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Pilot Study Work Plan
Seattle Fire Station #25

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Prepared for

Washington State Department of Ecology
PO Box 47600
Olympia, Washington 98504

K/J Project No. 1696040.02

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Section 1: Introduction and Pilot Study Summary

This work plan summarizes the approach and activities that will be performed as a field pilot study at the Fire Station #25 site (site) located at 1300 East Pine Street in Seattle, Washington. This work is being performed on behalf of the Washington State Department of Ecology (Ecology). The purpose of the pilot study is to assess whether or not *in situ* bioremediation may be a viable remedial technology to address residual petroleum hydrocarbons in soil and groundwater resulting from a former underground storage tank (UST) release.

The proposed *in situ* Pilot Study (pilot study) includes injection of a cultured bacteria consortium, enzyme, and nutrient solution through a manually-controlled short-term (2-day) field work event. The pilot study for the site will consist of three main work phases, including:

1. Installation and development of two multi-purpose wells

2. Completion of field activities associated with the pilot study

3. Post pilot study groundwater monitoring to evaluate its effectiveness.

It is anticipated that the work associated with Phases 1 and 2 will be completed before 31 March 2017. Phase 3 (post pilot study groundwater monitoring) will be performed approximately six weeks after the completion of the pilot study.

Section 2: Overview of the Bioremediation Process

Bioremediation involves bioaugmentation (i.e., addition of specific microorganisms) and/or stimulation of petroleum-degrading bacteria to mineralize the petroleum hydrocarbon compounds (i.e., convert them to carbon dioxide and water). In addition, this process typically requires adding now-depleted macronutrients (nitrogen as ammonia and phosphorous as phosphate), terminal electron acceptors (TEAs) for microbial respiration [i.e., dissolved oxygen (DO), nitrate, etc.], and, if warranted, bacteria that are selectively cultured for their petroleum-degrading capabilities (e.g., facultative petroleum hydrocarbon-degrading bacteria).

A bioremediation product solution consisting of a blend of a cultured bacteria consortium, enzymes, and nutrients will be injected into site wells in the area of the former underground storage tank and source of residual total petroleum hydrocarbons (TPH) in the subsurface. The mixture of products will work together to degrade TPH.

For the impacted area at the site, an estimated 750 pounds of nutrients and 15 gallons of bacteria consortium will be mixed with enough tap water to make a minimum 1,000 gallons of solution for injection. The bacteria consortium has been pre-acclimated to optimize growth of a healthy, in-situ, hydrocarbon-degrading microbial population. The volume of injection is intended to maximize contact between the subsurface TPH and the bacteria. The bacteria must physically contact the TPH (used as a food source) and the electron acceptors (oxygen, nitrate, and sulfate) in the injectate in order to biochemically oxidize the petroleum to carbon dioxide and water.

Section 3: Proposed New Multi-Purpose Well Installation and Remediation Product Delivery Method

The bioremediation phase of this process requires physical contact of amendments to the TPH in the subsurface in order to be effective. The chemical/biological amendments require distribution in the impacted subsurface to achieve contact with the contaminated media (soils and groundwater). For this pilot study, contact of amendments will be performed using new site multi-purpose wells.

3.1 Multi-Purpose Well Installation

Two 4-inch multi-purpose wells are scheduled to be installed during the week of 20 March 2017. The new 4-inch multi-purpose wells (RW-1 and RW-2) can be used for injection purposes during the pilot study. The proposed locations of the new wells are illustrated on Figure 1. The proposed locations of the new wells were selected to target the area where hydrocarbon concentrations in soil and groundwater are greatest.

Upon installation, the wells will be developed to remove accumulated sediment and allow flow of natural groundwater into the well. Development will be accomplished by surging using a vented surge block, then pumping or bailing until water of relatively low turbidity is produced. Field parameters will be measured during the development process and recorded on field forms.

3.2 Bioremediation Equipment and Products

For this pilot study, we propose to extract groundwater and inject amendment solutions using a portable, trailer-mounted system supplied by Etec Environmental Technologies (Etec) located in Washougal, Washington. Use of the trailer-mounted system will allow use of the aboveground hose, eliminating the need to trench and install permanent piping between the wells and system.

Etec will mobilize a truck/trailer-mounted injection system consisting of a large poly tanks (holding tank and mixing tanks), injection/transfer pumps, injection lines, valves/fittings, flow meters, pressure gauges, and other ancillary equipment. A generator will also be supplied to power the injection pumps. Etec will have an injection header that has two stations, each with its own flow meter, pressure gauge, and gate valve for independent flow control.

