FINAL WHITE PAPER
LEAKING UNDERGROUND STORAGE TANKS
MONTESANO, WASHINGTON

AUGUST 30, 2007

FOR
WASHINGTON STATE DEPARTMENT OF ECOLOGY

GEOENGINEERS

File No. 0504-038-00

Final White Paper
Leaking Underground Storage Tanks
Montesano, Washington
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INTRODUCTION

Leaking underground storage tanks pose risks to both public health and the environment. The Washington State Department of Ecology (Ecology) estimates there are hundreds, if not thousands of leaking underground storage tanks in Washington State. Underground storage tanks, or "USTs", are often used to store petroleum hydrocarbons including gasoline, diesel fuel, oil and other products such as those used at dry cleaning operations. When USTs leak they are called leaking underground storage tanks, or LUSTs.

In this paper we present a discussion of Ecology's successful city-wide investigation of petroleum-related LUSTs in Montesano, Washington. The paper discusses the history, methods, results, as well as "lessons learned" from the investigation that was performed in 2005 and 2006. The primary contaminants discussed in this paper are gasoline and a group of four related chemicals found in gasoline called benzene, toluene, ethylbenzene, and xylene (BTEX). These four components of gasoline are of particular importance because they are either known or suspected cancer-causing compounds.

HISTORICAL CONTEXT

Montesano is located in western Washington, between the cities of Olympia and Aberdeen. A map showing Montesano's location is included as Figure 1. Up until 1967, Highway 12 was located along present-day Pioneer Avenue within Montesano. Numerous gasoline stations were located along Pioneer Avenue, as Montesano was a popular refueling area for weekend travelers on their way to and from the west coast of Washington. In 1967-1968, Highway 12 was relocated to its present location south of Montesano, and many of the gasoline stations along or near Pioneer Avenue closed.

Regulations regarding proper monitoring and closing of USTs were enacted in Washington State in 1990. Before this time, petroleum products were not always completely removed from USTs when gasoline stations closed. Because almost all USTs used during that time were constructed of a single-walled steel tank, many of them eventually rusted and began leaking any remaining petroleum products to the subsurface in Montesano.

In the late 1980s, the City of Montesano replaced its gravity sewer system with a Septic Tank Effluent Pump (STEP) system. During installation, it was observed that some of the subsurface soil and groundwater in Montesano contained petroleum contamination; although a complete investigation was not undertaken at that time. The gravity flow sanitary sewer was not abandoned by backfilling, so groundwater continues to infiltrate and flow within the former sanitary sewer pipes. Additionally, groundwater leaks into the City's stormwater system, which is a separate system from the sanitary sewer system. Both the abandoned sanitary sewer and current stormwater system drain to the Chehalis River. Sewage flows from the STEP system are pumped to the City of Montesano Treatment Plant.

Ecology has maintained monitoring wells in Montesano since 1991 and is aware of several former and currently operating gasoline stations with LUSTs. Ecology was unsure; however, how many sources were contributing to the problem, and how contamination might be traveling between and among various sources, within the downtown Montesano area. Although numerous investigations had been performed in downtown Montesano, the information gathered from these investigations was collected by different organizations and contained in separate reports. Having this information in so many different forms made it difficult to understand how contamination was distributed across downtown Montesano. One of the goals of this investigation was to electronically store the available information for the site in a format known as Geographic Information Systems or GIS. GIS allows information about the site such as contamination in water or soil and soil types to be retrieved simply by clicking on various points of a map of the site. This permits a person to quickly look at a wide area of the site and quickly and intuitively understand what the amounts and types of contaminants are in a given regional area.

There is approximately 20 feet of sandy soil underneath the City of Montesano, that was deposited by the Chehalis River over the last several thousand years. Underneath this sandy soil is a layer of clay of unknown thickness. Downward groundwater flow through the clay is limited. Groundwater is found in the sandy soil at depths ranging between 5 and 15 feet below ground surface (bgs). Groundwater typically flows to the south-southeast toward the Chehalis River. However, it can also flow into the stormwater system or the abandoned sanitary sewer system. When groundwater flows into either of these systems, the flow direction follows the path of least resistance in either the permeable backfill around the pipes, or in the pipes themselves.

