INDEPENDENT REMEDIAL ACTION PLAN

PROPOSED REDEVELOPMENT PROPERTY
104-124 12TH AVENUE & 1209 E. FIR STREET
SEATTLE, WASHINGTON 98122

April 2, 2019
Project No. WES-1591A

WHITMAN Environmental Sciences

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EXECUTIVE SUMMARY

Whitman Environmental Sciences (WES) was retained by Mr. Michael Pollard of the Centric Partners LLC to prepare this Independent Remedial Action Plan for cleanup actions that will be performed as part of the redevelopment of the property as a mixed-use building. The property and surrounding area have had a history of uses that have resulted in soil and groundwater contamination by petroleum and chlorinated solvents.

As part of redevelopment, tasks to be completed include removal of any remaining features and encountered contamination, if encountered, from:

- A former service station at 130 12th Avenue,
- A former auto repair in the basement level of the 104 12th Avenue building,
- A floor sump in the basement of the104 12th Avenue building,
- A current auto repair building at 1209 E. Fir Street.

In addition, in-situ methods will be used to demobilize and degrade low concentrations of vinyl chloride or other chlorinated solvents in groundwater in the southeastern parking lot of the property.

This document presents our approach for the in-situ groundwater remediation and proper removal and disposal or treatment of soil containing petroleum hydrocarbons, lead and other contaminants, if encountered. The proposed cleanup is to be carried out as an independent remedial action, in compliance with the substantive requirements of the Model Toxics Control Act (MTCA) Cleanup Regulation, Chapter 173-340 WAC. The completed cleanup will be documented and the results will be submitted to the Washington State Department of Ecology Voluntary Cleanup Program (VCP) for a formal opinion.

The site will be redeveloped as a six-story mixed-use building with approximately 280 residential units, 16 live-work units and about 10,000 square feet of ground floor commercial spaces. Although this cleanup action will be coordinated with the redevelopment, this work plan details only those aspects of the work specific to cleanup. Demolition of the current structures and any new construction are being managed separately.

Model Toxics Control Act (MTCA) Method A Cleanup Levels and Method B Standard Formula Values for soil and groundwater will be used to determine compliance with MTCA cleanup standards. Performance sampling throughout the excavation will be used to document proper management of excavated soil and seepage water. Confirmation monitoring will be conducted at the completion of the excavation phase to document that soil at the standard points of compliance meets applicable MTCA standards. Post-treatment groundwater monitoring in the southeastern parking lot will be used to demonstrate compliance with groundwater cleanup levels.

TABLE OF CONTENTS

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1.0 INTRODUCTION

Whitman Environmental Sciences (WES) was retained by Mr. Michael Pollard of Centric Partners LLC to prepare this Independent Remedial Action Plan for cleanup in conjunction with redevelopment of the above referenced site. Figure 1, a Site Location Map, shows the project site and surrounding area. Figure 2 is a Site Plan showing the current layout of site features. The property and surrounding area have had a history of uses that have resulted in soil and groundwater contamination by petroleum and chlorinated solvents.

Environmental site investigations have identified petroleum contaminated soil and groundwater remaining from historical site uses of the western portion of the site. Groundwater in the southeastern parking lot area is impacted with a plume of chlorinated solvents (tetrachloroethylene, trichloroethylene and vinyl chloride).

This cleanup is to be conducted as an independent remedial action under Chapter 173-340-515 WAC, the Model Toxics Control Act (MTCA). The intent is to remediate the site to a condition which will meet all applicable cleanup standards, allow the Washington Department of Ecology to review the cleanup under its Voluntary Cleanup Program (VCP) and make a formal determination that no further action will be required. The site is enrolled in VCP and has been assigned VCP Project ID NW3194. This work plan will be provided to Ecology for an opinion prior to beginning the cleanup work. If accepted, the agency will issue a “likely No Further Action” opinion, indicating they agree that the cleanup approach, if successful, is likely to meet all requirements of MTCA cleanup standards.

2.0 PROJECT BACKGROUND

2.1 Property Description and Development Plan

The subject property consists of approximately 47,433 square feet of land located on the east side of 12th Avenue, between the intersections with Yesler Way E. and E. Fir Street, in Seattle, Washington. The site is bordered on the east by warehouses operated by the King County Archives.

The site will be redeveloped as a six-story mixed-use building with approximately 280 residential units, 16 live-work units and about 10,000 square feet of ground floor commercial spaces. Figures 3 and 4 show the proposed footprint and design elevations for the planned structure. Although this cleanup action will be coordinated with the redevelopment, this work plan details only those aspects of the work specific to cleanup. Demolition of the current structures and any new construction are being managed separately.

The property consists of four adjoining tax parcels totaling 47,433 square feet. Table 1 identifies the parcels which make up the subject property.

Table 1
Subject Property Parcels

Street Address	***King County Parcel ID***	***Approximate Area (Sq. ft.)***
104 12th Avenue	806100-0025	10,000
No address – Parking lot only	806100-0035	14,000
110-118 12th Avenue	806100-0015	10,000
124 12th Avenue	806100-0005	13,433
Total Site Area:		***47,433***

The 104 12th Avenue property is almost completely covered by the footprint of a two-story concrete building that most recently houses the Seattle Curtain Manufacturing Company. The adjoining parcel to the east is a paved parking lot for the 104 12th Avenue building. The 110-118 12th Avenue parcel has an older one-story commercial building in poor condition that currently houses an Ethiopian restaurant and has a large vacant tenant space on its north end. The 124 12th Avenue parcel includes a gravel surfaced parking lot and a building addressed 1209 E. Fir Street that has housed auto repair facilities throughout its history.

2.2 Property History

Selected references illustrating aspects of the site history are included in Appendix A. These include historical aerial photographs and archived records from the King County Assessor's office.

The earliest readily ascertainable references to the property date to an 1893 Sanborn Fire Insurance Rate Map, which shows that by that date the street right-of-ways were laid out in approximately their current alignment and like many parts of the city, the street names were different than their current nomenclature. Sections of all of the adjacent roads were shown to be "Not Opened" indicating unimproved right-of-ways. Undated street grading profiles obtained from the City of Seattle show the approximate current and former ground surface profiles for the surrounding streets. Adjacent to the property, 12th Avenue was filled by as much as 16 feet of soil, while a high area was removed from the area north of Fir Street. This is consistent with the depth of poorly consolidated fill material found during our site investigations, discussed below.

The first apparent on-site development was the building at 104 12th Avenue, constructed in 1926. The lower floor was accessed from Yesler and addressed 1206 Yesler. A 1928 H.C. Gray street directory identified the addresses 106 12th Avenue and 1206 Yesler Way as the location of J. M. Smith and Yesler Auto Paint Shop. The earliest photograph of the building from Assessor's records dates about 1937. The upper floor of the building was nondescript, with no signage. The lower floor along Yesler was painted with signs for an auto garage, for "Storage", "Washing", "Repairing" and "Auto Painting". Currently, there is still signage visible on the rear of the building for Yesler Garage (later painted over to be Modern Garage), addressed 1206 Yesler. It includes a Shell Oil logo and notes gasoline and motor oil.

A 1938 Polk's commercial city directory lists the 1206 Yesler address as Coles Horticultural Products, fertilizer manufacturers. A 1942 Polk directory lists the upper floor of the building as the location of B. Radinsky & Son, junk dealers. After about 1948 all of the identified uses of the building have been environmentally benign.

The adjacent parking lot to the east has no history of development and appears to have been vacant land until at least the date of a 1946 aerial photograph. After that, it was used as parking for the building. Early photographs suggest in may have been paved since at least the 1950s.

The commercial building at 110-118 12th Avenue was built in 1940 immediately to the north of 104 12th building, along the east side of 12th Avenue. The upper floor at street level was divided into small storefronts. Most recorded uses of these spaces were benign. Of the building's uses, two identified tenants had activities that inherently used or managed hazardous or regulated materials, both located in the northern tenant space addressed 118 12th Avenue. From about 1958 to 1962 the space was a screen print shop. Screen printers use a variety of inks, solvents and cleaning chemicals that are potential sources of recognized environmental conditions, if mismanaged. Later, that space was occupied by a dry cleaner. Polk directories note the 118 12th address was occupied by Robertson's Laundry & Dry Cleaners from 1966 until the 1971-72 edition. All uses were limited to the upper floor of the building. The lower level is a tall unfinished crawlspace and may have been used for basic utilities but does not appear to have been habitable or suited for tenant uses other than limited storage.

The current gravel parking lot in the northwestern part of the property has an extended history of use as a gas station and auto repair. The station was built in about 1941 as a Maxwell Petroleum station, with a single pump island holding three pumps and a small auto repair building addressed 124 12th Avenue. It is unclear how many tanks were originally installed, but later records suggest up to six tanks may have been on the property, ranging from 1,000 to 4,000 gallons in capacity. Over the history of the station it was identified as a Mobil station, Texaco and variety of independent operators. Some of the operators were limited to auto repair, while others may have continued to sell fuel. The building and tanks were reportedly removed in 1990 and limited cleanup was conducted at that time, removing a reported total of 761 tons of contaminated soil. A 2014 ground penetrating radar survey of the station area found no evidence of tanks (AEG, 2014), and subsequent investigation drilling has not encountered any underground structures or tanks.

The building at 1209 E. Fir Street was constructed in about 1949 as a smaller structure. It was expanded with an addition on the south end in about 1988. Throughout its history the building has been used for auto repair. The addition appears to be a paint booth and workshop for auto body repair.

2.3 Prior Environmental Actions and Investigations

To prepare this work plan, WES reviewed available documents and conducted extensive environmental site investigations to collect soil and groundwater samples from the site and surrounding area (WES, 2017, 2017a, 2018, 2019). The work was conducted to identify and delineate the extent of recognized environmental conditions on the property. Other prior environmental and geotechnical investigations have also been conducted, some of which were made available (in whole or in part), as sources of data for this assessment (AEG, 2014, Farallon 2016, Geotech, 2017, 2018). The combined investigations have involved drilling 55 soil borings on and around the perimeter of the property and laboratory analysis of soil and groundwater samples for petroleum related compounds, chlorinated solvents and regulated metals.

Tables summarizing the soil and groundwater samples selected for testing, the laboratory analytical results and Washington State Model Toxics Control Act soil cleanup criteria are included in Appendix B.

3.0 SOIL AND GROUNDWATER CONDITIONS

As determined by the prior site investigations, soil conditions consist of a layer of relatively unconsolidated fill containing organic material and debris, overlying brown to grayish brown clayey sand and gravel interpreted to be glacial till, or weathered, till-derived sediments. Where present, groundwater was encountered in sandier zones, including thinly layered interbeds in otherwise silty soil. These sandy zones are only partially continuous across the site. Cross sections demonstrating the interpreted geologic stratification within the depths drilled are attached as Figures 5A, 5B and 5C. A cross section orientation plan is included as Figure 5.

The extent of fill appears to be greatest in the northwestern part of the property, where depths of up to 20 feet have been encountered. The fill depths generally coincide with historical street grading profiles from the City of Seattle engineering archives, which show the original ground surface profile and final grade of the right-of-ways of 12th Avenue and Yesler Way. The grading occurred prior to any of the known developments of the property. In particular, 12th Avenue was filled extensively with soil taken from a localized high area directly north of Fir Street. This suggests the on-site fill dates to about the time the adjacent streets were constructed.

Below this layer, the borings encountered organic silty soils that may have been a former topsoil horizon, overlying relatively dense silt or clayey sands extending throughout the depths drilled.

Groundwater was encountered in sandier zones ranging from thin fine sand zones laminated with silt to thicker water-bearing zones up to four feet in thickness. In general, groundwater flow is limited. Preliminary pump tests as part of the geotechnical evaluation for foundation drainage design found yield rates of 0.1 gallon per minute or less from a 2-inch diameter monitoring well screened from depths of 20 to 35 feet. The engineer’s preliminary estimate is that less than 2 gallons per minute would be generated along the entire perimeter foundation wall of the proposed building, a length of about 840 feet.

The groundwater static level appears to be at an elevation of about 201 feet by City of Seattle Reference in the northwestern part of the site, falling to an elevation of about 187 in the southeastern corner. This suggests a gradient to the southeast at depths ranging from about 15 feet below the current ground surface in the northwest, to about 6 to 10 feet below the surface in the southeastern parking lot.

There was evidence of discoloration or petroleum odors, sheens or staining at six of the borings. These borings were located in the southwestern and southeastern parts of the lower level of the 104 12th Avenue building (borings WES-1 and WES-2); near the former location of the service station pump island (boring BN-7); at the south end of the gravel parking lot presumed to be the former underground storage tank area (borings BN-9 and BN-10); and in the crawlspace beneath the 118 12th Avenue tenant space (boring HA-N).

Laboratory analyses of soil samples found gasoline-range petroleum hydrocarbons (TPH-G), in six samples from five different boring locations. These correspond to the former service station pump island location, the south end of the gravel parking lot, under the northern edge of the adjacent 118 12th Avenue tenant space and near the southeastern and southwestern corners of the 104 12th Avenue building. Motor oil-range TPH was found to exceed the MTCA Method A cleanup level at only one location, corresponding to the area of the service bay in the former service station (boring BN-8).

Only two soil samples taken from boring BN-7 near the pump island area of the former service station, evidenced volatile organic compounds above MTCA Method A cleanup levels. A sample from 12 feet below the ground surface contained ethylbenzene and xylenes, while a deeper sample from 17 feet contained benzene at a concentration of 0.033 mg/kg. None of the soil samples contained detectable concentrations of any chlorinated volatile organic compounds that would indicate dry cleaning chemical releases to soil.

Lead was detected in a sample from a boring at the south end of the 1209 E. Fir building (boring BN-11). The sample was fill soil taken from a depth of 12 feet below the ground surface.

Groundwater samples were found to contain elevated concentrations of total petroleum hydrocarbons in the same borings where impacted soil was identified and at several other surrounding boring locations, including borings WES-4, WES-10, BN-8, and HA-S. Groundwater at these locations reflect total petroleum hydrocarbons in the gasoline, diesel or motor oil range and a variety of volatile organic compounds related to gasoline. Benzene was found to exceed MTCA Method A groundwater cleanup levels in samples from borings BN-7 and BN-10.

In the southeastern parcel, groundwater sampling has identified a low-level plume of chlorinated volatile organic compounds. Groundwater samples from monitoring wells MW-1, MW-5, B-7, B-9 and borings WES-11 and WES-13 have found vinyl chloride at concentrations ranging from 0.2 to 1.9 ug/l. Tetrachloroethene and trichloroethene have also been detected at concentrations that exceed MTCA Method A cleanup levels.

Tables in Appendix B summarize the soil and groundwater samples taken during the site investigations.

4.0 CONCEPTUAL SITE MODEL

Chapter 173-340 of the Washington Administrative Code (The Model Toxics Control Act) defines a contaminated site as the full extent of contaminated media, whether on the property where the contamination originated or surrounding properties that have been impacted by the contamination. Based on the history and results of our site investigations, petroleum contaminants and chlorinated solvents will be encountered on the subject site. The distribution suggests the areas are relatively limited and contaminants originating on site have not migrated beyond the property boundaries. Chlorinated solvents appear to be tetrachloroethene (PCE) and daughter products of its degradation that may extend in a groundwater plume onto the southeastern parcel of the property.

4.1 Areas of Concern and Indicator Substances

Based on the investigations conducted to date, three areas of petroleum impacts to soil and groundwater have been defined; the former gas station at 130 12th, a former auto repair and a floor sump, both located in the lower level of 104 12th. One area of chlorinated solvent impacts to groundwater has been identified in the southeastern parking lot. Lead contaminated soil has been found in a fill slope near the south end of the 1209 E. Fir Street building. In general, these areas appear to be distinct, with no evidence of co-mingled contaminants. No free-phase petroleum products or chlorinated solvents have been found in any of the site investigations. Figure 6 shows the estimated extent of the identified areas.

Table 2 identifies the contaminants of concern and the maximum identified concentration found by laboratory testing to date. These parameters will be considered the indicator contaminants of concern for this cleanup action in accordance with WAC 173-340-703. Indicator substances will be used to direct the proposed soil excavation program and will be the parameters tested for final compliance sampling.

Table 2
104-130 12th Avenue & 1209 E. Fir Street
Indicator Contaminants of Concern

Parameter	***Maximum Detected Soil Concentration (mg/kg)***	***Maximum Detected Groundwater Concentration (ug/l)***
Total Petroleum Hydrocarbons Gasoline Range Organics Diesel Range Organics Motor Oil Range Organics	 780 440 (Below CUL) 3,300	 3,200 1,000 680
Benzene	0.033	11
Ethylbenzene	6.8	85 (Below CUL)
Xylenes	59	432 (Below CUL)
Tetrachloroethene	Not Detected (<0.025)	12 (Below CUL)

Parameter	*Maximum Detected Soil Concentration (mg/kg)*	*Maximum Detected Groundwater Concentration (ug/l)*
Trichloroethene	Not Detected (<0.02)	17
Vinyl Chloride	Not Detected (<0.05)	1.9
Lead	330	Not Detected (<1)

(Below CUL) – Maximum reported value is below applicable Model Toxics Control Act Method A clean up level.
Not Detected (<X.X) – Not detected above the noted laboratory reporting limit. All reporting limits are below CULs.

Although some of these indicator substances have not been detected in the site investigations or are limited to one media, there is a potential that they would be present, given the known history of the site and those related substances that have been detected. Compliance monitoring for this cleanup will include these parameters as deemed necessary based on field observations.

4.2 Contaminant Sources

The primary sources of the contaminants of concern appear to be the historical former service station, the former auto repair, the floor sump, potential dumping or impacted fill placed on the slope (possibly at the time of construction of the building at 1209 E. Fir), and migration of chlorinated solvents in groundwater. All of the activities that were potential sources have been curtailed. There are no known remaining tanks on the property. However, this work plan anticipates the excavation contractor will be prepared to remove any tanks, lines, hydraulic lifts, sumps or other structures encountered during the work.

4.3 Transport Mechanisms

In general, the available information suggests there is low potential for contaminants to be transported beyond the currently identified areas. Since all source activities ceased anywhere from 30 to as much as 70 years ago, it is likely that the current extent of contamination is near an equilibrium between transport and attenuation mechanisms. There is little likelihood of the observed contamination migrating further within the time frames before this cleanup action begins.

Potential transport mechanisms for contaminants have included leaching by infiltration that could drive migration of contaminants downward through soil, capillary action, migration of dissolved phase contaminants with groundwater, or migration of vapors toward site structures. The central portion of the property is an exposed slope, partially vegetated. This area has a potential for surface exposure of contaminated soil. Wind-blown particulates or erosion are potential transport mechanisms in this area. It is likely transport would result in movement of surficial soil down the slope, within the boundaries of the property. There are no surface waters on the property or in the immediate surrounding area, so surface water is not a likely transport mechanism.

4.4 Exposure Pathways and Receptors

The site has limited exposure pathways in its current state. There is little or no potential direct contact exposure to petroleum hydrocarbons due to the depth of the zone of contaminated soil (about six to 17 feet below the surface, or below structures). None of the contaminated soil is within right-of-ways or areas that would be exposed by utility work. There is no indication of petroleum contaminated groundwater leaving the property. There are no drinking water wells on-site or reported within at least one-half mile of the property. There are no surface waters on the property or in the immediate surrounding area.

There is a current potential for petroleum vapor intrusion into existing structures. However, all site structures are businesses with limited hours of operation and other factors that limit the potential for exposures. The Seattle Curtain Company at 104 12th Avenue is only occasionally active, with only one or two employees and all activities are on the second floor of the building. The lower level is used only for long-term storage. The commercial building at 110-118 12th has only one occupied tenant space and it is located above a tall crawl-space open to the outside air. The 1209 E. Fir building is an open-air repair garage and paint booth with extensive ventilation. Vapor intrusion does not appear to be a likely exposure pathway to receptors in these structures.

The area impacted by chlorinated solvents to groundwater is covered by an impervious asphalt surface. There are currently no structures overlying the on-site plume or activities in the parking area that could result in exposure.

The central portion of the site, where there is a potential for surface exposure of contamination, is fenced, has no active use and not accessible to tenants or the public.

The potential for inhalation, ingestion and dermal contact by site workers will temporarily increase during the cleanup action as petroleum contaminated soil (PCS) is exposed while being excavated for transportation and disposal. During the time cleanup occurs site access will be limited to contractor personnel with proper personal protective equipment through the duration of the cleanup.

After this cleanup action, all site soil and groundwater is anticipated to meet Washington State Model Toxics Control Act Method A cleanup criteria for the indicator substances. No exposure pathways will remain.

5.0 MODEL TOXICS CONTROL ACT CLEANUP LEVELS

Standard Method A soil and groundwater cleanup criteria will be used to determine compliance with MTCA cleanup standards.

Table 3 summarizes the MTCA Method A soil and groundwater cleanup levels for the contaminants of concern identified above. Where no Method A cleanup criteria is available, the MTCA Method B standard formula value is included. These values will be used for performance monitoring and final confirmation sampling during the cleanup. Soil and groundwater found to be at or below these concentrations will be considered in compliance with MTCA cleanup standards.

Table 3
104-130 12th Avenue & 1209 E. Fir Street
Model Toxics Control Act Method A Cleanup Criteria
for Unrestricted Land Use

Parameter	*MTCA Method A Soil Cleanup Criteria (mg/kg)*	*MTCA Method A Groundwater Cleanup Criteria (ug/l)*
Total Petroleum Hydrocarbons		
Gasoline Range Organics	30	800
Diesel Range Organics	2,000	500
Motor Oil Range Organics	2,000	500
Benzene	0.03	5
Ethylbenzene	6	700
Xylenes	9	1,000
Tetrachloroethene	0.05	5
Trichloroethene	0.03	5
Vinyl Chloride	0.67*	0.2
Lead	250	15

*No MTCA Method A soil cleanup level is available for vinyl chloride. Noted value is Method B standard formula value for direct contact carcinogenicity, per WA Dept. of Ecology CLARC database guidance. Note that vinyl chloride has not been detected in site soil.

The cleanup actions described in this work plan are expected to result in complete removal of all contaminated soil and treatment or sequestration of all indicator contaminants of concern in groundwater exceeding Method A cleanup criteria. Any concentrations that remain are expected to be below these Method A cleanup levels. Post-treatment groundwater monitoring will be used to confirm the effectiveness of in-situ groundwater contaminant reductions. Testing will be conducted during the construction phase of this cleanup to confirm that soil is in compliance with applicable MTCA standards. The cleanup action and confirmation testing programs are described below.

6.0 REMEDIAL ACTION SCOPE OF WORK

The remedial action planned for this site will occur in two phases. Initially, in-situ groundwater treatment will be conducted in the southeastern parking lot area while it remains paved and otherwise unused. Excavation of petroleum impacted soil in the western part of the property will be conducted later, in conjunction with redevelopment.

The cleanup will involve the following steps:

- Conduct an in-situ groundwater treatment program, including injection of an activated carbon (to act as an adsorption mass) and a chemical reduction agent along the north perimeter of the southeastern parking lot. A grid of injection points will also be used throughout the plume to apply products intended to promote biological degradation of the remaining chlorinated compounds.
- Install four additional monitoring wells within the groundwater plume area for expanded compliance monitoring.
- Conduct periodic groundwater monitoring to evaluate performance. (Quarterly until all indicator substances are below MTCA cleanup criteria for four consecutive quarters).
- Conduct additional treatment injections and repeat compliance monitoring, if necessary.
- Demolish the site buildings.
- Install drilled pile shoring along the west property line (12th Avenue), north property line (E. Fir Street) east property lines (adjacent to the King County Archives warehouses) and about 100 feet along the south property line from the intersection of Yesler and 12th Avenue. Segregate and dispose any drill cuttings that evidence petroleum contamination.
- Decommission monitoring wells that are within the excavation area.
- Excavate for redevelopment, assess and dispose of any underground storage tanks, piping or hydraulic lifts encountered during digging.
- Excavate and dispose of petroleum contaminated soil (PCS) as it is encountered, estimated to be 1,500 to 2,600 cubic yards, from depths of about six to 18 feet.
- Conduct confirmation sampling throughout work areas.
- Additional excavation and retesting, if confirmation sampling fails.
- Document the cleanup and all compliance sampling and submit the information to Ecology's VCP Site Manager.
- Interact with Ecology's assigned Site Manager to facilitate a formal opinion letter.

6.1 In-Situ Groundwater Remediation

Figure 7 shows the proposed are of injection for in-situ remediation products. This work will be conducted in coordination with Regenesis, Inc., the product manufacturer and technical consultant for this aspect of the cleanup. In the northern portion of the parking lot, a combination of two products will be used to form an adsorption and treatment zone in the area where the highest concentrations have been observed. PlumeStop™ liquid activated carbon will be injected to sorb chlorinated compounds from groundwater. In-situ chemical reduction will be promoted using S-MicroZVI™ within this zone. An additional grid application of S-MicroZVI, 3-D Microemulsion™ and Bio-Dechlor Inoculum (BDI Plus™) will be used to treat the remaining plume area.

PlumeStop is a very finely milled activated carbon in a water-based solution that readily injects and adsorbs contaminants from groundwater. It then more slowly adheres to soil particles, binding the contaminants and sequestering them in solid phase. Since the carbon forms a coating on soil grains, the chlorinated compounds are exposed and readily accessible for in-situ chemical reduction and naturally-occurring biotic contaminant degradation. S-MicroZVI is a powdered zero valent iron suspended in food grade glycerol, that creates an anoxic and highly reducing environment, which allows enhanced anaerobic biodegradation to destroy chlorinated contaminants.

3-D Microemulsion is a combination of three types of lactic and fatty acids that provide a controlled-release of electron donors over the time necessary to degrade contaminants. This helps create an anaerobic environment in the groundwater treatment zone. BDI Plus is a mixture of a variety of *Dehalococcoides sp.* bacteria which are capable of dechlorinating contaminants. BDI Plus has been shown to stimulate rapid dechlorination of chlorinated compounds such as tetrachloroethene, trichloroethene, dichloroethene, and vinyl chloride, including in in-situ anaerobic remediation programs. Product information is included in Appendix C.

Design verification testing will be conducted to determine the appropriate spacing of injection points and soil characteristics that could influence the effectiveness of the treatment program. Testing will include a clean water injection test to determine the radius of influence that can be achieved and field and laboratory analysis of soil parameters that can influence the required volume of injection. The final quantities, spacing and injection rates will depend on the design verification testing.

Preliminary design anticipates an injection volume of approximately 5,500 gallons of a mixture of Plume Stop and S-MicroZVI will be injected in a band of about 10 injection points along the northern edge of the parking lot. The injection will be conducted using Geoprobe direct-push points and will target permeable zones from a depth of about five to 14 feet below the surface. The anticipated area of influence will be approximately 10 to 15 feet wide, by 60 to 80 feet long.

A grid of injection points will be established throughout the plume downgradient of this zone which will inject an anticipated 9,100 gallons of a mixture of 3-D Microemulsion, S-MicroZVI & BDI Plus in approximately 29 injection points targeting an interval about nine to 18 feet below the surface. Regenesis anticipates the injection program can be completed within about one week of field operations.

6.1.1 Pre and Post-Treatment Monitoring

Prior to injection, four additional monitoring wells will be installed in the southeastern parking lot, to provide coverage throughout the anticipated plume area. The proposed locations are noted in Figure 7. These locations are approximate and may be revised to minimize interference with planned construction in this area. The wells in this part of the property will most likely need to be preserved through at least part of the construction of the new site developments.

Groundwater monitoring will be conducted throughout the verification testing and injection period. An initial set of groundwater samples will be analyzed for volatile organic compounds from all of the existing monitoring wells in the southern parking lot prior to injection (MW-1, MW-2, MW-4, MW-5, MW-10, B-7, B-9 and the four new monitoring wells).

Following injection, field measurable parameters will be checked to evaluate progress. Dissolved oxygen, pH, conductivity and turbidity will be tested on a bi-weekly basis.

PlumeStop may take several months to adsorb to soil in the formation, so groundwater in the treatment area will temporarily appear black. Although chlorinated compounds will rapidly absorb onto the activated carbon, laboratory analyses will still show concentrations of solvents as long as the carbon remains suspended in the groundwater. Although periodic progress sampling may be conducted on individual wells, no overall rounds of sampling will be conducted until turbidity testing shows that carbon has mostly adsorbed to soil. Most likely this will fall within a normal quarterly monitoring schedule. Monitoring will continue on a quarterly basis until all of the wells in and around the treatment area meet MTCA Method A cleanup levels for all indicator contaminants of concern for four consecutive quarters.

If construction is scheduled to begin before four quarterly rounds of sampling is complete, the wells will need to be protected to avoid damage by excavators and traffic. If the asphalt is removed, the current protective monuments will most likely prevent damage, but deeper excavation could require other protective measures. Protective bollards or other means of protection can be used to limit access to the area around each well. If damaged, the wells will need to be restored or replaced until the monitoring period is complete. After sampling data indicates the groundwater consistently meets MTCA standards, the wells can be abandoned by a licensed water well driller using approved methods.

6.2 Site Excavation

Redevelopment of the site will involve excavation of approximately 38,500 in place cubic yards of soil. All parcels of the property except the S.E. parking lot will be developed with below grade parking. The anticipated excavation base will be at an elevation of 186 feet by City of Seattle reference, or approximately 32 feet below current ground surface at the northwestern corner and about 13 feet below ground surface in the southwestern corner. Two elevator pits will be excavated to elevations of about 180 feet. The perimeter walls of the site will be supported by temporary shoring and tie-backs into the surrounding soil.

Shallow areas of PCS that are readily accessible during demolition of the site structures can be removed as part of early site preparations. Other areas will be impractical to remove in advance and will need to be segregated during the mass excavation of the site.

Figure 8 shows a cross section of the proposed site building demonstrating the extent of excavation that will be conducted. The depths and locations of samples evidencing soil contamination are projected onto the cross-section line at the appropriate depths. The planned depth of excavation is at least 5.5 to 15 feet below the lower limit of known PCS in the impacted areas. If necessary, additional excavation will be conducted in any area where contamination extends below the planned base elevations. Those areas will be backfilled under the direction of the project geotechnical engineer.

The following work procedures will be utilized throughout the remedial action:

- The contractors chosen for this project shall assume full responsibility for compliance with all applicable federal, state, and local regulations pertaining to work practices, hauling, disposal, and protection of workers, visitors to the property, and persons occupying areas adjacent to the property.

- The excavation contractor will be responsible for mobilizing the necessary excavation equipment and personnel to the property, setting up equipment at the property, and holding safety meetings. The general contractor will be responsible for designating an appropriate staging area for the excavation contractor.

- The work will be conducted following a site-specific Health & Safety Plan. The general contractor is responsible for developing and complying with the Health and Safety Plan for its employees and subcontractors.

- Work in the area where PCS is expected will be conducted with dedicated excavation equipment and trucks that are working only within the contaminated soil zone. All soil from this area will be managed separately from other excavation spoils unless specifically cleared for management as “clean” soil suitable for reuse or export. See Section 6.3 for soil screening criteria.

- PCS removed during excavation will be trucked to a treatment or disposal facility. The disposal or treatment method selected will be based on the current tipping and transportation cost and the capacity of all providers at the time the work is conducted. One or more disposal or treatment option will be selected before site excavation begins.

- The contractor will be responsible for developing and adhering to a truck routing plan to be used during soil loading and transporting activities. The excavation contractor will be responsible for providing sealable dump trucks suitable for containing and transporting PCS that may contain minor quantities of groundwater.

- The excavation contractor will be responsible for loading the PCS into the trucks and transporting these soils to the selected disposal facility in accordance with all local, state, and federal regulations. Prior to the trucks exiting the Site, the excavation contractor will inspect each truck to ensure that loading was conducted properly and that petroleum-impacted soils are not adhering to the truck body or tires. The excavation contractor will be responsible for disposing petroleum-impacted soils in accordance with federal, state, and local regulations.

- After completion of remediation activities, the excavation contractor shall ensure that equipment that has come in contact with the affected soils will be washed with high-pressure water in an area built to contain the wash water. The water will be disposed in accordance with applicable discharge guidelines and requirements. Following wastewater removal, accumulated sediments (if any) will be sampled and analyzed for waste designation purposes. Following designation, these sediments will be removed and disposed accordingly. The general contractor shall also be responsible for disposal of municipal-type solid wastes (e.g., Tyvek and gloves) generated during field activities.

Excavation will continue until confirmation testing indicates that all on-site PCS has been removed to levels at or below the Method A cleanup levels summarized in Table 3.

6.2.1 Work Preparations and Permitting

In preparation for this cleanup, WES will make arrangements for contaminated soil disposal. Each potential soil disposal option requires waste characterization testing and an application for approval prior to accepting any waste shipments. WES will obtain approval for disposal at Republic Services, Waste Management, Inc. and Cemex, in Everett, Washington. Typically, the combined cost of trucking and disposal at Cemex is the most economical disposal option for PCS. However, lead contaminated soil or material containing excessive debris cannot be disposed at Cemex.

WES will submit existing soil data to the Department of Ecology Hazardous Waste and Toxics Reduction Program for a “contained-in determination” which sets terms for soil management, should solvent-contaminated soil be found during excavation. Current data suggests it is unlikely to be encountered, but having the determination prepared in advance will avoid possible project delays if any are found.

Required permits for this work will be part of the overall building permit process of the City of Seattle. No other grading or demolition permitting is required. Asbestos abatement and management of other hazardous building materials will be conducted prior to demolition. These aspects of demolition will be managed separately and are not within the scope of this remedial action plan.

If tanks are encountered, a Seattle Fire Department tank decommissioning permit will be necessary for each closure. These can be obtained on an as-needed basis.

Existing monitoring wells within the excavation area will be properly abandoned by a licensed well driller, following accepted techniques. Well abandonment logs will be submitted to the Washington Department of Ecology, as required by State regulations.

6.2.2 Demolition and Surface Removal

The excavation phase of cleanup will commence with demolition of the buildings and the removal of the asphalt or concrete surfaces to expose the entire surface area for inspection and additional sampling. The debris will be transported off-site for recycling. Any observed stained areas or petroleum odors with be marked and sampled for possible inclusion in PCS soil removal.

6.2.3 Shoring Installation

Drilled pile installation will be conducted along the boundaries of the site to allow excavation to the base depth. Approximately thirty-inch diameter borings will be drilled to about 10 feet below the excavation base elevation, steel beam piles will be installed and the borings backfilled with a lean-mixed concrete.

Current site investigation data suggests no petroleum impacts have extended to or beyond the site perimeter. As a cautionary measure, WES will observe and monitor soil cuttings from the pile installation for evidence of contamination. The location and depth where any PCS is generated will be noted and that information used to direct digging during the site mass excavation. Any PCS will be segregated from other soil and properly disposed.

Tie-backs will be installed as the mass excavation is conducted to stabilize the vertical excavation walls. The redevelopment area will be excavated in about six-foot tiers, with tie-backs installed as new sections of the wall are exposed. Tie-backs are drilled horizontally into the wall, then the wall surface is coated with shot-crete. The end result will be a continuous vertical wall around the building footprint from the current elevations to the lowest part of the excavation.

As the excavation reaches the depth of PCS, materials will be segregated for disposal. Samples of the sidewalls will be obtained to demonstrate the conditions prior to installation of the shotcrete wall. If PCS is encountered in the sidewall, WES will observe the tie-back drilling to evaluate the extent and distance beyond the wall the PCS extends.

6.2.4 Mass Excavation

Trackhoes will be used to excavate soil throughout the site to the design elevation for construction. Based on the currently available information, this depth will be sufficient to remove the full anticipated volume of PCS. If impacted soil extends deeper, the excavation will be continued under the direction of the project's geotechnical engineer. Any excavation below the planned base depth of digging will be documented and the area restored using compacted structural fill or lean concrete mix meeting the requirements of the engineer.

