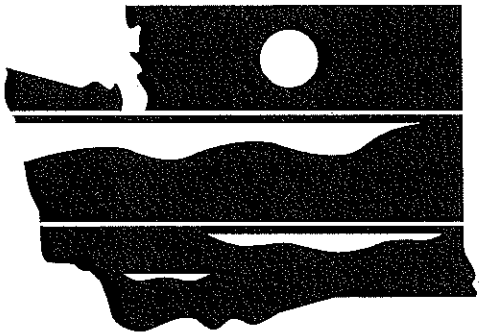

REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
CIRCLE K STATION #1461
SEATTLE, WASHINGTON

Prepared by

Washington State Department of Ecology
3190 160th Avenue Southeast
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October 2009
DRAFT

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LIST OF ACRONYMS

ARAR	Applicable or Relevant and Appropriate Requirement
bgs	Below Ground Surface
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
DRO	Diesel Range Organics
Ecology	Washington State Department of Ecology
EPA	United States Environmental Protection Agency
FS	Feasibility Study
ft	Feet
GRO	Gasoline Range Organics
mg/kg	Milligram per Kilogram
MTCA	Model Toxics Control Act
MW	Monitoring Well
RCW	Revised Code of Washington
RI	Remedial Investigation
SVE	Soil Vapor Extraction
TPH	Total Petroleum Hydrocarbons
µg/L	Microgram per Liter
UST	Underground Storage Tank
WAC	Washington Administrative Code

EXECUTIVE SUMMARY

The Site had been operated as a retail gasoline station from 1968 to 1990, and then has been operated as a retail dry-cleaning store. Petroleum contamination was discovered in both soil and groundwater after a release in 1989 at the Site. Results from the most recent groundwater monitoring events conducted in November 2006 still showed presence of free products in two wells located within the property and two wells located on East McGraw Street (EA 2006).

The Feasibility Study evaluated remedial alternatives. The preferred remedial alternative includes applications of Surfactant-Enhanced Fluid Recovery (EFR), followed by in-situ chemical injection and groundwater monitoring.

1.0 INTRODUCTION

1.1 GENERAL FACILITY INFORMATION

Site Name: Circle K Station #1461
Property Address: 2350 24th Avenue East, Seattle, Washington

Facility Site Identification Number: 2322
Order Number for Consent Decree: 92-2-08095-8
Effective Date of Decree: April 8, 1992

Project Coordinator: Jing Liu, Ecology NWRO
Project Coordinator Address: 3190 160th Ave SE, Bellevue, Washington 98008
Project Coordinator Phone Number: (425) 649-4310

Current Owner: Mr. Kuk Jin Choung
Legal Description of the Facility: PIKES 2ND ADD TO UNION CITY 1&2 LESS E 6 FT

1.2 PURPOSE OF THIS REPORT

The purpose of this report is to satisfy the requirements of Chapter 173-340 Washington Administrative Code (WAC) and Consent Decree No. 92-2-08095-8 regarding a Remedial Investigation and Feasibility Study (RI/FS) for the Circle K Station #1461 in Seattle, Washington.

According to WAC 173-340-350(1), the purpose of an RI/FS is to collect, develop, and evaluate sufficient information regarding a site to select a cleanup action under WAC 173-340-360 through 173-340-390.

2.0 REMEDIAL INVESTIGATION

2.1 SITE DEFINITION AND SETTING

The Site is associated with a former gasoline service station property (the Property) at 2350 24th Avenue East in Seattle, Washington. The Site location relative to surrounding physical features is shown in Figure 1. Petroleum and associated products were released to soil and groundwater at the Property and comprise the Site. The plume has extended off-property beneath adjacent streets and residential property.

The Property is approximately 0.26 acres, located southeast of the intersection between 24 Ave East and East McGraw Street, approximately 1800 feet south of Lake Washington. It is in the Montlake neighborhood. The area surrounding this Site consists mainly of residential houses and buildings, with some small commercial business located west of the Site along the 24th Ave East. The Property consists of a one-story building and a newer addition to it, which are presently being utilized as a retail dry-cleaning store and a convenience store, known as Jay's Cleaners and Mont Market.

2.2 PROPERTY DEVELOPMENT AND HISTORY

The Property was operated as a gasoline and convenience store from 1968 to 1981, owned by Mr. George Renale. Prior to 1968, it is believed the Property was residential.

From 1981 to July 1990, the Property was leased by Mr. Renale to Circle K Corporation, who also operated the facility as a gasoline and convenience store. In November 1990, Mr. Kuk Jin Choung, the current owner, purchased the Property from Mr. Renale and has operated it as a retail dry-cleaning retail store since then.

In February 1992, Mr. Choung entered a Consent Decree with Ecology to begin investigation and remediation of contamination at the Site. Ecology's lien on the Property for the sum of $50,000 was released in January 2008 after Ecology received the full payment.

2.3 GEOLOGIC AND HYDROGEOLOGIC SETTING

2.3.1 TOPOGRAPHY

The regional topography in the vicinity of the Site slopes downward the north and northeast. The ground surface elevation at the Site is approximately 70 feet above mean sea level.

2.3.2 GEOLOGY

According to GeoEngineers, layers of sandy silt and silty fine sand were encountered beneath surface layers of asphalt, concrete, and fill material. Individual layers of sandy silt and silty sand vary in thickness over short distances and are often laterally discontinuous (GeoEngineers 1990a). Occasional gravel and cobbles were encountered. A very dense to hard layer consisting

of fine-grained glacial sediment was encountered at depths greater than approximately 14 feet in most of the borings.

2.3.3 HYDROGEOLOGY

Depth to groundwater at the Site ranges from approximately 9 to 12 feet bgs based on available data. The groundwater flow direction in the vicinity of the Site determined by using the data obtained in 1989 was to the northeast at a gradient of approximately 0.024 ft/ft (GeoEngineers 1990a). During operation of the product recovery system, there was a stable cone of depression encompassing the estimated lateral extent of the free product plume. However, groundwater level data obtained after the system was shut down did not suggest a strong groundwater gradient. It is assumed that groundwater levels in the wells have not only been affected by seasonal precipitation, but also by the utility corridors in the area. Groundwater elevation data are available for 2005 and 2006 in Table 3. Figure 5 shows groundwater elevations and contour lines using data collected from August 2006.

2. 4 SITE DISCOVERY

The former gasoline service station used to include a store building, a fuel pump island, two 4,000-gallon gasoline USTs, two 6,000-gallon gasoline USTs, one 500-gallon waste oil UST, and one 500-gallon heating oil tank. A generalized site plan of the former gasoline service station is presented in Figure 2.

As shown in Figure 2, several underground sewer lines are located beneath the north part of the Property. All of these lines drain north toward the main sanitary sewer line located beneath the center of East McGraw Street. The sanitary sewer line on East McGraw Street is located at a depth of approximately 12 feet below the surface of the street. The upgradient terminus of this sewer line is located immediately west of the manhole in front of the store. The sewer line slopes downward toward the east. The two catch basins located on the Property drain surface water runoff into the sanitary sewer system.

In August 1989, a leak was discovered in one of the gasoline USTs. Approximately 4,000 to 6,000-gallons of gasoline were released between 22 June 1989 and 7 August 1989 (GeoEngineers 1990a). Fuel odors were observed at Seattle Museum of History and Industry, approximately 2000 feet north of the Property subsequent to the discovery of the leak. Vapors were also observed at several other locations in the sanitary sewer line downgradient of this Property. It was believed that petroleum plume originated from the Property has migrated through the sanitary sewer system and resulted in the presence of vapor at these downgradient locations.

2. 5 ENVIRONMENTAL INVESTIGATION AND REMEDIAL ACTIVITIES

A subsurface contamination investigation was conducted by GeoEngineers from September to December 1989 by drilling sixteen borings to depth ranging from 19.0 to 31.0 feet bgs and installation of sixteen groundwater monitoring wells. Most of the wells were screened from 5 to 20 feet bgs, several wells were screened from about 4 to 19 feet bgs. Copies of the well logs are

included in Appendix A of GeoEngineers 1990a report. During monitoring wells installation, petroleum contaminated soil was observed at depth ranging from 8 to approximately 20 feet bgs. Monitoring well construction and field measurement data is in Table 1. Table 2 lists the soil analytical sample data collected during well installation. Free product was also observed during the investigation. Maximum product thickness was measured at 9.5 feet in MW-8 in December 1989. It appeared that free product initially flowed in a direction transverse to the direction of shallow groundwater flow in the vicinity of the Site. The lateral extent of the free product plume was defined and appeared to be confined to the area in the vicinity of the gasoline UST area and north of the leaky UST beneath the East McGraw Street (MW-2, MW-3, MW-4, MW-8 and MW-9). Petroleum contaminated groundwater was encountered in wells located immediately outside of the edge of the free product plume (MW-6, MW-13 and MW-15).

High concentrations of hydrocarbon vapors were detected in wells located in the vicinity of the free product plume. The low concentrations of hydrocarbon vapors measured in outlying wells indicated that subsurface hydrocarbon vapors in the soil probably have not migrated a significant distance laterally from the edge of the free product plume. Although fuel odors were detected in the sanitary sewer lines downgradient form the leaky tank, no evidence was observed that free product of fuel vapors flowed directly into the sanitary sewer system (GeoEngineers 1990a).

