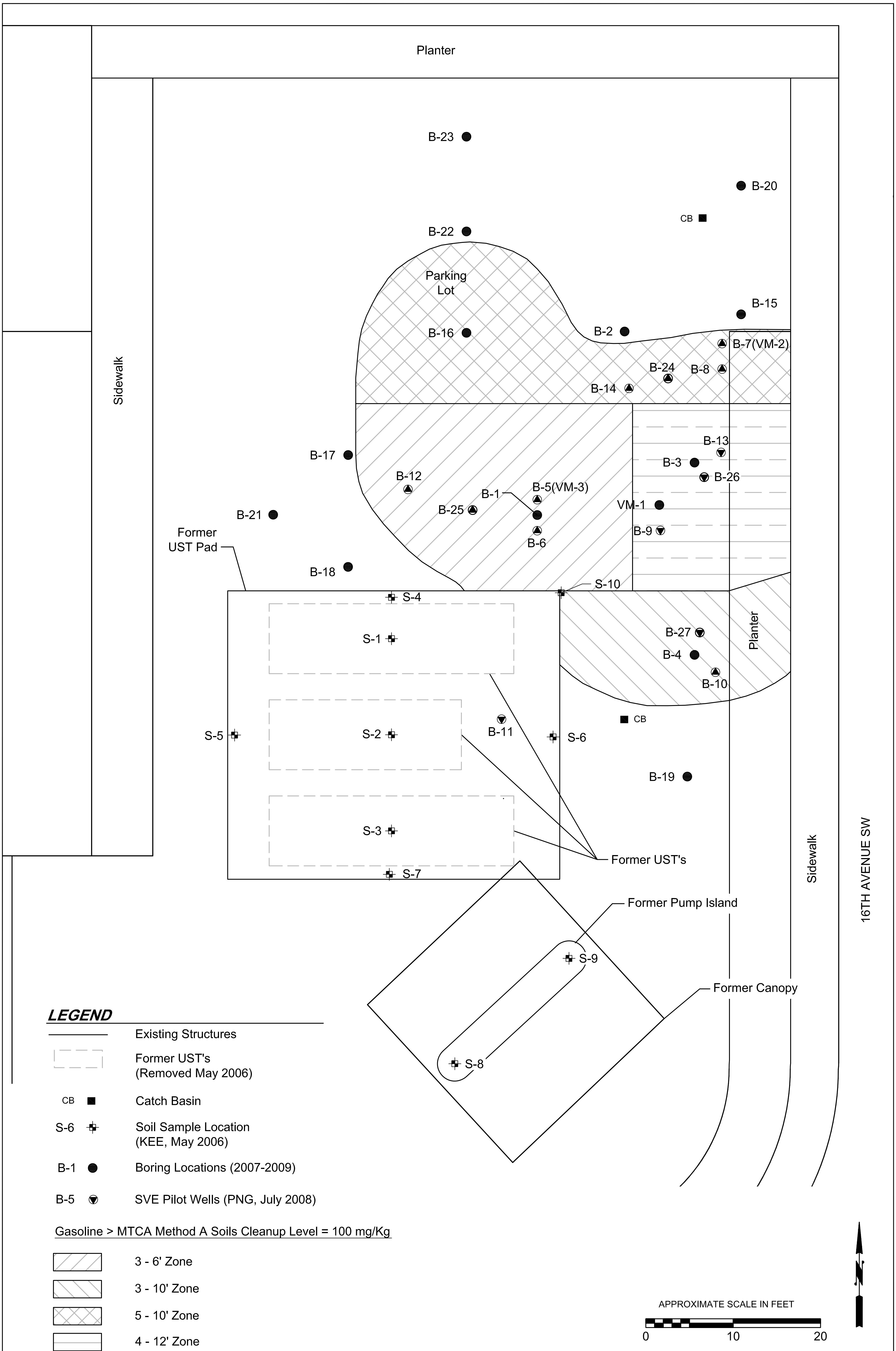
DATE: 6-23-10 FILE NAME: 1133-01 DRAWN BY: JJT APPROVED BY:	PLAID PANTRY #324 10645 16TH AVE. SW. SEATTLE, WASHINGTON	SITE FEATURES	Project No. 1133-01	Figure No. 2



PNG ENVIRONMENTAL, INC. 6665 SW Hampton St., Ste. 101 TEL (503) 620-2387 Tigard, OR 97223 FAX (503) 620-2977	DATE: 6-23-10 FILE NAME: 1133-01 DRAWN BY: JJT APPROVED BY:	PLAID PANTRY #324 10645 16TH AVE. SW. SEATTLE, WASHINGTON	APPROXIMATE EXTENT OF PETROLEUM IMPACTED SOILS	Project No. 1133-01 Figure No. 3