During excavation, WES will field screen soils as they are excavated for petroleum odors, discoloration or elevated vapor measurements using a field photoionization meter. Soils exhibiting obvious indications of contamination will be considered "Class 3" soil, impacted to a level where there is no suitable reuse. Questionable soil that may or may not meet MTCA cleanup criteria can be segregated and tested to determine appropriate handling. This soil may be trucked to Cemex or other facilities as "Class 2" soil, which meets MTCA cleanup criteria but may still exhibit odors or discoloration to a degree that it would not be accepted at "clean" fill sites.

Lead contaminated soil in the central slope area of the site may not evidence field observable odor or sheens that identify the impacted material. Performance sampling will be needed to determine the extent of excavation required in this area, or other locations where debris or other indications of contamination are encountered. The fill soil may evidence discoloration, debris or ash. Cemex treatment or disposal is not approved for this material. This area will need to be excavated separately from PCS and the soil managed as waste through Rabanco or Waste Management, Inc. at a Sub-Title D landfill. Disposal of this soil will require characterization testing for a suite of metals by the Toxicity Characteristic Leaching Procedure (TCLP). This soil will be stockpiled until approved for disposal as a separate waste stream from the site.

2.5 Groundwater Management

Groundwater is not expected to be a significant factor in the excavation and no large-scale disposal of groundwater is anticipated. There will be an on-site management system for run-off and storm water control, with an approved and permitted discharge to sanitary sewer. During excavation, storm water may come in contact with PCS and will requiring periodic testing prior to discharge. If necessary, minor groundwater seepage can be collected and managed along with storm water. The general contractor is responsible for complying with all local, state and federal stormwater and wastewater regulations and permit requirements.

6.3 Soil Screening Criteria

Field screening and soil segregation will be directed by a WES environmental geologist or technician experienced in cleanup and excavation procedures. Any soil evidencing discoloration, petroleum odors or sheen will be segregated and unless specifically cleared via laboratory testing, will be managed as waste soil. Within the expected contaminant areas, only those soils with appropriate confirmatory laboratory testing can be excluded from disposal or treatment.

All sampling conducted during excavation will be considered progress sampling, intended for waste characterization. Progress sample analysis may be limited to the parameters suspected to be present at any given location. Final confirmation samples will be analyzed for the full list of indicator substances in Table 1. The number of progress samples will be dependent upon the characterization needed to properly segregate soils.

6.4 Underground Storage Tank Removal (If Necessary)

Should remaining underground storage tanks be encountered they will be removed under the direction of a licensed UST service provider following all appropriate permitting and safety procedures. Any encountered tank will be emptied, rinsed and pumped, then placed in an inert state by a licensed marine chemist, using compressed carbon dioxide. The tank will be checked by a representative of the Seattle Fire Department and when confirmed to be inert, will be removed from the ground, sealed and removed from the site the same day.

Any tanks will be transported to a facility that will clean them further and cut them up for scrap. The facility issues a certificate of destruction as documentation.

The condition of any encountered tanks and the surrounding soil will be documented by a registered underground tank assessor. As part of the documentation for this project, a Department of Ecology Tank Site Assessment Checklist will be prepared for any commercial tank encountered. Heating oil tanks are exempt from this requirement.

The tank excavation will be expanded to remove any adjoining petroleum contaminated soil, if necessary.

6.5 Hydraulic Lift Removal (If Necessary)

Hydraulic lifts could be encountered in the lower level of the 104 12th Avenue building or the former location of the gas station. If encountered, all lifts will be disconnected from any remaining piping then removed intact from the ground. Each lift will be wrapped in plastic and transported to the facility of Marine Vacuum Services, Inc., where it will be drained of oil and scrapped. The oil will be tested for PCBs prior to disposal or recycling.

If PCBs are present, the oil will be managed by Marine Vacuum as a separate waste stream. If no PCBs are present, MarVac is free to mix the oil with other waste oils for recycling. The lift excavation will be visually checked for possible petroleum leaks. The areas of the lift will be excavated to the extent necessary to remove any PCS and confirmation samples will be obtained, as discussed below.

7.0 CONFIRMATION SAMPLING AND CLEANUP DOCUMENTATION

7.1 Final Soil Confirmation Sampling

The objective of soil confirmation sampling is to collect representative data that can be used to compare final site conditions with regulatory criteria and document that the excavation has removed soils above the specified Method A cleanup levels. All sampling conducted for this remedial action will follow appropriate environmental field sampling and chain-of-custody protocols throughout sample handling.

Soil confirmation sampling will include the following:

- Underground storage tank assessment samples (if any) will be taken at the time any tanks are removed to comply with UST closure requirements. Sampling will include at least five soil samples from the base and sidewalls of each tank area, as well as one sample beneath each 50 feet of product piping that may be encountered. The samples will be taken from locations deemed to be the most likely to evidence petroleum releases, if present. The samples will be analyzed following the requirements of MTCA regulations, Table 830-1, following Washington State accepted laboratory methods. All samples from gasoline tank excavations will be analyzed for total petroleum hydrocarbons in the gasoline range and the volatile organic compounds benzene, toluene, ethylbenzene and xylenes. If the tank is suspected to have been a waste oil tank, additional analyses will be conducted for the required parameters listed in Table 830-1. All samples from waste oil tank excavations and the soil stockpile generated from them will be analyzed for total petroleum hydrocarbons in the gasoline, diesel and motor oil ranges. One sample, demonstrating the highest TPH concentrations, if any, will also be analyzed for volatile and semi-volatile organic compounds, PCBs, lead, arsenic, cadmium, chromium and mercury. Any suspected heating oil tanks will be analyzed for total petroleum hydrocarbons in the diesel range.

- Base and sidewall sampling from the floor sump area in the basement of 104 12th Avenue and any other sumps found during excavation will include analyses in Table 830-1 intended for waste oil tanks, including total petroleum hydrocarbons in the gasoline, diesel and motor oil ranges. One sample, demonstrating the highest TPH concentrations, if any, will also be analyzed for volatile and semi-volatile organic compounds, PCBs, lead, arsenic, cadmium, chromium and mercury.

- A minimum of two soil samples will be taken from any hydraulic lift area. These samples will be tested for total petroleum hydrocarbons in the oil range and PCBs. If PCS is encountered, the area will be excavated further and re-sampled to document the conditions at the boundaries of the final lateral extent of digging.

- Base and sidewall sampling and screening will be used to document the conditions at the final extent of mass excavation. The number of final base samples will depend on the observed extent of the contamination zones. Sampling will be conducted at a rate of approximately one sample per 600 square feet of the areal extent of contaminated soil excavation (an approximately 25' x 25' area) and approximately 25-foot intervals along the sidewalls in any part of the shored area where PCS was encountered within 10 feet of the wall. Based on the current information, this will result in a total of approximately 18 to 20 base samples from directly below the impacted soil zones and 5 to 10 sidewall samples.

Excavation will continue until confirmation testing indicates that all on-site impacted soil has been removed to levels at or below the Method A cleanup levels summarized in Table 2.

7.2 Sample Collection and Handling Procedures

Sampling and sample handling will be conducted in accordance with the Department of Ecology's *"Guidance on Sampling and Data Analysis Methods"*, Ecology Publication 94-49. Sampling will be conducted using new, factory-prepared disposable equipment and supplies; decontamination and re-use of any equipment contacting soil samples will not be allowed. Samples will be immediately chilled and held under chain of custody throughout delivery to the laboratory.

Samples will be taken in laboratory-prepared sample containers appropriate for the intended analyses. Soil samples subject to analyses for gasoline range organics and other volatile organic compounds will be taken following EPA Method 5035A to reduce volatilization. Samples for other analyses will be taken in laboratory-prepared 4 oz. glass jars with Teflon lined lids.

7.3 Laboratory Data Requirements

All laboratory analyses will be conducted following appropriate quality assurance/quality control procedures by a Washington State accredited laboratory. Laboratory testing will be conducted following methods specified in WAC Chapter 173-340-830 (3). Analyses will be conducted with reporting limits appropriate for direct comparison to regulatory criteria.

7.4 Final Documentation

The remedial action will be documented in final reports that summarizes the work conducted for cleanup, the conditions encountered during confirmation groundwater monitoring, the volume of soil and groundwater removed for treatment or disposal, the final conditions of the property and the tabulated results of all progress and final confirmation sampling. Copies of all laboratory analytical reports and truck weight tickets will be included as part of the final report. If groundwater compliance monitoring is completed before the excavation phases of the project are complete, that aspect of the cleanup may be reported separately, to expedite review. All reports will be suitable for submittal to the Department of Ecology in support of the VCP review and a request for a No Further Action determination.

8.0 CLOSURE

8.1 Limitations

This work plan was prepared for the exclusive use of Centric Partners LLC, their agents, assigns and lenders, specifically to address the current conditions of this property. WES will not be responsible for the interpretation of its data or conclusions by others. WES obtained, reviewed, and evaluated information available from the property owner, other consultants, and local, state, or federal agencies. WES's conclusions, opinions, and recommendations are based, in part, on this information. Where possible, WES has made efforts to identify mistakes or insufficiencies in the information provided, but verification of all of the information provided is beyond the scope of this work plan.

WES does not guarantee that the site is free of hazardous or potentially hazardous materials or conditions, or that latent or undiscovered conditions will not become evident in the future. This report represents the professional opinions and judgements of WES, prepared in accordance with commonly practiced environmental assessment and remediation procedures. No other warranties, representations, or certifications are made. No environmental assessment can wholly eliminate uncertainty regarding the potential for recognized environmental conditions in connection with a property. Environmental conditions and regulations are subject to constant change and reinterpretation. Current conditions or regulatory status should not be assumed to represent conditions at some future time.

8.2 Signature of Environmental Professional

Whitman Environmental Sciences has been pleased to be of service in this matter. If you have any questions regarding the information contained in this report, or if we may be of any further assistance, please feel free to contact me.

Respectfully submitted,
Whitman Environmental Sciences

Daniel S. Whitman, LG
Principal

State of Washington
889
Licensed Geologist
DANIEL S WHITMAN

9.0 REFERENCES

Prior Environmental Studies:

AEG, 2014 - Associated Environmental Group, Inc., Phase II Environmental Site Assessment, Conducted on 12th Avenue Parking Lot, 110 & 124 12th Avenue, Seattle, Washington, AEG Project No. 14-142, November 14, 2014

Farallon, 2016 – Farallon Consulting, Phase I Environmental Site Assessment Report, 12th & Yesler Property, 104-108 12th Avenue and 1206 Yesler Way, Seattle, Washington, Farallon Project No. 1200-003, January 4, 2016.

Washington State Department of Ecology, 1994. Early Notice Letter, T&D Auto Body& Repair, 1209 E. Fir Street, Seattle, Washington, September 22, 1994.

Washington State Department of Ecology, 2001. Site Hazardous Assessment, TD Auto Body & Repair, Ecology Facility ID: 2501, September 11, 2001.
Repair, Ecology Facility ID: 2501, September 11, 2001.

WES, 2017 - Whitman Environmental Sciences, Phase I & II Environmental Site Assessment, Potential Redevelopment Property, 104-124 12th Avenue & 1209 E. Fir Street Seattle, Washington 98122 (Project No. WES-1591)

WES, 2017a - Whitman Environmental Sciences, Additional Off-Site Environmental Site Investigation, 104-124 12th Avenue & 1209 E. Fir Street Seattle, Washington 98122 (Project No. WES-1591)

WES, 2018 - Whitman Environmental Sciences, June-July 2018 Groundwater Monitoring Results, 104-124 12th Avenue & 1209 E. Fir Street, Seattle, Washington, August 22, 2018, Amended February 20, 2019.

Geotech, 2017 - Geotech Consultants, Inc., Preliminary Geotechnical Engineering Study, Proposed Mixed-Use Building, 104, 110, and 124- 121h Avenue, Seattle, Washington, August 2, 2017, Project JN17357.

Geotech, 2018 - Geotech Consultants, Inc., Geotechnical Engineering Study Addendum and Correction Response, Proposed Mixed-Use Building, 104, 110, and 124- 121h Avenue, Seattle, Washington, December 7, 2018, Project JN17357.

Regulations and Guidance Documents

Model Toxics Control Act Cleanup Regulation WAC Chapter 173-340

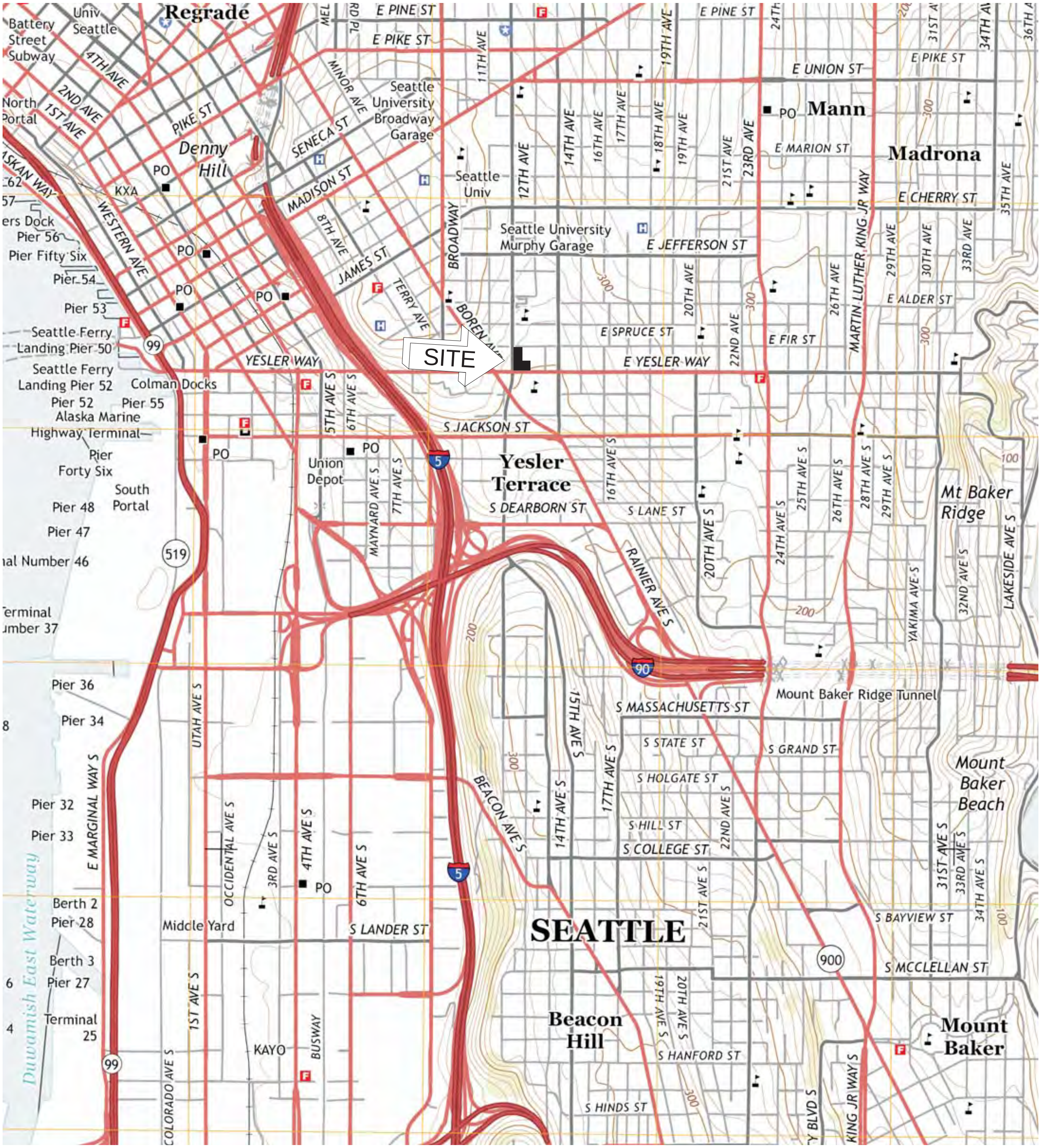
“Guidance for Remediation of Petroleum Contaminated Soil
WDOE Publication #10-09-057, Revised June 2016

"Guidance for Site Checks and Site Assessments for Underground Storage Tanks"
WDOE Publication #90-52.

"Guidance on Sampling and Data Analysis Methods", WDOE Publication No 94-49, 1995

Technical Memorandum #5 – "Collecting and Preparing Soil Samples for VOC Analysis", WDOE Publication 04-09-087

FIGURES



North

0 2000'

Scale 1 : 24,000

From USGS

Figure 1 - Site Map

104-124 12th Avenue & 1209 E. Fir Street
Seattle, Washington 98122

Project No.	WES - 1591
Date	June 11, 2017
File ID.	1591F1

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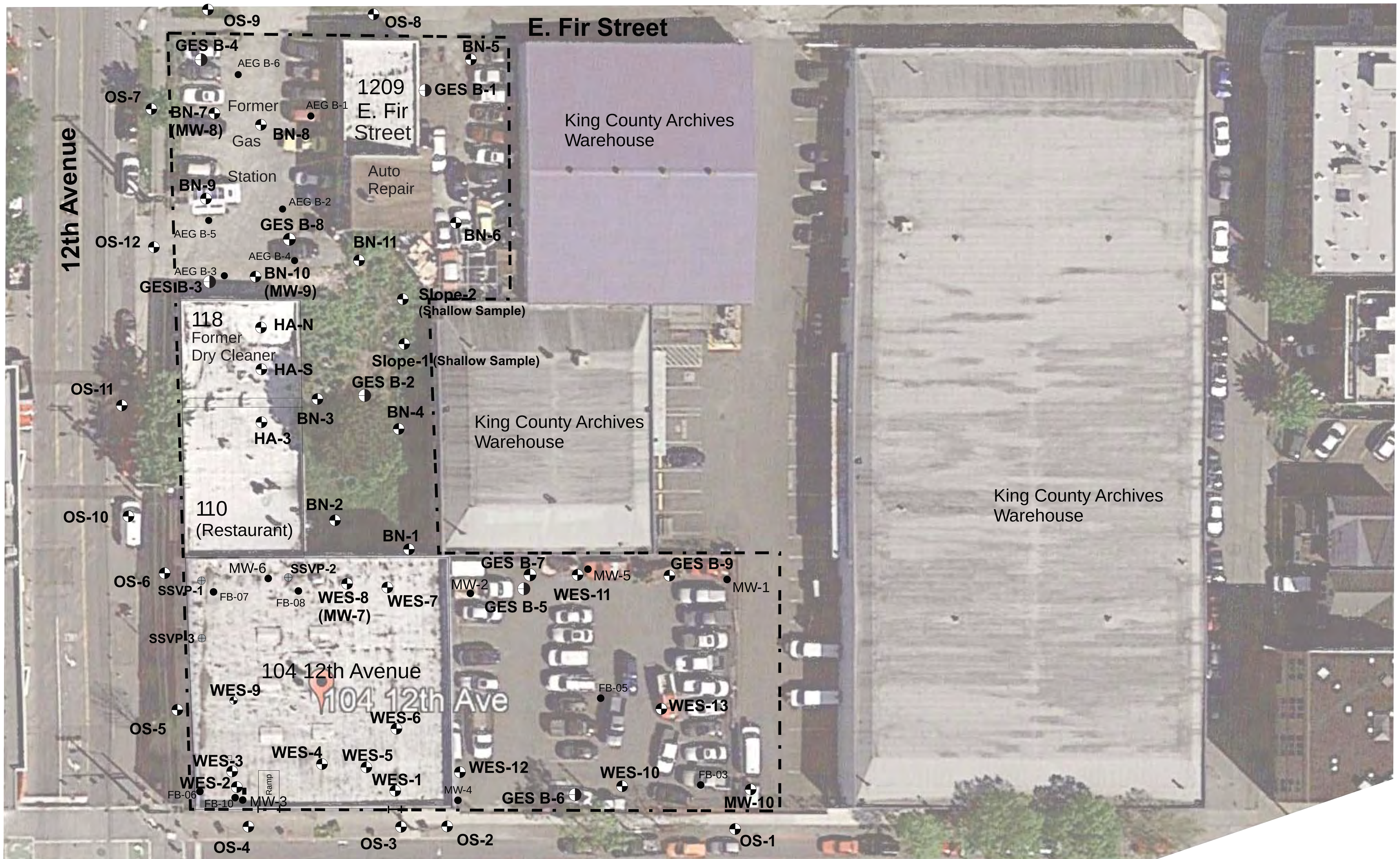

Legend

- Approximate Location of Current Environmental Soil Boring or Monitoring Well
- Approximate Location of Current Geotechnical Soil Boring (Limited Data)
- Approximate Location of Sub-Slab Soil Vapor Sample
- Approximate Location of Previously Drilled Soil Boring or Monitoring Well (2014-16, Limited Data)

Approximate Property Boundary

North

0 40'
Scale 1" = Approx. 40 feet

Figure 2 - Site Plan

Proposed Redevelopment Property
104-124 12th Avenue & 1209 E. Fir Street
Seattle, WA

Project No.	WES - 1591A
Date	Jan 20, 2019
File ID.	1591AF2

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North

0 40'

Scale 1" = Approx. 40 feet

Legend

Planned Elevations of Ground Surface or Structure

Development Plan from Clark Barnes Architects, 2019

Figure 3 - Proposed Redevelopment Plan

Proposed Redevelopment Property
104-124 12th Avenue & 1209 E. Fir Street
Seattle, WA

Project No.	WES - 1591
Date	Jan 15, 2019
File ID.	1591AF3

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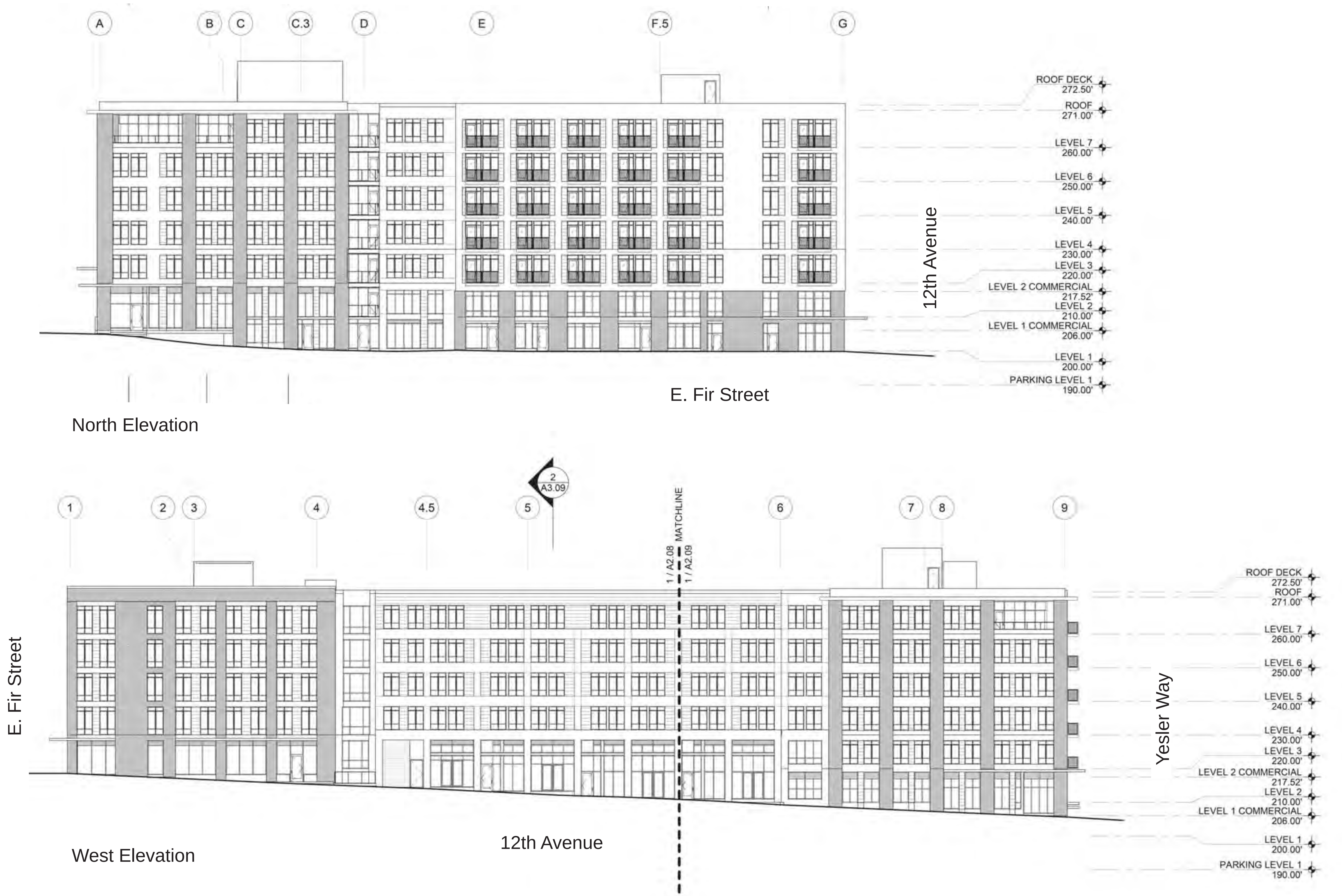

Development Plan from Clark Barnes Architects, 2019

Figure 4 - Proposed Redevelopment Elevations

Proposed Redevelopment Property
104-124 12th Avenue & 1209 E. Fir Street
Seattle, WA

Project No.	WES - 1591A
Date	Jan 15, 2019
File ID.	1591AF4

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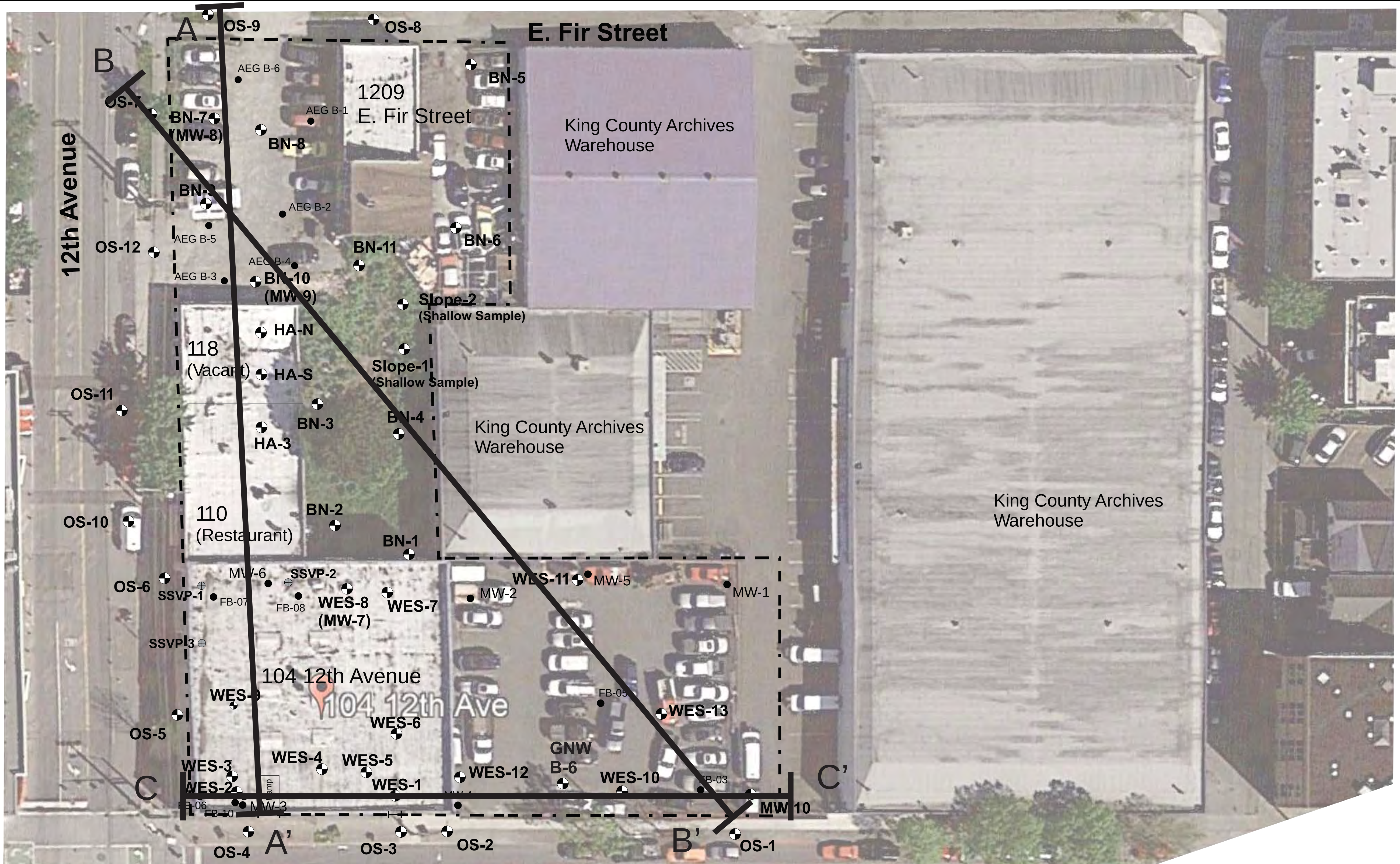


Legend

- Approximate Location of Current Soil Boring or Monitoring Well
- Approximate Location of Previously Drilled Soil Boring or Monitoring Well (2014-16)
- Approximate Location of Current Sub-Slab Soil Vapor Sample
- Approximate Property Boundary

North

0 40'

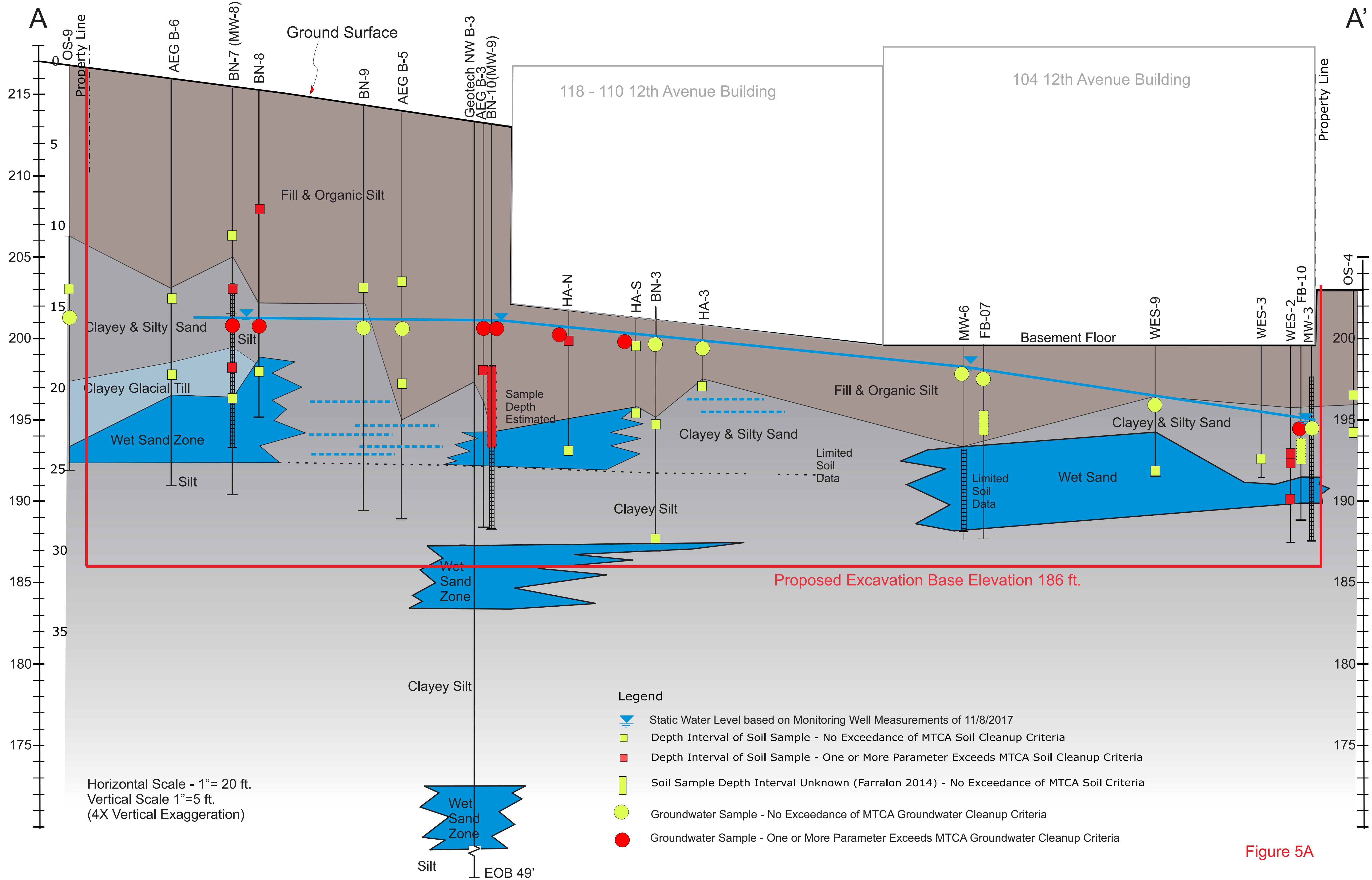
Scale 1" = Approx. 40 feet

Figure 5 - Cross Section Orientation Plan

Proposed Redevelopment Property
104-124 12th Avenue & 1209 E. Fir Street
Seattle, WA

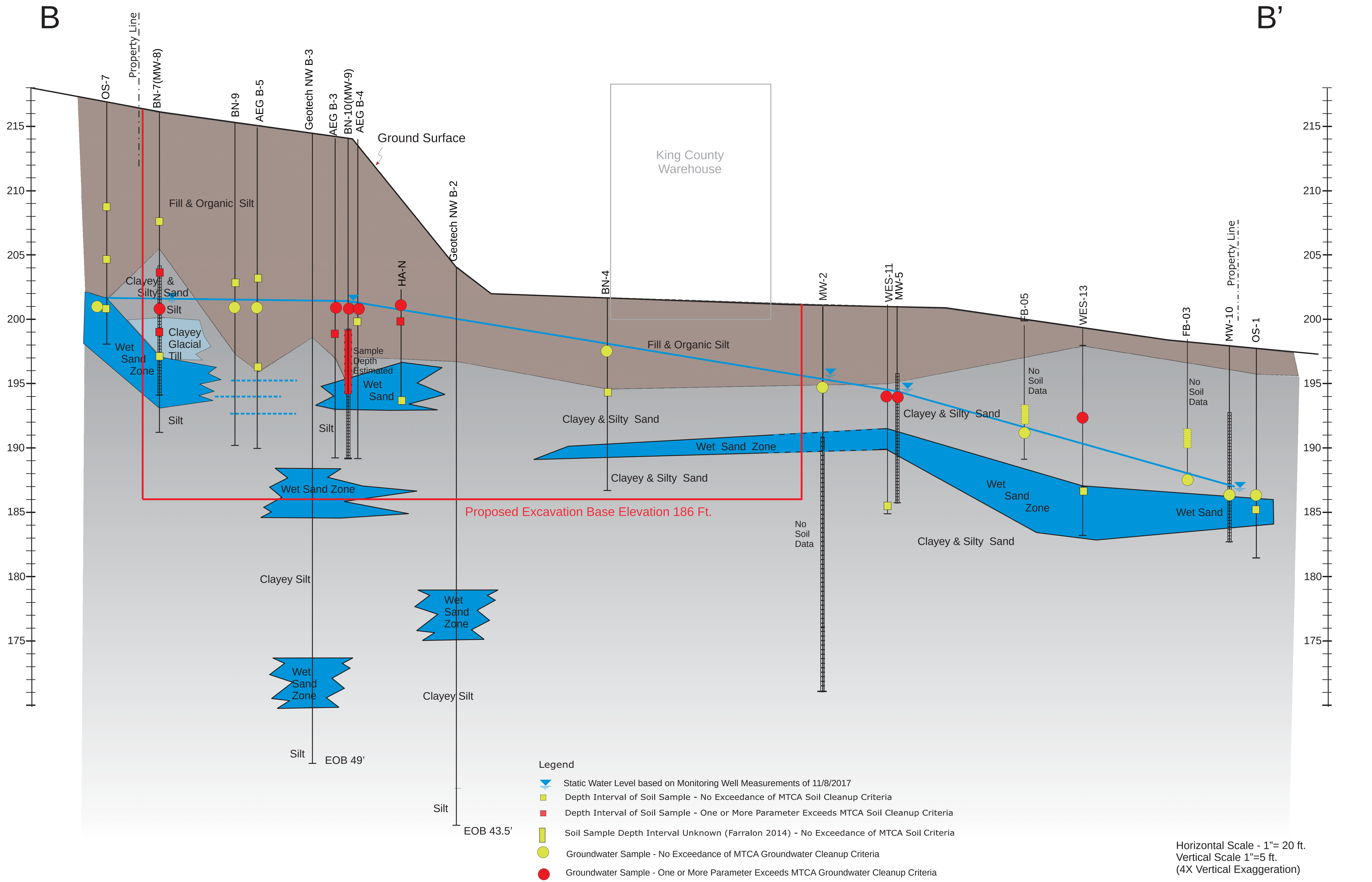
Project No.	WES - 1591
Date	Aug 15, 2017
File ID.	1591F5