Remaining product in the tank reportedly was removed, and all six onsite USTs were excavated in October 1989, along with approximately 900 cubic yards of contaminated soil. Approximately 80 to 100 gallons of free product were recovered from the open excavation. Analytical results from soil confirmation samples collected at the waste oil and heating oil tank excavation areas showed compliance with cleanup levels. Contaminated soil in the gasoline UST area was removed to a depth of approximately 14 to 16 feet bgs. However, analytical results from samples collected from the north, south, and west walls of the gasoline tank excavation contained high concentrations of gasoline and/or BTEX far above the MTCA soil cleanup levels (GeoEngineers 1990a). The most extensive soil contamination appears to be located north and west of the gasoline UST area. The extent of the remaining soil contamination was not determined at that time. Soil and tank excavations are shown in Figure 3.

The pump island was demolished in March 1990, no information is available on confirmation sampling.

In December 1989, installation of a product recovery and groundwater treatment system was completed. The system was operated by Circle K briefly after it was installed till September 1990, and then Glacier was contracted by Ecology to operate and maintain the system from April 1992 to May 2000. Ecology then decided to shut down the system due to a low recovery rate, and evaluated some other treatment alternatives.

An SVE system was also installed in the tank excavation area. The period of operation of the SVE system is not known; however, it apparently was shut down in 1997 after readings indicated insignificant concentrations of hydrocarbons were being removed. The treatment system is now defunct.

In June 2005, a pilot test of EFR technology was conducted at the Site in an effort to remove free product, impacted groundwater, and petroleum vapors from targeted monitoring well locations.

EcoVac Services, Inc. was contracted to perform the test on four monitoring wells MW-4, MW-8, MW-9, and MW-13. During the 8-hr test, approximately 112 pounds of petroleum hydrocarbons (approximately 18 equivalent gallons of gasoline) were extracted. Free product levels were highest in MW-4, and measurable in wells MW-8, MW-9 and MW-13 prior to conducting the test. Follow-up monitoring sampling conducted two weeks after the EFR test showed that free product was not present in measurable quantities in any well, though trace quantities were found in MW-4, MW-8 and MW-9.

Three quarterly sampling events were conducted since the EFR pilot test, free product levels in the monitoring wells are rebounding slowly, though they have not returned to pre-test levels in MW-4. Table 4 summarizes free product levels before and after testing. Field observations conducted in February 2008 still indicated trace amount of free products in two wells located within the property (MW-4 and MW-13), and sheens and petroleum odors were observed in three wells located off-property to the north (MW-8, MW-9 and MW-15). However, data collected so far indicates that the extent of the contamination including free product remains relatively stable in the past twenty years, still being limited to the area north and west of the former excavation area (Figure 4). Groundwater Monitoring Results are summarized in Table 5.

2. 6 DATA GAPS

The extent of the petroleum plume has not been fully defined. It is possible that petroleum contaminated groundwater could extend beneath the nearest residence to the north. Also, the plume is undefined to the west and could possibly extend beneath 24th Avenue East. Additional investigations may be necessary to determine the full extent of residual soil contamination at the Site.

It is not clear whether the former tank excavation area has been re-contaminated. An addition to the former gasoline service station building has been constructed right above the former tank excavation area. No information is available whether contamination was encountered during construction. In addition, no information is available associated with the removal of the former pump island.

Soil vapor data should be collected to determine whether soil to vapor pathway is a potential concern at the Site.

2. 7 CONCEPTUAL MODEL

Gasoline was released to soil at this Site due to a leak from a UST as discovered in August 1989. The contamination reached the water table at about 8 feet below land surface and spread laterally to the north and west.

It appears that petroleum hydrocarbons in soil are located in a "smear zone," a zone created by fluctuations in the water table elevation, likely are a source of groundwater contamination. Contamination also exists in unsaturated soil (soil above the water table) and saturated soil (soil below the water table). It is estimated that contaminated soil exists at this Site from approximately 8 to 20 feet bgs in the areas north and west of the former UST excavation area,

and may also exists in the excavation backfill. The lateral extent of soil contamination has not been fully determined. Free product has been consistently observed in MW-4, MW-8, MW-9 and MW-13 since 2003. Groundwater plume appears larger than the extent of free product and has migrated beneath the East Mcgraw Street to the north, and possibly to the west beyond MW-13.

The following potential exposure/risk pathways may exist at this Site and has been evaluated as below.

- Direct Soil Contact Pathway: the majority of the Site is covered by buildings or asphalt pavement that prevents direct contact. However, direct contact exposure may occur if future site redevelopment or construction activities require excavation into contaminated subsurface soil. Potential receptors in this scenario would be workers involved in the excavation, and exposure duration would be limited.

- Groundwater Pathway: groundwater contamination detected at the Site mirrors the nature and extent of contaminants detected in soil. Until petroleum trapped in soil in the smear zone is addressed, it will continue to act as a source of groundwater contamination. However, SPU's water system provides all the drinking water supplies for this Property and the surrounding area. Ingestion of contaminants in groundwater is not likely a viable human exposure pathway. Table 5 includes a copy of ground water analytical data generated during previous studies.

- Vapor Pathway: an addition to the former gasoline service station structure was build right above the former gasoline UST area. It appears that petroleum contaminated soil still remains after tank removal on the bottom of the excavation. There is a potential for vapor intrusion in the store building. No data has been collected to determine if there is a potential for vapor intrusion in the adjacent residential houses.

- Surface Water: no surface water data are available. From the data collected so far, it is unlikely that contaminants form this Site has reached any surface waterbody.

The Site is qualified for an exemption of Terrestrial Ecological Evaluation in accordance with WAC 173-340-7491(1) because there is less than 1.5 acres of contiguous undeveloped land within 500 feet of any area of the Site.

2.8 SUMMARY OF FINDINGS

Gasoline petroleum contamination in soil and groundwater exists at the Property and has migrated off- property to the north and west. Migration of contaminants is very slow at this Site probably due to the low soil permeability; also it might be related with the previous operation of the product recovery and groundwater treatment system.

3.0 FEASIBILITY STUDY

3.1 CLEANUP OBJECTIVES

- Protect human health and the environment
- Comply with cleanup standards
- Comply with applicable laws
- Provide for compliance monitoring
- Provide a reasonable restoration time-frame
- Use permanent solutions to the maximum extent practicable
- Consider public concerns
- Achieve source control

3.2 DEVELOPMENT OF CLEANUP STANDARDS

Under MTCA, cleanup standards are to be established on a site by site basis, and consist of the following:

- Cleanup levels for hazardous substances present at the site;
- Points of compliance, the location where these cleanup levels must be met;
- Other applicable regulatory requirements that apply to the site ("applicable state and federal laws").

3.2.1 CLEANUP LEVELS

Based on the findings of the previous investigations, the primary contaminants of concerns for the Site are TPH-G, benzene, toluene, ethylbenzene and total xylenes. Cleanup levels are established for the above identified contaminants as described below.

3.2.1.1 SOIL CLEANUP LEVELS

MTCA Method A cleanup levels are designed for relatively simple sites with few hazardous substances, and as such should be applicable to this Site. Method A soil cleanup levels are the appropriate choice for this Site.

3.2.1.2 GROUNDWATER CLEANUP LEVELS

As stated in Section 3.2.1.1, Method A cleanup levels are appropriate for this Site. The Method A groundwater cleanup levels will be applied to all the identified contaminants.

3.2.1.3 AIR CLEANUP LEVELS

Air cleanup levels are needed for this Site because of the potential for vapor intrusion into the store building and residential houses downgradient of the Site. Since Method A cleanup levels are not available for the contaminants as identified for this Site, Method B cleanup levels for indoor and outdoor air will be applied. Method B cleanup levels are established using applicable state and federal laws and the risk assessment equations and other requirements specified for each medium. Method B may be used at any site and is the most common method for setting up cleanup levels when sites are contaminated with substances not listed under Method A.

Any cleanup of soil or ground water would need to result in air concentrations less than the cleanup levels.

3.2.2 POINTS OF COMPLIANCE

Based on the investigations completed thus far, the following standard points of compliance are appropriate for this Site:

Soil: Soil at the Site needs to be protective of contact, vapor inhalation, and leaching. The point of compliance is therefore throughout the Site.

Groundwater: The point of compliance for groundwater is throughout the site.

Air: The point of compliance for air is ambient air throughout the site.

3.2.3 SUMMARY OF CLEANUP STANDARDS

Contaminated Media	TPH-G	Benzene	Toluene	Ethyl-benzene	Xylenes
Soil mg/Kg	30	.03	7	6	9
Air ug/m^3	none	.32	2,200	460	46
Ground Water ug/L	800	5	1,000	700	1,000
Point of Compliance	Soil	Throughout the Site			
	Air	Ambient air throughout the Site			
	Ground Water	Throughout the Site			

3.2.4 RELEVANT AND APPROPRIATE REQUIREMENTS

MTCA requires that cleanup actions comply with applicable state and federal laws [WAC 173-340-360(2)]. MTCA defines applicable state and federal laws to include "legally applicable

requirements" and "relevant and appropriate requirements" (ARARS). ARARS for the implementation of the cleanup action at this Site follow.