For safety reasons, Etec will provide a minimum of two employees to conduct the work. Etec will need a potable water source onsite to complete their work.

During performance of the pilot study, Etec will use cones, caution tape, and barricades to control vehicle and foot traffic to the work areas. Attempts will be made to reduce the footprint of the work area so there is the least impact on the site operations.

3.2.1 Remediation Products

Initially, Etec will start the pilot study with injection of approximately 1,000 gallons of dilute (approximately 4 percent) hydrogen peroxide catalyzed by with a ferrous iron solution. The

hydrogen peroxide will act as an oxidant to immediately start remediation of the residual petroleum hydrocarbon through chemical oxidation. This initial phase of the pilot study will be performed over a 1 day period.

On the second and third days of the pilot study, Etec will inject and circulate biological amendments to support future biodegradation of the residual hydrocarbon compounds. For biological products at this site, Etec recommends their TPH Bacterial Consortium (EZT-A2TM) and Enzyme Accelerator (EZT-EATM) which make up their PetroBacTM product bundle. Their CBNTM (NutriMaxTM) nutrients, which include macro- and micro-nutrients specially blended for in-situ bioremediation, will also be necessary. These biological enhancements work together to efficiently degrade petroleum hydrocarbons; benzene, toluene, ethylbenzene, and total xylenes (BTEX); naphthalenes; and other organic contaminants.

The application of the biological products will perform three critical functions, including:

1. Supply of a large population of pre-acclimated facultative bacteria to optimize initial growth of a healthy, *in situ*, hydrocarbon-degrading microbial population.

2. Maximize contact between the contaminants (dissolved and adsorbed) and the bacteria. Effective bioremediation relies on physical contact with the hydrocarbon food source and the electron acceptors (oxygen, nitrate, sulfate) to biochemically oxidize the contaminants to carbon dioxide (CO_2) and water.

3. Supplying critical nutrients like nitrogen, phosphorus, and potassium help support ongoing biological growth. The nitrogen compounds also act as secondary electron acceptors to ensure continuous *in situ* contaminant degradation during temporary absences of oxygen.

Additionally, the supply of critical nutrients like nitrogen, phosphorus, and potassium are included in the injectate to support ongoing biological growth and TPH degradation. The nitrogen compounds will act as secondary electron acceptors to facilitate continuous contaminant degradation during temporary absences of dissolved oxygen.

3.3 Potential Future Remediation Events

If the results of post-remediation groundwater sampling (described in Section 4) indicates that the remedial process is successful at reducing the hydrocarbon concentrations in groundwater, these multi-purpose wells can be used in the future for additional injection and monitoring events. Typically, these events could be repeated every 6 to 18 months (as needed) until cleanup standards are achieved. It is typically preferable to conduct these events as close the seasonal high groundwater elevation timeframe (i.e., late fall through spring) in order to obtain more complete contact with the smear zone.

Section 4: Post-Remediation Groundwater Monitoring

One round of groundwater monitoring will be completed approximately four weeks after the injection phase of the pilot study. Groundwater samples will be collected from both of the multi-purpose wells for analysis of for: NWTPH-Dx, benzene, toluene, ethel benzene, xylene (BTEX), naphthalene, nitrate, ammonia, ortho phosphate, dissolved iron, dissolved manganese, sulfate, alkalinity, and methane. Field parameters including dissolved oxygen, oxygen reduction potential (ORP), and pH will be logged in the field notebook.

Kennedy/Jenks personnel will follow Standard Operating Procedures (SOP) as presented in the Fire Station 25 Sampling and Analysis Plan/Quality Assurance Project Plan, dated 16 November 2016, including:

- SOP-7: Groundwater Sampling
- SOP-8: Measuring Groundwater Levels
- SOP-9: Well Construction and Development
- SOP-10: Measurement of Field Parameters: pH, Dissolved Oxygen, Specific Conductance, Turbidity, Oxidation-Reduction Potential, and Temperature
- SOP-12: Sample Packing and Shipping (Soil, Sediment, and Water)
- SOP-15: Handling and Disposal of Investigative-Derived Waste.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

- Geoprobe Boring Location November 2016
- Proposed Multipurpose Well Location
- Former Fueling Line

Notes:

1. All locations are approximate.
2. Site features are estimated from a Garry Struthers Associates, Inc. 1999 report; parcel information is from King County.

N

0 10 20

Scale: Feet

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DRAFT

Seattle Fire Station 25
1300 E Pine St
Seattle, Washington

Site Map and Proposed Multipurpose Well Locations

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Figure 1