WHITMAN
Environmental Sciences



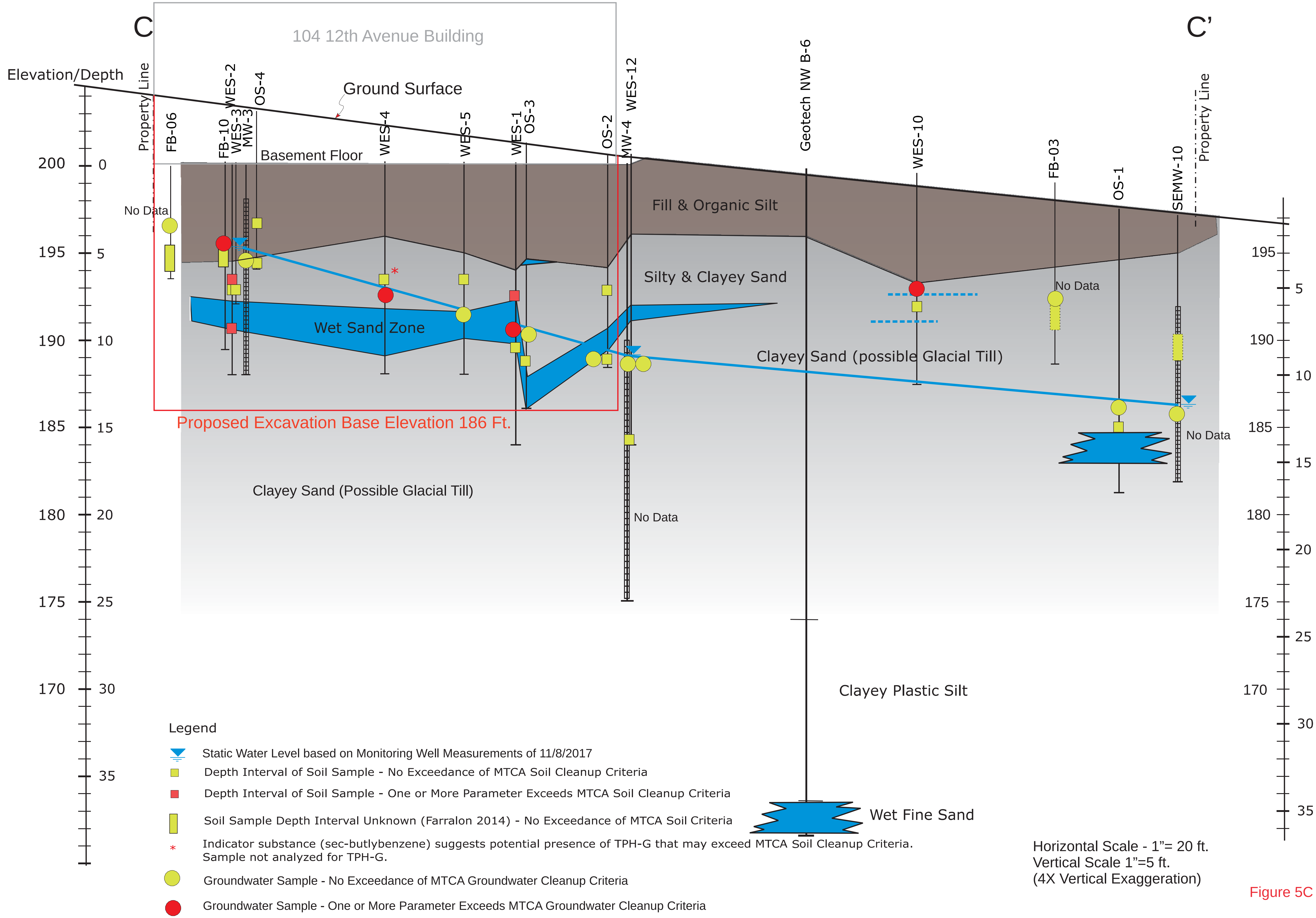
A
A'
Ground Surface
OS-9
Property Line
AEG B-6
BN-7 (MW-8)
BN-8
BN-9
AEG B-5
Geotech NW B-3
AEG B-3
BN-10(MW-9)
118 - 110 12th Avenue Building
104 12th Avenue Building
Property Line
Fill & Organic Silt
Clayey & Silty Sand
Silt
Clayey Glacial Till
Wet Sand Zone
Silt
Sample Depth Estimated
HA-N
HA-S
BN-3
HA-3
Clayey & Silty Sand
Limited Soil Data
Clayey Silt
MW-6
FB-07
Basement Floor
WES-9
WES-3
WES-2
FB-10
MW-3
OS-4
Fill & Organic Silt
Clayey & Silty Sand
Limited Soil Data
Wet Sand
Wet Sand Zone
Proposed Excavation Base Elevation 186 ft.
Clayey Silt
Wet Sand Zone
Silt
EOB 49'
Horizontal Scale - 1"= 20 ft.
Vertical Scale 1"=5 ft.
(4X Vertical Exaggeration)
Legend
Static Water Level based on Monitoring Well Measurements of 11/8/2017
Depth Interval of Soil Sample - No Exceedance of MTCA Soil Cleanup Criteria
Depth Interval of Soil Sample - One or More Parameter Exceeds MTCA Soil Cleanup Criteria
Soil Sample Depth Interval Unknown (Farralon 2014) - No Exceedance of MTCA Soil Criteria
Groundwater Sample - No Exceedance of MTCA Groundwater Cleanup Criteria
Groundwater Sample - One or More Parameter Exceeds MTCA Groundwater Cleanup Criteria

Figure 5A



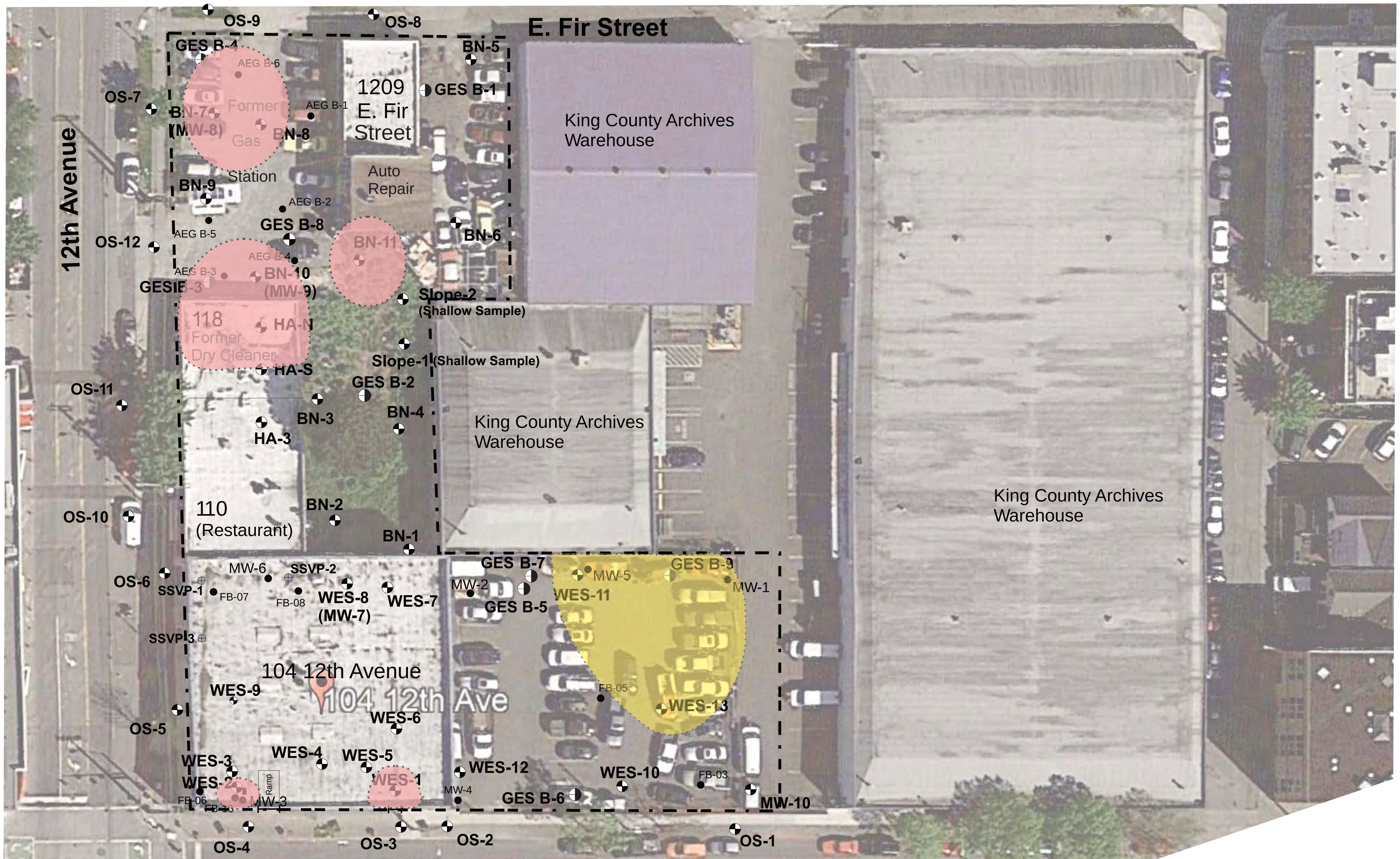
B
B'
Ground Surface
King County Warehouse
Fill & Organic Silt
Clayey & Silty Sand
Clayey Glacial Till
Wet Sand Zone
Silt
Sample Depth Estimated
Wet Sand
Wet Sand Zone
Clayey Silt
EOB 49'
EOB 43.5'
Proposed Excavation Base Elevation 186 Ft.
No Soil Data
Wet Sand
Legend
Static Water Level based on Monitoring Well Measurements of 11/8/2017
Depth Interval of Soil Sample - No Exceedance of MTCA Soil Cleanup Criteria
Depth Interval of Soil Sample - One or More Parameter Exceeds MTCA Soil Cleanup Criteria
Soil Sample Depth Interval Unknown (Farralon 2014) - No Exceedance of MTCA Soil Criteria
Groundwater Sample - No Exceedance of MTCA Groundwater Cleanup Criteria
Groundwater Sample - One or More Parameter Exceeds MTCA Groundwater Cleanup Criteria
Horizontal Scale - 1"= 20 ft.
Vertical Scale 1"=5 ft.
(4X Vertical Exaggeration)

Figure 5B



C
C'
104 12th Avenue Building
Elevation/Depth
Ground Surface
Basement Floor
Property Line
FB-06
FB-10
WES-2
WES-3
MW-3
OS-4
WES-4
WES-5
WES-1
OS-3
OS-2
MW-4
WES-12
Geotech NW B-6
WES-10
FB-03
OS-1
SEMW-10
Property Line
No Data
Fill & Organic Silt
Silty & Clayey Sand
Wet Sand Zone
Clayey Sand (possible Glacial Till)
Proposed Excavation Base Elevation 186 Ft.
Clayey Sand (Possible Glacial Till)
No Data
No Data
No Data
Clayey Plastic Silt
Wet Fine Sand
Legend
Static Water Level based on Monitoring Well Measurements of 11/8/2017
Depth Interval of Soil Sample - No Exceedance of MTCA Soil Cleanup Criteria
Depth Interval of Soil Sample - One or More Parameter Exceeds MTCA Soil Cleanup Criteria
Soil Sample Depth Interval Unknown (Farralon 2014) - No Exceedance of MTCA Soil Criteria
* Indicator substance (sec-butlybenzene) suggests potential presence of TPH-G that may exceed MTCA Soil Cleanup Criteria. Sample not analyzed for TPH-G.
Groundwater Sample - No Exceedance of MTCA Groundwater Cleanup Criteria
Groundwater Sample - One or More Parameter Exceeds MTCA Groundwater Cleanup Criteria
Horizontal Scale - 1"= 20 ft.
Vertical Scale 1"=5 ft.
(4X Vertical Exaggeration)

Figure 5C



Legend

- Approximate Location of Current Environmental Soil Boring or Monitoring Well
- Approximate Location of Current Geotechnical Soil Boring (Limited Data)
- Approximate Location of Sub-Slab Soil Vapor Sample
- Approximate Location of Previously Drilled Soil Boring or Monitoring Well (2014-16, Limited Data)
- Estimated Areas of Petroleum Contaminated Soil
- Estimated Areas of Chlorinated Solvent in Groundwater

0 40'

Scale 1" = Approx. 40 feet

North

Figure 6 - Estimated Extent of Contaminated Soil and Groundwater

Proposed Redevelopment Property
104-124 12th Avenue & 1209 E. Fir Street
Seattle, WA

Project No.	WES - 1591A
Date	Feb 15, 2019
File ID.	1591AF6

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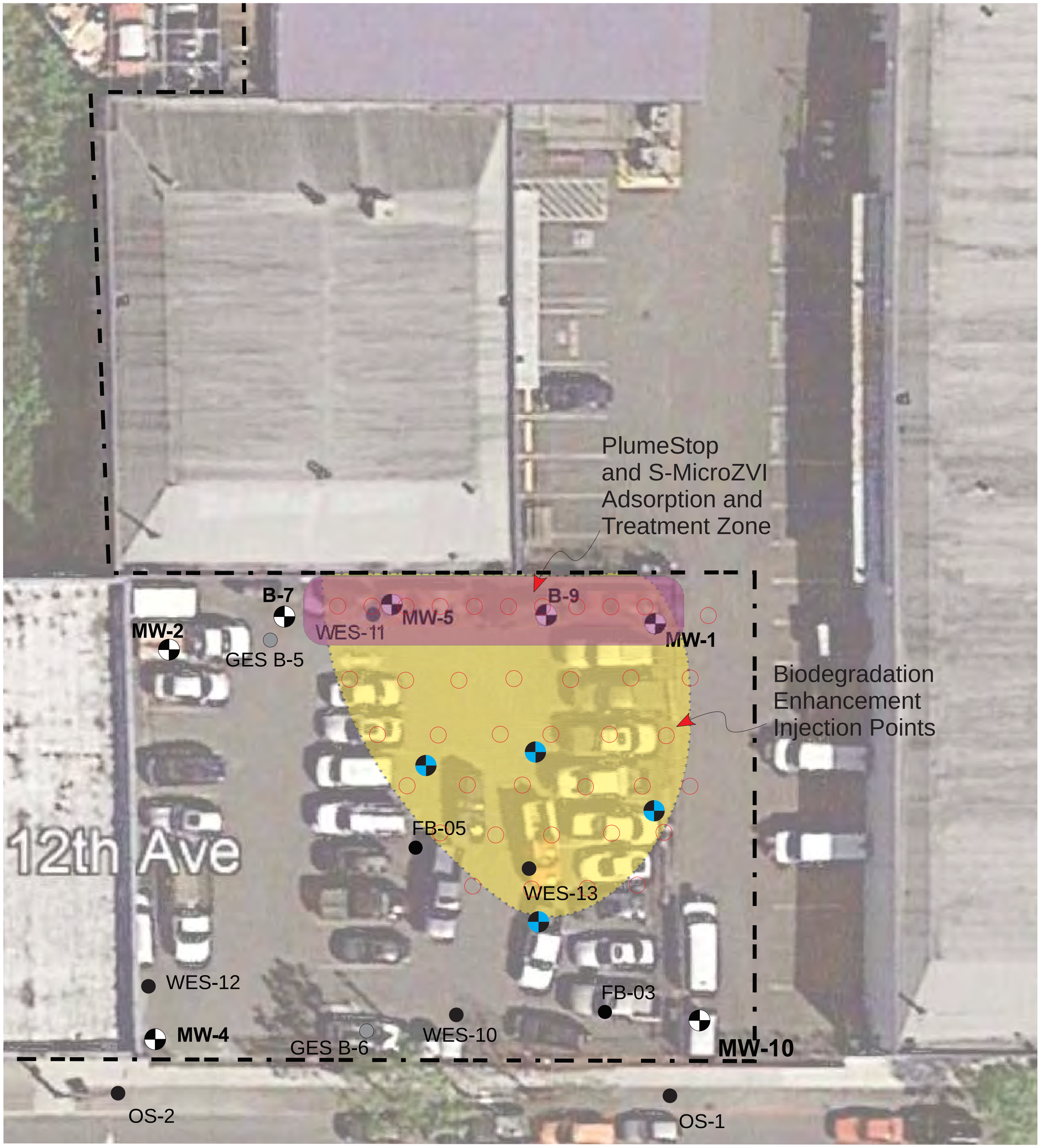

Existing Monitoring Wells

Soil Borings or Temporary Wells not Available for Monitoring

Proposed Injection Point

Proposed New Monitoring Wells

Anticipated Plume Area

Figure 7 - Proposed In-Situ Groundwater Remediation Injection Plan

Proposed Redevelopment Property
104-124 12th Avenue & 1209 E. Fir Street
Seattle, Washington

Project No.	WES - 1591
Date	Mar 9, 2019
File ID.	1591AF7

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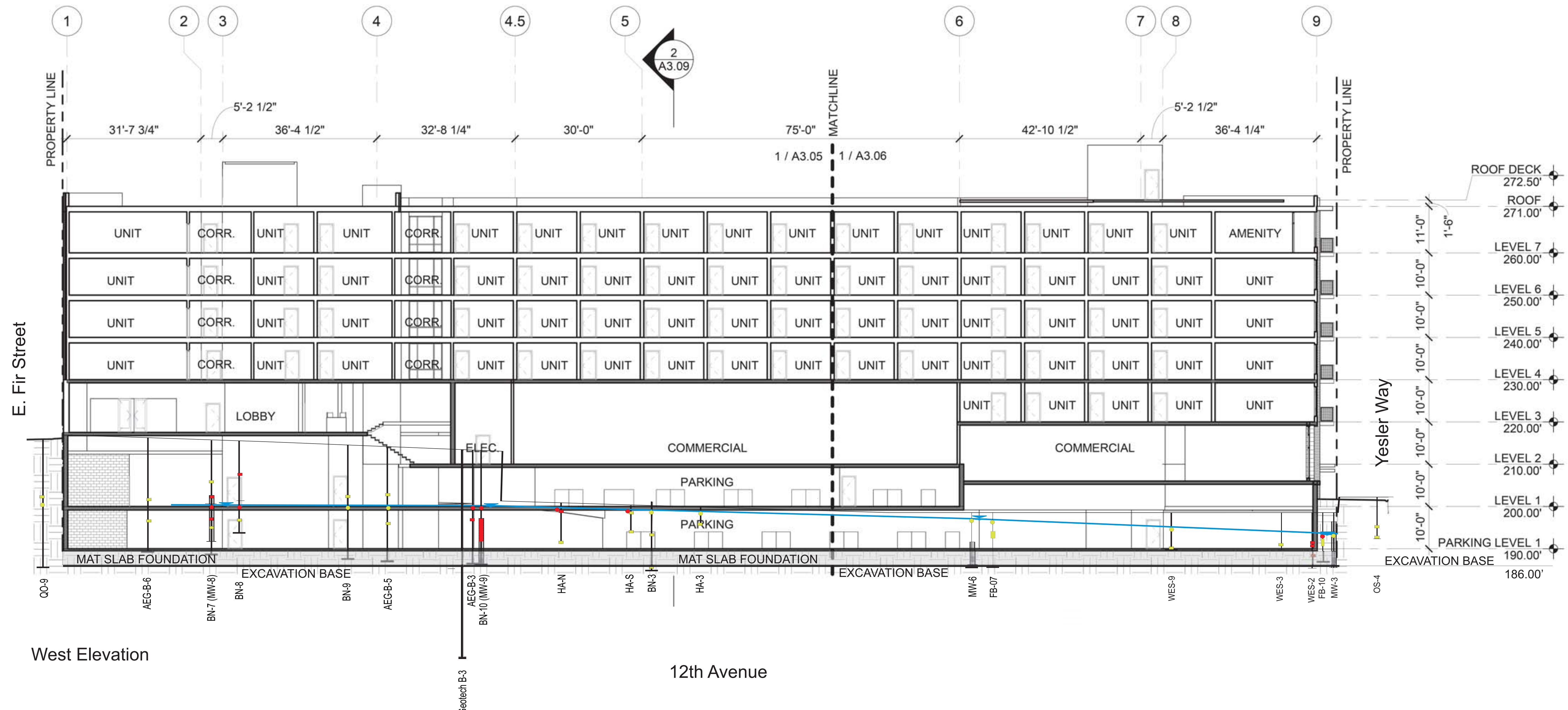
Environmental Sciences



Legend

- Static Water Level based on Monitoring Well Measurements of 11/8/2017
- Depth Interval of Soil Sample - No Exceedance of MTCA Soil Cleanup Criteria
- Depth Interval of Soil Sample - One or More Parameter Exceeds MTCA Soil Cleanup Criteria
- Soil Sample Depth Interval Unknown (Farralon 2014) - No Exceedance of MTCA Soil Criteria
- Groundwater Sample - No Exceedance of MTCA Groundwater Cleanup Criteria
- Groundwater Sample - One or More Parameter Exceeds MTCA Groundwater Cleanup Criteria

Development Plan from Clark Barnes Architects, 2019

Figure 8 - Proposed Redevelopment Elevation with Soil and Groundwater Data

Proposed Redevelopment Property
104-124 12th Avenue & 1209 E. Fir Street
Seattle, WA

Project No.	WES - 1591A
Date	Jan 15, 2019
File ID.	1591AF8

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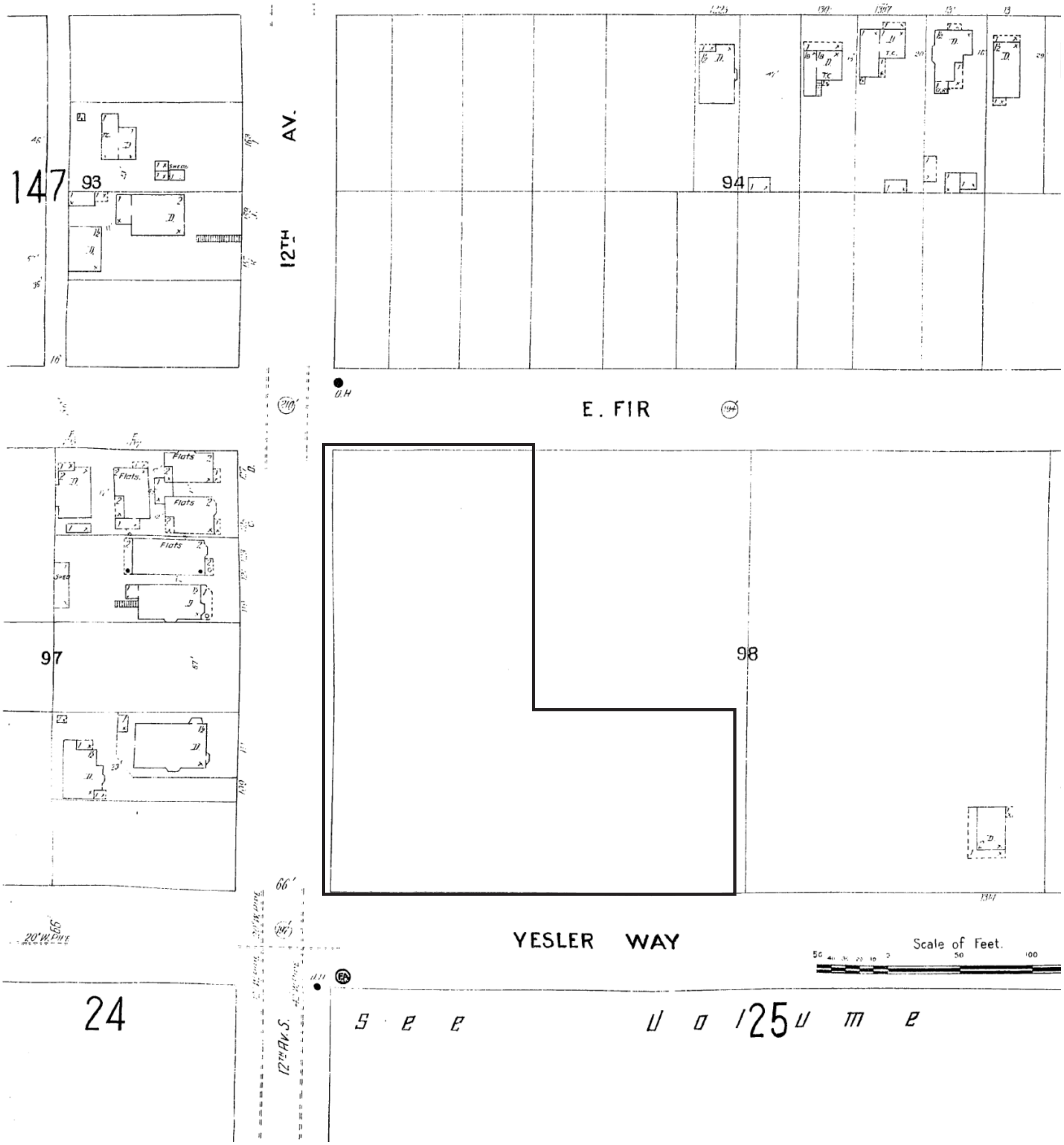
Environmental Sciences

APPENDIX A
Historical References and Aerial Photographs



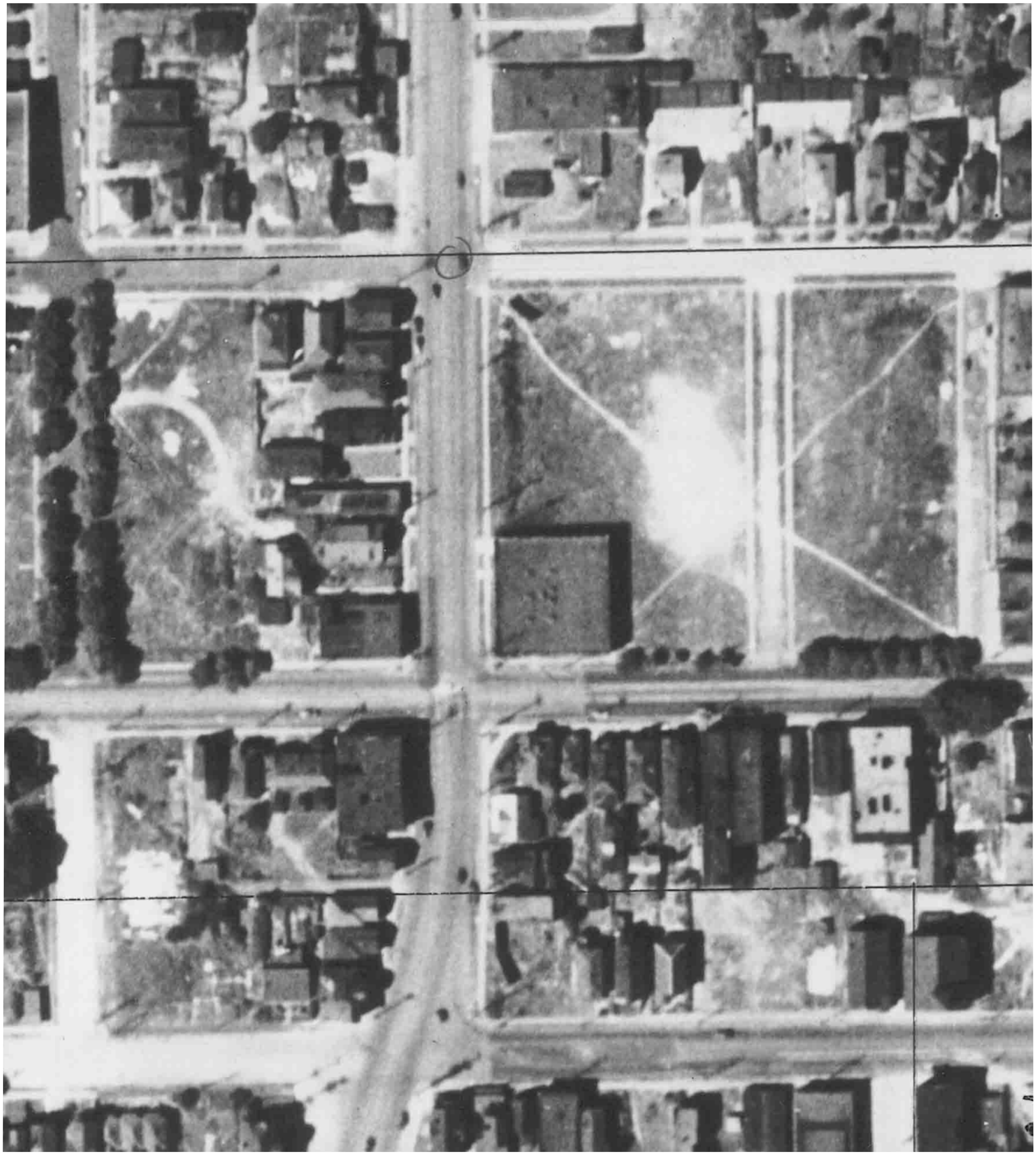
From Seattle Public Library

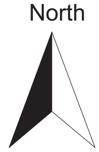
Historical Sanborn Map - 1905

104-124 12th Avenue & 1209 E. Fir Street
Seattle, Washington 98122

Project No.	WES - 1591
Date	Mar 11, 2017
File ID.	1591SM05

WHITMAN
Environmental Sciences





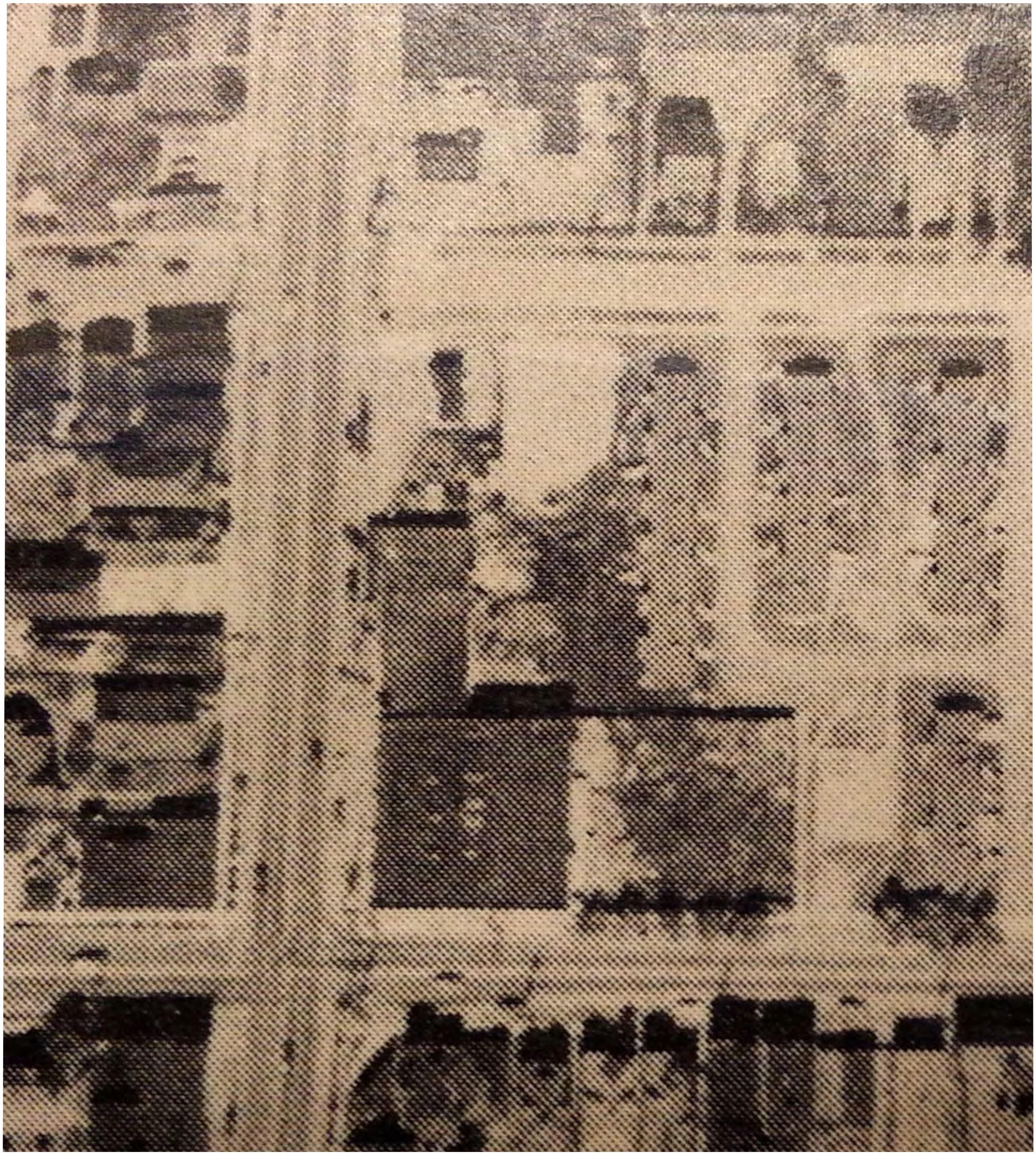
From King County Map Vault

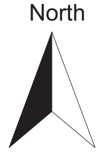
Historical Aerial Photograph - 1937

104-124 12th Avenue & 1209 E. Fir Street
Seattle, Washington

Project No.	WES - 1591
Date	Jun 20, 2017
File ID.	1585AP37

WHITMAN
Environmental Sciences



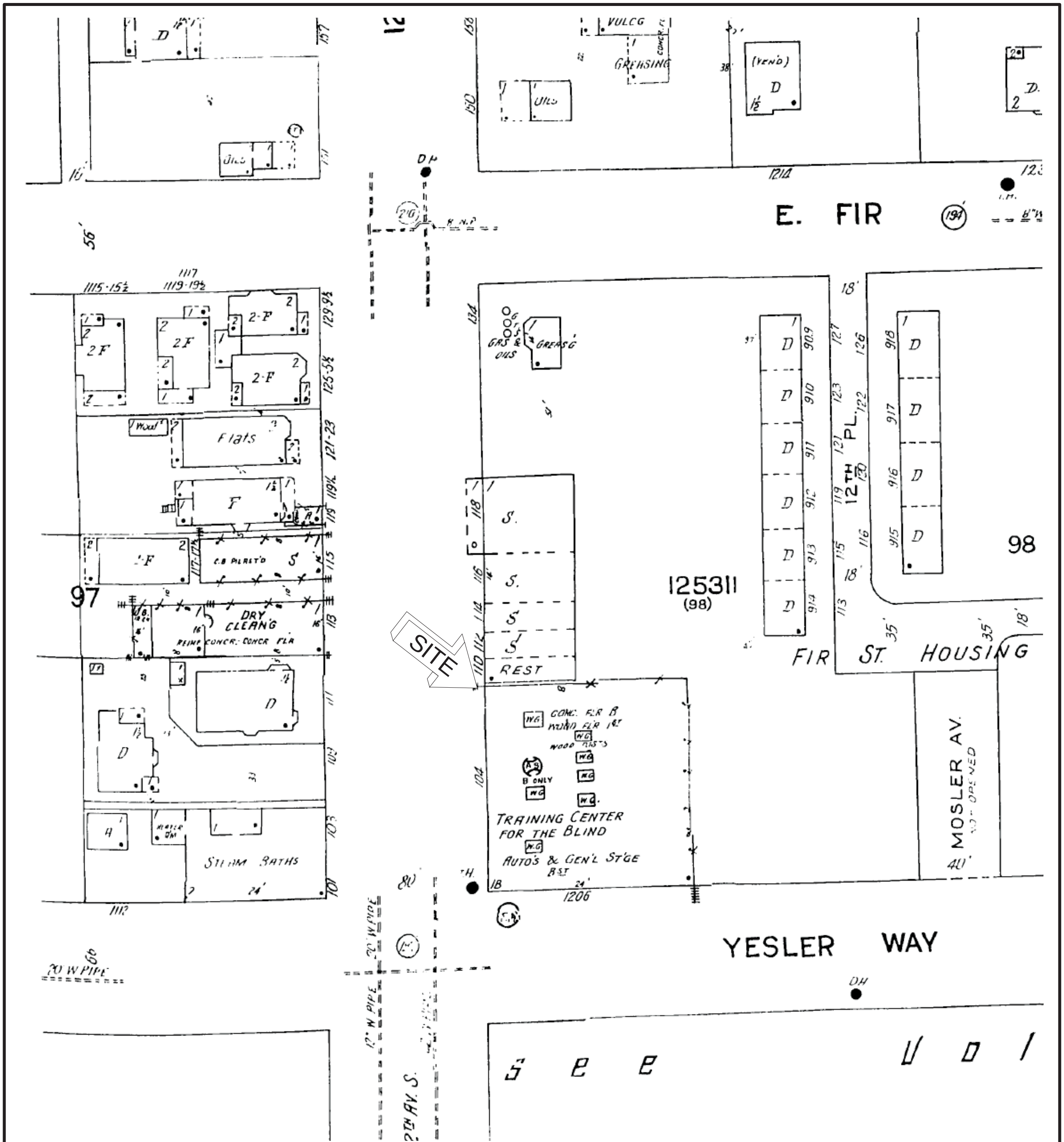


Historical Aerial Photograph - 1946

104-124 12th Avenue & 1209 E. Fir Street
Seattle, Washington

Project No.	WES - 1591	WHITMAN Environmental Sciences
Date	Jun 20, 2017	
File ID.	1591AP46	