Federal Requirements

- Clean Water Act
- Clean Air Act
- Resource Conservation and Recovery Act (RCRA)
- Occupational Safety and Health Act (29 CFR 1910)
- Safe Drinking Water Act
- Rules for Transport of Hazardous Waste (49 CFR 107, 49 CFR 171)

State Requirements

- Model Toxics Control Act Regulations (WAC 173-340)
- Dangerous Waste Regulations (WAC 173-303)
- Minimum Standards for Construction and Maintenance of Wells (WAC 173-160) Regulation and Licensing of Well Contractors and Operators (WAC 173-162)
- State Clean Air Act, Chapter 70.94 RCW
- Washington Industrial Safety and Health Act Regulations (WAC 296-62)
- Water Pollution Control Act, Chapter 90.48 RCW
- Water Quality Standards for Surface Waters of the State of Washington (WAC173-201A)
- Water Quality Standards for Groundwater of the State of Washington (WAC 173-200)
- Underground Injection Control (WAC 173-218)
- Maximum Environmental Noise Levels (WAC 173-60)

Local Requirements

- City of Seattle Grading Permit
- Puget Sound Clean Air Agency Regulations

All actions carried out by Ecology or Ecology's contractor under the Consent Decree will be done in accordance with all applicable federal, state, and local requirements, including requirements to obtain necessary permits, except as provided in RCW 70.105D.090. The permits or other federal, state or local requirements that the agency has determined are applicable and that are known at this time are listed above. Under RCW 70.105D.090(1), Ecology and its consultants are exempt from the procedural requirements of Chapters 70.94, 70.95, 70.105, 77.55, 90.48, and 90.58 RCW and of any laws requiring or authorizing local government permits or approvals. However, Ecology and its consultants shall comply with the substantive requirements of such permits or approvals. During remedial action, Ecology and its consultants will continue to determine whether additional permits or approvals addressed in RCW 70.105D.090 (1) would otherwise be required for the remedial action under the Consent Decree. Ecology will be responsible for contacting the appropriate state and/or local agencies and working with those agencies to determine the substantive requirements those agencies believe are applicable to the remedial action. Pursuant to RCW 70.105D.090(2), in the event Ecology

determines that the exemption from complying with procedural requirements of the laws referenced in RCW 70.105D.090(1) would result in the loss of approval from a federal agency that is necessary for the State to administer any federal law, the exemption will not apply and Ecology and its consultants will comply with both the procedural and substantive requirements of the laws referenced in RCW 70.105D.090(1) including any requirements to obtain permits.

3.3 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

This section identifies and screens remedial technologies that are potentially applicable to this Site. The technologies passing through this screening process will be used to develop remedial alternatives and are further evaluated in the next section.

3.3.1 CONTAINMENT

Containment means a container, vessel, barrier, or structure, whether natural or constructed, that confines a hazardous substance within a defined boundary and prevents or minimizes its release into the environment (WAC 173-340-200). Slurry or sheet pile walls and surface capping are commonly used techniques to encapsulate contamination. Unless it is combined with another treatment technology it does nothing to destroy or eliminate the source of soil or groundwater contamination.

Since this technology does not destroy the contaminants of concern, it will not be retained for further evaluation.

3.3.2 EXCAVATION AND OFF-SITE DISPOSAL

Excavation is used to remove contaminated soil from a source area. This approach can be effective and relatively inexpensive if the contaminants are located at a shallow depth, above the water table, and there are no major obstructions on the Site. Although excavation is possible below the water table, it can be substantially more expensive because it is necessary to either dewater the Site (if possible) or to provide water management for the saturated soils. The excavation depth is typically limited by available equipment. Standard backhoes can reach an average depth of 15 feet bgs; deeper excavations require either larger, more expensive equipment or creating benches below the ground surface, to increase the reach of the equipment.

Roads, utilities, structures, and other obstructions at the Site can limit the location and depth of excavations, particularly in unstable soils. Shoring, protecting, or relocating the obstruction may be necessary. Excavation around obstructions is possible but may result in a substantial amount of contaminants remaining on the Site.

Excavated soil can either be transported off-site for treatment or disposal, or treated on site. Off site treatment and/or disposal can be expensive depending on the location of the Site relative to treatment or disposal facilities, the volume of soil involved, and the availability of different treatment or disposal options in the area. In addition, generally the same volume of soil hauled off site for disposal or treatment must be hauled back to the Site as backfill for the excavation.

Excavation of contaminated soil at this Site has been conducted in the past. This remedial alternative is primarily limited by location of the road and convenience store on each side of the treatment area and the depth of the water table. Therefore excavation alone may not address all areas of contamination leaving some portions of the Site untreated, yielding the similar results as previous attempts at this remedial alternative.

It is not practicable to excavate the remaining known contaminated area at this time. The Site is located in the intersection between 24 Ave East and East McGraw Street in Seattle. 24th Avenue is an arterial street in the MontLake area, the traffic is very busy. Excavation will cause traffic shut down or re-route and will affect the business in the vicinity of the Site. Also due to the presence of utility lines beneath the street, it is not possible to dig without damage/replace the utility lines. Therefore, excavation will not be retained for further evaluation at this time. However, it could be applied if future investigation identifies any contaminated soil which is accessible for excavation.

3.3.3 AIR SPARGING AND SOIL VAPOR EXTRACTION

Air Sparging (also known as "in-situ air stripping" and "in-situ volatilization") is a remedial technology that reduces concentrations of volatile constituents in petroleum products that are adsorbed to soils and dissolved in groundwater by the injection of contaminant-free air into the subsurface saturated zone, enabling a phase transfer of hydrocarbons from a dissolved state to a vapor phase. The air is then vented through the unsaturated zone.

Air Sparging is often used together with Soil Vapor Extraction (SVE). The SVE system creates a negative pressure in the unsaturated zone through a series of extraction wells to control the vapor plume migration (EPA 2004).

Air Sparging/SVE only treats unsaturated-zone soils; other methods may also be needed to treat saturated-zone soils and groundwater. SVE system was previously tried at this Site, but not successful. The presence of free product might have negatively impacted the treatment effectiveness. Also, considering the low permeability of subsurface soil at this Site and high cost associated with system setup and long-term operation and maintenance, it appears this technology is not appropriate for this Site at this time, and it will not be retained for further evaluation.

3.3.4 DUAL/MULTI-PHASE EXTRACTION

Dual-phase extraction (DPE), also known as multi-phase extraction, vacuum-enhanced extraction, or sometimes bioslurping, is an *in-situ* technology that uses pumps to remove various combinations of contaminated groundwater, separate-phase petroleum product, and hydrocarbon vapor from the subsurface. Extracted liquids and vapor are treated and collected for disposal, or re-injected to the subsurface (EPA 2004).

EFR is one form of a multi-phased extraction system which can simultaneously removes vapors, free product, and groundwater from the subsurface. It volatilizes adsorbed and free phase VOCs through a process similar to vapor extraction, but with a much higher vacuum and radius of

influence. EFR is also very unique in that it can treat adsorbed phase VOCs existing within the "smear zone" (i.e. the zone of seasonal or climatic groundwater fluctuation) that act as a continuing source for dissolved phase VOCs. EFR dewaters and exposes the smear zone to the effects of "high rate" soil vapor extraction. EFR has also been well documented to be effective in the reduction in dissolved phase concentrations. Importantly, EFR also introduces oxygen to the vadose and saturated zones, thereby enhancing aerobic biodegradation. However, multiple spaced EFR may be needed to allow for natural vertical flushing by water table rebound and seasonal water table fluctuation.

EFR can be a relatively inexpensive treatment method. The process is extremely mobile, and does not need long-term operation and maintenance. A typical EFR event lasts for one day and as many as eight monitoring/recovery wells can be treated at one time. The effectiveness of EFR at sites with small quantities of free product and/or very high hydrocarbon concentrations, such as this Site, can be improved by the use of a surfactant to increase mobility of the free product and hydrocarbons adsorbed to the soil. Surfactants facilitate contaminant removal primarily by means of enhancing mobility of the contaminant through the subsurface by reducing interfacial tension. Contaminant solubility may also increase by the formation of micro-emulsions, which are subsequently "captured" (generally within 16 to 48 hours) by the EFR capture process. Aerobic biodegradation is enhanced during this process, as the surfactants are considered a co-metabolite to aerobic hydrocarbon digesting microbes.

In June 2005 an EFR pilot test was conducted on four monitoring wells at this Site. Approximately 112 pounds of hydrocarbons was removed during the 8-hour EFR test period. It is likely that repeated applications of EFR could help remove free product and dissolved hydrocarbons and vapors from the subsurface, and the efficiency may be improved by adding surfactant to the treatment. However, it may not be possible to achieve cleanup standards in a reasonable timeframe just by applying EFR. For this reason, EFR will be carried forward for further consideration in conjunction with other remedial technologies.

3.3.5 IN-SITU CHEMICAL OXIDATION

In-situ chemical oxidation technologies can be used for in-situ destruction of petroleum contaminants. A variety of chemical oxidants and application techniques are commercially available that can be used at sites contaminated with petroleum compounds. With sufficient contact time, chemical oxidants are capable of converting the petroleum hydrocarbon mass to carbon dioxide and water and ultimately irreversibly reduce the concentration of petroleum hydrocarbons in soil and groundwater. In contrast to other remedial technologies, contaminant reduction can be achieved relatively quickly (e.g., weeks or months) (EPA 2004).

While many of the chemical oxidants have been used in wastewater treatment for decades, only recently have they been used to treat hydrocarbon contaminated groundwater and soil in-situ. Chemical oxidation technologies are predominantly used to address contaminants in the source area saturated zone and capillary fringe, however recent developments in soil mixing technology in combination with fast reaction time of chemical oxidants are allowing for treatment of the unsaturated and smear zone because the soil can be mixed thoroughly maximizing contact of contaminated soil and chemical oxidant.

At petroleum contaminated UST sites, the most commonly used chemical oxidants are hydrogen peroxide/Fenton's reagent and ozone. Sodium or Potassium Permanganate has been used, but experiences with these compounds are more limited.