From UW Suzzallo Library Collection



North

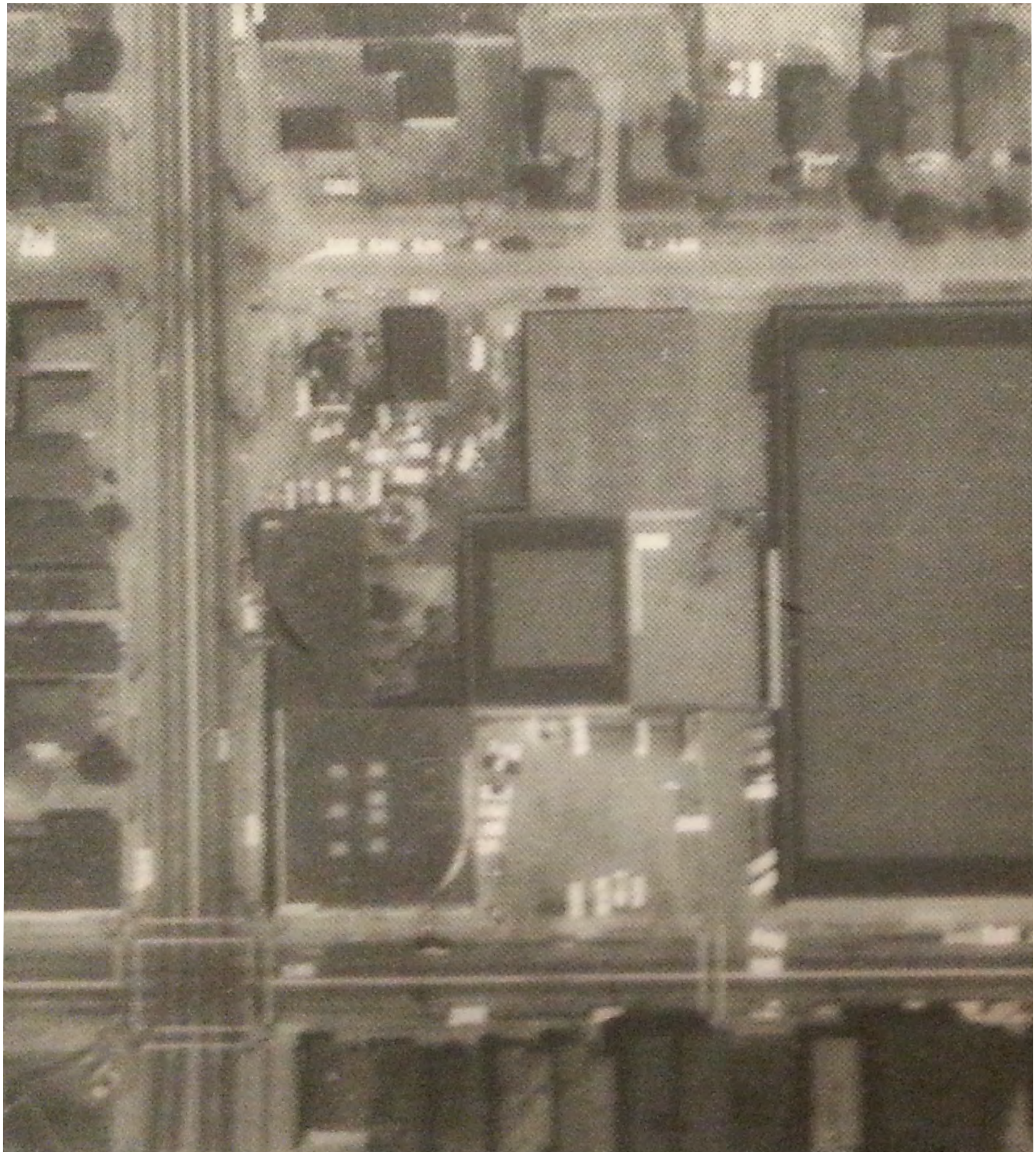
Historical Sanborn Map - 1950

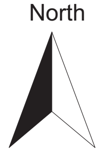
104 12th Avenue
Seattle, Washington 98122

Project No.	WES - 1591
Date	Mar 11, 2017
File ID.	1591SM50

WHITMAN
Environmental Sciences

From Seattle Public Library





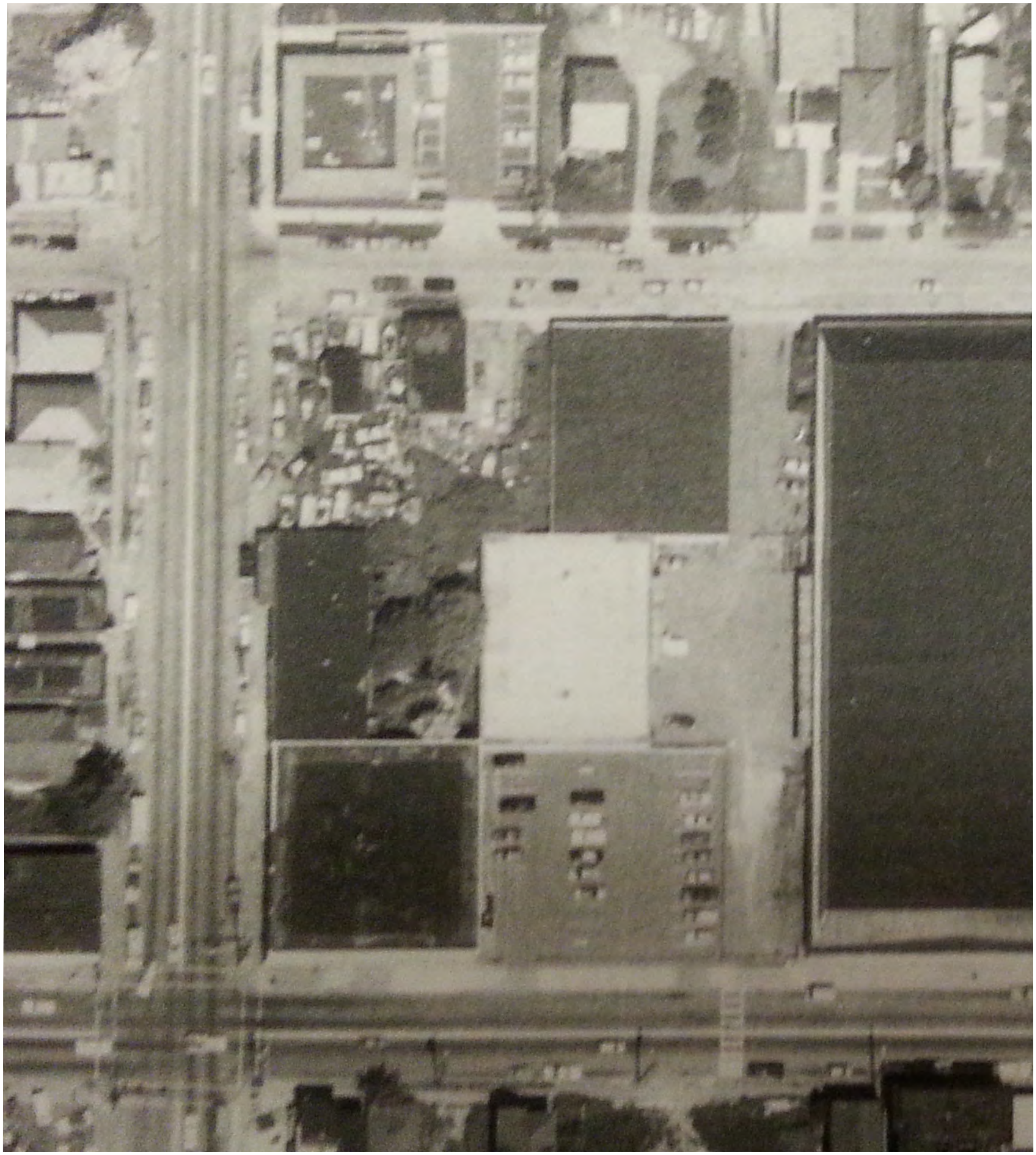
Historical Aerial Photograph - 1965

104-124 12th Avenue & 1209 E. Fir Street
Seattle, Washington

Project No.	WES - 1591
Date	Jun 20, 2017
File ID.	1585AP65

WHITMAN
Environmental Sciences

From UW Suzzallo Library Collection



North

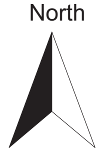
Historical Aerial Photograph - 1985

104-124 12th Avenue & 1209 E. Fir Street
Seattle, Washington

Project No.	WES - 1591
Date	Jun 20, 2017
File ID.	1591AP85

WHITMAN
Environmental Sciences

From UW Suzzallo Library Collection



From UW Suzzallo Library Collection

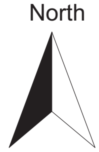
Historical Aerial Photograph - 1989

104-124 12th Avenue & 1209 E. Fir Street
Seattle, Washington

Project No.	WES - 1591
Date	Jun 20, 2017
File ID.	1591AP89

WHITMAN
Environmental Sciences

North



Historical Aerial Photograph - 1995

104-124 12th Avenue & 1209 E. Fir Street
Seattle, Washington

Project No.	WES - 1591
Date	Jun 20, 2017
File ID.	1591AP95

WHITMAN
Environmental Sciences

From UW Suzzallo Library Collection

Historical King County Assessor Records

el
ec
Total
DIMENSIONS | SQ. FT. AREA

SC. BARS, Etc.	ELEVATORS	DOCKS AND PIERS	WIRING
HOISTS			

DIMENSIONS 100 x 100 x


A.K.
11-7-58
F2393
STRUVE'S
5-24-4 B-1 L-5+6
106-08 12th AVE
1
IGA FOODS
IGA FOODS
IGA FOODS
PARKING


H.C.S
10-30-64
T-2393
Struves Add
5-24-4 B.1 L 5+6
106-08-12th Ave
5.
2

3-16-71
H.H.

FOLIO 2393

PERMIT NO.

DATE

FM-1 3-20-71 20X40 OFF. REM-SEAL

M1-0055

ADDITION STRUVES

Section N.E.5 Twp 24 Range 4 EWM. Block 1 Lot or 5&6

Tax Lot ____ Tract ____

Address 106-08 — 12th AVE

FOR REFERENCE ONLY

Fee Owner RALPH CAPELUTO

Zoning ____ Condition of Exterior A Interior F Foundation A Floor Plan: Good ____ Accept. ____ Poor ____

Architect ____ Contractor ____

USE ~~MFG & GROCERY~~

1	No. Stories
1	No. Stores
5	No. Rooms
	Basement
	No. Offices Unit Sq. Ft.
	No. Apartmts.
	1 rm. ☐ 2 rm. ☐ 3 rm.
	4 rm. ☐ 5 rm. ☐ 6 rm.

ROOF CONSTRUCTION

X	Frame-Joist
	Mill-Deck
	Rein. Conc. ____ GLB
	Steel Fr. ____ Metal Deck
	Trusses ____ Span
	Wood ____ Steel

FLOOR FINISHES

REM	Fir	☐	Maple
	Oak	☐	2x6TG
	Lino	☐	3x6TG
	Cement	☐	Lgtwgt. Conc.
	Terrazzo		
40% or	Asphalt Tile	☐	Vinyl Tile

☐ Tile ☐ Lino ☐ Form.

	Bath Floor
	Bath Walls
	Tub Recess
	Drain Bds.
	Vanities

PLUMBING

17	No. Fixtures
7	Toilets ____ Urinals
	Tubs Leg. or Pem.
7	Basins ____ Dr. Ftns.
2	Sinks
	Washers ____ Dryers
	Showers (tub) (stall)
1	H.W. Tanks ____ Ldy. Trays
	D-Washers ____ Disposals
WET	Sprinkler Sys. 100x100 BSMT

Date Built 1926 Date Add. Built ____ ☒ Finished ☐ Unfinished ☐ Remodeled

Effective Age 44 Years Future Life ____ Years

Dep. for Cond. ____ Dep for Ob. ____ Dep. for Es. ____ Total ____

FACTOR | ITEM | DIMENSIONS | SQ. FT.

TYPE OF CONSTRUCTION

	Frame
	Metal-Prefab
X	Ordinary Masonry
	Mill Construction
	Class A Rein. Conc.
	Stru. Steel and Conc.
	Struct. Steel, Frame

QUALITY-TYPE

...od Med. X Cheap

...UNDATION

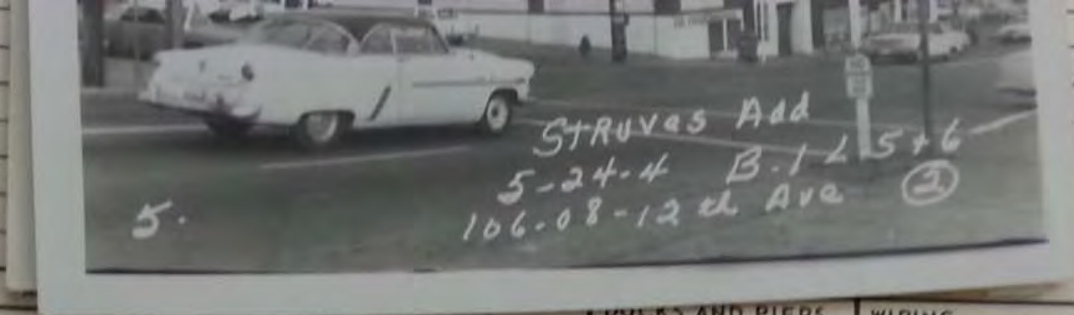
	Mud Sill ☐ Post Pier
X	Conc. ☐ Brick
	Load Hgt. ☐ Piling

...EMENT 60X100 - S-C

HEATING 100% St. + 60X10...

	Elec. ____ Oil ____ X Gas
	H.W. ____ X St. ____ H.A.
	B.Bd. ____ Suspended
	FHA ____ Pipeless
	A. Cond. ____ Wall Unit
	Comb. Unit ____ Custom
	Refrig. ____ Convector
	Heat Pump ____ Fireplace

YEAR	ASSESSED VALUE



Mud Sill ☐ Post Pier
X Conc. ☐ Brick
Load Hgt. ☐ Piling

BASEMENT 60x100 S-C [illegible]
X Full REM-SEB Part.
Sub-Basement
Size 100X100
Garage ☐ No. Cars
60x100 [illegible] SEM-CONC Floors
Plastered ☐ Pl. Bd.
No. Apartments
Service Rooms

EXTERIOR WALL CONST.
Single ☐ Double
Stud Walls
100% Brick SOLID Pil. ☐
Conc. ____ Pil. ☐
Rein. Conc. Skeleton
Str. Stl.-Frame
Pre-Fab Metal
Tilt-Up
____ Filler Wall
____ Curtain Wall

EXTERIOR FACING
Siding
100% [illegible] Stucco ____ Shakes
Marblecrete
REM Brick ☐ Veneer
Conc. ☐ Conc. Blk.

FLOOR CONSTRUCTION
Joist 2 x 12 x 16 O.C.
Mill ____ Car Deck
R-Conc. ____ Elev.
Steel ____ GLB.
or

ROOF COVERING
Blt.-Up X Tar.&Gr.

HOISTS: Elec. Hydr.
SEE OVER

INTERIOR WALLS & CEILING
X Stud X Wood Metal
X Plaster Dry Wall
Acc. Tile Celotex
Ceiled Plywood
Solid Block
Sound Proofed Lamin.
Finished Unfinished
X Painted Varnished

INSULATION UNK
Exter. ____ Partitions
Roof ____ Floor

INTERIOR TRIM
X Fir ____ Birch
Mah. ____ Oak
Metal
X Wood ____ Metal Doors
X Wood ____ Metal Sash

ELEVATORS
Pass. ____ Frght.
Auto. ____ Elec.
Man. ____ Hydr.
Doors-Auto ____ Man. ____
Escalators
Stops ____ Speed
Cap'y.

DOCKS AND PIERS
Hvy. ____ Med. ____ Lgt.
Untrtd. Pile Tmbr.
Conc. Piles & Bms.
Trtd. Pile Tmbr.
Paved
Dolphins
Deck

WIRING
Knob & Tube
Flex. Cable
X Conduit
Pwr. Wiring
Range Wiring
____ Outlets

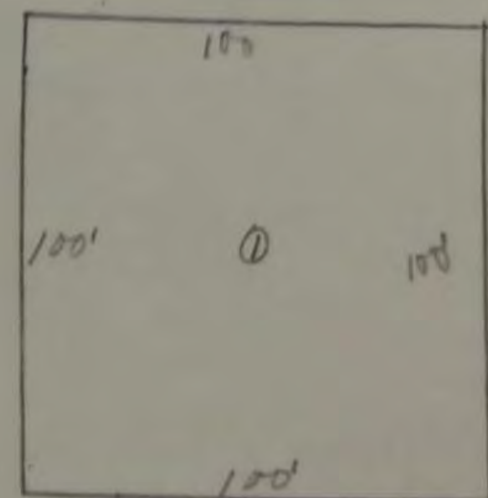
Heat Pump ____ Fireplace

YEAR	ASSESSED VALUE
	SEATTLE CURTAIN MFG. CO. + TOM BOY [illegible]

	C. Hgt.
SB	
B	12
1	12
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	

GROUND FLOOR AREA
TOTAL FLOOR AREA

HGT. 12'
1CM=20
ST. [illegible] CURTAIN



OWNER OCCUPIED
4-21-80 SEATTLE CURTAIN MFG 1st FLOOR - STORAGE & WAREHOUSING 135MT

SMALL GRO STORE TO MOVE JUNE THIS YEAR OWNER NEEDS THE SPACE RCA

BUILDING TYPE	CONSTRUCTION	SIZE	GRADE	AGE
GARAGE				
St. FR.	Wd. St.	25 L/F		

INCOME:
1St. FL. OWNER OCCUPIED. SEATTLE CURTAIN MFG.
BSMT. RENTED FOR GROCERY @ $500.= PER. MO.
3-16-71 H.H.

FOLIO 2393

PERMIT NO.

DATE

ADDITION Struves

Section ___ Twp. ___ Range ___ Ewm. Block 1 Lot or Tract 7+8 ___ Tax Lot

L. 7+8 + Por vac. St Adj.

Address 1214 Yesler Way.

Fee Owner ___ Architect ___

Condition of Exterior ___ Interior ___ Foundation ___ Floor Plan: Good ___ Accept ___ Good ___

VOID

PAV. HAS NO VALUE

USE Parking

No. Stories
No. Stores
No. Rooms
Basement
No. Offices
No. Apartments
1 rm. ☐ 2 rm. ☐ 3 rm.
4 rm. ☐ 5 rm. ☐ 6 rm.

TYPE OF CONSTRUCTION

Frame
Single ☐ Double
Ordinary Masonry
Mill Construction
Class A Rein. Con.
Stru. Steel and Con
Tile ☐ Brick
Con. ☐ Rein. Con.
Good ___ Med. ___ Cheap ___

FOUNDATION

Mud Sills
Post and Pier
Brick
Concrete
Pile

BASEMENT

Full ☐ %
Sub-Basement
Size
Garage ☐ No. Cars
___ Floors
Plastered
Living Rooms
Service Rooms

EXTERIOR WALL CONST.

Single ☐ Double

ROOF CONSTRUCTION

Frame Lam ☐
Mill Construction
Rein. Concrete
No. Trusses
Wood ☐ Steel

ROOFING MATERIAL

Tar and Gravel
Or

FLOOR FINISHES

Fir ☐ Maple
Oak ☐ 2"x6" T&G
Lino. ☐ 3"x6" T&G
Cement
Terrazzo
Rubber
Tile
Or

Tile ☐ Lino.
Baths ☐ Fl. ☐ Walls
Tile Total: Sq. Ft. ___ Floors; Sq. Ft. ___ Walls; Lin. Ft. ___ Dr. Bds.
Lino Total: Sq. Ft. ___ Floors; Sq. Ft. ___ Walls; Lin. Ft. ___ Dr. Bds.
Kit's ☐ Fl. ☐ Walls

Date Built 1954. ☐ Finished ☐ Unfinished ☐ Remodeled
Effective Age ___ Years Future Life ___ Years
Dep. for Cond. ___ Dep. for Ob. ___ Dep. for Es. ___ Total ___

REPRODUCTION COST Factor Make Up

Factor	Plus or Minus	Dimensions	S. F. Area	Factor	Cost
$	Asphalt Paving	100 x 120	12000	$ .10	$ 1200
		x			$
		x			$
		x			$
		Pch. x			$
		Pch. x			$

no Per

Total ___ $
Less Depreciation ___ $
Total ___ $
Other Buildings ___ $
Total Value (Full) ___ $
Assessed Valuation 50% ___ $

PLUMBING

No. Fixtures
Toilets
Tubs, Leg or Pem.
Basins, Ped.
Sinks
Urinals
Showers (Tub) (Stall)
Laundry Trays
H. W. Tank Fl. Drains ☐
Sprink. Sys. No. ___ Hds.

HEATING

Stove
Pipeless Furnace
Gravity H. A.
Air Cond., Fan
Suspended Gas, Hot Water
Steam Heat
Hot Water
Oil Burner

Year	Assessed Value
1956	~~600~~ K55
'71	1200.

TANKS, ETC., LIST

Hoists: Elec. ___ Hyd. ___

ELEVATORS

Pass. ☐ Freight
Auto. ☐ Elec.
Man. ☐ Hyd.
☐ Man.

DOCKS AND PIERS

Treated Piles, Timb
Untreated
Treated Piles only
Average Length
Paved

WIRING

Knobs & Tube
Flex. Cable
Conduit
Power Wiring
Range Wiring
No. Outlets

INTERIOR WALLS

C. H.

GROUND FLOOR AREA 12000

Mud Sills
Post and Pier
Brick
Concrete
Pile

Pch. x
Pch. x

Total $
Less Depreciation $
Total $
Other Buildings $
Total Value (Full) $
Assessed Valuation 50% $

no Pix

Oil Burner

Year	Assessed Value
1956	-600- R55
'71	1200.

BASEMENT

Full % Sub-Basement Size Garage No. Cars Floors Plastered Living Rooms Service Rooms

TANKS, ETC., LIST

Hoists: Elec. Hyd.

ELEVATORS

Pass. Freight Auto. Elec. Man. Hyd. Man.

DOCKS AND PIERS

Treated Piles, Timb. Untreated Treated Piles only Average Length Paved

WIRING

Knobs & Tube Flex. Cable Conduit Power Wiring Range Wiring No. Outlets

EXTERIOR WALL CONST.

Single Double 2" x 4" Stud Walls 2" x 6" Stud Walls Brick Walls Brick with Pilasters Concrete Walls Con. with Pilasters Tile Walls Rein. Con. Skel. Filler Walls Laminated Walls

INTERIOR WALLS

Stud and Plaster Lam. Plastered Plywood Ceiled Plaster Board Painted Stain Varnish Kalsomine Whitewashed Unfinished

C. H.

B 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

VOID

GROUND FLOOR AREA 12000

TOTAL FLOOR AREA

I.G.A. PARKING LOT.

EXTERIOR FACING

Siding Shingles Shakes Stucco Brick Veneer Kind Stone Cast S. Terra Cotta Struct. Glass Trim

INTERIOR TRIM

Fir Mah. Oak Metal Doors Windows Stained Varnished Painted Unfinished

FLOOR CONSTRUCTION

Joist Con. Size x
O.C. In Bridg.
Mill Construction
Rein. Con.

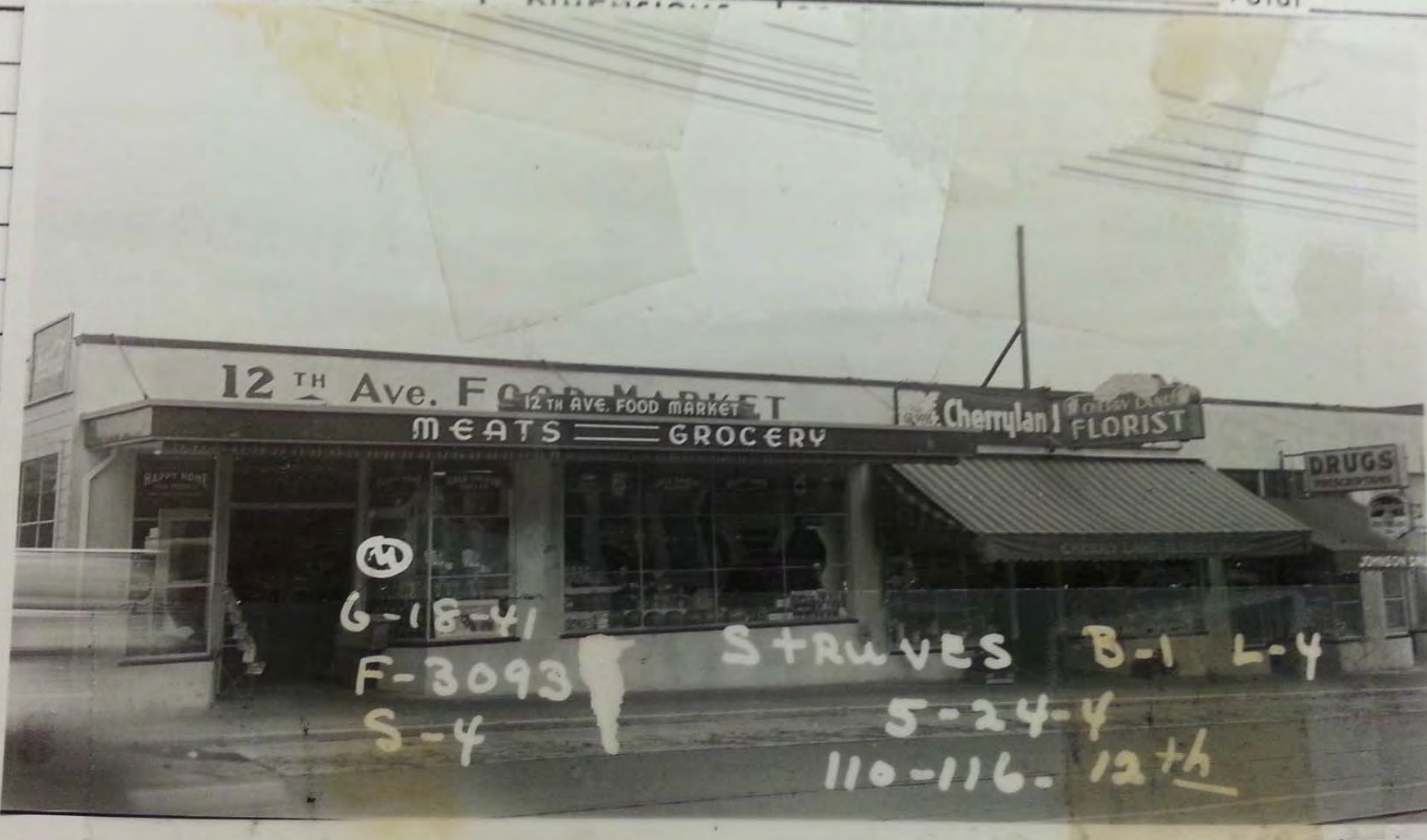
Other Buildings	Construction	Floor	Roof	Stories	Dimensions	S. F. Area	Factor	Value	% Dep.	Deprec.	Net Value
Garage					x			$		$	$
					x			$		$	$
					x			$		$	$
					x			$		$	$

Unfinished | Remodeled

tive Age 30 Years | Future Life ______ Years

for Cond. ______ Dep for Ob. ______ Dep. for Es. ______ Total ______

TOR | ITEM



ASSESSED VAL.

C. TANKS, Etc.	ELEVATORS		DOCKS AND PIERS		WIRING	
OISTS: Elec. Hydr.		Pass. Frght		Hvy Med Lat		Knob & Tube

RVI150-18

.15

3-15-71 HH

FOLIO 2393

PERMIT NO. 339705

DATE

51-B 3-26-71 on

100% S-C

ADDITION Struves ADD 0015

NE Section 5 Twp 24 Range 4 EWM. Block 1 Lot or 3-4

Tax Lot ___ Tract ___

FOR REFERENCE ONLY

Address 110-116 12th Ave.

Fee Owner ___

Zoning ___ Architect ___ Contractor ___

Condition of Exterior F Interior F Foundation A Floor Plan: Good ___ Accept. ___ Poor ___

USE STORES

1	No. Stories
5	No. Stores
8	No. Rooms
	Basement
	No. Offices
	No. Apartmts.

Unit Sq. Ft.

1 rm. ☐ 2 rm. ☐ 3 rm. ☐ 4 rm. ☐ 5 rm. ☐ 6 rm. ☐

ROOF CONSTRUCTION

X	Frame-Joist
	Mill-Deck
	Rein. Conc. ___ GLB
	Steel Fr. ___ Metal Deck
	Trusses ___ Span
	Wood ___ Steel

FLOOR FINISHES

REM	Fir	☐	Maple
	Oak	☐	2x6TG
10%	Lino	☐	3x6TG
	Cement	☐	Lgtwgt. Conc.
	Terrazzo		
40%	Asphalt Tile	☐	Vinyl Tile
or			

☐ Tile ☐ Lino ☐ Form.

	Bath Floor
	Bath Walls
	Tub Recess
	Drain Bds.
	Vanities

PLUMBING

10	No. Fixtures
5	Toilets ___ Urinals
	Tubs Leg. or Pem.
	Basins ___ Dr. Ftns.
5	Sinks
	Washers ___ Dryers
	Showers (tub) (stall)
	H.W. Tanks ___ Ldy.Trays
	D-Washers ___ Disposals
	Sprinkler Sys.

Date Built 1940 Date Add. Built ___ ☐ Finished ☐ Unfinished ☐ Remodeled

Effective Age 30 Years Future Life ___ Years

Dep. for Cond. ___ Dep for Ob. ___ Dep. for Es. ___ Total ___

FACTOR | ITEM | DIMENSIONS

TYPE OF CONSTRUCTION

X	Frame
	Metal-Prefab
	Ordinary Masonry
	Mill Construction
	Class A Rein. Conc.
	Stru. Steel and Conc.
	Struct. Steel, Frame

or

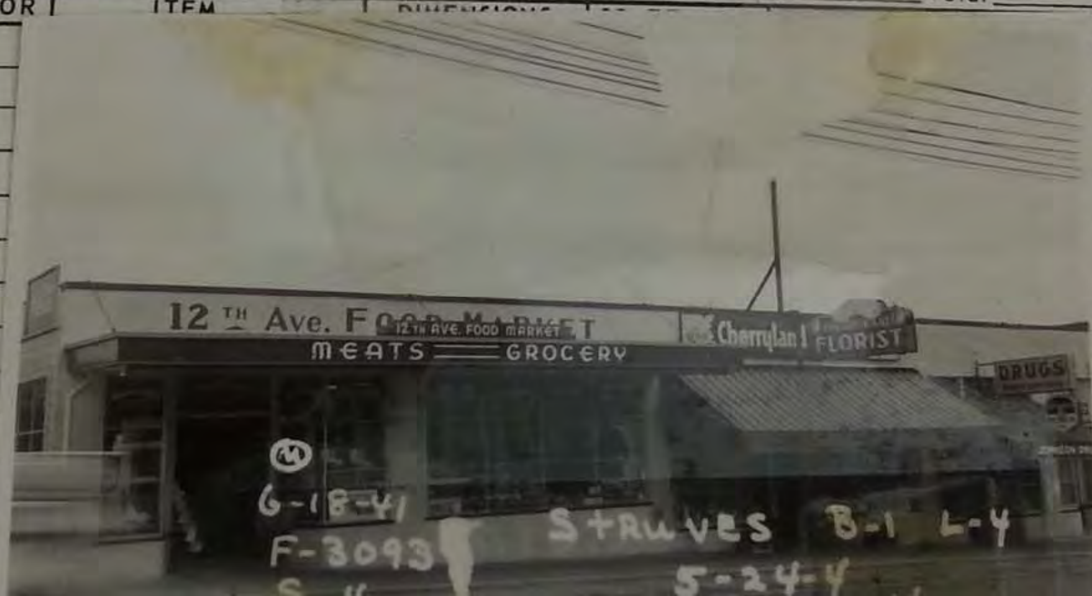
QUALITY-TYPE

Good ___ Med. X Cheap

FOUNDATION

	Mud Sill ☐ Post Pier
X	Conc. ☐ Brick
	Load Hgt. ☐ Piling

ASEMENT



HEATING

	Elec. ___ Oil X Gas
	H.W. ___ St. ___ H.A.
	B.Bd. / Suspended
	FHA ___ Pipeless
	A. Cond. ___ Wall Unit
	Comb. Unit ___ Custom
	Refrig. ___ Convector
	Heat Pump ___ Fireplace

YEAR	ASSESSED VALUE

DISTRICT 17A ADDITION STRUVES ADD. 3093

Section 5 Twp. 24 Range 4 Ewm. Block 1 Tract or Lot 4 & 3.