One limitation of this technology is the depth below the surface that can be treated with soil mixing. In addition, clays and silts may not be as easy to mix thoroughly as these soils are more cohesive than sands and gravels. Consequently, the product may not contact all areas of contamination leaving areas untreated. The performance of chemical oxidation systems are negatively impacted by the presence of free product. While the chemical reaction is capable of treating the contaminants, the concentration of contaminants will overwhelm the treatment capacity. Due to the presence of free product at this Site, other remedial technologies (e.g., free product recovery) may need to precede chemical oxidation for the remediation to be safe and cost effective. For this reason chemical oxidation will be carried forward for further consideration in conjunction with other remedial technologies.

3.3.6 IN-SITU BIOREMEDIATION

In-situ bioremediation is a treatment process that uses naturally occurring microorganisms to break down petroleum hydrocarbons into less toxic or nontoxic substances (EPA 1996).

Numerous bioremediation technologies are commercially available to enhance microbial growth and population size by creating optimal environmental conditions. In-situ bioremediation systems treat the contaminated soil or groundwater in the location in which it was found. Generally, treatment involves injecting or mixing (through wells, excavation, or direct push technologies) solutions containing oxygen, nutrients and/or microbes into the saturated soil that will enhance and accelerate the natural bioremediation process.

In-situ bioremediation is an effective and inexpensive approach to remediate low levels of petroleum contamination. However, it may be difficult to inject product into low permeable soils. Consequently, the product may not contact all areas of contamination leaving some areas untreated. For this Site, due to the presence of free product, other remedial technologies (e.g., free product recovery) may need to precede in-situ bioremediation for the remediation to be effective. This technology will be carried forward for further consideration in conjunction with other remedial technologies.

3.3.7 NATURAL ATTENUATION

Natural Attenuation refers to physical, chemical or biological processes that act without human intervention to clean up hazardous substances in the environment. These processes include adsorption on soil particles, biodegradation, dilution and dispersion in groundwater.

Natural Attenuation will not provide for a reasonable restoration time frame at this Site itself. Contamination was discovered more than 20 years ago and free product was still present during the most recent field activities conducted in 2008. The extent of the contamination including free product appears to be stabilizing and not retreating. This indicates that natural attenuation alone is unable to achieve cleanup goals within a reasonable timeframe at this Site, and more active remedial measures will be required.

3.4 DEVELOPMENT OF REMEDIAL ALTERNATIVES

Based on the evaluation of the Site and the available cleanup technologies, the following three alternatives have been developed by combining technologies considered above. Please note the remedial alternatives described below only address the contamination as currently known. If future investigation identifies new contamination, the remedial alternatives need to be re-evaluated and may need to be revised.

3.4.1 ALTERNATIVE NO. 1: EFR WITH NATURAL ATTENUATION

Alternative No. 1 would include applications of EFR, followed by natural attentuation, plus long-term groundwater monitoring. The EFR pilot test conducted in 2005 has demonstrated that application of this technique is likely to help remove free product and dissolved hydrocarbons and vapors from the subsurface. Results from other similar sites have shown that the effectiveness of EFR can be improved by the use of a surfactant to increase the mobility of the free product and hydrocarbons adsorbed to the soil.

EFR will be conducted in 4 phases, as described below.

Phase 1: EFR Event The first phase of EFR includes 8-hr extraction from four monitoring wells, MW-4, MW-8, MW-9 and MW-13. The existing product recovery well may also be pumped to remove any free product that has accumulated since the system was shut off.

Phase 2: Surfactant Injection: one 8-hr EFR/surfactant injection events will be conducted, consisting of approximately 4 to 6 hours of extraction followed by 2 to 4 hours of surfactant injection.

Phase 3: Surfacant "Capture": Two 8-hr EFR/surfactant capture events will take place on consecutive days, commencing approximately 16 to 48 hours following the completion of the EFR/surfactant injection events. The goal of the EFR/surfactant capture event is to recover approximately 100 or more times the volume of the undiluted surfactant.

Phase 4: "Polishing" EFR Event: an 8-hr "polishing" event will take place approximately four weeks following the completion of the EFR/surfactant capture events to remove any remnants of free product, surfactant, and/or microemulsions that may exist.

Effectiveness of EFR treatment will be evaluated. Multiple EFR treatments may be needed. If confirmation sampling shows that residual contamination still remains on the Site following EFR applications, then monitored natural attenuation will start. However, if cleanup standards can not be achieved within a reasonable timeframe, then more aggressive remedial techniques should be considered.

3.4.2 ALTERNATIVE NO. 2: EFR WITH IN-SITU CHEMICAL OXIDATION

Alternative No. 2 would include applications of EFR as described in Section 3.4.1, followed by in-situ chemical oxidation, plus confirmation groundwater monitoring.

3.4.3 ALTERNATIVE NO. 3: EFR WITH IN-SITU BIOREMEDIATION

Alternative No. 2 would include applications of EFR, followed by in-situ bioremediation, plus confirmation groundwater monitoring.

3.5 EVALUATION OF ALTERNATIVES

This section provides comparative evaluation of the remedial alternatives in accordance with WAC 173-340-350, "Remedial Investigation and Feasibility Study". The alternatives are evaluated against criteria stated in WAC-173-340-360, "Selection of Cleanup Actions". The following table contains a detailed evaluation of alternatives and their applied technologies.

Detailed Evaluation of Alternatives and Applied Technologies			
Alternative Number	**Alternative 1**	**Alternative 2**	**Alternative 3**
Description, and Ranking	EFR and natural attenuation	EFR and in-situ chemical oxidation	EFR and in-situ bioremediation
Compliance with MTCA Threshold Criteria			
Protection of Human Health and the Environment	Yes – Alternative will protect human health and the environment.	Yes – Alternative will protect human health and the environment.	Yes – Alternative will protect human health and the environment.
Compliance with Cleanup Standards	Yes –Active remedial measure of EFR and monitored natural attentuation are used for soils and groundwater not complying with cleanup standards.	Yes –Active remedial measures (EFR and in-situ chemical oxidation) are used for soils and groundwater not complying with cleanup standards.	Yes –Active remedial measures (EFR and in-situ bioremediation) are used for soils and groundwater not complying with cleanup standards.
Compliance with Applicable State and Federal Laws	Yes – Alternative complies with applicable laws.	Yes – Alternative complies with applicable laws.	Yes – Alternative complies with applicable laws.
Provision for Compliance Monitoring	Yes – Alternative includes provisions for compliance monitoring (i.e., long-term groundwater monitoring).	Yes – Alternative includes provisions for compliance monitoring.	Yes – Alternative includes provisions for compliance monitoring.
Restoration Time Frame	Restoration time frame is 8 to 10 years or even longer.	Restoration time frame is 5-6 years.	Restoration time frame is 5-6 years
Evaluation Criteria			
Protectiveness (30% Weighted Factor):	This alternative will achieve overall protection (6).	This alternative will be most protective for the Site (9).	This alternative will achieve overall protection (8).
Permanence (20% Weighted Factor):	Applications of EFR will help remove contaminants. However, residual contamination may remain on the Site. Natural attentuation may not be able to address the residual contamintion as expected. This alternative is not as permanent as Alternatives 2 or 3 (5).	Alternative reduces the volume of impacted material by removal of contaminants through applications of EFR and destruction of contaminants through in-situ chemical oxidation (9).	Alternative reduces the volume of impacted material by removal of contaminants through applications of EFR and destruction of contaminants through in-situ bioremediation (9).
Long-Term Effectiveness (20% Weighted Factor):	Residual contamination may remain on the Site after EFR applications. This will be addressed through natural attentuation. However, the effectiveness of natural attentuation is not known at this time (5).	Alternative destroys the contaminants, its long effectiveness is high. However, it is likely that additional applications of chemical injection will be needed to achieve the cleanup standards (7).	Alternative destroys the contaminant. However, it's very challenging to make conditions favorable for microbe growth (7).
Short-Term Risk Management (10% Weighted Factor):	Short-term risks include exposure to chemicals used in EFR , exposure to noise etc. This alternative has the lowest short-term risks (8).	Short-term risks include exposure to chemicals used in EFR and in-situ chemical oxidation, exposure to noise etc. There may be repeated applications of both EFR and in-situ chemical oxidation. Short-term risks are higher than Alternative 1 (7).	Short-term risks include exposure to chemicals used in EFR and in-situ bioremediation, exposure to noise etc. There may be repeated applications of both EFR and in-situ chemical oxidation. Short-term risks are higher than Alternative 1 (7).
Implementability (10% Weighted Factor):	Most Implementable; it may require shut down of East McGraw street for EFR applications.	Implementable; it may require shut down of East McGraw street during EFR applications and in-situ chemical oxidation (6).	Implementable; it may require shut down of East McGraw street during EFR applications and in-situ bioremediation (6).
Public Concerns (10% Weighted Factor):	Temporary access restrictions to East McGraw Street during EFR applications (7).	Temporary access restrictions to East McGraw Street during EFR applications and in-situ chemical oxidation (6).	Temporary access restrictions to East McGraw Street during EFR applications and in-situ bioremediation (6).
Overall Alternative Ranking	6.0	8.0	7.6

3.6 PREFERRED ALTERNATIVE

The preferred alternative for this Site is Alternative 2, which consists of EFR and in-site chemical oxidation and confirmation groundwater monitoring. Selection of this alternative over Alternative 1 and 3 as the preferred alternative is primarily based on its relatively high certainty to achieve cleanup objectives within a reasonable timeframe.