PERMIT No. 339705 AMT $7500

DATE AUG. 20. 1940 SHEET # 4

Fee Owner Y. FUKUDA

Condition of Exterior Good Interior Good Foundation Good Address of Property 110-116 12TH AVE Architect

Floor Plan: Good Accept. Poor

USE STORES

1	No. Stories
3	No. Stores
8	No. Rooms
1	Basement
	No. Offices
	No. Apartments
	1 rm. ☐ 2 rm. ☐ 3 rm.
	4 rm. ☐ 5 rm. ☐ 6 rm.

TYPE OF CONSTRUCTION

✓	Frame
	Single ☒ Double
	Ordinary Masonry
	Mill Construction
	Class A Rein. Con.
	Stru. Steel and Con.
	Tile ☐ Brick
	Con. ☐ Rein. Con.

Good ___ Med. X Cheap ___

FOUNDATION

	Mud Sills
	Post and Pier
	Brick
✓	Concrete
	Pile

BASEMENT

	Full ☐ %
	Sub-Basement
X	Size 18 x 28
	Garage ☐ No. Cars
	Cement Floors
	Plastered
	Living Rooms
	Service Rooms

NONE

ROOF CONSTRUCTION

X	Frame Lam ☐
	Mill Construction
	Rein. Concrete
	No. Trusses
	Wood ☐ Steel

ROOFING MATERIAL

✓	Tar and Gravel
Or.	

FLOOR FINISHES

✓	Fir ☐ Maple
	Oak ☐ 2" x 6" T&G
X	Lino. 60% ☐ 3" x 6" T&G
	Cement
	Terrazzo
	Raecolith
Asph	Tile 20%
Or.	

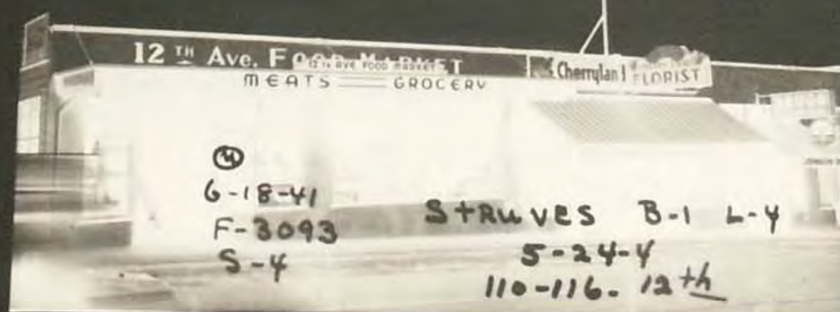
Tile ☐ Lino.	
Baths ☐ Fl. ☐ Walls	
Tile Total	Sq. Ft. ___ Floors
	Sq. Ft. ___ Walls
	Lin. Ft. ___ Dr. Bds.
Lino. Total	Sq. Ft. ___ Floors
	Sq. Ft. ___ Walls
	Lin. Ft. ___ Dr. Bds.
Kit's. ☐ Fl. ☐ Walls	

Date Built 1940 ☒ Finished ☐ Unfinished ☐ Remodeled

Effective Age ___ Years ___ Future Life ___ Years

Dep. For Cond. 36 Dep. For Ob. ___ Dep. For Es. 5 Total 41%

REPRODUCTION COST Factor Make Up



Assessed Value 50% $ 3750

Sup. Building A. V. $

8 . Total $

Permit 7500.00

PLUMBING

	No. Fixtures
5	Toilets
	Tubs, Leg or Pem.
	Basins, Ped.
5	Sinks
	Urinals
	Showers (Tub) (Stall)
	Laundry Trays
	H. W. Tank Fl. Drains ☐
	Sprink. Sys. No. ___ Hds.

HEATING

✓	Stove
	Pipeless Furnace
	Gravity H. A.
	Air Cond., Fan
1	~~Arcola~~ Susp. Gas.
	1-Pipe Steam
	2-Pipe St. or Vapor
	Hot Water
	Oil Burner
	Coal Stoker

WIRING

	Knobe & Tube
	Flex Cable
X	Conduit
	Power Wiring
	Range Wiring
	No. Outlets

ELEVATORS

Pass. ☐	Freight
Auto. ☐	Elec.
Man. ☐	Hyd.
☐	Man.

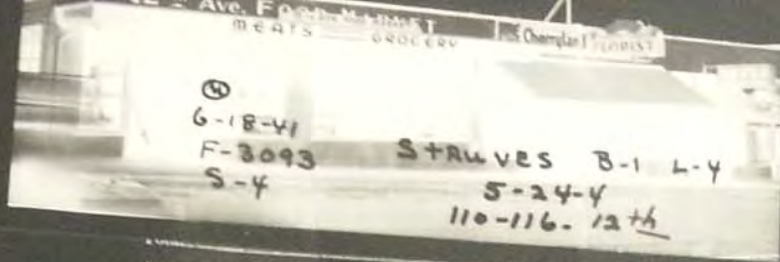
NONE

7500 3750

~~4600~~ 9200

EXTERIOR WALL CONSTR.	INTERIOR WALLS	GAS STATIONS	C. H.	GROUND FLOOR AREA 4500
Single ☒ Double	✓ Stud and Plaster	Frame	S. B.	TOTAL FLOOR AREA

Concrete
Pile



BASEMENT

Full ☐ %
Sub-Basement
X Size 18 x 28
Garage ☐ No. Cars
~~Cement~~ Floors
Plastered
Living Rooms
Service Rooms

NONE

Assessed Value 50% $ 3750
Sup. Building A. V. $
Total $

Permit 7500.00

WIRING

Knobe & Tube
Flex Cable
X Conduit
Power Wiring
Range Wiring
No. Outlets

ELEVATORS

Pass. ☐ Freight
Auto. ☐ Elec.
Man. ☐ Hyd.
☐ Man.

NONE

7500
3750
4600
9200

EXTERIOR WALL CONSTR.

Single ☒ Double
X 2" x 4" Stud Walls ✓
2" x 6" Stud Walls
Brick Walls
Brick With Pilasters
Concrete Walls
Con. With Pilasters
Tile Walls
Rein. Con. Skel.
Filler Walls
✓ Laminated Walls

EXTERIOR FACING

✓ Siding ☐ Shingles
Shakes ☒ Stucco
Brick Veneer
Kind
Stone ☐ Cast S.
Terra Cotta
Struct. Glass
Trim

FLOOR CONSTRUCTION

Joist Con. Size 2 x 14
O. C. 16" In Bridg ✓ ☐
Mill Construction
Rein. Con.

INTERIOR WALLS

✓ Stud and Plaster
Lam. ☐ Plastered
Ply Wood
Ceiled
Plaster Board
Painted
Stain ☐ Varnish
Kalsomine
Whitewashed
Unfinished

INTERIOR TRIM

✓ Fir
Mah. ☐ Oak
Metal
Doors
Windows
Stained
Varnished
Painted
Unfinished

GAS STATIONS

Frame
Metal
Masonry
Plastered or Ceiled
Floors

SERVICE BUILDING

Frame
Metal
Masonry
Plastered or Ceiled
Floors

TANKS, ETC., LIST

Hoists: Elect. Hyd.

DOCKS AND PIERS

Treated Piles and Timbers
Untreated
Treated Piles only
Average Length
Paved

C. H.	
S.B.	
B	10'
1	14'3"
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	

GROUND FLOOR AREA 4500

TOTAL FLOOR AREA

Other Buildings	Construction	Floor	Roof	Stories	Dimensions	S. F. Area	Factor	Value	% Dep.	Deprec.	Net Value
NONE											
Garage					x			$		$	$
					x			$		$	$
					x			$		$	$
					x			$		$	$

ction

. Con.

nd Con.

Brick

Rein. Con.

Cheap

%

No. Cars

Floors

REPRODUCTION COST Factor Make Up

Factor	Plus or Minus	Dimensions	S. F. Area	Factor	Cost

Bldg. "A"

Sup. Building A. V. $

Total $

DISTRICT 77A | ADDITION STRUVE'S

Section 5 Twp. 24 Range 4 Ewm.

PERMIT No. 341006 | Block 1 | Tract or Lot 1 | 3093

DATE 11-4-40 | AMT $2500 | SHEET #1

Fee Owner

Condition of Exterior Good | Interior Good | Foundation Good | Address of Property 124- 12TH AVE. | Architect

USE GAS STATION | Floor Plan: Good | Accept. | Poor

	USE		ROOF CONSTRUCTION		FLOOR FINISHES		PLUMBING
1	No. Stories	X	Frame ☐ Lam		Fir ☐ Maple	3	No. Fixtures
	No. Stores		Mill Construction		Oak ☐ 2" x 6" T&G	2	Toilets
	No. Rooms		Rein. Concrete		Lino. ☐ 3" x 6" T&G		Tubs, Leg or Pem.
	Basement		No. Trusses	X	Cement	2	Basins, Ped.
	No. Offices		Wood ☐ Steel		Terrazzo	1	FOUNTAIN
	No. Apartments		ROOFING MATERIAL		Rasmolith		Urinals
	1 rm. ☐ 2 rm. ☐ 3 rm.		Tar and Gravel		Tile		Showers (Tub) (Stall)
	4 rm. ☐ 5 rm. ☐ 6 rm.	Or.	Paper	Or.			Laundry Trays

Tile ☐ Lino. | Baths ☐ Fl. ☐ Walls | Tile Total: Sq. Ft. ___ Floors; Sq. Ft. ___ Walls; Lin. Ft. ___ Dr. Bds. | Lino. Total: Sq. Ft. ___ Floors; Sq. Ft. ___ Walls; Lin. Ft. ___ Dr. Bds. | Kit's. ☐ Fl. ☐ Walls

H. W. Tank Fl. Drains ☐

Sprink. Sys. No. ___ Hds.

TYPE OF CONSTRUCTION

X	Frame
	Single ☐ Double
	Ordinary Masonry
	Mill Construction
	Class A Rein. Con.
	Stru. Steel and Con.
	Tile ☐ Brick
	Con. ☐ Rein. Con.

Good ___ Med. X Cheap ___

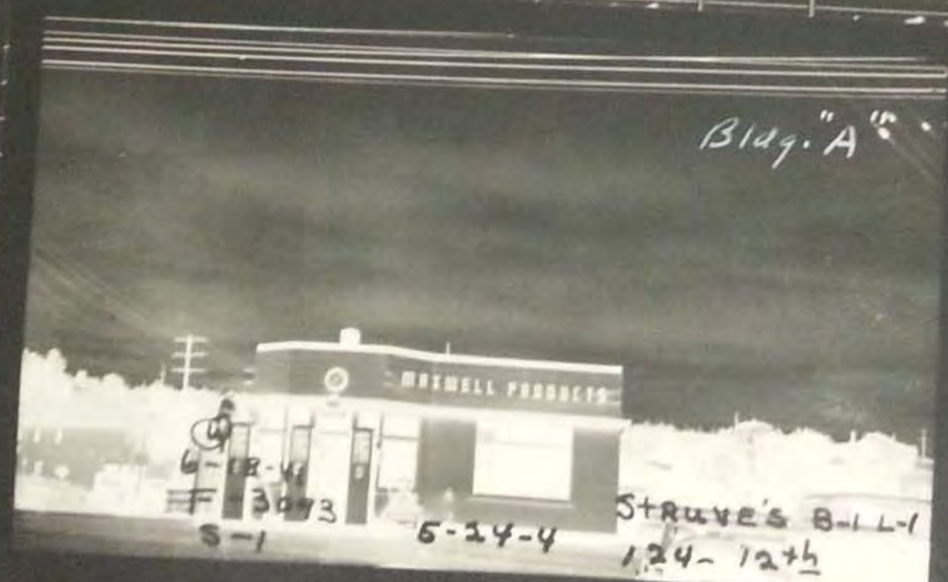
Date Built 1941 ☒ Finished ☐ Unfinished ☐ Remodeled

Effective Age ___ Years ___ Future Life ___ Years

Dep. For Cond. ___ Dep. For Ob. ___ Dep. For Es. ___ Total 23%

REPRODUCTION COST Factor Make Up

Factor	Plus or Minus	Dimensions	S. F. Area	Factor	Cost



Sup. Building A.V.

FOUNDATION

	Mud Sills
	Post and Pier
	Brick
X	Concrete
	Pile

BASEMENT

N	Full ☐ %
O	Sub-Basement
N	Size ___ x
E	Garage ☐ No. Cars
	___ Floors
	Plastered

HEATING

X	Stove
	Pipeless Furnace
	Gravity H. A.
	Air Cond., Fan
	Areola
	1-Pipe Steam
	2-Pipe St. or Vapor
	Hot Water
	Oil Burner
	Coal Stoker

WIRING

	Knobe & Tube
	Flex Cable
X	Conduit
	Power Wiring
2	~~Range Wiring~~ FLOOD LIGHT POLES
12	No. Outlets

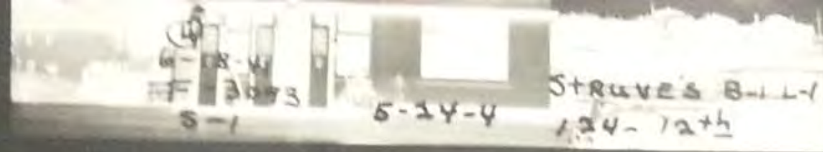
2000 — 1000

F.M-67 ~~1500~~

ELEVATORS

N	Pass. ☐ Freight

	Full ☐ %
N	Sub-Basement
o	Size x
N	Garage ☐ No. Cars
e	Floors
	Plastered
	Living Rooms
	Service Rooms



Sup. Building A. V. $

Total $

	Power Wiring
2	~~Lamp Wiring~~ Flood Light Poles
12	No. Outlets

2000 ~~1000~~

F.M.-67 ~~1500~~

~~1100~~

1500

ELEVATORS

N	Pass.	☐	Freight
o	Auto.	☐	Elec.
N	Man.	☐	Hyd.
e		☐	Man.

~~1270~~

EXTERIOR WALL CONSTR.

	Single ☒ Double
X	2" x 4" Stud Walls
	2" x 6" Stud Walls
	Brick Walls
	Brick With Pilasters
	Concrete Walls
	Con. With Pilasters
	Tile Walls
	Rein. Con. Skel.
	Filler Walls
	Laminated Walls

EXTERIOR FACING

X	Siding ☐ Shingles
	Shakes ☐ Stucco
	Brick Veneer
	Kind
	Stone ☐ Cast S.
	Terra Cotta
	Struct. Glass
	Trim

FLOOR CONSTRUCTION

Joist Con. Size x

O. C. In Bridg ☐

	Mill Construction
X	Mem. Con.

INTERIOR WALLS

	Stud and Plaster
	Lam. ☐ Plastered
X	Ply Wood
	Ceiled
	Plaster Board
X	Painted
	Stain ☐ Varnish
	Kalsomine
	Whitewashed
	Unfinished

INTERIOR TRIM

X	Fir
	Mah. ☐ Oak
	Metal
	Doors
	Windows
	Stained
	Varnished
	Painted
	Unfinished

GAS STATIONS

X	Frame
	Metal
	Masonry
	Plastered or Ceiled
X	Floors Conc.

SERVICE BUILDING

	Frame
	Metal
	Masonry
	Plastered or Ceiled
1	Floors CATCH BASIN

TANKS, ETC., LIST

4	1000 tank
1	4000 Tank
2	LT STDS
2	Hose wells
X	Hoists: Elect. 1 Hyd.

DOCKS AND PIERS

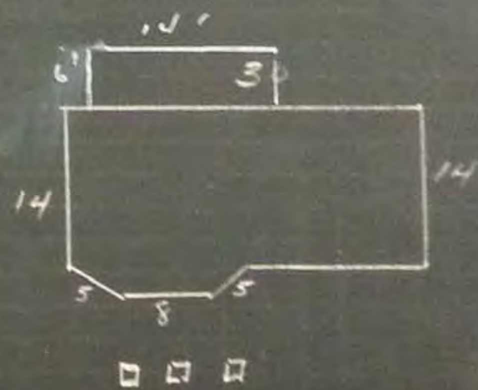
	Treated Piles and Timbers
	Untreated
	Treated Piles only
	Average Length
	Paved

C. H.

S.B.	
B	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	

GROUND FLOOR AREA ~~464~~ 543

TOTAL FLOOR AREA



	Other Buildings	Construction	Floor	Roof	Stories	Dimensions	S. F. Area	Factor	Value	% Dep.	Deprec.	Net Value
	Garage					x			$		$	$
						x			$		$	$
						x			$		$	$
						x			$		$	$

r Cond.__________ Dep for Ob. __________ Dep. for Es. __________ Total ______

R	ITEM	DIMENSIONS	SQ. FT. AREA	FACTOR	COST

ASSESSED VAL.

. TANKS, Etc.	ELEVATORS	DOCKS AND PIERS	WIRING
ISTS: Elec. H...			

3-15-71
HH

WF-F 3-26-71 ON

100% UNF

0005
2 of 2

FOLIO 2393

PERMIT NO.

DATE

ADDITION Struves Add.

Section NE 5 Twp 24 Range 4 EWM. Block 1 Lot or 1 & 2 + W 33' of 12

Tax Lot ____ Tract ____

Address 1209 E. Fir

FOR REFERENCE ONLY

Fee Owner ____ Architect ____ Contractor ____

Zoning ____ Condition of Exterior F Interior F Foundation F Floor Plan: Good ____ Accept. ____ Poor ____

USE GARAGE

1	No. Stories
	No. Stores
	No. Rooms
	Basement
	No. Offices — Unit Sq. Ft.
	No. Apartmts.
	1 rm. ☐ 2 rm. ☐ 3 rm. ☐
	4 rm. ☐ 5 rm. ☐ 6 rm. ☐

ROOF CONSTRUCTION

X	Frame-Joist
	Mill-Deck
	Rein. Conc. ____ GLB
	Steel Fr. ____ Metal Deck
	Trusses ____ Span
	Wood ____ Steel

FLOOR FINISHES

	Fir	☐	Maple
	Oak	☐	2x6TG
	Lino	☐	3x6TG
100%	Cement	☐	Lgtwgt. Conc.
	Terrazzo		
	Asphalt Tile	☐	Vinyl Tile
or			

☐ Tile ☐ Lino ☐ Form.

	Bath Floor
	Bath Walls
	Tub Recess
	Drain Bds.
	Vanities

PLUMBING

2	No. Fixtures
1	Toilets ____ Urinals
	Tubs Leg. or Pem.
1	Basins ____ Dr. Ftns.
	Sinks
	Washers ____ Dryers
	Showers (tub) (stall)
	H.W. Tanks ____ Ldy. Trays
	D-Washers ____ Disposals
	Sprinkler Sys.

Date Built 1949 Date Add. Built ____ ☐ Finished ☐ Unfinished ☐ Remodeled

Effective Age 22 Years Future Life ____ Years

Dep. for Cond. ____ Dep for Ob. ____ Dep. for Es. ____ Total ____

TYPE OF CONSTRUCTION

	Frame
	Metal-Prefab
X	Ordinary Masonry
	Mill Construction
	Class A Rein. Conc.
	Stru. Steel and Conc.
	Struct. Steel, Frame
or	

QUALITY-TYPE

Good Med. Cheap

FOUNDATION

	Mud Sill ☐ Post Pier
X	Conc. ☐ Brick
	Load Hgt. ☐ Piling

BASEMENT NONE

	Full ____ % Part.
	Sub-Basement
	Size
	Garage ☐ No. Cars
	Floors

FACTOR	ITEM	DIMENSIONS	SQ. FT. AREA	FACTOR	COST

HEATING NHEQ

	Elec. ____ Oil ____ Gas
	H.W. ____ St. ____ H.A.
	B.Bd. ____ Suspended
	FHA ____ Pipeless
	A. Cond. ____ Wall Unit
	Comb. Unit ____ Custom
	Refrig. ____ Convector
	Heat Pump ____ Fireplace

YEAR	ASSESSED VALUE

ASSESSED VAL.

MISC. TANKS, Etc.	ELEVATORS	DOCKS AND PIERS	WIRING
HOISTS: ...			

F-2393

1 + 2 + W 33' of 12

ADDITION Struves Add

Section 5 Twp. 24 N. Range 4 Ewm. Block 1 Tract or Lot No. 1

Permit No. 391654 E 35 ft 1...

Date 10-1948

Address of Property 1209 - E - FIR

Fee Owner

Condition of Exterior G Interior G

USE Garage

CONSTRUCTION Conc Block

FOUNDATION Conc

BASEMENT

WALLS Conc Blks

EXTERIOR C Blks

INTERIOR C Blks

ATTIC

ROOF Frame

Comp

FIREPLACE

TILEWORK Sq. Ft.

INTERIOR TRIM Fir

BUILDINGS 1

FLOORS Concrete

INTERIOR WALL FINISH White Wash

PORCHES

YEAR BUILT 1949

EFFECTIVE AGE

PLUMBING

No. FIXTURES 2

GRADE

D. S. SEWER CONN.

HEATING Stove

WIRING Conduit

FINISHED 1 UNFINISHED

FUTURE LIFE

ELEVATORS

CONVEYORS

EXTRA FEATURES

REMODELED

DEP. 10%

CON.

FLOORS

SERVICE BLDG.

CON.

FLOORS

TANKS (List)

SPRINKLER SYSTEM

No. HEADS

DOCKS AND PIERS

Length of Piles

Treated Piles and Timber

Untreated

Treated Piles Only

Paved

DIMENSIONS x

SQ. FT. AREA

No. Stories

No. Stores

No. Rooms

~~1250~~ 1249

CEILING HEIGHTS

S.B.		1.	11	3.	
B.		2.		4.	

FACTOR	ITEM	DIMENSIONS	S. F. AREA	FACTOR	COST

3200
~~1600~~
~~1700~~

REMARKS

Garage with 2-overhead doors not much else Gray 6/49

APPENDIX B

Summary Soil and Groundwater Data Tables
(WES, 2016, 2017)

Soil Data Tables from 2017 WES Phase II Investigation

TABLE 2
Summary of Soil Sample Organic Chemistry Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Sample I.D.	*Depth (ft.)*	*Sample Location*	*Laboratory Analytical Results (mg/kg)*		
			Total Petroleum Hydrocarbons *(by Method NWTPH-HCID or NWTPH-G and NWTPH-D(x)*	***Benzene Toluene Ethyl benzene Xylenes*** *(by EPA Methods 8021B or 8260C)*	***Other Volatile Organic Compounds*** *(List of 58 Additional Compounds Detectable by the Laboratory Method.)*
104 12th Avenue - Interior of Seattle Curtain Co. Building					
WES-1	7.5'	6 ft. inside double doors in SE corner of basement	***Gasoline: 710*** Diesel: 160^{x} Motor Oil: ND (<250)	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	sec-Butylbenzene 0.35 ND (all others)
	10'	Same	Gasoline: NA Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA
WES-2	6'	Adjacent to oil/water separator by entry ramp in SW corner of basement	***Gasoline: 390*** Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	sec-Butylbenzene 0.086 ND (all others)
	7'	Same	Gasoline: NA Diesel: 340^{x} Motor Oil: ND (<250)	NA	NA
	9'	Same	***Gasoline: 230*** Diesel: 440^{x} Motor Oil: ND (<250)	NA	NA
WES-3	7'	10 ft NW of WES-2, near oil/water separator	Gasoline: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
WES-4	6'	In corridor through shelving area in S central part of basement	Gasoline: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	sec-Butylbenzene 0.11 ND (all others)

TABLE 2
Summary of Soil Sample Organic Chemistry Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Sample I.D.	Depth (ft.)	Sample Location	Laboratory Analytical Results (mg/kg)		
			Total Petroleum Hydrocarbons (by Method NWTPH-HCID or NWTPH-G and NWTPH-D(x)	**Benzene Toluene Ethyl benzene Xylenes** (by EPA Methods 8021B or 8260C)	**Other Volatile Organic Compounds** (List of 58 Additional Compounds Detectable by the Laboratory Method.)
WES-5	6'	In shelving area corridor, NW of WES-1, near SE entry double doors	Gasoline: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
WES-6	8'	In main corridor 30 ft. N of SE entry double doors	Gasoline: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
WES-7	10'	Near NE corner of basement	Gasoline: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
WES-8	11.5'	In N corridor, 25' W of WES-7	Gasoline: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
WES-9	8'	I W central part of basement, near boiler room door	Gasoline: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
104 12th Avenue - Parking Lot East of Seattle Curtain Co. Building					
WES-10	7'	In S central part of parking lot	Gasoline: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
WES-11	15'	In N central part of parking lot, adjacent to previous boring MW-5	Gasoline: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)

TABLE 2
Summary of Soil Sample Organic Chemistry Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Sample I.D.	**Depth (ft.)**	**Sample Location**	**Laboratory Analytical Results (mg/kg)**		
			Total Petroleum Hydrocarbons *(by Method NWTPH-HCID or NWTPH-G and NWTPH-D(x)*	***Benzene Toluene Ethyl benzene Xylenes*** *(by EPA Methods 8021B or 8260C)*	***Other Volatile Organic Compounds*** *(List of 58 Additional Compounds Detectable by the Laboratory Method.)*
WES-12	16'	In SW corner of parking lot	Gasoline: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
WES-13	12'	In E central part of parking lot	Gasoline: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
110 12th Avenue - Borings in Open Area in Central Property					
BN-1	9'	In SE corner of open area	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
	15'	Same	Gasoline: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
BN-2	3'	Near SW corner of open area	Gasoline: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
	13'	Same	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)

TABLE 2
Summary of Soil Sample Organic Chemistry Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Sample I.D.	Depth (ft.)	Sample Location	Laboratory Analytical Results (mg/kg)		
			Total Petroleum Hydrocarbons (by Method NWTPH-HCID or NWTPH-G and NWTPH-D(x)	**Benzene Toluene Ethyl benzene Xylenes** (by EPA Methods 8021B or 8260C)	**Other Volatile Organic Compounds** (List of 58 Additional Compounds Detectable by the Laboratory Method.)
BN-3	7'	Outside rear entry to 110 12th Avenue bldg.	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
	14.5'	Same	Gasoline: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
BN-4	7'	In E central part of open area, adjacent to Archives bldg.	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
Slope 1	2.5'	In NE part of property, fill slope down to open area	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA Metals analysis,	NA see Table 2
Slope 2	1.5'	In NE part of property, top of fill slope	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: 660	NA Metals analysis,	NA see Table 2
110 12th Avenue - Hand Auger Borings in Basement					
HA-N	2.5	In N. portion of building basement	***Gasoline: 730*** Diesel: 230x Motor Oil: ND (<250)	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	n-Propylbenzene 0.24 sec-Butylbenzene 0.60 ND (all other)
	9'	Same	Gasoline: 3.9 Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)

TABLE 2
Summary of Soil Sample Organic Chemistry Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Sample I.D.	Depth (ft.)	Sample Location	Laboratory Analytical Results (mg/kg)		
			Total Petroleum Hydrocarbons (by Method NWTPH-HCID or NWTPH-G and NWTPH-D(x)	**Benzene Toluene Ethyl benzene Xylenes** (by EPA Methods 8021B or 8260C)	**Other Volatile Organic Compounds** (List of 58 Additional Compounds Detectable by the Laboratory Method.)
HA-S	2.5'	In S portion of building basement	Gasoline: 7.0 Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
	6'	Same	Gasoline: 11 Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	n-Propylbenzene 0.12 ND (all other)
HA-3	4'	In S portion of basement below 110 tenant space	Gasoline: ND (<2) Diesel: ND (<50) Motor Oil: ND (<250)	NA	ND (all)
1209 E. Fir Street - Borings East of Auto Repair Building					
BN-5	5'	In NE corner of parking lot, near oil/water separator	Gasoline: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
	11'	Same	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA
	18'	Same	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA

TABLE 2
Summary of Soil Sample Organic Chemistry Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Sample I.D.	Depth (ft.)	Sample Location	Laboratory Analytical Results (mg/kg)		
			Total Petroleum Hydrocarbons (by Method NWTPH-HCID or NWTPH-G and NWTPH-D(x))	**Benzene Toluene Ethyl benzene Xylenes** (by EPA Methods 8021B or 8260C)	**Other Volatile Organic Compounds** (List of 58 Additional Compounds Detectable by the Laboratory Method.)
BN-6	1'	In S area of parking lot, near paint booth sump	Gasoline: 2.7 Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
	9'	Same	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA
	15'	Same	Gasoline: ND (<2) Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
124 12th Avenue - Borings at Former Service Station in NW Portion of Property					
BN-7	9'	NW corner of property - former location of gas station pump island	Gasoline: 14 Diesel: NA Motor Oil: NA	Benzene: ND (<0.02) Toluene: ND (<0.02) Ethylbenzene: ND (<0.02) Xylenes: 0.082	NA
	12'	Same	***Gasoline: 780*** Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) ***Ethylbenzene: 6.8*** ***Xylenes: 59***	Isopropylbenzene: 2.6 n-Propylbenzene : 10 p-Isopropyltoluene: 0.56 sec-Butylbenzene: 1.2 1,2,4 Trimethylbenzene: 63 1,3,5 Trimethylbenzene: 20 Naphthalene: 4.9 ND (all other)
	17'	Same	Gasoline: 24 Diesel: NA Motor Oil: NA	***Benzene: 0.033*** Toluene: ND (<0.02) Ethylbenzene: 0.26 Xylenes: 2.0	NA
	19'	Same	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA

TABLE 2
Summary of Soil Sample Organic Chemistry Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Sample I.D.	***Depth (ft.)***	***Sample Location***	***Laboratory Analytical Results (mg/kg)***		
			Total Petroleum Hydrocarbons ***(by Method NWTPH-HCID or NWTPH-G and NWTPH-D(x)***	***Benzene Toluene Ethyl benzene Xylenes (by EPA Methods 8021B or 8260C)***	***Other Volatile Organic Compounds*** ***(List of 58 Additional Compounds Detectable by the Laboratory Method.)***
BN-8	7'	N central part of property - former location of gas station service bay	Gasoline: ND (<20) Diesel: ND (<50) ***Motor Oil: 3,300***	NA	NA
	17'	Same	Gasoline: ND (<2) Diesel: NA Motor Oil: NA	Benzene: ND (<0.02) Toluene: ND (<0.02) Ethylbenzene: ND (<0.02) Xylenes: ND (< 0.06)	NA
BN-9	12'	W central part of parking lot- likely former UST location	Gasoline: ND (<2) Diesel: NA Motor Oil: NA	Benzene: ND (<0.02) Toluene: ND (<0.02) Ethylbenzene: ND (<0.02) Xylenes: ND (< 0.06)	NA
BN-10	15-20'	S end of parking lot - likely S of former UST location	***Gasoline: 490*** Diesel: 160x Motor Oil: ND (<250)	Benzene: ND (<0.02) Toluene: ND (<0.02) Ethylbenzene: 2.6 Xylenes: 0.44	Hexane: 5.1 Isopropylbenzene: 2.0 n-Propylbenzene : 8.5 p-Isopropyltoluene: 0.36 sec-Butylbenzene: 0.94 1,2,4 Trimethylbenzene: 3.5 1,3,5 Trimethylbenzene: 1.7 Naphthalene: 0.86 ND (all other)
BN-11	12'	At S end of 1209 Fir bldg, inside gate to open area	NA	NA Metals analysis only,	NA see Table 2
	20'	Same	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)		

TABLE 2
Summary of Soil Sample Organic Chemistry Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Sample I.D.	***Depth (ft.)***	***Sample Location***	***Laboratory Analytical Results (mg/kg)***		
			Total Petroleum Hydrocarbons *(by Method NWTPH-HCID or NWTPH-G and NWTPH-D(x)*	***Benzene Toluene Ethyl benzene Xylenes*** *(by EPA Methods 8021B or 8260C)*	***Other Volatile Organic Compounds*** *(List of 58 Additional Compounds Detectable by the Laboratory Method.)*
MTCA Soil Cleanup Criteria			***Gasoline: 30*** ***If no benzene present: 100*** ***Diesel or Motor Oil: 2,000***	***Benzene: 0.03*** ***Toluene: 7*** ***Ethylbenzene: 6*** ***Xylenes: 9***	***Hexane: 4,800*** ***Isopropylbenzene: 8,000*** ***n-Propylbenzene : 8,000*** ***p-Isopropyltoluene: NV*** ***sec-Butylbenzene: 8,000*** ***1,2,4 Trimethylbenzene: NV*** ***1,3,5 Trimethylbenzene: 800*** ***Naphthalene: 5*** ***Other VOCs vary***

Table 1 Notes:
ND (<XXX) - Parameter not detected at concentrations at or above the noted reporting limit.
NA - Sample not analyzed for the listed parameter.
Gasoline Range Total Petroleum Hydrocarbons by Method NWTPH-G.
Diesel and Motor Oil Range Total Petroleum Hydrocarbons by Method NWTPH-D(x).
x - Sample Chromatogram does not resemble fuel standard used for analysis. Most likely carry over from gasoline range hydrocarbons or organic material.
BTEX compounds as part of volatile organic analysis by EPA Method 8260C.
Volatile organic compounds by EPA Method 8260C for a list of 62 different volatile parameters. Detection limits vary.

MTCA Soil cleanup criteria per Chapter 173-340-740 WAC. Method A criteria presented where available. Otherwise, Method B standard formula values presented.

Sample results exceeding applicable cleanup criteria are noted in ***Bold Italic***.

TABLE 2A
Summary of Soil Sample Metals Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Sample I.D.	***Depth (ft.)***	***Sample Location***	***Laboratory Analytical Results (mg/kg)***	
			Total Metals ***(by EPA Methods 8021B or 8260C)***	
Slope 1	2.5'	In NE part of property, fill slope down to open area	Arsenic: Cadmium Chromium Lead: Mercury:	2.13 ND (<1) 12.9 2.2 ND (<1)
Slope 2	1.5'	In NE part of property, top of fill slope	Arsenic: Cadmium: Chromium: Lead: Mercury:	3.91 1.21 16.5 243 ND (<1)
BN-11	12'	At S end of 1349 Fir bldg, inside gate to open area	Arsenic: Cadmium Chromium ***Lead*** Mercury	4.30 ND (<1) 17.5 ***330*** ND (<1)
MTCA Method A Soil Cleanup Criteria			***Arsenic:*** ***Cadmium*** ***Chromium*** ***Lead*** ***Mercury***	***20*** ***2*** ***19**** ***250*** ***2***

Table 2 Notes:
ND (<X) - Parameter not detected at concentrations at or above the noted reporting limit.
Total Metals by EPA Method 200.8

MTCA Method A Soil cleanup criteria per Chapter 173-340-740 WAC.

*Chromium Method A cleanup level for Cr VI. Test method determines total chromium, but cannot distinguish between Cr III and Cr VI valance states. If total concentration exceeds 19 mg/kg, further testing would be needed to evaluate whether or not Cr VI was present. MTCA Method A cleanup level for Cr III is 2,000 mg/kg

Sample results exceeding applicable cleanup criteria are noted in ***Bold Italic***.