4.0 REFERENCES

EA November 2006, *Circle K Station #1461, Groundwater Monitoring Data Summary, Work Order #17079, Contract Number: 30700*

EA August 2006, *Circle K Station #1461, Groundwater Monitoring Data Summary, Work Order #17079, Contract Number: 30700*

EA May 2006, *Circle K Station #1461, Groundwater Monitoring Data Summary, Work Order #17079, Contract Number: 30700*

EA February 2006, *Circle K Station #1461, Groundwater Monitoring Data Summary, Work Order #17079, Contract Number: 30700*

EA June 2005, *Investigation Report for Washington State Department of Ecology, Mixed Funding LUST Sites, Circle K Station #1461.*

EPA 2004. *How to Evaluate Alternative Cleanup Technologies for Underground Storage Tank Sites: A Guide for Corrective Action Plan Reviewers.*

(EPA 510-B-94-003; EPA 510-B-95-007; and EPA 510-R-04-002).

Ecology November 2003, *Circle K Station #1461, 2350 24th Avenue East, Seattle, WA, Field Investigations, 2003.*

Glacier Environmental Services 2000, *Interim Report, Groundwater Treatment System, Jay's Cleaners, 2350 24th Ave East, Seattle, WA.*

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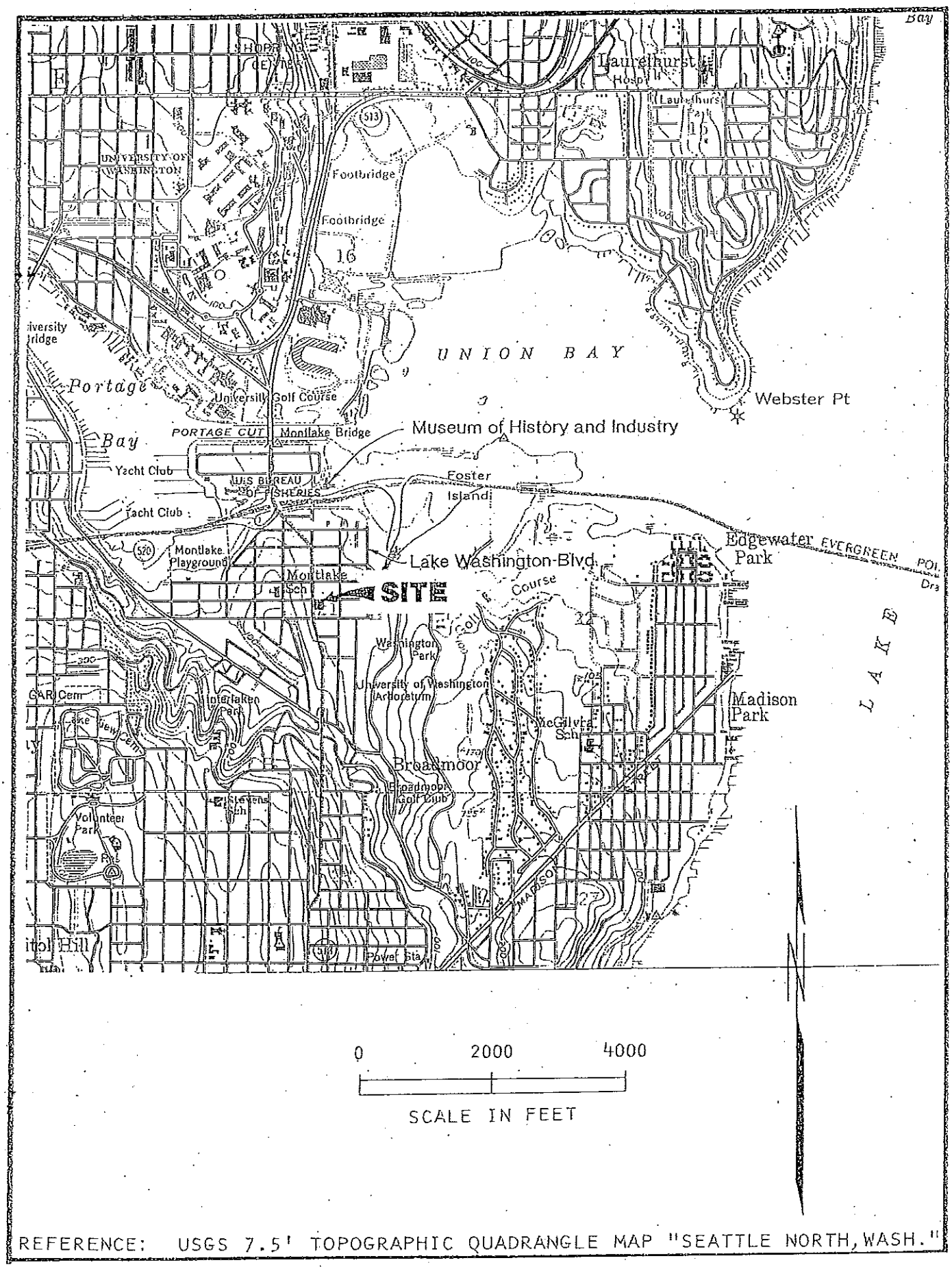
Glacier Environmental Services 1992, *Report of First Phase Activity, Former Circle K #146, Seattle, Washington.*

GeoEngineers 1990c, *Progress Report No. 2, Remedial Monitoring Program, Circle K Facility 1461, Seattle, Washington for Circle K Corporation,* November 1990.

GeoEngineers 1990b, *Progress Report No. 1, Remedial Monitoring Program, Circle K Facility 1461, Seattle, Washington for Circle K Corporation,* August 1990.

GeoEngineers 1990a, *Report of Geotechnical Services, Subsurface Contamination Study and Remedial Action Monitoring, Circle K Facility 1461, Seattle, Washington,* March 1990.

Figures



REFERENCE: USGS 7.5' TOPOGRAPHIC QUADRANGLE MAP "SEATTLE NORTH, WASH."

1780:001-804 TEP:KKT 9.19.

Figure 1 Site Location

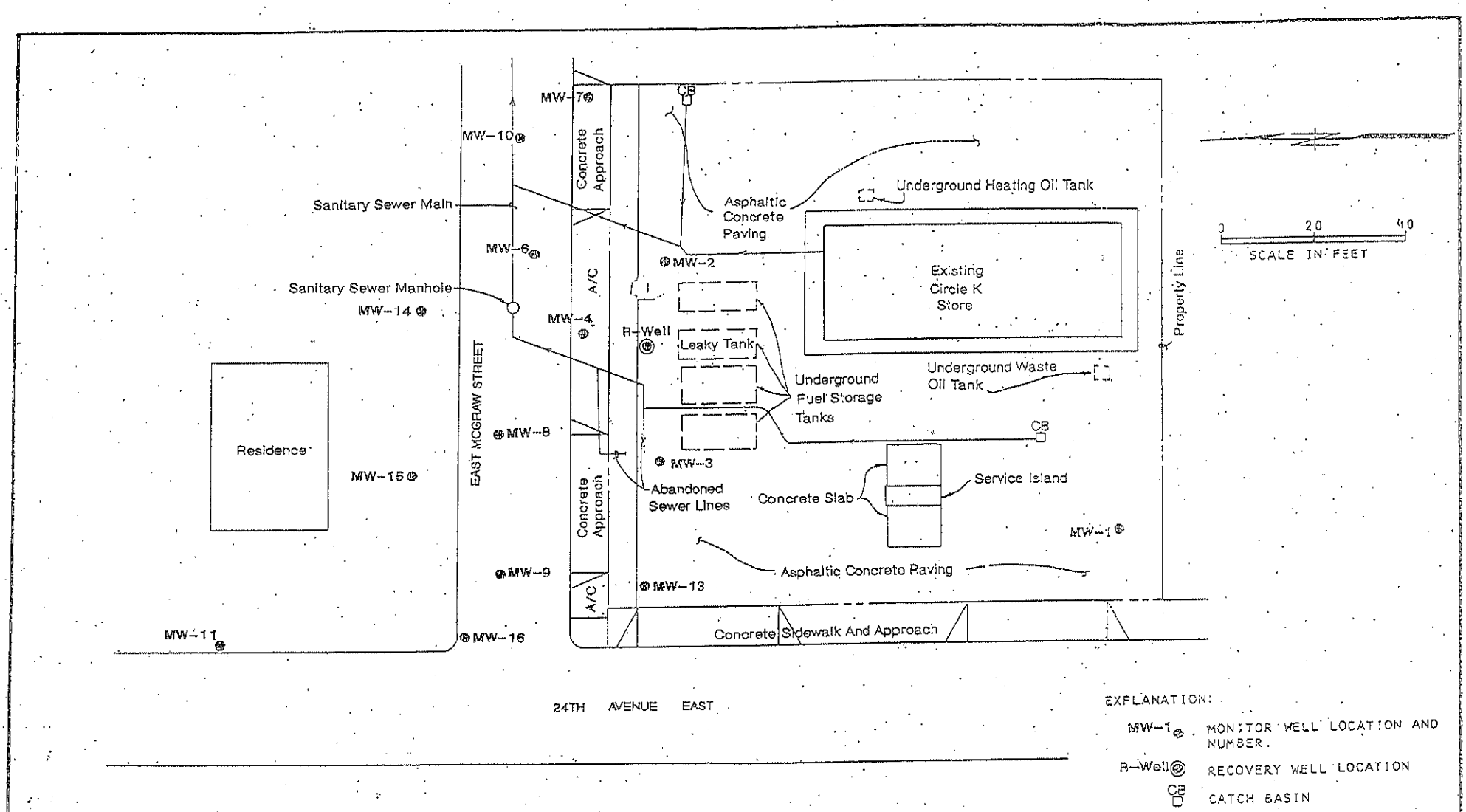
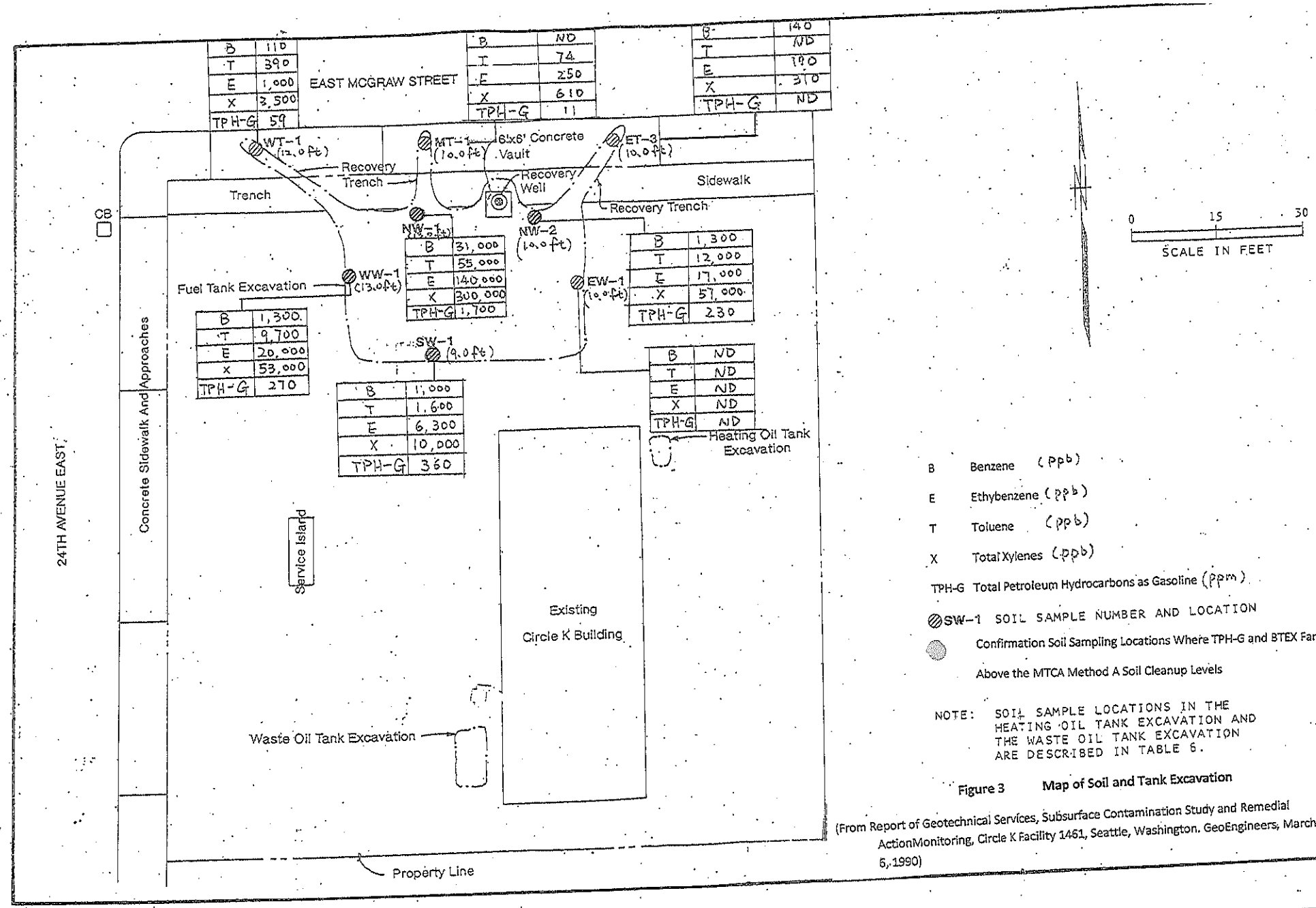


Figure 2 Former Circle K Station #1461 Site Layout

(From Report of Geotechnical Services, Subsurface Contamination Study and Remedial Action Monitoring, Circle K Facility 1461, Seattle, Washington. GeoEngineers, March 6, 1990)



B Benzene (ppb)

E Ethybenzene (ppb)

T Toluene (ppb)

X Total Xylenes (ppb)

TPH-G Total Petroleum Hydrocarbons as Gasoline (ppm)

SW-1 SOIL SAMPLE NUMBER AND LOCATION

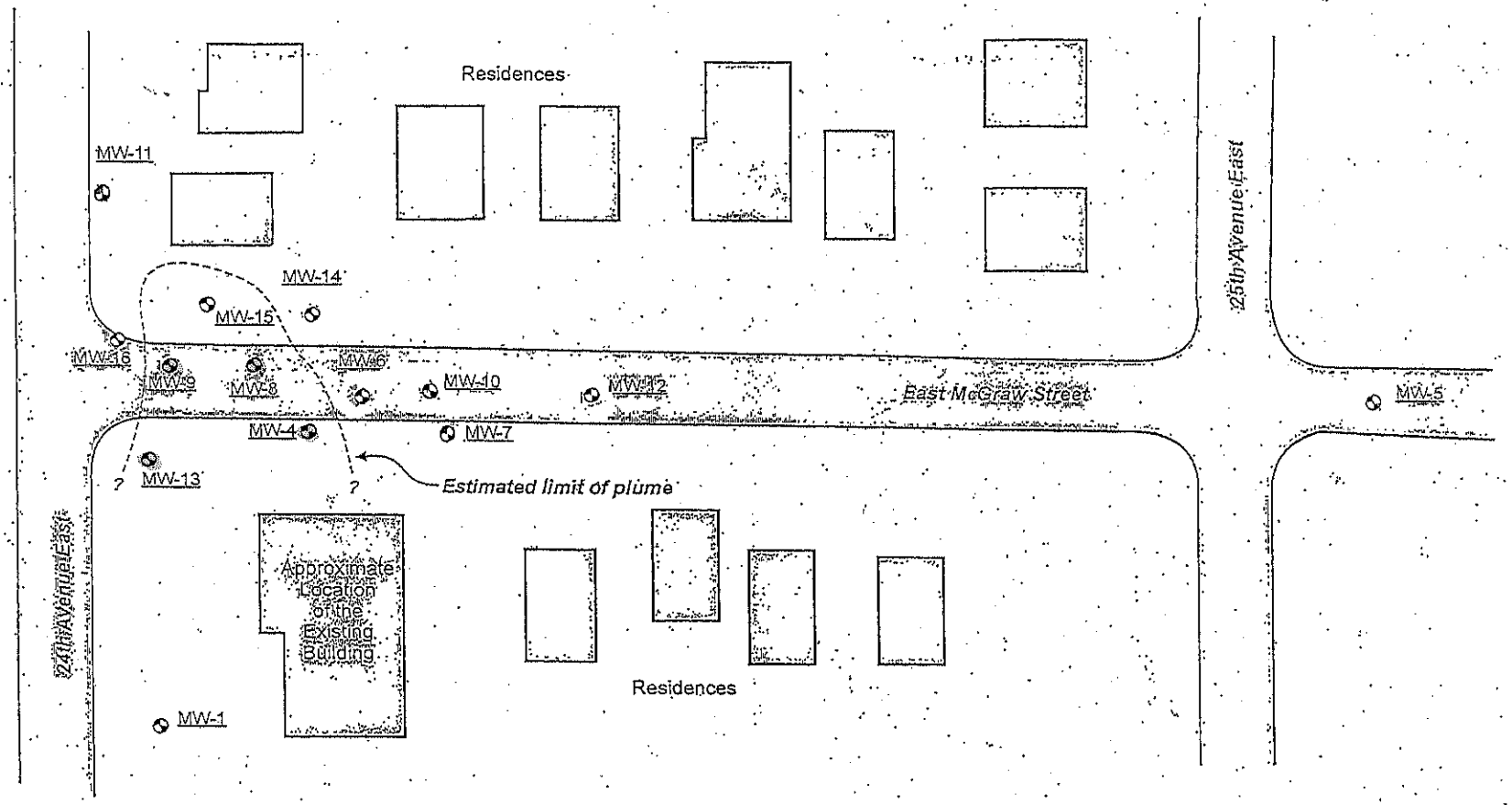
Confirmation Soil Sampling Locations Where TPH-G and BTEX Far Above the MTCA Method A Soil Cleanup Levels

NOTE: SOIL SAMPLE LOCATIONS IN THE HEATING OIL TANK EXCAVATION AND THE WASTE OIL TANK EXCAVATION ARE DESCRIBED IN TABLE 6.