Soil Data Tables from 2017 WES Off-Site Investigation

TABLE 1
Summary of Off-site Soil Sample Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Boring I.D.	***Total Depth Drilled (ft.)***	***Sample Depth (ft.)***	***Boring Location***	***Laboratory Analytical Results (mg/kg)***		
				Total Petroleum Hydrocarbons *(by Method NWTPH-HCID or NWTPH-G & NWTPH-D(x)*	***Benzene Toluene Ethyl benzene Xylenes*** *(by EPA Method 8260C)*	***Other Volatile Organic Compounds*** *(List of 58 Additional Compounds Detectable by the Laboratory Method.)*
OS-1	16'	12'	In sidewalk of Yesler Way, adjacent to SE corner of parking lot for 104 12th Ave. bldg.	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA
OS-2	12'	7.5'	In sidewalk of Yesler Way, adjacent to SE corner of 104 12th Ave. bldg.	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA
		11'	Same	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA
OS-3	15'	12'	In sidewalk of Yesler Way, SW of double doors to basement, 30' W of bldg. corner.	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA
OS-4	9' (refusal)	6'	In sidewalk of Yesler Way, SW of garage door into 104 12th Ave. bldg.	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA
		9'	Same	Gasoline: ND (<2) Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)

TABLE 1
Summary of Off-site Soil Sample Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Boring I.D.	Total Depth Drilled (ft.)	Sample Depth (ft.)	Boring Location	Laboratory Analytical Results (mg/kg)		
				Total Petroleum Hydrocarbons *(by Method NWTPH-HCID or NWTPH-G & NWTPH-D(x)*	**Benzene Toluene Ethyl benzene Xylenes** *(by EPA Method 8260C)*	**Other Volatile Organic Compounds** *(List of 58 Additional Compounds Detectable by the Laboratory Method.)*
OS-5	14'	7'	In sidewalk of 12th Ave., 40' N of SW corner of 104 12th bldg.	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA
		14'	Same	Gasoline: ND (<2) Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
OS-6	12'	7'	In sidewalk of 12th Ave., 15' S of NW corner of 104 12th bldg.	Gasoline: ND (<2) Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
		10'	Same	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA
OS-7	20'	8'	In Sidewalk of 12th Ave., adjacent to tree, 40' S of NW corner of 124 12th parking lot.	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA
		12'	Same	Gasoline: ND (<2) Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
		16'	Same	Gasoline: 2.5 Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)

TABLE 1
Summary of Off-site Soil Sample Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Boring I.D.	Total Depth Drilled (ft.)	Sample Depth (ft.)	Boring Location	Laboratory Analytical Results (mg/kg)		
				Total Petroleum Hydrocarbons (by Method NWTPH-HCID or NWTPH-G & NWTPH-D(x)	**Benzene Toluene Ethyl benzene Xylenes** (by EPA Method 8260C)	**Other Volatile Organic Compounds** (List of 58 Additional Compounds Detectable by the Laboratory Method.)
OS-8	20'	7'	In blvd. gravel strip N. of 1209 E. Fir bldg.	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA
		17'	Same	Gasoline: ND (<2) Diesel: NA Motor Oil: NA	Benzene: ND (<0.03) Toluene: ND (<0.05) Ethylbenzene: ND (<0.05) Xylenes: ND (<0.15)	ND (all)
OS-9	25'	14'	In blvd. grass strip N. of 124 12th Ave. parking lot	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA
OS-10	30'	6'	In curb lane of 12th Ave., 10' N. of NW corner of 104 12th Ave. bldg.	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA
		10'	Same	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA
OS-11	20'	9'	In curb lane of 12th Ave., adjacent to vacant 118 12th Ave. bldg.	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA
		11'	Same	Gasoline: ND (<20) Diesel: ND (<5) Motor Oil: ND (<25)	NA	NA

TABLE 1
Summary of Off-site Soil Sample Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Boring I.D.	***Total Depth Drilled (ft.)***	***Sample Depth (ft.)***	***Boring Location***	***Laboratory Analytical Results (mg/kg)***		
				Total Petroleum Hydrocarbons *(by Method NWTPH-HCID or NWTPH-G & NWTPH-D(x)*	***Benzene Toluene Ethyl benzene Xylenes*** *(by EPA Method 8260C)*	***Other Volatile Organic Compounds*** *(List of 58 Additional Compounds Detectable by the Laboratory Method.)*
OS-12	20'	13'	In sidewalk at S entry drive to 124 12th Ave., parking lot.	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA
		16'	Same	Gasoline: ND (<20) Diesel: ND (<50) Motor Oil: ND (<250)	NA	NA
MTCA Soil Cleanup Criteria				***Gasoline: 30*** ***If no benzene present: 100*** ***Diesel or Motor Oil: 2,000***	***Benzene: 0.03*** ***Toluene: 7*** ***Ethylbenzene: 6*** ***Xylenes: 9***	***Other VOCs vary***

Table 1 Notes:
ND (<XXX) - Parameter not detected at concentrations at or above the noted reporting limit.
NA - Sample not analyzed for the listed parameter.
Gasoline Range Total Petroleum Hydrocarbons by Method NWTPH-HCID or NWTPH-G.
Diesel and Motor Oil Range Total Petroleum Hydrocarbons by Method NWTPH-HCID or NWTPH-D(x).
BTEX compounds as part of volatile organic analysis by EPA Method 8260C.
Volatile organic compounds by EPA Method 8260C for a list of 62 different volatile parameters. Detection limits vary.

MTCA Soil cleanup criteria per Chapter 173-340-740 WAC. Method A criteria presented where available. Otherwise, Method B standard formula values presented.

Sample results exceeding applicable cleanup criteria are noted in ***Bold Italic***.

Groundwater Data Table from 2017 WES Phase II Investigation

TABLE 3
Summary of Groundwater Sample Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Boring/ Sample I.D.	Sample Date	Laboratory Analytical Results (ug/l)		
		Total Petroleum Hydrocarbons *(by Methods NWTPH-G & NWTPH-D(X))*	**Benzene** **Toluene** **Ethyl benzene** **Xylenes** *(by EPA Method 8260C)*	**Other Volatile Organic Compounds** *(by EPA Method 8260C)* *List of 58 Additional Compounds Detectable by the Laboratory Method.*
104 12th Avenue - Interior of Seattle Curtain Manufacturing Co. Building				
WES-1-GW	4/3/2017	***Gasoline Range: 1,700*** ***Diesel: 690***[x] Motor Oil: ND (<250)	Benzene: 0.42 Toluene: 6.7 Ethylbenzene: 2.2 Xylenes: 20.5	Isopropylbenzene : 1.2 n-Propylbenzene: 1.7 Naphthalene: 14 sec-Butylbenzene: 5.3 1,2,4-Trimethylbenzene: 12 1,3,5-Trimethylbenzene: 2.7 ND (all other)
WES-4-GW	4/3/2017	Gasoline Range: 560 ***Diesel: 1,000***[x] ***Motor Oil: 680***	Benzene: ND (<0.35) Toluene: 3.6 Ethylbenzene: 1.5 Xylenes: 13.7	Naphthalene: 6.4 sec-Butylbenzene: 1.7 1,2,4-Trimethylbenzene: 9.0 1,3,5-Trimethylbenzene: 1.9 ND (all other)
WES-5-GW	4/3/2017	Gasoline Range: 220 Diesel: 460[x] Motor Oil: ND (<300)	Benzene: ND (<0.35) Toluene: 6.0 Ethylbenzene: 2.3 Xylenes: 21.3	n-Propylbenzene: 1.0 Naphthalene: 6.0 1,2,4-Trimethylbenzene: 14 1,3,5-Trimethylbenzene: 2.7 ND (all other)
WES-6-GW	4/3/2017	Gasoline Range: NA Diesel: 78[x] Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: 1.4 Ethylbenzene: ND (<1) Xylenes: 5.7	cis-1,2-Dichloroethene: 3.9 Naphthalene: 1.4 1,2,4-Trimethylbenzene: 3.6 ND (all other)

TABLE 3 (Continued)
Summary of Groundwater Sample Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Boring/ Sample I.D.	**_Sample Date_**	**_Laboratory Analytical Results (ug/l)_**		
		Total Petroleum Hydrocarbons ***(by Methods NWTPH-G & NWTPH-D(X))***	**_Benzene Toluene Ethyl benzene Xylenes_** ***(by EPA Method 8260C)***	**_Other Volatile Organic Compounds_** ***(by EPA Method 8260C)*** ***List of 58 Additional Compounds Detectable by the Laboratory Method.***
WES-7-GW	4/4/2017	Gasoline Range: NA Diesel: 56[x] Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: 4.0	Naphthalene: 1.1 1,2,4-Trimethylbenzene: 2.5 ND (all other)
WES-8-GW (Completed as MW-7)	6/30/2017	Gasoline Range: ND (<100) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	ND (all)
WES-9-GW	4/4/2017	Gasoline Range: NA Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: 1.6 Ethylbenzene: ND (<1) Xylenes: 7.6	Naphthalene: 1.5 1,2,4-Trimethylbenzene: 4.6 ND (all other)
104 12th Avenue - Parking Lot East of Seattle Curtain Co. Building				
WES-10-GW	4/5/2017	Gasoline Range: ND (<100) Diesel: 180[x] ***Motor Oil: 530***	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: 3.7	1,2,4-Trimethylbenzene: 2.2 ND (all other)
WES-11-GW	4/5/2017	Gasoline Range: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: 4.1	Acetone: 27 cis-1,2-Dichloroethene: 9.4 ***Tetrachloroethene: 12*** ***Trichloroethene: 17*** ***Vinyl Chloride: 0.39*** 1,2,4-Trimethylbenzene: 2.6 ND (all other)

TABLE 3 (Continued)
Summary of Groundwater Sample Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Boring/ Sample I.D.	*Sample Date*	*Laboratory Analytical Results (ug/l)*		
		Total Petroleum Hydrocarbons *(by Methods NWTPH-G & NWTPH-D(X))*	***Benzene Toluene Ethyl benzene Xylenes*** *(by EPA Method 8260C)*	***Other Volatile Organic Compounds*** *(by EPA Method 8260C)* *List of 58 Additional Compounds Detectable by the Laboratory Method.*
WES-12-GW	4/5/2017	Gasoline Range: NA Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	Acetone: 29 ND (all other)
WES-13-GW	4/5/2017	Gasoline Range: NA Diesel: 120x Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	cis-1,2-Dichloroethene: 12 Tetrachloroethene: 3.1 ***Trichloroethene: 10*** ***Vinyl Chloride: 0.23*** ND (all other)
Pre-existing Monitoring Wells on 104 12th Avenue Property				
MW-1-GW	6/30/2017	Gasoline Range: ND (<100) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	Vinyl Chloride: 0.20 ND (all other)
MW-2-GW	4/4/2017	Gasoline Range: NA Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	ND (all)
MW-3-GW	4/3/2017	Gasoline Range: 110 Diesel: 400x Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: 2.5 Ethylbenzene: ND (<1) Xylenes: 7.9	Acetone: 11 Naphthalene: 4.7 ***Vinyl Chloride: 0.34*** 1,2,4-Trimethylbenzene: 4.9 1,3,5-Trimethylbenzene: 1.1 ND (all other)

Boring/ Sample I.D.	Sample Date	Laboratory Analytical Results (ug/l)		
		Total Petroleum Hydrocarbons (by Methods NWTPH-G & NWTPH-D(X))	**Benzene Toluene Ethyl benzene Xylenes** (by EPA Method 8260C)	**Other Volatile Organic Compounds** (by EPA Method 8260C) List of 58 Additional Compounds Detectable by the Laboratory Method.
MW-4-GW	4/5/2017	Gasoline Range: NA Diesel: 67[x] Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	ND (all)
MW-5-GW	4/5/2017	Gasoline Range: NA Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	Acetone: 12 ND (all other)
MW-6-GW	4/4/2017	Gasoline Range: NA Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: 1.2 Ethylbenzene: ND (<1) Xylenes: 5.5	cis-1,2-Dichloroethene: 1.3 1,2,4-Trimethylbenzene: 3.4 ND (all other)
110 12th Avenue - Borings in Open Area in Central Property				
BN-1-GW	5/12/2017	Gasoline Range: ND (<100) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	ND (all)
BN-2-GW	5/12/2017	Gasoline Range: ND (<100) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	ND (all)
BN-3-GW	5/12/2017	Gasoline Range: ND (<100) Diesel: 79[x] Motor Oil: ND (<250)	Benzene: 0.65 Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	ND (all)

Boring/ Sample I.D.	***Sample Date***	***Laboratory Analytical Results (ug/l)***		
		Total Petroleum Hydrocarbons ***(by Methods NWTPH-G & NWTPH-D(X))***	***Benzene Toluene Ethyl benzene Xylenes*** ***(by EPA Method 8260C)***	***Other Volatile Organic Compounds*** ***(by EPA Method 8260C)*** ***List of 58 Additional Compounds Detectable by the Laboratory Method.***
BN-4-GW	5/12/2017	Gasoline Range: ND (<100) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	ND (all)
110 12th Avenue - Hand Auger Borings in Basement				
HA-N-GW	5/15/2017	Gasoline Range: 770 Diesel: 410[x] Motor Oil: ND (<250)	Benzene: 1.9 Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	cis-1,2-Dichloroethene: 5.3 Isopropylbenzene : 3.5 n-Propylbenzene: 12 Naphthalene: 14 sec-Butylbenzene: 9.9 Trichloroethene: 1.6 ***Vinyl chloride: 1.9*** ND (all other)
HA-S-GW	5/15/2017	Gasoline Range: 600 ***Diesel: 730[x]*** Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	Isopropylbenzene : 9.3 n-Propylbenzene: 45 sec-Butylbenzene: 7.5 ND (all other)
HA-3-GW	8/7/2017	Gasoline Range: ND (<100) Diesel: 100[x] Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	ND (all)

Summary of Groundwater Sample Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Boring/ Sample I.D.	Sample Date	Laboratory Analytical Results (ug/l)		
		Total Petroleum Hydrocarbons (by Methods NWTPH-G & NWTPH-D(X))	**Benzene Toluene Ethyl benzene Xylenes** (by EPA Method 8260C)	**Other Volatile Organic Compounds** (by EPA Method 8260C) List of 58 Additional Compounds Detectable by the Laboratory Method.
1209 E. Fir Street - Borings East of Auto Repair Building				
BN-5-GW	5/12/2017	Gasoline Range: ND (<100) Diesel: 64[x] Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	ND (all)
BN-6-GW	5/12/2017	Gasoline Range: ND (<100) Diesel: 100[x] Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	Acetone: 11 ND (all other)
125 12th Avenue - Borings at Former Service Station in NW Portion of Property				
BN-7 (Completed as MW-8)	8/3/2017	***Gasoline Range: 3,200*** ***Diesel: 790[x]*** Motor Oil: ND (<250)	***Benzene: 11*** Toluene: ND (<1) Ethylbenzene: 71 Xylenes: 419	Isopropylbenzene: 12 n-Propylbenzene: 24 Naphthalene: 8.9 p-Isopropyltoluene: 1.1 sec-Butylbenzene: 1.8 1,2,4-Trimethylbenzene: 180 1,3,5-Trimethylbenzene: 59 ND (all other)
BN-8-GW	5/15/2017	***Gasoline Range: 1,300*** ***Diesel: 830[x]*** Motor Oil: ND (<250)	Benzene: 1.6 Toluene: 1.3 Ethylbenzene: 12 Xylenes: 6.9	Hexane: 1.1 Isopropylbenzene: 28 n-Propylbenzene: 39 Naphthalene: 2.1 sec-Butylbenzene: 1.5 1,2,4-Trimethylbenzene: 3.9 ND (all other)

TABLE 3 (Continued)
Summary of Groundwater Sample Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Boring/ Sample I.D.	***Sample Date***	***Laboratory Analytical Results (ug/l)***		
		Total Petroleum Hydrocarbons *(by Methods NWTPH-G & NWTPH-D(X))*	***Benzene Toluene Ethyl benzene Xylenes*** *(by EPA Method 8260C)*	***Other Volatile Organic Compounds*** *(by EPA Method 8260C)* *List of 58 Additional Compounds Detectable by the Laboratory Method.*
BN-9-GW	5/15/2017	Gasoline Range: ND (<100) Diesel: 120x Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	ND (all)
BN-10-GW (Completed as MW-9)	8/3/2017	Gasoline Range: 500 Diesel: 270x Motor Oil: ND (<250)	***Benzene:*** ***6.8*** Toluene: 1.3 Ethylbenzene: 6.3 Xylenes: 4.3	Hexane: 4.3 Isopropylbenzene: 7.2 n-Propylbenzene: 17 sec-Butylbenzene: 1.5 1,2,4-Trimethylbenzene: 1.3 1,3,5-Trimethylbenzene: 1.4 ND (all other)
BN-11-GW	5/15/2017	Gasoline Range: ND (<100) Diesel: 460x Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	ND (all)
Washington State MTCA Groundwater Cleanup Criteria (ug/l)		***Gasoline: 800*** ***(Benzene is present)*** ***Diesel or Motor Oil: 500*** ***(combined)***	***Benzene: 5*** ***Toluene: 1,000*** ***Ethylbenzene: 700*** ***Xylenes: 1,000***	***Acetone: 7,200*** ***cis-1,2-Dichloroethene: 16*** ***Hexane: 480*** ***Isopropylbenzene: 800*** ***n-Propylbenzene: 800*** ***Naphthalene: 160*** ***p-Isopropyltoluene: NV*** ***sec-Butylbenzene: NV*** ***tert-Butylbenzene: NV*** ***Tetrachloroethene: 5*** ***Trichloroethene: 5*** ***Vinyl chloride: 0.2*** ***1,2,4-Trimethylbenzene: NV*** ***1,3,5-Trimethylbenzene: 80***

Table 3 Notes:
ND (<XXX) - Parameter not detected at concentrations at or above the noted reporting limit.
NA - Sample not analyzed for the listed parameter.
Gasoline Range Total Petroleum Hydrocarbons by Method NWTPH-G.
Diesel and Motor Oil Range Total Petroleum Hydrocarbons by Method NWTPH-D(x).
^{x} - Indicates sample chromatogram does not resemble fuel standard used for analysis. Most likely carry over from gasoline range hydrocarbons.
BTEX compounds and other volatile organic compounds by EPA Method 8260C. All detected compounds summarized here. See laboratory report for full list of analyzed parameters.

MTCA Groundwater cleanup criteria per Chapter 173-340-720 WAC. Method A criteria presented where available. Method B standard formula values shown where no Method A criteria available. Method B standard formula values from Dept. of Ecology Cleanup Levels and Risk Calculation (CLARC) database. NV indicates no value available from CLARC.

Sample results exceeding applicable cleanup criteria are noted in ***Bold Italic***.

Groundwater Data Table from 2017 WES Off-Site Investigation

TABLE 2
Summary of Off-Site Groundwater Sample Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Boring/ Sample I.D.	Sample Date	Laboratory Analytical Results (ug/l)		
		Total Petroleum Hydrocarbons *(by Methods NWTPH-G & NWTPH-D(X))*	**Benzene Toluene Ethyl benzene Xylenes** *(by EPA Method 8260C)*	**Other Volatile Organic Compounds** *(by EPA Method 8260C)* *List of 58 Additional Compounds Detectable by the Laboratory Method.*
OS-1-GW	8/3/2017	Gasoline Range: ND (<100) Diesel: 110^{x} Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	cis-1,2-Dichloroethene: 3.5 Trichloroethene: 2.7 ND (all other)
OS-2-GW	8/3/2017	Gasoline Range: ND (<100) Diesel: 130^{x} Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	cis-1,2-Dichloroethene: 1.4 ND (all other)
OS-3-GW	8/3/2017	Gasoline Range: ND (<100) Diesel: 220^{x} Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	ND (all)
OS-5-GW	8/3/2017	Gasoline Range: ND (<100) Diesel: ND (<150) Motor Oil: ND (<750) (elevated D(x) detection limits due to limited sample volume)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	ND (all)
OS-6-GW	8/30/2017	Gasoline Range: ND (<100) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: 1.1 Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	ND (all)
OS-7-GW	8/3/2017	Gasoline Range: ND (<100) Diesel: 84^{x} Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	ND (all)

TABLE 2 (Continued)
Summary of Off-Site Groundwater Sample Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Boring/ Sample I.D.	*Sample Date*	*Laboratory Analytical Results (ug/l)*		
		Total Petroleum Hydrocarbons *(by Methods NWTPH-G & NWTPH-D(X))*	***Benzene Toluene Ethyl benzene Xylenes*** *(by EPA Method 8260C)*	***Other Volatile Organic Compounds*** *(by EPA Method 8260C)* *List of 58 Additional Compounds Detectable by the Laboratory Method.*
OS-8-GW	4/5/2017	Gasoline Range: ND (<100) Diesel: 66x Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	ND (all)
OS-9-GW	4/5/2017	Gasoline Range: ND (<100) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	ND (all)
OS-12-GW	8/3/2017	Gasoline Range: ND (<100) Diesel: 290x Motor Oil: ND (<250)	Benzene: 0.5 Toluene: 2.5 Ethylbenzene: ND (<1) Xylenes: ND (<3)	ND (all)
Washington State MTCA Groundwater Cleanup Criteria (ug/l)		***Gasoline: 800 (Benzene is present)*** ***Diesel or Motor Oil: 500 (combined)***	***Benzene: 5*** ***Toluene: 1,000*** ***Ethylbenzene: 700*** ***Xylenes: 1,000***	***cs-1,2-Dichloroethene: 16*** ***Trichloroethene: 5*** ***Other compounds vary***

Table 2 Notes:
ND (<XXX) - Parameter not detected at concentrations at or above the noted reporting limit.
Gasoline Range Total Petroleum Hydrocarbons by Method NWTPH-G.
Diesel and Motor Oil Range Total Petroleum Hydrocarbons by Method NWTPH-D(x).
x - Indicates sample chromatogram does not resemble fuel standard used for analysis. Most likely carry over from gasoline range hydrocarbons or organic material.
BTEX compounds and other volatile organic compounds by EPA Method 8260C. All detected compounds summarized here. See laboratory report for full list of analyzed parameters.

MTCA Groundwater cleanup criteria per Chapter 173-340-720 WAC. Method A criteria presented where available. Method B standard formula values shown where no Method A criteria available. Method B standard formula values from Dept. of Ecology Cleanup Levels and Risk Calculation (CLARC) database. NV indicates no value available from CLARC.

Sample results exceeding applicable cleanup criteria are noted in ***Bold Italic***.

Groundwater Level Data Summary from 2018 WES Groundwater Monitoring Report

Table 1
Summary of Groundwater Level Measurements
104 - 124 12th Avenue & 1209 E. Fir Street
Seattle, Washington

Monitoring Well	***Date***	***Top of Pipe Elevation***	***Water Level Below T.O.P.***	***Water Elevation***	***Comments***
MW-1	10/30/2017	200.26	-6.68	193.58	2" Well, 29' deep
	11/7/2017		-6.37	193.89	
	6/14/2018		-6.28	193.98	
MW-2	10/30/2017	201.08	-5.94	195.14	2" Well, 29' deep
	11/7/2017		-5.78	195.30	
	6/14/2018		-5.83	195.25	
MW-3	10/30/2017	199.98	-4.81	195.17	3/4" Well, 10.6' deep
	11/7/2017		-5.09	194.89	
	6/14/2018		-4.80	195.18	
MW-4	10/30/2017	199.36	-8.65	190.71	2" Well, 29' deep
	11/7/2017		-8.45	190.91	
	6/14/2018		-8.32	191.04	
MW-5	10/30/2017	200.99	-6.53	194.46	3/4" Well, 12' deep
	11/7/2017		-6.22	194.77	
	6/14/2018		-6.10	194.89	

Table 1
Summary of Groundwater Level Measurements
104 - 124 12th Avenue & 1209 E. Fir Street
Seattle, Washington

MW-6	10/30/2017	200.27	-2.75	197.52	3/4" Well, 12' deep
	11/7/2017		-2.10	198.17	
	6/14/2018		-2.82	197.45	
MW-7	10/30/2017	199.56	-2.41	197.15	1" Well, 11.5' deep
	11/7/2017		-1.70	197.86	
	6/14/2018		-2.66	196.90	
MW-8 (Formerly BN-7)	10/30/2017	216.51	NM	--	2" Well, 22' deep
	11/7/2017		-15.16	201.35	
	6/28/2018		-15.27	201.24	
MW-9 (Formerly BN-10)	10/30/2017	214.25	NM	--	2" Well, 25' deep
	11/7/2017		-13.14	201.11	
	7/13/2018		-13.99	200.26	
MW-10 (Formerly SMW-01)	10/30/2017	196.88	Not installed yet		
	11/7/2017		-10.21	186.67	2" Well, 15' deep
	6/14/2018		-9.88	187.00	

Table XXX Notes:
NM - Not measured due to obstruction over well.
Top of Pipe elevations determined by site survey Terrane, Inc., November 2017

Groundwater Data Periodic Monitoring Summary from 2018 WES Groundwater Monitoring Report

Table 3
Summary of 2017-2018 Groundwater Sample Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Boring/ Sample I.D.	**Sample Date**	**Laboratory Analytical Results (ug/l)**		
		Total Petroleum Hydrocarbons *(by Methods NWTPH-G & NWTPH-D(X))*	**Benzene Toluene Ethyl benzene Xylenes** *(by EPA Method 8260C)*	**Other Volatile Organic Compounds** *(by EPA Method 8260C)* *List of 58 Additional Compounds Detectable by the Laboratory Method.*
MW-1-GW	6/30/2017	Gasoline Range: ND (<100) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	Vinyl Chloride: 0.20 ND (all other)
	10/30/2017	Gasoline Range: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	ND (all)
	6/14/2018	Gasoline Range: ND (<100) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	***Vinyl Chloride: 0.27*** ND (all other)
MW-2-GW	4/4/2017	Gasoline Range: NA Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	ND (all)
	10/30/2017	Gasoline Range: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	ND (all)
	6/14/2018	Gasoline Range: ND (<100) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	ND (all)

Table 3
Summary of 2017-2018 Groundwater Sample Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Boring/ Sample I.D.	Sample Date	Laboratory Analytical Results (ug/l)		
		Total Petroleum Hydrocarbons *(by Methods NWTPH-G & NWTPH-D(X))*	**Benzene Toluene Ethyl benzene Xylenes** *(by EPA Method 8260C)*	**Other Volatile Organic Compounds** *(by EPA Method 8260C)* *List of 58 Additional Compounds Detectable by the Laboratory Method.*
MW-3-GW	4/3/2017	Gasoline Range: 110 Diesel: 400^x Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: 2.5 Ethylbenzene: ND (<1) Xylenes: 7.9	Acetone: 11 Naphthalene: 4.7 ***Vinyl Chloride: 0.34*** 1,2,4-Trimethylbenzene: 4.9 1,3,5-Trimethylbenzene: 1.1 ND (all other)
	10/30/2017	Gasoline Range: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	ND (all)
	6/14/2018	Gasoline Range: ND (<100) Diesel: 210^x Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	ND (all)
MW-4-GW	4/5/2017	Gasoline Range: NA Diesel: 67^x Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	ND (all)
	10/30/2017	Gasoline Range: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	ND (all)
	6/14/2018	Gasoline Range: ND (<100) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	ND (all)

Table 3
Summary of 2017-2018 Groundwater Sample Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Boring/ Sample I.D.	***Sample Date***	***Laboratory Analytical Results (ug/l)***		
		Total Petroleum Hydrocarbons *(by Methods NWTPH-G & NWTPH-D(X))*	***Benzene Toluene Ethyl benzene Xylenes*** *(by EPA Method 8260C)*	***Other Volatile Organic Compounds*** *(by EPA Method 8260C)* *List of 58 Additional Compounds Detectable by the Laboratory Method.*
MW-5-GW	4/5/2017	Gasoline Range: NA Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	Acetone: 12 ND (all other)
	10/30/2017	Gasoline Range: NA Diesel: NA Motor Oil: NA	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	***Vinyl Chloride: 0.29*** cis-1,2-Dichloroethene: 10 Tetrachloroethene: 1.4 ***Trichloroethene: 9.1*** ND (all other)
	6/14/2018	Gasoline Range: ND (<100) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	***Vinyl Chloride: 0.25*** cis-1,2-Dichloroethene: 8.3 Tetrachloroethene: 1.3 Trichloroethene: 5.0 ND (all other)
MW-6-GW	4/4/2017	Gasoline Range: NA Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: 1.2 Ethylbenzene: ND (<1) Xylenes: 5.5	cis-1,2-Dichloroethene: 1.3 1,2,4-Trimethylbenzene: 3.4 ND (all other)
	6/14/2018	Gasoline Range: ND (<100) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	cis-1,2-Dichloroethene: 9.6 Chloroform 1.1 Tetrachloroethene 1.2 ND (all other)

Table 3
Summary of 2017-2018 Groundwater Sample Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Boring/ Sample I.D.	***Sample Date***	***Laboratory Analytical Results (ug/l)***		
		Total Petroleum Hydrocarbons *(by Methods NWTPH-G & NWTPH-D(X))*	***Benzene Toluene Ethyl benzene Xylenes*** *(by EPA Method 8260C)*	***Other Volatile Organic Compounds*** *(by EPA Method 8260C)* *List of 58 Additional Compounds Detectable by the Laboratory Method.*
MW-7 (Originally Boring WES-8)	6/30/2017	Gasoline Range: ND (<100) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	ND (all)
	6/14/2018	Gasoline Range: ND (<100) Diesel: ND (<50) Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<3)	ND (all)
MW-8 (Originally Boring BN-7)	8/3/2017	***Gasoline Range: 3,200*** ***Diesel: 790^x^*** Motor Oil: ND (<250)	***Benzene: 11*** Toluene: ND (<1) Ethylbenzene: 71 Xylenes: 419	Isopropylbenzene: 12 n-Propylbenzene: 24 Naphthalene: 8.9 p-Isopropyltoluene: 1.1 sec-Butylbenzene: 1.8 1,2,4-Trimethylbenzene: 180 1,3,5-Trimethylbenzene: 59 ND (all other)
	6/28/2018	***Gasoline Range: 2,400*** ***Diesel: 160^x^*** Motor Oil: ND (<250)	Benzene: 2.9 Toluene: ND (<1) Ethylbenzene: 85 Xylenes: 432	Isopropylbenzene: 14 n-Propylbenzene: 33 Naphthalene: 1.6 p-Isopropyltoluene: 1.1 sec-Butylbenzene: 1.9 1,2,4-Trimethylbenzene: 150 1,3,5-Trimethylbenzene: 54 ND (all other)

Table 3
Summary of 2017-2018 Groundwater Sample Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Boring/ Sample I.D.	***Sample Date***	***Laboratory Analytical Results (ug/l)***		
		Total Petroleum Hydrocarbons *(by Methods NWTPH-G & NWTPH-D(X))*	***Benzene Toluene Ethyl benzene Xylenes*** *(by EPA Method 8260C)*	***Other Volatile Organic Compounds*** *(by EPA Method 8260C)* *List of 58 Additional Compounds Detectable by the Laboratory Method.*
MW-9 (Originally Boring BN-10)	8/3/2017	Gasoline Range: 500 Diesel: 270[x] Motor Oil: ND (<250)	***Benzene: 6.8*** Toluene: 1.3 Ethylbenzene: 6.3 Xylenes: 4.3	Hexane: 4.3 Isopropylbenzene: 7.2 n-Propylbenzene: 17 sec-Butylbenzene: 1.5 1,2,4-Trimethylbenzene: 1.3 1,3,5-Trimethylbenzene: 1.4 ND (all other)
	7/13/2018	Gasoline Range: 470 Diesel: 180[x] Motor Oil: ND (<250)	Benzene: 5.0 Toluene: ND (<1) Ethylbenzene: 8.5 Xylenes: 3.2	n-Propylbenzene: 23 sec-Butylbenzene: 1.9 1,2,4-Trimethylbenzene: 1.1 ND (all other)
MW-10 (Originally Boring SMW-01)	11/3/2017 (by Sound Earth)	Gasoline Range: ND (<100) Diesel: 69[x] Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	ND (all)
	6/14/2018	Gasoline Range: ND (<100) Diesel: 66[x] Motor Oil: ND (<250)	Benzene: ND (<0.35) Toluene: ND (<1) Ethylbenzene: ND (<1) Xylenes: ND (<1)	cis-1,2-Dichloroethene: 1.2 ND (all other)

Table 3
Summary of 2017-2018 Groundwater Sample Analytical Results
104 - 124 12th Avenue & 1209 E. Fir Street, Seattle, Washington

Boring/ Sample I.D.	Sample Date	Laboratory Analytical Results (ug/l)		
		Total Petroleum Hydrocarbons (by Methods NWTPH-G & NWTPH-D(X))	Benzene Toluene Ethyl benzene Xylenes (by EPA Method 8260C)	Other Volatile Organic Compounds (by EPA Method 8260C) List of 58 Additional Compounds Detectable by the Laboratory Method.
Washington State MTCA Groundwater Cleanup Criteria (ug/l)		Gasoline: 800 (Benzene is present) Diesel or Motor Oil: 500 (combined)	Benzene: 5 Toluene: 1,000 Ethylbenzene: 700 Xylenes: 1,000	Acetone: 7,200 cis-1,2-Dichloroethene: 16 Hexane: 480 Isopropylbenzene: 800 n-Propylbenzene: 800 Naphthalene: 160 p-Isopropyltoluene: NV sec-Butylbenzene: NV tert-Butylbenzene: NV Tetrachloroethene: 5 Trichloroethene: 5 Vinyl chloride: 0.2 1,2,4-Trimethylbenzene: NV 1,3,5-Trimethylbenzene: 80

Table 3 Notes:
ND (<XXX) - Parameter not detected at concentrations at or above the noted reporting limit.
NA - Sample not analyzed for the listed parameter.
Gasoline Range Total Petroleum Hydrocarbons by Method NWTPH-G.
Diesel and Motor Oil Range Total Petroleum Hydrocarbons by Method NWTPH-D(x).
x - Indicates sample chromatogram does not resemble fuel standard used for analysis. Most likely carry over from gasoline range hydrocarbons.
BTEX compounds and other volatile organic compounds by EPA Method 8260C. All detected compounds summarized here. See laboratory report for full list of analyzed parameters.

MTCA Groundwater cleanup criteria per Chapter 173-340-720 WAC. Method A criteria presented where available. Method B standard formula values shown where no Method A criteria available. Method B standard formula values from Dept. of Ecology Cleanup Levels and Risk Calculation (CLARC) database. NV indicates no value available from CLARC.

Sample results exceeding applicable cleanup criteria are noted in ***Bold Italic***.

APPENDIX C
Regenesis Product Information and Technical Papers

PLUMESTOP Liquid Activated Carbon

PlumeStop® Liquid Activated Carbon™ Technical Description

PlumeStop Liquid Activated Carbon is an innovative groundwater remediation technology designed to rapidly remove and permanently degrade groundwater contaminants. PlumeStop is composed of very fine particles of activated carbon (1-2µm) suspended in water through the use of unique organic polymer dispersion chemistry. Once in the subsurface, the material behaves as a colloidal biomatrix, binding to the aquifer matrix, rapidly removing contaminants from groundwater, and promoting permanent contaminant biodegradation.

This unique remediation technology accomplishes treatment with the use of highly dispersible, fast-acting, sorption-based technology, capturing and concentrating dissolved-phase contaminants within its matrix-like structure. Once contaminants are sorbed onto the regenerative matrix, biodegradation processes achieve complete remediation.

Distribution of PlumeStop in water

To see a list of treatable contaminants with the use of PlumeStop, view the Range of Treatable Contaminants Guide.