Figure 3 Map of Soil and Tank Excavation

(From Report of Geotechnical Services, Subsurface Contamination Study and Remedial ActionMonitoring, Circle K Facility 1461, Seattle, Washington. GeoEngineers, March 6,1990)

1780-001-804 JGR-BDH 1-16-90



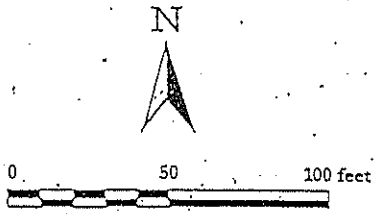


Figure 4 Current Site Layout and Approximate Extent of Gasoline Plume

● Wells with Free Product (2/15/2008)

Locations of All Features Shown Are Approximate

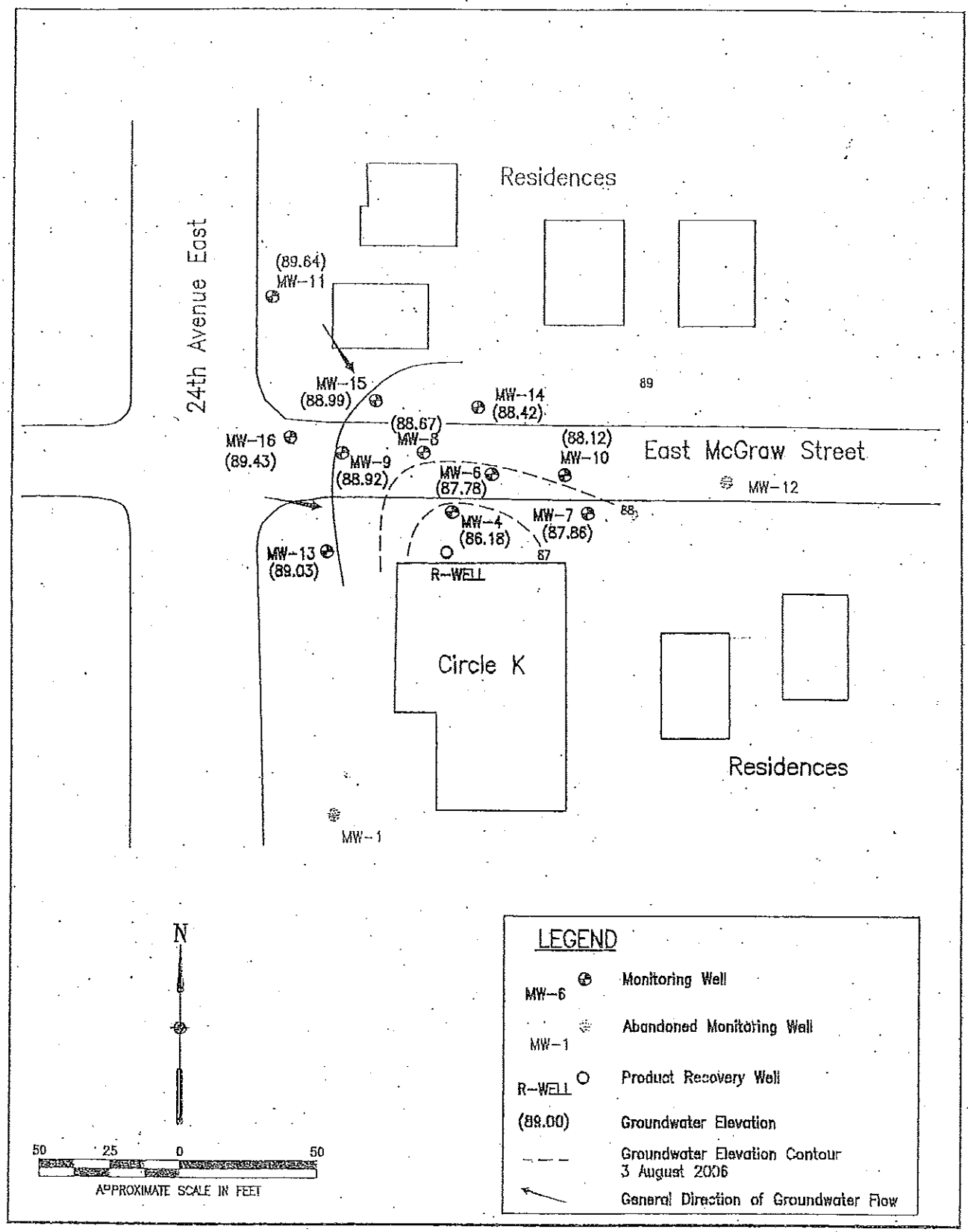


Figure 5 Groundwater Elevations and Contour Lines, 3 August 2006

From Report *Circle K Station #1461, Groundwater Monitoring Data Summary, Work Order #17079, Contract Number: 30700,* EA November 7, 2006

TABLES

TABLE 1. MONITORING WELL CONSTRUCTION AND FIELD MEASUREMENT DATA - CIRCLE K STATION #1461

Well ID	Date Installed	Well Diameter (inches)	Reported Screen Depth (ft bgs)	Total Depth (ft btoc)	Top of Casing Elevation (ft)	Depth to Water 3-Aug-06 (ft btoc)	Depth to Product 3-Aug-06 (ft btoc)	Free Product Thickness 3-Aug-06 (ft)	Groundwater Elevation 3-Aug-06 (ft)
MW-4	9/12/1989	2	4 - 18.5	17.90	100.73	14.67	14.55	0.12	86.18
MW-6	10/2/1989	2	5 - 20	20.43	100.24	12.46	NA	NA	87.78
MW-7	10/2/1989	2	5 - 20	20.49	99.75	11.89	NA	NA	87.86
MW-8	10/3/1989	2	5 - 20	19.45	100.70	12.04	12.03	0.01	88.67
MW-9	10/3/1989	2	5 - 21	20.35	101.41	12.50	12.49	0.01	88.92
MW-10	10/3/1989	2	5 - 20	20.47	99.96	11.84	NA	NA	88.12
MW-11	10/4/1989	2	5 - 20	20.31	100.89	11.25	NA	NA	89.64
MW-12	10/4/1989	2	5 - 20	abandoned	abandoned	NA	NA	NA	NA
MW-13	12/20/1989	2	4 - 19	18.81	102.19	13.19	13.16	0.03	89.03
MW-14	12/20/1989	2	4 - 19	18.87	100.40	11.98	NA	NA	88.42
MW-15	12/21/1989	2	4 - 18.5	16.81	101.29	12.3	NA	NA	88.99
MW-16	12/21/1989	2	4 - 19	18.94	101.15	11.72	NA	NA	89.43

		Water Quality Parameters					
Well ID	Date Measured	pH	Conductivity (mS/cm)	Turbidity (NTUs)	Dissolved Oxygen (mg/L)	Temperature (°C)	Oxidation-Reduction Potential (mV)
MW-6	8/3/2006	7.06	1.67	1.5	0.71	17.6	-42
MW-15	8/3/2006	5.62	2.233	1.3	0.78	15.8	42.4

NOTES:

°C = degrees Celsius.
ft bgs = feet below ground surface.
ft btoc = feet below top of casing.
NA = Not applicable.
NTUs = Nephelometric turbidity units.
mS/cm = milliSiemans per centimeter.
mg/L = milligrams per liter.
mV = milliVolts

Table 2 Summary of Soil Sample Analytical Data, Monitor Well Borings

From *Report of Geotechnical Services, Subsurface Contamination Study and Remedial Action Monitoring, Circle K Facility 1461, Seattle, Washington,* GeoEngineers March 6, 1990

			EPA Method 8020				Modified EPA Method 8015	
Sample Number	Depth (feet)	Sample Date	Benzene (ppb)	Ethyl-Benzene (ppb)	Toluene (ppb)	Total Xylenes (ppb)	Gasoline (ppm)	Diesel (ppm)
MW-1	8.5	09/11/89	ND	ND	ND	ND	ND	ND
MW-2	8.5	09/11/89	ND	ND	ND	ND	ND	ND
MW-3	8.5	09/12/89	ND	57	72	310	9	ND
MW-4	8.5	09/12/89	ND	27,000	27,000	159,000	1,200	ND
MW-5	8.5	09/12/89	ND	ND	ND	ND	ND	ND
MW-6	8.0	10/02/89	ND	ND	ND	ND	ND	ND
MW-6	10.0	10/02/89	ND	ND	ND	ND	ND	ND
MW-7	10.0	10/02/89	ND	29	100	175	ND	ND
MW-8	10.0	10/03/89	ND	ND	ND	ND	ND	ND
MW-9	10.0	10/03/89	ND	ND	ND	ND	ND	ND
MW-10	10.0	10/03/89	ND	ND	ND	ND	ND	ND
MW-11	11.0	10/04/89	ND	ND	ND	ND	ND	ND
MW-12	10.0	10/04/89	ND	ND	ND	ND	ND	ND
MW-13	8.0	12/20/89	460	220	1100	1200	ND	ND
MW-14	13.0	12/20/89	ND	ND	ND	ND	ND	ND
MW-15	8.0	12/21/89	ND	ND	ND	ND	ND	ND
MW-15	13.0	12/21/89	510	90	840	510	ND	ND
MW-16	8.0	12/21/89	ND	ND	63	ND	ND	ND

Notes:
"ppb" = parts per billion
"ppm" = parts per million
"ND" = "not detected" - see lab data sheets in Appendix B for analyte detection limits

TABLE 3. GROUNDWATER ELEVATION SUMMARY - CIRCLE K STATION #1461

Well ID	Top of Casing Elevation (ft)	Groundwater Elevation 31 May 2005 (ft)	Groundwater Elevation 14 Feb 2006 (ft)	Groundwater Elevation 18 May 2006 (ft)	Groundwater Elevation 3 August 2006 (ft)	Annual Water Level Fluctuation (ft)
MW-4	100.73	91.02	92.10	90.75	86.18	5.92
MW-6	100.24	88.69	88.72	88.70	87.78	0.94
MW-7	99.75	90.63	94.12	90.15	87.86	6.26
MW-8	100.70	90.69	91.72	90.50	88.67	3.05
MW-9	101.41	91.34	92.71	90.99	88.92	3.79
MW-10	99.96	90.13	91.29	89.96	88.12	3.17
MW-11	100.89	92.23	98.52	91.29	89.64	8.88
MW-13	102.19	91.29	92.64	91.14	89.03	3.61
MW-14	100.40	91.62	93.36	91.15	88.42	4.94
MW-15	101.29	91.86	93.76	91.25	88.99	4.77
MW-16	101.15	91.64	93.15	90.55	89.43	3.72
					Average =	4.46

NOTES:

ft bgs = feet below ground surface.

ft btoc = feet below top of casing.