Chemical Composition

- Water - CAS# 7732-18-5
- Colloidal Activated Carbon ≤2.5 - CAS# µm 7440-44-0
- Proprietary Additives

Properties

- Physical state: Liquid
- Form: Aqueous suspension
- Color: Black
- Odor: Odorless
- pH: 8 - 10

Storage and Handling Guidelines

Storage
Store in original tightly closed container
Store away from incompatible materials
Protect from freezing

Handling
Avoid contact with skin and eyes
Avoid prolonged exposure
Observe good industrial hygiene practices
Wash thoroughly after handling
Wear appropriate personal protective equipment

PLUME STOP®
Liquid Activated Carbon

PlumeStop® Liquid Activated Carbon™ Technical Description

Applications

PlumeStop is easily applied into the subsurface through gravity-feed or low-pressure injection.

Health and Safety

Wash hands after handling. Dispose of waste and residues in accordance with local authority requirements. Please review the Material Safety Data Sheet for additional storage, usage, and handling requirements here: PlumeStop SDS.

REGENESIS

www.regenesis.com
1011 Calle Sombra, San Clemente CA 92673
949.366.8000

S-MicroZVI™
Sulfidated Zero-Valent Iron

S-MicroZVI Specification Sheet

S-MicroZVI Technical Description

S-MicroZVI™ is an *In Situ* Chemical Reduction (ISCR) reagent that promotes the destruction of many organic pollutants and is most commonly used with chlorinated hydrocarbons. It is engineered to provide an optimal source of micro-scale zero valent iron (ZVI) that is both easy to use and delivers enhanced reactivity with the target contaminants via multiple pathways. S-MicroZVI can destroy many chlorinated contaminants through a direct chemical reaction (**see Figure 1**). S-MicroZVI will also stimulate anaerobic biological degradation by rapidly creating a reducing environment that is favorable for reductive dechlorination.

S-MicroZVI is Best in Class For

- Longevity
- Reactivity
- Transport

Sulfidated ZVI

S-MicroZVI is composed of colloidal, sulfidated zero-valent iron particles suspended in glycerol using proprietary environmentally acceptable dispersants. The passivation technique of sulfidation, completed using proprietary processing methods, provides unparalleled reactivity with chlorinated hydrocarbons like PCE and TCE and increases its stability and longevity by minimizing undesirable side reactions.

In addition to superior reactivity, S-MicroZVI is designed for easy handling that is unmatched by any ZVI product on the market. Shipped as a liquid suspension, S-MicroZVI requires no powder feeders, no thickening with guar, and pneumatic or hydraulic fracturing is not mandatory. When diluted with water prior to application, the resulting suspension is easy to inject using either direct push or permanent injection wells.

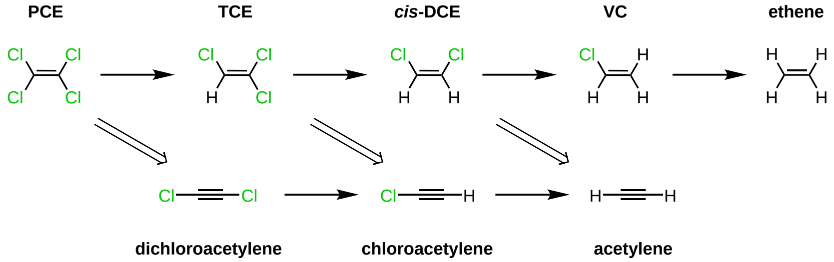


Figure 1: *Chlorinated ethene degradation pathways and products. The top pathway with single line arrows represent the reductive dechlorination (hydrogenolysis) pathway. The lower pathway with downward facing double line arrows represent the beta-elimination pathway.*

To see a list of treatable contaminants, view the S-MicroZVI treatable contaminants guide.

S-MicroZVI™
Sulfidated Zero-Valent Iron

S-MicroZVI Specification Sheet

Chemical Composition

Iron, powders CAS 7439-89-6
Iron (II) sulfide CAS 1317-37-9
Glycerol CAS 56-81-8

Properties

Physical State: Liquid
Form: Viscous metallic suspension
Color: Dark gray
Odor: Slight
pH: Typically 7-9 as applied
Density: 15 lb/gal

Storage and Handling Guidelines

Storage:
- Use within four weeks of delivery
- Store in original containers
- Store at temperatures below 95F°
- Store away from incompatible materials

Handling:
- Never mix with oxidants or acids
- Wear appropriate personal protective equipment
- Do not taste or swallow
- Observe good industrial hygiene practices

Applications

S-MicroZVI is diluted with water on site and easily applied into the subsurface through low-pressure injections. S-MicroZVI can also be mixed with products like 3-D Microemulsion® or PlumeStop® prior to injection.

Health and Safety

The material is relatively safe to handle; however, avoid contact with eyes, skin and clothing. OSHA Level D personal protection equipment including: vinyl or rubber gloves and eye protection are recommended when handling this product. Please review the Safety Data Sheet for additional storage, and handling requirements here: S-MicroZVI SDS.

REGENESIS®

www.regenesis.com

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S-Micro ZVI™
Sulfidated Zero-Valent Iron

Application Instructions

S-MicroZVI™ is a remediation amendment engineered for the *in situ* chemical reduction of chlorinated contaminants. The product features zero valent iron particles that are less than 5 microns in size and are suspended in a glycerol carrier. These materials are strong reductants and should never be combined with acids or oxidizers (see Health and Safety section).

S-MicroZVI Composition

40% sulfidated colloidal ZVI
45% food grade glycerol
15% water-based carrier

Physical Characteristics

Appearance: Dark gray viscous liquid
Viscosity: About 5000 cP (temperature dependent)
Density: 15 lb/gal

Helpful Chemical Property Measurements

The following solution characteristics measurements were obtained on a suspension mixture comprise of 4000 mg/L activated carbon from PlumeStop and 4000 mg/L zero valent iron from S-MicroZVI.

pH = 8.7
ORP = -492 mV
Conductivity = 2.36 mS/cm

Best Practices

Material Handling: S-MicroZVI is packaged in 50 lb buckets, 500 lb drums and 3000 lb totes. Use care/assistance if moving a tote with a pallet jack. A double diaphragm pump should be used to transfer S-MicroZVI from drums and totes into the mixing tank. Centrifugal drum pumps and dosing or metering pumps are not recommended due to the high viscosity of the material. Because of the low mass of S-MicroZVI typically required in the mixing tank, a bucket or similar container should be used to batch the ZVI material by weight or volume.

Mixing: S-MicroZVI should be homogenized in its packaging container before adding it into the mixing tank. Pails of S-MicroZVI are best mixed using a hand drill equipped with a paint mixer attachment. Totes and drums of S-MicroZVI should be mixed to a homogeneous consistency at the start of each application day using a 4 ft paint mixer attachment. As with all remedial reagents, it is a best practice to make sure the entire drum/tote is well mixed – including corners & bottom - before transferring into the mixing tank.

Mixing Order: Whenever S-MicroZVI is co-applied with other remedial reagents (PlumeStop®, 3D Microemulsion®, pH modifiers, etc.), the order of addition should be as follows:

1) Water
2) Other amendments (PlumeStop®, 3DME, etc.)
3) S-MicroZVI

Mix Tank: A conical tank less than 500 gal is recommended for batching. It should be equipped with a mixer than has enough power to gently agitate the mixture. The goal is to keep solids suspended without overly aerating the material.

Cleaning: Always thoroughly rinse all S-MicroZVI containers before disposal. Rinse water from this step should be placed into the mixing tank for application. Inspect tanks for any residue of reagents that were recently used in the tank. If there is any evidence rinse tank thoroughly. A thorough cleaning step should be performed at the end of each work day. This should be accomplished by flushing the entire injection system with municipal water.

Health & Safety

Risk Potential, Hydrogen Sulfide: S-MicroZVI will give off hydrogen sulfide (H2S) gas when exposed to acid. For this reason, it is imperative that low pH (acid) solutions NOT come into contact with solutions containing S-MicroZVI.

In the interest of safety, a hydrogen sulfide detector should be part of every S-MicroZVI application program.

S-MicroZVI™
Sulfidated Zero-Valent Iron

Hydrogen sulfide is toxic, corrosive, and flammable. The threshold of odor detection for hydrogen sulfide is approximately 0.0005 ppm; however, at higher concentrations hydrogen sulfide will suppress the olfactory senses. For this reason, one's sense of smell is not a reliable method of detection, and failure to rely on a hydrogen sulfide detector can lead to overexposure and potentially death. The OSHA Permissible Exposure Limit for an 8-hour timeweighted average is 10 ppm, and hydrogen sulfide is classified as Immediately Dangerous to Life and Health at 100 ppm. With proper handling, no detectable hydrogen sulfide will be produced by S-MicroZVI.

Do not mix S-MicroZVI with acid, this includes HRC or HRC Primer.

- Adding acid to S-MicroZVI can cause hydrogen sulfide to be produced for many hours. If hydrogen sulfide is being produced, work must stop.

Do not combine S-MicroZVI with any oxidizing agent (PersulfOx®, RegenOx®, etc.)

- S-MicroZVI is a strong reductant. Combining
- S-MicroZVI with oxidizers will cause a vigorous exothermic reaction and has the potential to produce hydrogen sulfide.

Preferred Storage Conditions: S-MicroZVI should be stored in cool, dry places if possible. Indoor storage is preferred – if this is not available, seek a covered or shaded spot outdoors.

Shelf Life:** S-MicroZVI should be used within 4 weeks of arrival onsite.

** Shelf life may decrease with extreme temperatures. For situations where prolonged temperature may exceed 90F we advise to use the product as soon as possible. Small amounts of hydrogen gas may evolve from the material during storage. For this reason, buckets, drums, and totes are vented.

Handling Practices: Standard PPE should be used when handling S-MicroZVI. This includes eye protection, gloves and face shield when mixing.

There are some specific characteristics to keep in mind for these materials:

Density: A half-full pail may be heavier than it appears, use care when lifting.
Cleanliness: This product will stain clothes.
Slip concerns: S-MicroZVI can be very slick if spilled. In the event of a spill, use caution as the floor may be very slippery.

Do's & Don'ts

Do

- ✓ Use a diaphragm pump to transfer S-MicroZVI from totes or drums.
- ✓ Use a bucket or graduated vessel to measure S-MicroZVI for the mixing tank from totes or drums.
- ✓ Rinse each mix tank at the end of the day to prevent excess buildup of ZVI solids.
- ✓ Use tap water for rinsing and cleaning.
- ✓ Inject the equivalent of a 7-borehole volume of clear water into injection wells and any affected monitoring well upon completion of the injection program.
- ✓ BDI Plus™ and S-MicroZVI are compatible. Apply BDI Plus as typical.
- ✓ Use pails of S-MicroZVI within 2-3 days of opening.
- ✓ Use standard PPE when using S-MicroZVI. This includes safety glasses, face shield, and gloves.

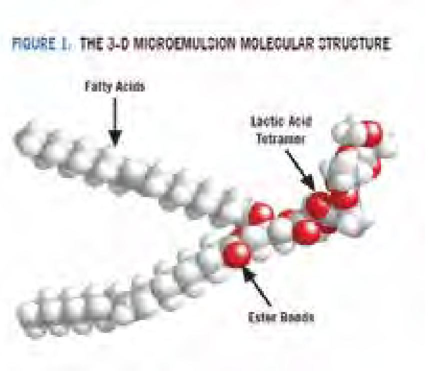
Don't

- ✗ Use dose pumps, drum pumps, etc. to transfer S-MicroZVI.
- ✗ Store product below 30 degrees to avoid thickening.
- ✗ Use buckets that contained RegenOx®, PersulfOx®, HRC®, or HRC Primer.
- ✗ Leave suspensions containing S-MicroZVI in the mixing tank overnight or for an excess period (4-5 hours).
- ✗ Ever add acid or oxidizers to S-MicroZVI.
- ✗ Use sodium bisulfite or other oxygen scavengers. These are unnecessary with S-MicroZVI.
- ✗ Use partial pails of S-MicroZVI that were opened for a previous site.
- ✗ When batching, add more than 50lb. of total suspension to pails

3-D Microemulsion® Factory Emulsified Technical Description

3-D Microemulsion (3DME®) is comprised of a patented molecular structure containing oleic acids (i.e., oil component) and lactates/polylactates, which are molecularly bound to one another (figure 1). The 3DME molecule contains both a soluble (hydrophilic) and in-soluble (lipophilic) region. These two regions of the molecule are designed to be balanced in size and relative strength. The balanced hydrophilic/lipophilic regions of 3DME result in an electron donor with physical properties allowing it to initially adsorb to the aquifer material in the area of application, then slowly redistribute via very small 3DME "bundles" called micelles. These 3DME micelles spontaneously form within sections of the aquifer where concentrations of 3DME reach several hundred parts per million. The micelles' small size and mobility allow it to move with groundwater flow through the aquifer matrix, passing easily through the pore throats in between soil grains resulting in the further redistribution of 3DME within the aquifer. This allows for advective distribution of the oleic acids which are otherwise insoluble and unable to distribute in this manner, allowing for increased persistence of the lactate/polylactates component due to their initial attachment to the oleic acids.

Example of 3-D Microemulsion



Due to its patented molecular structure, 3DME offers far greater transport when compared to blended emulsified vegetable oil (EVO) products, which fail to distribute beyond the limits of pumping. 3DME also provides greater persistence when compared to soluble substrates such as lactates or simple sugars. The 3DME molecular structures capitalize on the best features of the two electron-donor types while at the same time, minimize their limitations. 3DME is delivered to the site as a ready-to-apply emulsion that is simply diluted with water to generate a large volume of a 3DME colloidal suspension.

Suspension of 3DME generated by this mixing range from micelles on the order of .02 microns to .05 microns in diameter, to "swollen" micelles, (termed "microemulsions") which are on the order of .05 to 5 microns in diameter. Once injected into the subsurface in high volumes, the colloidal suspension mixes and dilutes in existing pore waters. The micelles/microemulsions on the injection front will then begin to sorb onto the surfaces of soils as a result of zeta potential attraction and organic matter within the soils themselves. As the sorption continues, the 3DME will "coat" pore surfaces developing a layer of molecules and in some cases a bilayer. This sorption process continues as the micelles/microemulsion moves outward and disassociates into their hydrophilic/hydrophobic components. The specialized chemistry of 3DME results in a staged release of electron donors: free lactate (immediate); polylactate esters (mid-range) and free fatty acids & fatty acid esters (long-term). Material longevity of three years or greater has been seen at most sites as determined from biogeochemical analyses.

For a list of treatable contaminants with the use of 3DME, view the Range of Treatable Contaminants Guide

Chemical Composition

- Hydrogen Release Compound Partitioning Electron Donor – CAS #823190-10-9
- Sodium Lactate – CAS# 72-17-3
- Water – CAS# – 7732-18-5

MICROEMULSION
Factory Emulsified

3-D Microemulsion® Factory Emulsified Technical Description

Properties

- Density – Approximately 1.0 grams per cubic centimeter (relative to water)
- pH – Neutral (approximately 6.5 to 7.5 standard units)
- Solubility – Soluble in Water
- Appearance – White emulsion
- Odor – Not detectable
- Vapor Pressure – None
- Non-hazardous

Storage and Handling Guidelines

Storage
Store in original tightly closed container
Store in a cool, dry, well-ventilated place
Store away from incompatible materials
Recommended storage containers: plastic lined steel, plastic, glass, aluminum, stainless steel, or reinforced fiberglass

Handling
Avoid contact with eyes, skin, and clothing
Provide adequate ventilation
Wear appropriate personal protective equipment
Observe good industrial hygiene practices

Applications

- 3DME is diluted with water prior to application. Resulting emulsion has viscosity similar to water.
- Easily injects into formation through direct push injection points, injection wells or other injection delivery systems.

Application instructions for this product are contained here 3DME FE Application Instructions.

Health and Safety

Material is food grade and relatively safe to handle. We recommend avoiding contact with eyes and prolonged contact with skin. OSHA Level D personal protection equipment including vinyl or rubber gloves, and eye protection are recommended when handling this product. Please review the Material Safety Data Sheet for additional storage, usage, and handling requirements here: SDS-3DME FE.

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BDI PLUS® Technical Description

Bio-Dechlor INOCULUM Plus (BDI PLUS®) is an enriched natural consortium containing species of Dehalococcoides sp. (DHC). BDI PLUS has been shown to simulate the rapid and complete dechlorination of chlorinated solvents such as tetrachloroethene (PCE), trichloroethene (TCE), dichloroethene (DCE) and vinyl chloride (VC) to non-toxic end products, ethene, carbon dioxide and water.

The culture also contains microbes capable of dehalogenating halomethanes (e.g., carbon tetrachloride and chloroform) and haloethanes (e.g., 1,1,1-TCA and 1,1-DCA) as well as mixtures of these contaminants.

Species of Dehalococcoides sp. (DHC)

For a list of treatable contaminants with the use of BDI PLUS, view the Range of Treatable Contaminants Guide

Chemical Composition

- Non-hazardous, naturally-occurring, non-altered anaerobic microbes and enzymes in a water-based medium.

Properties

- Appearance – Murky, yellow to grey water
- Odor – Musty
- pH 6.0 to 8.0
- Density – Approximately 1.0 grams per cubic centimeter (0.9 to 1.1 g/cc)
- Solubility – Soluble in Water
- Vapor Pressure – None
- Non-hazardous

Storage and Handling Guidelines

Storage
Store in original tightly closed container
Store away from incompatible materials
Recommended storage containers: plastic lined steel, plastic, glass, aluminum, stainless steel, or reinforced fiberglass
Store in a cool, dry area at 4-5°C (39 - 41°F)
Material may be stored for up to 3 weeks at 2-4°C without aeration

Handling
Avoid prolonged exposure
Observe good industrial hygiene practices
Wear appropriate personal protective equipment

BIO-DECHLOR INOCULUM

BDI PLUS® Technical Description

Applications

- BDI PLUS is delivered to the site in liquid form and is designed to be injected directly into the saturated zone requiring treatment.
- Most often diluted with de-oxygenated water prior to injection into either hydraulic push injection points or properly constructed injection wells.
- The typical dilution rate of the injected culture is 10 gallons of deoxygenated water to 1 liter of standard BDI PLUS culture.

Application instructions for this product are contained here BDI PLUS Application Instructions.

Health and Safety

Material is non-hazardous and relatively safe to handle; however avoid contact with eyes and prolonged contact with skin. OSHA Level D personal protection equipment including: vinyl or rubber gloves and safety goggles or a splash shield are recommended when handling this product. An eyewash station is recommended. Please review the Material Safety Data Sheet for additional storage, usage, and handling requirements here: BDI PLUS SDS.

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PlumeStop® Technical Bulletin 1.1

Distribution through a Permeable Medium

Quick Reference:

- PlumeStop distribution through > 16' (5 m) packed medium readily achieved
- Even coating of sand matrix with PlumeStop secured
- Retained coating not subject to washout
- No detectable impact on permeability

Background

PlumeStop® Liquid Activated Carbon™ is composed of very fine particles of activated carbon (1-2µm) suspended in water through the use of unique organic polymer dispersion chemistry. Once in the subsurface, the material behaves as a colloidal biomatrix, sorbing to the aquifer matrix, rapidly removing contaminants from groundwater, and expediting permanent contaminant biodegradation.

PlumeStop Flows through Permeable Media

PlumeStop is a very fine suspension of charged particles that resists clumping and has a very low viscosity that is similar to water. As a result, PlumeStop is easily applied to the subsurface through gravity-feed or low-pressure injection. Once applied, the material moves as a colloidal suspension through the permeable aquifer zones, coating the pore structures with a thin layer (ca.1µm) of PlumeStop particles.

Long Column Study - 16 Foot (5 meter)

Study Objective

In order to evaluate in detail the movement of PlumeStop through a simple permeable soil medium over field-relevant distances, an extended column study was undertaken in the laboratory.

Experimental Setup

A 16 foot (4.9 m) long by 2 inch (5 cm) diameter transparent PVC column was erected in a vertical position supported by a standing rack system (Figure 1). End-caps were affixed that were fitted with Viton® tubing (size 16; 0.12" / 3.1 mm ID). A white background was put in place with calibration marks every four feet (1.22 m). The column was then slurry packed with 35.4 lbs (16.1 kg) of Lapis Lustre #60 silica sand with particle size ranging from 210 µm to 420 µm (fine to medium sand). Based upon the volume and characteristics of the material packed within the column, the open pore volume (matrix total porosity) was calculated to be approximately 0.11 cubic feet (3.0 L) (30%).

Operation

A peristaltic pump was used to flow water and PlumeStop from a reservoir at the bottom of the column upward. Effluent leaving the top of the column was captured in a separate reservoir. Flow rates and pressures were measured at both the influent and effluent ports. Initially, water alone was pumped into the column at a target rate of 60 mL/minute (column seepage velocity 3.2 minutes per foot / 10.3 minutes per meter; = 0.16 cm/sec assuming unity of mobile and total porosity). Once the desired flow-rate was obtained and the system was tested for leaks, the influent reservoir was switched from clean water to a solution of PlumeStop. The system was operated until breakthrough of PlumeStop from the column was observed, and then continued at steady-state conditions for approximately 4 additional pore volumes before returning the influent to water only for approximately 9 pore volumes. Monitoring of influent and effluent PlumeStop concentrations proceeded until effluent concentrations declined to zero.

Figure 1. 16' Experimental Column.

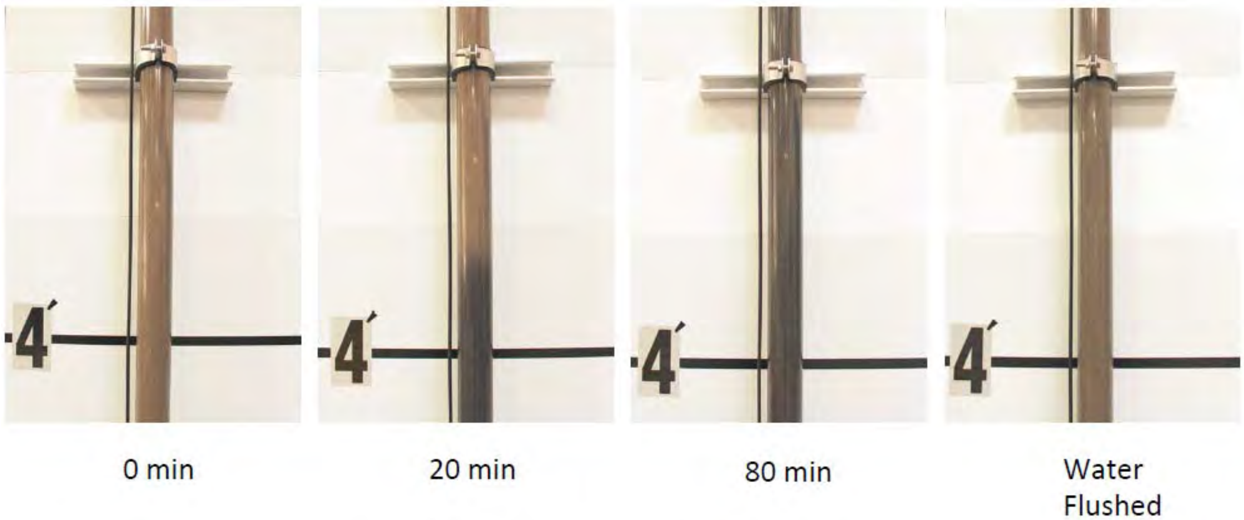

Figure 2. Visible PlumeStop migration front and coating residue following water-flush.

Results

The movement of the PlumeStop through the column was visually apparent, as the black color could be easily seen through the transparent PVC column casing (Figure 2). After 69 minutes or 1.2 pore volumes, PlumeStop had moved completely through the column at an even flow without fracture or visible fingering and was detected in the effluent. Shortly following breakthrough, the effluent PlumeStop concentration reached a steady state that equaled the influent concentration.

After approximately 4 additional pore volumes of PlumeStop were eluted at steady state, the influent solution was switched back to water only. PlumeStop concentrations in the effluent declined sharply after one pore volume of clean water and dropped beneath detection limits (0.1% of applied concentration) within 2 pore volumes. A total of 9 pore volumes of water were eluted post PlumeStop application. Data are presented graphically in Figure 3.

Carbon Retention Mass Balance

Mass balance calculations from the influent and effluent PlumeStop concentrations and the flow rate indicated that 5.7% of the applied PlumeStop carbon was retained within the column. This calculated value was further supported by elemental analysis of the column sand (analyzed destructively following the study and corrected against sand-only blanks), which revealed a consistent loading of 20 – 45 mg of elemental carbon per kg of sand throughout the column (Figure 4).

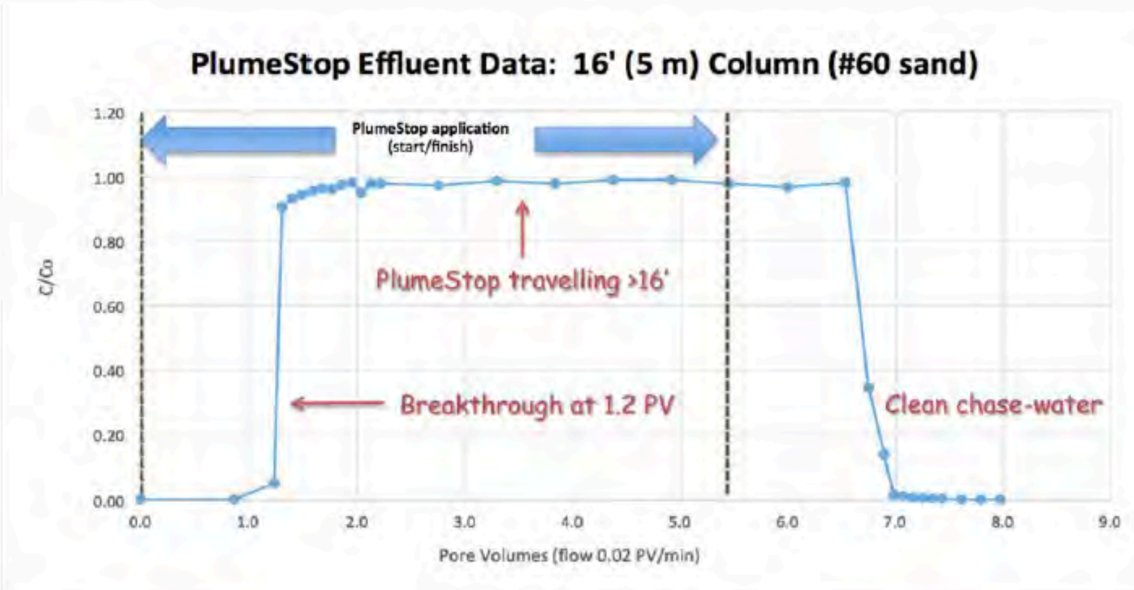

Figure 3. PlumeStop breakthrough dynamic – 16' (5m) column study.

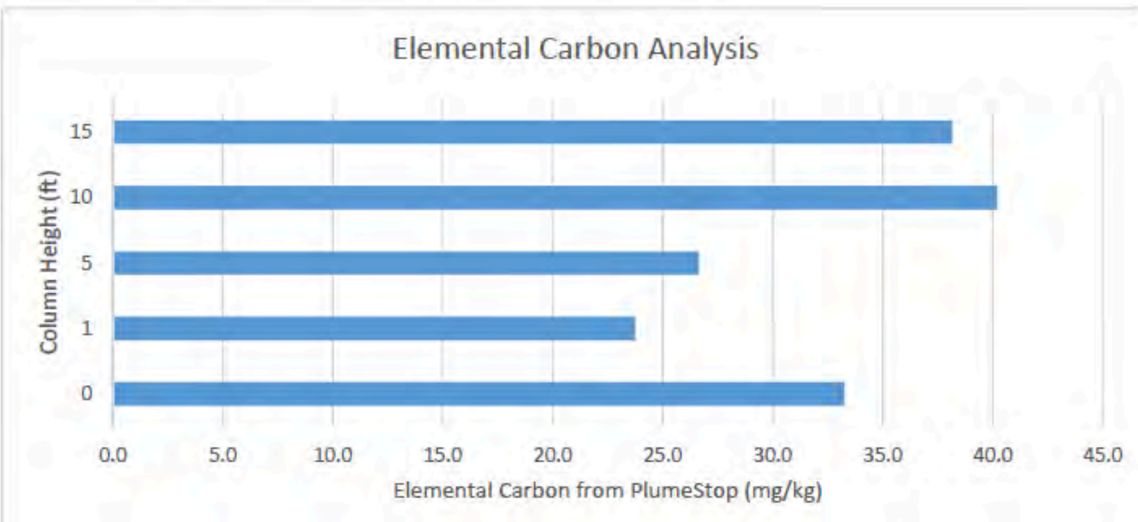

Figure 4. Elemental carbon (corrected against clean packing sand) at discrete depths.

Discussion

The ability to transport activated carbon as a liquid suspension through a permeable soil formation while leaving a dispersed bound residue that is resistant to washout was clearly demonstrated by this study. Breakthrough from the column following application of 1.2 pore volumes without visible soil fracturing or fingering illustrates the ease of distribution under low-pressure, advective flow.

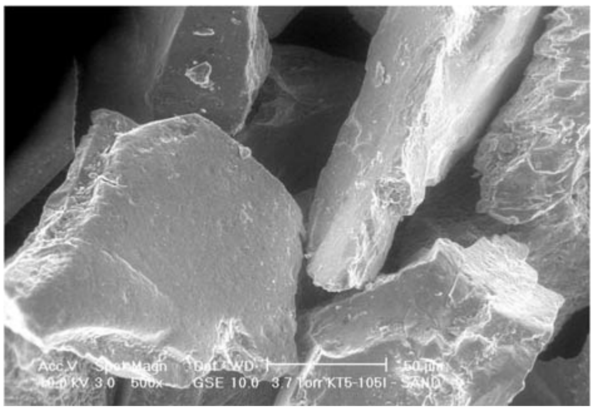
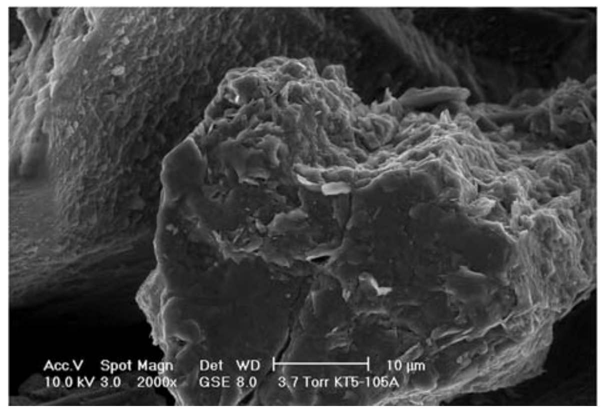

Figure 5. Scanning electron micrograph (SEM) of sand particles without PlumeStop (left) and coated with PlumeStop colloid (right) (Birnstingl et al., 2014).

Uniform retention of activated carbon on the soil matrix after extensive water flushing was visually apparent and was supported by elemental analysis of the sand after the study, which showed a loading of 20-45 mg per kg of sand throughout the column. An example of how activated carbon coats sand particles is shown in the scanning electron micrograph in Figure 5 (Birnstingl et al., 2014).

It should be noted that retention by other soil types will be different from that noted above – the present study is primarily intended to illustrate the principle of long-distance dispersive distribution and matrix-coating.

In field applications, the fraction of activated carbon retained per unit volume will be influenced both by soil type and volume, as well as by the manner of application. PlumeStop transport and retention through other soil types will be the subject of subsequent Technical Bulletins.

Conclusions

1. PlumeStop can be dispersed through at least 16' (5m) of fine to medium sand.
2. 5.7% of the PlumeStop carbon (dry weight) was retained on the column of the present study, suggesting that significantly greater radial transport distances would be possible when the product is injected through a well into an aquifer environment.

3. The retained activated carbon coating of the matrix was evenly distributed throughout the column diameter and length (20 – 45 mg/kg range throughout the column), and plugging, clumping, fracturing, or fingering were not observed.

4. The retained coating was not subject to washout, even under vigorous flushing of 9 pore volumes within 24 hours.

5. Total volume occupied by the retained solids was <0.1% of the soil pore volume and presented no measureable impact on permeability.

Literature Cited

1. Birnstingl, J., Sandefur, C., Thoreson, K., Rittenhouse, S., and Mork, B. (2014). PlumeStop Colloidal Biomatrix – securing rapid contaminant reduction and accelerated biodegradation using a dispersive injectable reagent. San Clemente, CA: REGENESIS Bioremediation Products.

PLUME STOP
Liquid Activated Carbon

PlumeStop® Technical Bulletin 2.1

Sorption of Contaminants from Solution: Terms & Principles

Quick Reference:

- Principles of PlumeStop sorption
- PlumeStop sorption isotherms
- Significance as a remediation tool

Background

PlumeStop® Liquid Activated Carbon™ is composed of very fine particles of activated carbon (1-2 µm) suspended in water through the use of unique organic polymer dispersion chemistry. Once in the subsurface, the material behaves as a colloidal biomatrix, sorbing to the aquifer matrix, rapidly removing contaminants from groundwater, and expediting permanent contaminant biodegradation.

Wide-Area Dispersive Distribution

Unlike any other sorbent technology, PlumeStop can be installed in the subsurface through dispersive flow from low-pressure injection (without fracturing the formation), providing a wide-area, thin-film coating of the aquifer matrix. It does not create preferential flow pathways, plug the formation, or compromise monitoring wells through extreme carbon loading, as is often the case with pressure-emplaced powdered activated carbon.

More information on low-pressure ease of distribution and dispersive emplacement of PlumeStop can be found in PlumeStop Technical Bulletin 1.1: Distribution through a Permeable Medium.

Rapid Removal of Contaminants from Groundwater

PlumeStop rapidly sorbs organic contaminants from aqueous solution within the timescale of hours. Pollutants partition directly into the PlumeStop particles that are sorbed to the soil formation, thereby removing the pollutants from groundwater. Contaminant advection in the aqueous phase is therefore eliminated, and partitioning into the vapor phase is also reduced (Henry's Law). Results can be dramatic, with groundwater cleanup objectives often met within days of PlumeStop application.

Sorption of contaminants by PlumeStop is the subject of the present technical bulletin.

Acceleration of Contaminant Biodegradation

Once sorbed to the soil and with contaminants partitioned onto its surface, PlumeStop is colonized by contaminant-degrading bacteria. These bacteria may be naturally present or applied as an inoculum. The concentration of the contaminants and the degradative microflora on the PlumeStop surface reduces mass-transfer kinetic constraints and supports greater speed and efficiency of degradation compared to solution-phase bioremedmdiation.

The net result is a substantial increase in the instantaneous rate and extent of contaminant destruction. Information on post-sorption biodegradation and rate acceleration by PlumeStop can be found in PlumeStop Technical Bulletin 3.1: Post-Sorption Contaminant Biodegradation.

PlumeStop Contaminant Sorption

Activated Carbon

The sorptive capacity of PlumeStop arises from its activated carbon content. The use of activated carbon for removal of organic contaminants from vapor and water streams is widespread in the environmental industry. Additionally, activated carbons are often the final polishing step in potable water clean up owing to their non-toxic nature and ability to remove very low levels of organic (and some inorganic) contaminants.

Activated carbon materials can be formed from a range of organic and mineral carbonaceous feedstocks through heat and/or chemical treatment to provide a high-purity material with a microporous structure that yields a very high adsorptive surface area of 500 – 1,500 m^2/g (1). As a result of this high surface area, the sorptive capacity of the carbon is increased significantly over that of the natural carbon. In the case of PlumeStop, this increase is 50 – 100 x greater than an equivalent mass of natural soil organic carbon (foc) (dry mass basis).