TOC elevations are per INCA 22 March 2006 survey.

Table 4 Thickness of Free Product in Groundwater Monitoring Wells (feet)

Monitoring Wells	6/16/2003	5/31/2005 Before EFR Test	6/23/2005 2 Weeks after EFR Test	2/14/2006	5/18/2006	8/3/2006	2/15/2008
MW-4	0.09	0.3	Trace	0.02	0.14	0.12	Trace<0.01
MW-6	--	--	--	Not observed	Not observed	--	Not observed
MW-7	--	--	--	Trace	Not observed	--	--
MW-8	0.9	Trace	Trace	Trace	0.05	0.01	Sheen and hydrocarbon observed
MW-9	0.02	0.02	Trace	0.02	Trace	0.01	No product measured, sheen observed
MW-10	--	--	--	Trace	Not observed	--	--
MW-11	--	--	--	Not observed	Not observed	--	--
MW-12	--	--	--	--	Not observed	--	Abandoned
MW-13	0.01	0.01	Not Measured	Trace	Trace	0.03	0.01
MW-14	--	--	--	Trace	Not observed	--	--
MW-15	Not observed	--	--	Not observed	Not observed	--	No product measured, sheen and ordor observed
MW-16	--	--	--	Trace	Not observed	--	Not observed

--: Not measured

Table 5 Summary of Groundwater Analytical Data

Well ID	Sampling Date	TPH-G (ug/L)	Benzene (ug/L)	Toluene (ug/L)	Ethylbenzene (ug/L)	Xylenes (ug/L)
MW-1	9/13/1989	--	1.5	ND	1.9	1.6
	3/9/1990	--	ND	ND	ND	ND
	4/9/1992	<100	51	14	14	9
	6/4/1999	ND	ND	3.59	3.87	0.83
	4/11/2001	50.0 U	0.500 U	0.500 U	0.500 U	1.00 U
	6/16/2003	50.0 U	0.500 U	0.500 U	0.500 U	1.00 U
MW-4	4/9/1992	Not sampled - Free product observed in well				
	6/4/1999	30,800	3,580	3,490	3,920	788
	4/11/2001	117,000	7,370	28,000	2,680	17,100
	6/16/2003	Not sampled - Free product observed in well				
	5/31/2005	Not sampled - Free product observed in well				
	6/23/2005	65,600	240	3,750	1,640	10,700
	2/14/2006	Not sampled - Free product observed in well				
	5/18/2006	Not sampled - Free product observed in well				
	8/3/2006	Not sampled - Free product observed in well				
MW-5	4/9/1992	<100	<1	1	<1	3
	4/11/2001	50.0 U	0.500 U	0.500 U	0.500 U	1.00 U
	6/16/2003	50.0 U	0.500 U	0.500 U	0.500 U	1.00 U
MW-6	10/9/1989	--	250	ND	3.2	110
	3/8/1990	--	14	0.5	2.8	1.8
	6/11/1990	--	18	1.7	6.2	7.9
	4/9/1992	<100	4	1	<1	3
	6/4/1999	ND	ND	2.88	ND	ND
	4/11/2001	50.0 U	0.500 U	0.500 U	0.500 U	1.00 U
	6/16/2003	50.0 U	0.500 U	0.500 U	0.500 U	1.00 U
	2/14/2006	67.5	0.982	0.500 U	3.84	7.13
	5/18/2006	50.0 U	0.514	0.500 U	1.48	1.00 U
	5/18/2006	50.0 U	0.500 U	0.500 U	1.28	1.00 U
	8/3/2006	50.0 U	0.500 U	0.500 U	0.500 U	1.00 U
MW-7	10/9/1989	--	3	ND	1	ND
	3/8/1990	--	1	ND	ND	ND
	4/9/1992	<100	4	<1	5	9
	6/4/1999	ND	ND	3.38	2.29	ND
	4/11/2001	0.05 U	0.500 U	0.500 U	0.500 U	1.00 U
	6/16/2003	0.05 U	0.500 U	0.500 U	0.500 U	1.00 U
MW-8	6/4/1999	43700	570	6,130	17,000	1,220
	4/11/2001	464,000	802	9,770	1,520	7,030
	6/16/2003	Not sampled - Free product observed in well				
	5/31/2005	Not sampled - Free product observed in well				
	6/23/2005	Not sampled - Free product observed in well				
	2/14/2006	102,000	342	143,000	2,670	14,800
	2/14/2006*	89,000	452	14,000	2,770	14,900
	5/18/2006	Not sampled - Free product observed in well				
	8/3/2006	Not sampled - Free product observed in well				
MW-9	6/4/1999	54,400	610	4,990	6,760	1,230
	4/11/2001	35,400	420	2,310	1,500	7,350
	6/16/2003	Not sampled - Free product observed in well				
	5/31/2005	Not sampled - Free product observed in well				
	6/23/2005	71,300	1,820	6,140	1,820	9,350
	2/14/2006	Not sampled - Free product observed in well				

Table 5 Summary of Groundwater Analytical Data

Well ID	Sampling Date	TPH-G (ug/L)	Benzene (ug/L)	Toluene (ug/L)	Ethylbenzene (ug/L)	Xylenes (ug/L)
	5/18/2006	52,200	535	2,300	1,730	8,390
	8/3/2006	Not sampled - Free product observed in well				
MW-10	10/9/1989	--	1.2	ND	ND	ND
	3/8/1990	--	ND	ND	ND	ND
	6/11/1990	--	ND	ND	ND	ND
	6/4/1999	ND	ND	ND	3.03	ND
	5/18/2006	50.0 U	0.500 U	0.500 U	0.500 U	1.00 U
MW-11	10/9/1989	--	3	ND	ND	3
	3/9/1990	--	0.9	ND	0.9	ND
	6/11/1990	--	ND	ND	ND	ND
	4/9/1992	<100	1	<1	<1	<1
	6/4/1999	ND	ND	35.8	ND	ND
	4/11/2001	50.0 U	0.500 U	0.500 U	0.500 U	1.00 U
	6/16/2003	50.0 U	0.500 U	0.500 U	0.500 U	1.00 U
	2/14/2006	50.0 U	0.500 U	0.500 U	0.500 U	1.00 U
MW-12	4/9/1992	<100	4	<1	<1	3
	6/4/1999	ND	ND	2.99	1.14	ND
MW-13	12/21/1989	--	13,000	1,700	20,000	8,800
	3/9/1990	--	54,000	3,500	50,000	18,000
	6/11/1990	--	31,000	1,800	24,000	12,000
	4/9/1992	56,000	5,900	5,700	1,200	6,400
	7/13/2003	Not sampled - Free product observed in well				
	5/13/2005	Not sampled - Free product observed in well				
	6/23/2005	115,000	8,560	16,800	1,920	12,900
	6/23/2005*	121,000	8,560	16,900	1,880	12,700
	2/14/2006	74,700	2,270	6,660	1,530	14,100
	5/18/2006	109,000	7,260	14,700	1,810	15,500
	8/3/2006	Not sampled - Free product observed in well				
MW-14	12/21/1989	--	1.1	1.9	5.7	13.0
	3/8/1990	--	4.7	0.7	6.3	4.5
	6/11/1990	--	ND	ND	49	ND
	4/9/1992	<100	4	2	5	8
	4/11/2001	50.0 U	0.500 U	0.500 U	0.500 U	1.00 U
	6/16/2003	50.0 U	0.500 U	0.500 U	0.500 U	1.00 U
	5/31/2005	50.0 U	0.500 U	0.500 U	0.500 U	1.00 U
MW-15	12/21/1989	--	7,300	1,000	9,000	5,800
	3/8/1990	--	28,000	1,400	22,000	6,500
	6/11/1990	--	20,000	1,800	28,000	10,000
	6/4/1999	24,700	37.9	367	3,100	547
	4/11/2001	23,800	58.4	310	526	2,920
	6/16/2003	3,150	6.22	83.3	12.6	199
	5/31/2005	878	1	0.500 U	2.60 I	3.39 I
	6/23/2005	950	2.01	3.18	2.48	6.34
	2/14/2006	137	0.5U	0.5U	0.5U	1.0 U
	5/18/2006	381	0.791	1.69	0.816	5.82
	8/3/2006	1,350	2.92	6.86	6.03	42
	8/3/2006*	1,580	3.29	6.60	6.78	45.1
MW-16	12/21/1989	--	4.30	7.10	20.00	36.0
	3/8/1990	--	ND	ND	ND	ND
	6/11/1990	--	ND	ND	ND	0.8

Table 5 Summary of Groundwater Analytical Data

Well ID	Sampling Date	TPH-G (ug/L)	Benzene (ug/L)	Toluene (ug/L)	Ethylbenzene (ug/L)	Xylenes (ug/L)
MW-16	4/9/1992	<100	5	2	5	9
	6/4/1999	182	ND	3.39	8.93	1.93
	4/11/2001	50.0 U	0.500 U	0.500 U	0.500 U	1.00 U
	6/16/2003	50.0 U	0.500 U	0.500 U	0.500 U	1.00 U
	2/14/2006	50.0 U	0.500 U	0.500 U	0.500 U	1.00 U
Note:						
* Duplicate						
--: Not measured						
U: not detected at or above the specified reporting limit						
I: The analyte concentration may be artificially elevated due to coeluting compounds or components.						