Forms of Activated Carbon

Traditionally, activated carbon has been available in two principle forms – Powdered Activated Carbon (PAC) and Granular Activated Carbon (GAC), both finding use primarily in *ex situ* applications. The development of PlumeStop introduces a third class of composition – that of a *Liquid Activated Carbon* (LAC).

This new carbon composition extends the range of possible uses to include *in situ* applications, most notably subsurface applications, owing to the ability of the material to disperse freely through and coat permeable granular media (PlumeStop Technical Bulletin 1.1: Distribution through a Permeable Medium).

Contaminant Removal by Activated Carbon

Contaminant removal by activated carbon occurs principally through adsorption. This is driven by the hydrophobic / lipophilic character of the sorbing species but also by electrostatic Van der Waals interactions between the sorbent and sorbate (*1*).

By nature, there is no fixed 'capacity' of sorption by activated carbon in the sense of filling a container, but rather an equilibrium between sorbed-phase and desorbed-phase concentrations that is itself dependent on:

- The nature of the activated carbon (sorbent);
- The mass of the activated carbon;
- The concentration and hydrophobic / lipophilic nature of the contaminant (sorbate)
- The concentration of the contaminant (sorbate);
- The presence of, and interactions with, other contaminants and naturally occurring species.

Isotherms

The influence of the above factors on the sorption equilibrium of contaminants on PlumeStop may be conveniently described using sorption isotherms–plots of sorbate mass adsorbed per mass of sorbent as a function of equilibrium concentration of sorbate in solution. These are commonly summarized from empirical data using the Freundlich equation[1] (*2*). Example sorption isotherms for benzene and TCE are presented in Figures 1 and 2. Freundlich parameters of common groundwater contaminants on PlumeStop are presented in Table 1.

[1]Freundlich Equation is $\mathbf{q_e = K_f C_e^{1/n}}$

and can be linearized as: $\mathbf{\log q_e = \log K_f + 1/n * \log C_e}$

q_e = equilibrium loading on the sorbent (mg chemical/g sorbent)

C_e = equilibrium concentration in the water (mg chemical/L)

K_f = adsorption capacity at unit concentration $(mg/g)/(mg/L)^{1/n}$

1/n = strength of adsorption (dimensionless)

PLUME STOP
Liquid Activated Carbon

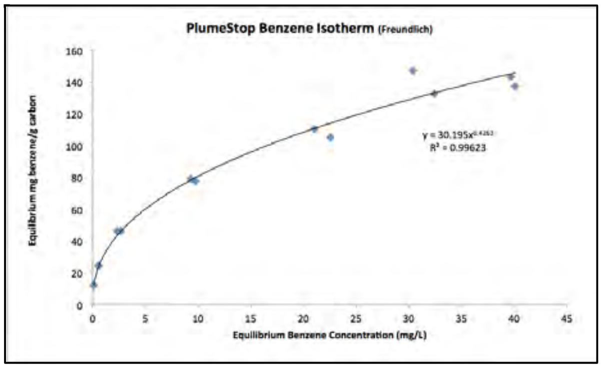

Figure 1. Sorption isotherm of benzene on PlumeStop

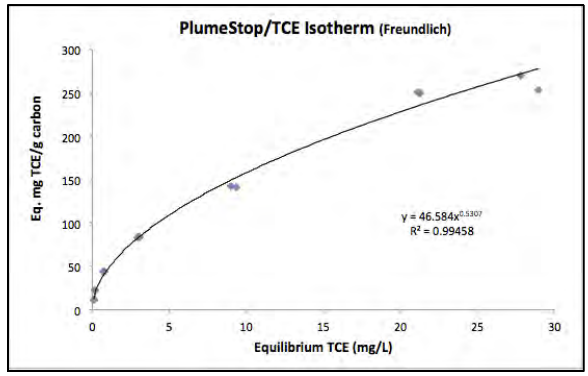

Figure 2. Sorption isotherm of TCE on PlumeStop

Note that while each contaminant will have a slightly different sorption isotherm with PlumeStop, the Freundlich nature of these isotherms means that sorption efficiency always increases as the solution concentration drops – the sorbed: solution ratio increases as the curve steepens at the lower end. In practical engineering terms, this translates as greater capture efficiency at lower concentrations, and as such may present a welcome contrast to the majority of remediation technologies that typically exhibit decreasing performance at lower contaminant concentrations.

Table 1. Selected PlumeStop® Freundlich Adsorption Isotherm Constants

Non-chlorinated Species			Chlorinated Species		
Compound	**K_f**	**1/n**	**Compound**	**K_f**	**1/n**
Benzene	30.2	0.427	PCE	105	0.422
Toluene*	97.0	0.429	TCE	46.6	0.531
Ethylbenzene*	163	0.415	cis-1,2-DCE	11.7	0.548
o-xylene	217	0.428	VC*	4.16	0.339
p-xylene*	226	0.418	1,1,1-TCA	19.2	0.634
MtBE	6.54	0.397	1,2-DCA	11.3	0.454
Naphthalene*	132	0.420	Chlorobenzene	135	0.315
Phenanthrene*	215	0.440	1,2-Dichlorobenzene	326	0.209
Benzo(a)pyrene*	34.0	0.440	2-Chlorotoluene	173	0.202
Styrene*	327	0.480	Pentachlorophenol*	443	0.340
K_f =(mg/g)/(mg/L)$^{1/n}$; n = dimensionless. Data derived empirically, unless * Data estimated from literature.					

Sorption and Bioavailability

Importantly, the capture of organic species by the activated carbon results from a partitioning equilibrium between sorbed-phase and aqueous phase concentrations rather than a 'fixed binding' as is the case in immobilization technologies. As a result, the binding remains dynamic, with contaminants continually sorbing and desorbing on the PlumeStop surface. However, the sorbed-phase concentration always dominates the equilibrium when sufficient activated carbon is present.

On the macro scale, the partitioning equilibrium of organic species on the carbon surface resembles 'fixed binding' as the contaminants are removed from the aqueous phase by the sorbent. However, on the micro scale, the repeated local desorption and re-sorption allows the contaminants to move about the sorbent surface. This process is strongly beneficial to post-sorption contaminant biodegradation because it overcomes local depletion of substrate around the immobile contaminant-degrading microorganism and thus ensures continued contaminant bioavailability.

Contaminant degradation is further enhanced through the concentration of the contaminants and degrading microflora together on the carbon surface, increasing the instantaneous rate of reaction through first-order kinetic principles (3) and overcoming limitations of degradation threshold (S_{min}) concentrations (4, 5).

Significance as a Remediation Tool

PlumeStop is not a Binding / Immobilization Technology

Although a key property for the success of PlumeStop in groundwater remediation is the ability to rapidly remove contaminants from the aqueous phase, sorption of contaminants by PlumeStop is secondary to the reagent's primary function. The ultimate purpose of PlumeStop is to expedite contaminant degradation at low concentrations for the management of back-diffusion, diffuse plume elimination, and reduction of flux across property boundaries. Contaminant sorption supports this degradative process and in so doing conveniently provides a rapid reduction in risk rather than long-term immobilization and storage.

PlumeStop as a Means of Engineering Plume Dynamics

Within the context of Contaminant Fate & Transport, the sorptive capacity of PlumeStop provides a means of controlling contaminant migration rate and/or residence time within a treatment zone. This control can be used to reduce attenuation distance and therefore restrict plume expansion on monitored natural attenuation (MNA) projects, as well as for risk-based corrective action strategies. It can similarly provide a means of increasing contaminant residence time within a focused treatment zone to increase efficiency and reduce the spatial footprint of compatible reagent injections.

PlumeStop as a Means of Reducing Risk

Rapid removal of contaminants from the aqueous phase provides a correspondingly fast reduction in risk within the timescale of days. Contaminants are rapidly removed from the aqueous phase, thereby reducing migration and exposure via groundwater pathways. Partitioning from groundwater to the vapor-phase is also reduced as a consequence (Henry's Law).

PlumeStop as a Means of Enhancing Contaminant Biodegradation

Contaminant biodegradation is accelerated on PlumeStop (Technical Bulletin 3.1: Post Sorption Contaminant Biodegradation). This is attributed to the reduction of mass-transfer kinetic constraints on contaminant bioavailability as a result of bringing the contaminants and the degrading microflora together on the PlumeStop surface (3). Additionally, PlumeStop can accumulate very low-level contaminants on its surface until threshold concentrations for microbial activity (S_{min}) are secured. As a result, bioremediation can be made effective for clean-up of trace plumes and back-diffusion management that otherwise respond poorly to biostimulation or augmentation.

PlumeStop as a Means of of Back-Diffusion Management

The combined features of PlumeStop – wide-area dispersion, contaminant capture, contaminant biodegradation enhancement, and bio-regeneration of sorptive capacity – create a novel tool for back-diffusion management (Technical Bulletins 1.1: Distribution through a Permeable Medium; 3.1: Post Sorption Contaminant Biodegradation; and 4.1: Regeneration of Sorptive Capacity). The material may be dispersed freely through the primary porosity, where it will sorb to the soil, capture and degrade contaminants, and maintain a diffusion gradient out of the secondary porosity, thereby providing sustained capture and destruction of back-diffusing mass.

Literature Cited

1. F. Çeçen, Ö. Aktas, *Activated carbon for water and wastewater treatment: Integration of adsorption and biological treatment* (John Wiley & Sons, 2011).

2. F. HMF, *ZPhys Chem* **57**, 385 (1906).
3. J. G. A. Birnstingl, Sandefur, C., Thoreson, K., Rittenhouse, S., Mork, B., www.plumestop.com (2014).
4. F. Roch, M. Alexander, *Environmental toxicology and chemistry* **16**, 1377 (1997).
5. L. Toräng, N. Nyholm, H.-J. Albrechtsen, *Environmental Science & Technology Environ. Sci. Technol.* **37**, 3095 (2003).

PlumeStop® Technical Bulletin 3.1

Post-Sorption Contaminant Biodegradation

Quick Reference:

- Demonstration of post-sorption contaminant biodegradation
- Net acceleration of contaminant biodegradation rate

Background

PlumeStop® Liquid Activated Carbon™ is composed of very fine particles of activated carbon (1- 2 µm) suspended in water through the use of unique organic polymer dispersion chemistry. Once in the subsurface, the material behaves as a colloidal biomatrix, sorbing to the aquifer matrix, rapidly removing contaminants from groundwater, and expediting permanent contaminant biodegradation.

Wide-Area Dispersive Distribution

Unlike any other sorbent technology, PlumeStop can be installed in the subsurface through dispersive flow from low-pressure injection (without fracturing the formation), providing a wide-area, thin-film coating of the aquifer matrix. It does not create preferential flow pathways, plug the formation, or compromise monitoring wells through extreme carbon loading, as is often the case with pressure-emplaced powdered activated carbon products.

More information on low-pressure ease of distribution and dispersive emplacement of PlumeStop can be found in PlumeStop Technical Bulletin 1.1: Distribution through a Permeable Medium.

Rapid Removal of Contaminants from Groundwater

PlumeStop rapidly sorbs organic contaminants from aqueous solution within the timescale of hours. Pollutants partition directly into the PlumeStop particles that are sorbed to the soil formation, thereby removing the pollutants from groundwater. Contaminant advection in the aqueous phase is therefore eliminated, and partitioning into the vapor phase is also reduced (Henry's Law). Results can be dramatic, with groundwater cleanup objectives often met within days of PlumeStop application.

Information on the sorption of contaminants by PlumeStop can be found in PlumeStop Technical Bulletin 2.1: Sorption of Contaminants from Solution.

Acceleration of Contaminant Biodegradation

Once sorbed to the soil and with contaminants partitioned onto its surface, PlumeStop is colonized by contaminant-degrading bacteria. These may be naturally present or applied as an inoculum. The concentration of the contaminants and the degradative microflora on the PlumeStop surface reduces mass-transfer kinetic constraints and supports greater speed and efficiency of degradation compared to solution-phase bioremediation.

The net result is a substantial increase in the instantaneous rate and extent of contaminant destruction. Post-sorption biodegradation and rate acceleration by PlumeStop is the topic of the present technical bulletin.

Biodegradation Study

Study Objective

The present study provides an illustration of the synergy of sorption and degradation of PlumeStop. Both post-sorption degradation and the net effect on degradation rate are evaluated.

Test Procedure

Batch-equilibrium samples were prepared in 227 mL (8 oz.) amber serum bottles sealed with Mininert™ valves (Figure 1). All bottles contained 10 g of site soil and 70 mL of water spiked with 3 mg of benzene, thereby filling approximately one third of the container volume.

The resulting headspace in the bottles provided adequate oxygen to maintain aerobic status throughout the study. The four conditions tested are summarized in Table 1.

Table 1. Batch-Equilibrium Study – Conditions tested

Condition	Description
Sterile control	Autoclaved soil and sodium azide (abiotic control)
Live control	Natural soil (biotic control)
PlumeStop Treated	Soil and PlumeStop (biotic test)
Sterile PlumeStop Treated	Autoclaved soil, PlumeStop and sodium azide (abiotic test)

The conditions were tested in parallel and run over a period of 28 days. Microcosms were sampled destructively in triplicate on days 1, 7, 14, 21, and 28. Benzene was quantified in the aqueous phase and also as a mass-balance extract of the total soil-water system (i.e. the aqueous and solid-phase microcosm contents together).

Figure 1. Batch-Equilibrium Study – Experimental Set-up

Test Results

Aqueous-phase concentrations of benzene are presented graphically in Figure 2. Data from the total system extractions are presented in Figure 3.

Figure 2 illustrates a rapid and nearly equal reduction in aqueous-phase benzene concentration in both the biotic and abiotic PlumeStop systems within the first sampling period. Thereafter, the aqueous benzene concentration in the biotic PlumeStop system continued to decrease to non-detect levels, whereas that in the abiotic PlumeStop control remained broadly static.

Benzene concentrations in the soil-only control (biotic, no PlumeStop) changed little in the first week, suggestive of an acclimation period, and thereafter declined steadily. Benzene concentrations in the soil-only sterile control did not change significantly for the first 21 days but showed a minor decrease thereafter.

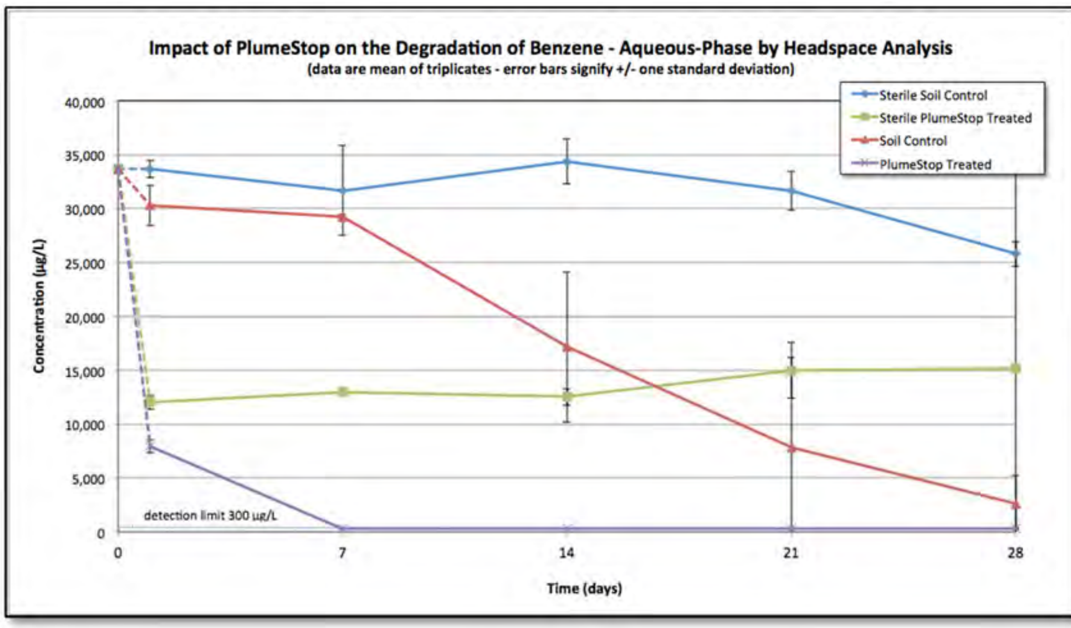

Figure 2. Batch-Equilibrium Study – Aqueous-Phase Results

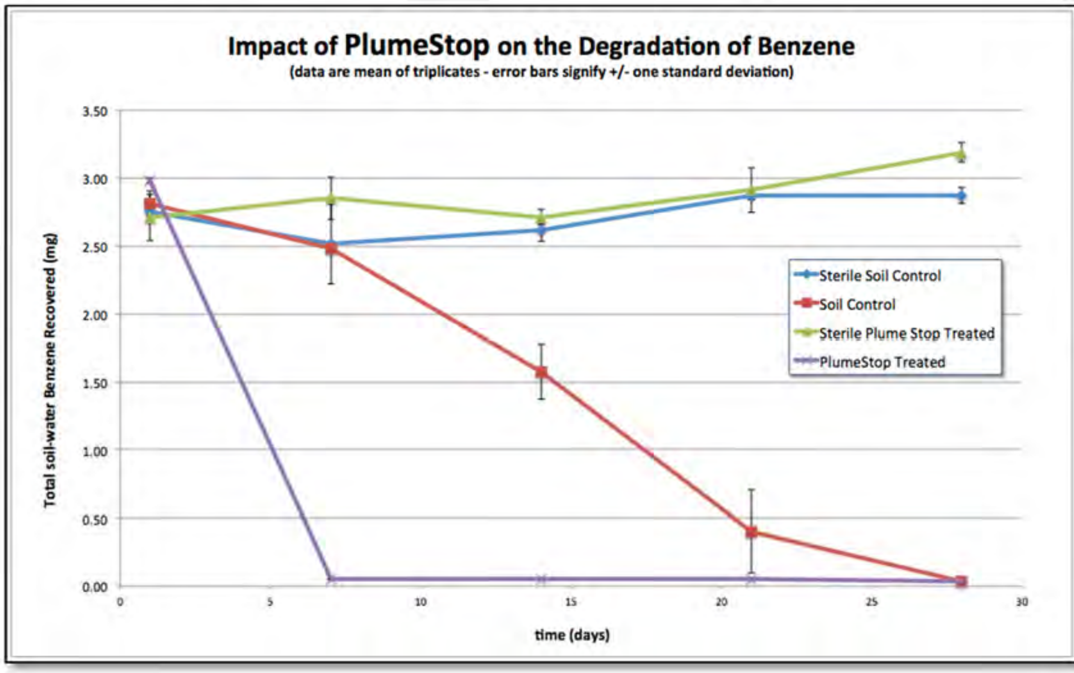

Figure 3. Batch-Equilibrium Study – Total System Extraction

Total system extract data (both aqueous-phase and soil-phase microchosm combined) are presented in Figure 3. In both the sterile control and the sterile PlumeStop treated samples, the total benzene mass remained constant at approximately 3 mg throughout the entire experiment. In contrast, the benzene concentrations in both biotic systems declined through the course of the experiment, with a markedly sharper decline in the PlumeStop-treated system; the treated system reached the detection limit by the seven-day time point compared to a 90% reduction at 28 days for the soil-only system.

Test Conclusion

The rapid and significant reductions in the aqueous-phase benzene concentrations over the first sampling period in both the biotic and abiotic PlumeStop systems may reasonably be attributed to abiotic sorption processes (Figure 2). The continued aqueous-phase concentration reduction in the biotic PlumeStop system is consistent with a destructive process as opposed to further sorption, since the aqueous benzene concentration in the analogous abiotic PlumeStop control remained constant after the initial sorption process.

The destruction of benzene in the biotic PlumeStop system is further confirmed in the total system extractions (Figure 3), in which the full initial mass of benzene was recovered from the abiotic PlumeStop control, confirming non-destructive abiotic sorption (and also validation of the extraction method).

In contrast, the mass-balance of benzene in the biotic systems with and without PlumeStop describes a destructive reduction that is consistent with biodegradation. Benzene was fully degraded in the biotic PlumeStop system within the first seven days of the test, in contrast with 12.5% degradation over the same period in the biotic soil-only control. This approximates to a half-life of less than one day in the biotic PlumeStop system as compared to ten days in the biotic control and represents a >10x rate increase based on the first-order approximation. Note that the half-life estimated for the biotic soil-only control is consistent with aqueous biotic rates that are published in the literature[i].

Summary

The above study shows clearly that sorption of contaminants onto PlumeStop does not inhibit their subsequent biodegradation, but rather, the rate of degradation is significantly stimulated by amendment with PlumeStop.

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[i] P. H. Howard, R. S. Boethling, W. F. Jarvis, W. M. Meylan, E. M. Michalenko, Handbook of Environmental Degradation Rates,Lewis Publishers, Inc. ISBN 0 87371, 3 (1991).

PLUME STOP
Liquid Activated Carbon

PlumeStop® Technical Bulletin 4.1

Regeneration of Sorptive Capacity

Quick Reference:

- PlumeStop binding site bio-regeneration
- Extended functional longevity

Background

PlumeStop® Liquid Activated Carbon™ is composed of very fine particles of activated carbon (1-2 µm) suspended in water through the use of unique organic polymer dispersion chemistry. Once in the subsurface, the material behaves as a colloidal biomatrix, binding to the aquifer matrix, rapidly removing contaminants from groundwater, and expediting permanent contaminant biodegradation.

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Unlike any other sorbent technology, PlumeStop can be installed in the subsurface through dispersive flow from low-pressure injection (without fracturing the formation), providing a wide-area thin-film coating of the aquifer matrix. It does not create preferential flow pathways, plug the formation, or compromise monitoring wells through extreme carbon loading, as is often the case with pressure-emplaced powdered activated carbon products.

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PlumeStop rapidly sorbs organic contaminants from aqueous solution within the timescale of hours. Pollutants partition directly into the PlumeStop particles that are sorbed to the soil formation, thereby removing the pollutants from groundwater. Contaminant advection in the aqueous phase is therefore eliminated, and partitioning into the vapor-phase is also reduced (Henry's Law). Results can be dramatic, with groundwater cleanup objectives often met within days of PlumeStop application.

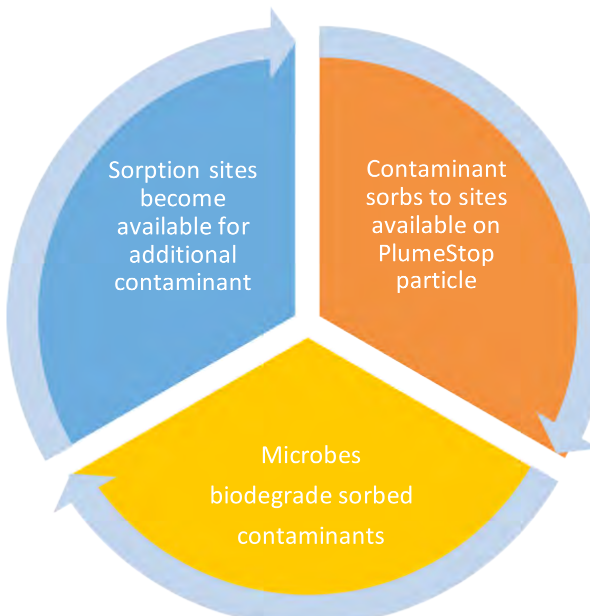
Acceleration of Contaminant Biodegradation

Once sorbed to the soil and with contaminants partitioned onto its surface, PlumeStop is colonized by contaminant-degrading bacteria. These may be naturally present or applied as an inoculum. The concentration of the contaminants and the degradative microflora on the PlumeStop surface reduces mass-transfer kinetic constraints and supports greater speed and efficiency of degradation compared to solution-phase bioremediation.

The net result is a substantial increase in the instantaneous rate and extent of contaminant destruction. Further information on post-sorption biodegradation and rate acceleration by PlumeStop can be found in PlumeStop Technical Bulletin 3.1: Post-Sorption Contaminant Biodegradation.

Regeneration *In-Situ*

Within the subsurface, the sorptive capacity of PlumeStop that has coated the aquifer pore structures continues to regenerate *in situ* by the continual cycle of contaminant sorption and biodegradation.



This cycle consists of three events:

- Dissolved-phase contaminants partition out of the groundwater and are concentrated on the PlumeStop particles.
- Opportunistic contaminant-degrading microbes colonize the PlumeStop to form the biomatrix.
- Biodegradation of contaminants within the biomatrix frees up sorption sites, allowing further partitioning of contaminants out of the groundwater.

As a result of this on-going regeneration of the PlumeStop biomatrix, each application of PlumeStop remains functional for an extended / indefinite period of time.

Data Supporting the *In Situ* Regeneration

To demonstrate the *in situ* regeneration of PlumeStop, a laboratory study was undertaken that compared the removal of perchloroethene (PCE) from a biotic soil/water slurry treated with PlumeStop versus two sterile soil/water slurries: one PlumeStop treated and the other a soil-only control. Throughout the study, the aqueous-phase and total-system PCE concentrations were monitored following cycles of PCE spikes and equilibration.

Test Procedure

For the biotic PlumeStop treated conditions, twenty-seven microcosm samples were prepared in 8 oz amber serum bottles sealed with Mininert™ valves (Figure 1). Each bottle contained site soil (20 g), PlumeStop (50 mg/L), microbial consortia (1 x 10^6 cells/mL Dehalococcoides ethenogenes), and sodium lactate as an electron donor to promote biological reductive dechlorination (1,000 mg/L). Similarly, the sterile control samples were prepared with autoclaved site soil (20 g), sodium lactate (1,000 mg/L), and sodium azide (200 mg/L), which was added as a biocide to inhibit biological activity. PlumeStop (50 mg/L) was also added to the PlumeStop treated sterile control.

Figure 1. Experimental set-up - test microcosms

The experiment was initiated with the addition of 2.3 mg of PCE to each bottle.

All bottles were placed on an orbital shaker at room temperature throughout the entire experiment. After 24 hours, three samples from each of the three conditions (biotic PlumeStop treated, sterile PlumeStop treated, and sterile soil-only control) were chilled prior to removing a 1 mL aliquot for headspace analysis by Gas Chromatography-Electron Capture Detector (GC-ECD) to determine the PCE concentration in water. The same sample bottles were then sacrificed and subjected to a 48-hour total system extraction with hexane. The hexane extract was analyzed by GC-ECD to give the total mass of PCE within each bottle, which includes both the aqueous-phase and the sorbed-phase (soil and PlumeStop) PCE.

After two weeks, the same sampling procedure described above was repeated on another set of sample bottles, three from each condition. At the same time, all remaining sample bottles were spiked with an additional 2.3 mg of PCE and 25 mg of sodium lactate. The freshly spiked bottles were allowed to equilibrate for six hours before an additional set of sacrificial bottles were sampled and analyzed in order to establish a new post-spike baseline. The identical procedure described above of analyzing–spiking–analyzing was repeated at the four- and six-week time points of the experiment, giving a total of four complete cycles of spiking and analyzing. Two additional PCE analysis-only cycles (no spikes) were also conducted at the eight and ten-week time points.

Results and Discussion

The aqueous-phase PCE concentrations of the soil-only sterile control vials indicated a PCE increase in the aqueous phase at the beginning of the experiment and with the addition of each successive PCE spike (Figure 2). Lower initial concentrations for the two PlumeStop treated conditions compared to the sterile soil-only control suggested rapid sorption of the PCE to PlumeStop in the early phase of the experiment. However, with successive PCE spikes, a build-up of PCE in the aqueous phase was also observed for the sterile PlumeStop treated control, while the concentrations in the biotic PlumeStop treated samples remained overall very low.

The lower aqueous phase concentrations of PCE in the biotic vs. sterile PlumeStop treated samples support *in situ* regeneration of PlumeStop's sorptive capacity by biodegradation. In the sterile samples with PlumeStop, continued addition of PCE to the system resulted in saturation of the PlumeStop sorption sites and an increase in aqueous phase PCE concentrations. In the biotic PlumeStop treated samples, degradation of the sorbed PCE regenerated the sorption sites, thereby allowing the aqueous phase concentrations to remain low throughout the experiment.

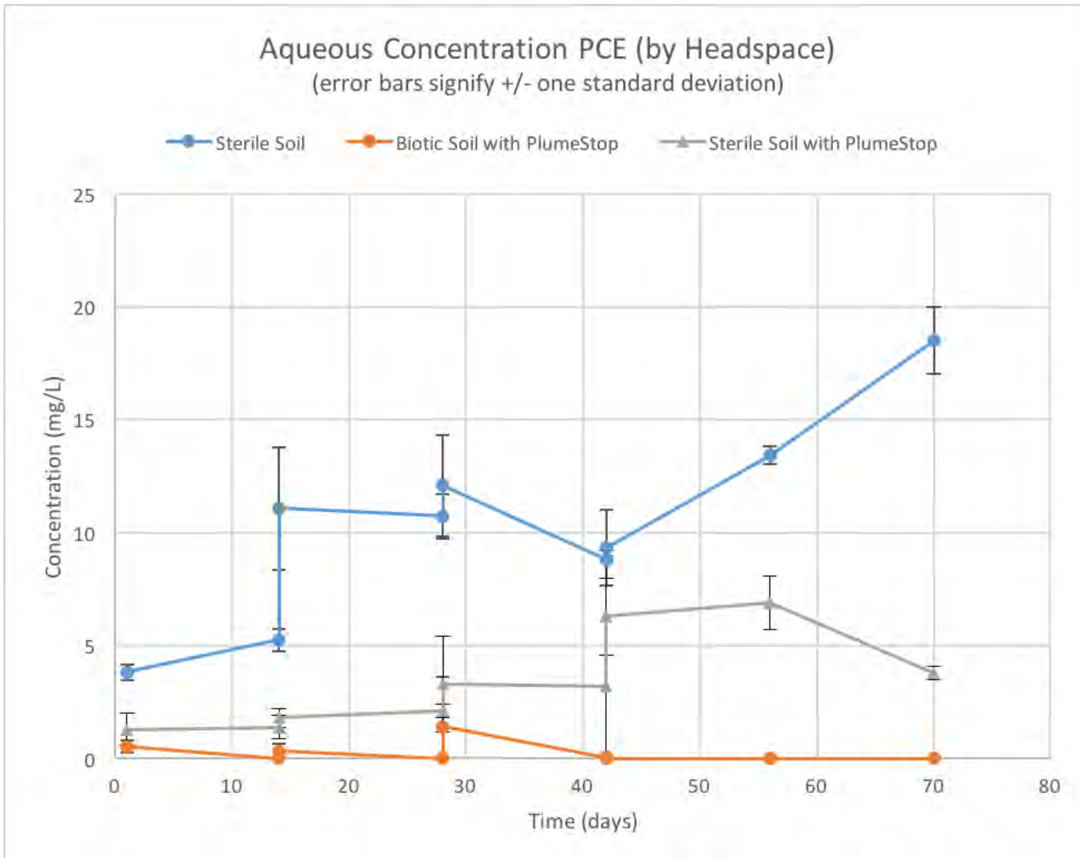


Figure 2. Comparison of dissolved-phase PCE concentrations upon cumulative loading.

Data from the total system extractions (Figure 3) confirmed rapid degradation of the added PCE in the biotic PlumeStop-amended vials; at the time of each sampling, less than 10% of the added PCE remained in the biotic PlumeStop samples prior to re-spiking with additional PCE. Conversely, in the sterile control vials both with and without PlumeStop, the total mass of PCE in the system was retained following each additional PCE spike, indicating that there was no destruction of the contaminants under those conditions. The degradation observed in the PlumeStop-amended vials serves to regenerate the sorptive capacity of PlumeStop, as observed in the aqueous-phase concentrations discussed above. Together, the aqueous-phase and total system extract data clearly support the ability of PlumeStop to maintain a continual cycle of contaminant sorption and degradation.

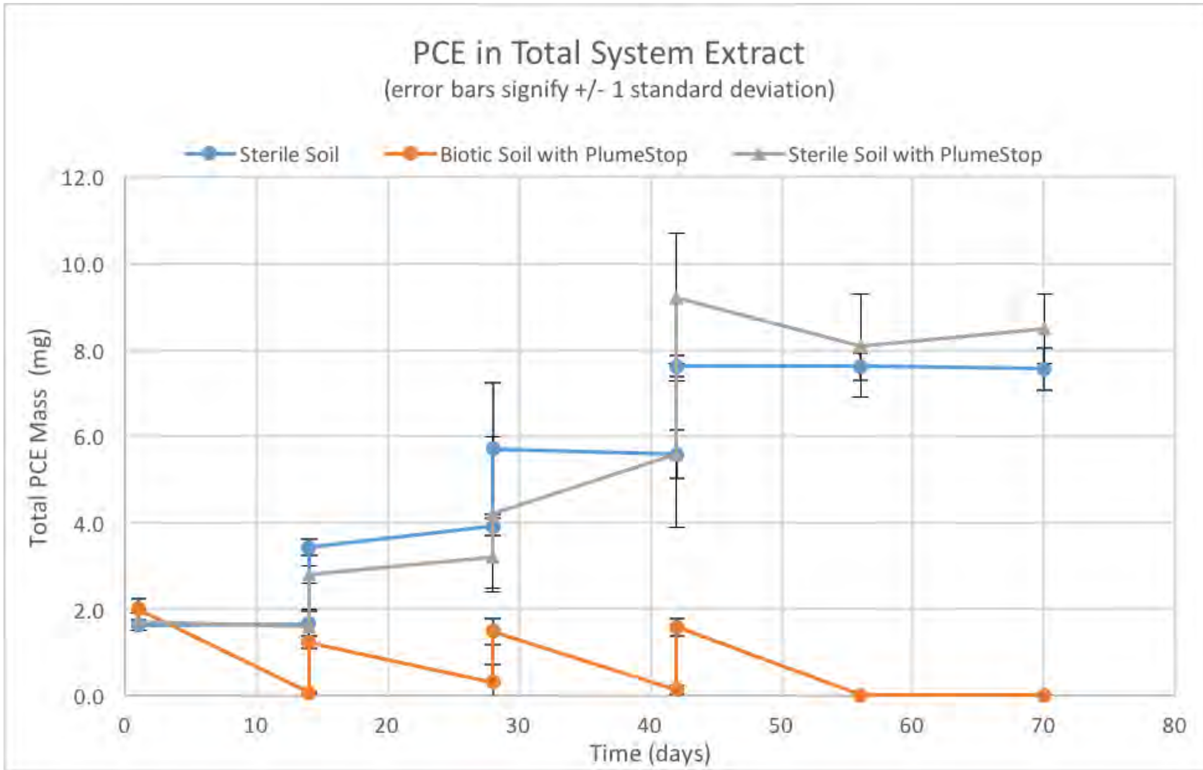


Figure 3. Comparison of PCE mass on cumulative loading– total system extracts.

Summary and Conclusion

The laboratory test clearly demonstrated the ability of PlumeStop to regenerate *in situ*:

- PCE rapidly partitioned onto the PlumeStop particles in the early phases of both the biotic and sterile Plumestop treated samples, removing PCE from the aqueous phase.
- Continued addition of PCE resulted in increasing aqueous-phase concentrations in the sterile samples containing PlumeStop as a result of the sorption sites becoming saturated.
- In the biotic PlumeStop samples, the sorbed PCE was degraded, leaving negligible PCE in the system (sorbed-phase or aqueous-phase).

- After sorbed PCE was degraded, the regenerated PlumeStop particles were again able to sorb additional PCE from solution, thereby providing capacity for continued contaminant sorption and degradation.

The demonstrated regeneration of PlumeStop's sorptive capacity during contaminant biodegradation suggests extended, if not indefinite, treatment longevity.