METHODS

In 2005, Ecology requested that GeoEngineers review existing data from Ecology's records describing contamination in groundwater and soil in Montesano. The data were reviewed to better understand the likely location of any LUSTs and the movement of contamination in the subsurface. Part of this work was to assess if it was possible that contamination was entering the Chehalis River by groundwater flow along the "preferential pathways" of the stormwater or abandoned sewer system. Additionally, contamination can enter the backfill that surrounds utility trenches and move more quickly compared to its rate of movement through "native" undisturbed soil. Figure 2 is a conceptual drawing of contamination moving along preferential pathways.

Soil and groundwater contamination in Montesano was investigated by GeoEngineers during 2005 to 2006 using the following methods:

- Review of Ecology's information regarding known and suspected LUSTs.
- Use of "ground penetrating radar" to detect the location of underground storage tanks.
- Soil borings for the collection of soil and groundwater samples. Installation of groundwater monitoring wells in some of the borings.
- Collection of water samples from stormwater and abandoned gravity sewer systems.
- Chemical analyses of soil and water samples by certified laboratories.

GROUND PENETRATING RADAR

Ground penetrating radar (GPR) is an investigative technique that uses a small device to send radar signals into the ground to detect buried objects. Previous interviews, historical information, and a review of site groundwater data using GIS were all used to identify potential locations for previously unidentified USTs. Ground penetrating radar was used in October 2005 and January 2006 to attempt to locate possible USTs in Montesano at approximately eight locations. GPR was also used to identify USTs in areas of identified contamination after soil and groundwater studies were completed. GPR results are described in subsequent sections of this report.

Soil Borings

Sixty-five soil borings were drilled at various locations in the City of Montesano. Borings were located at or near sites where Ecology had reason to suspect contamination was located such as current and former gas stations, along suspected preferential flow paths, and near other locations that had not been investigated as part of site-specific investigation activities. This information had been compiled in previous studies by Ecology, by searches of historical records, and by speaking with residents of Montesano. The results of ground penetrating radar were also used to target specific areas for borings. Finally, many borings were carefully located near buried utilities such that the borings would pass through utility trench backfill material.

The borings were drilled to depths ranging from 10 feet bgs to 30 feet bgs. Total boring depths were based on the likely depth of contamination. Gasoline and diesel contamination are less dense (lighter) than water, and typically float, or remain on top of the groundwater table. Therefore, borings were often ended about 5 feet below the surface of the groundwater table if no contamination was found between the ground surface and 5 feet below the surface of the groundwater table.

Soil and groundwater samples were collected from the borings. Permanent groundwater monitoring wells were installed at 13 of the boring locations. The other borings were backfilled in accordance with Ecology guidance.

Stormwater and Abandoned Sewer Water Sample Collection

Both the former sanitary sewer system and the storm drain collect groundwater, and this groundwater flows along the pipes in the sewer systems. This water flow is called baseflow. Baseflow water samples were collected from the stormwater conveyance system as well as the old gravity sewer system on three different dates between December 2005 and June 2006. Four sample locations were from the stormwater system and eight sample locations were from the abandoned gravity sewer system.

Laboratory Analysis

Soil and groundwater samples collected from the borings and stormwater and sewer systems were analyzed by laboratories for gasoline (WTPHG), diesel (WTPHDx) and BTEX (SW 8021). Because any contamination in the stormwater and abandoned sewer system was expected to be diluted by water in the pipes, special low-level detection techniques were used to detect and identify contaminants.

Results

Of the 65 borings drilled in Montesano, petroleum-contaminated soil and/or groundwater was found in 40 of them. Most of the contamination was in the form of gasoline and related (BETX) contaminants. The allowable limit for gasoline in soil and groundwater in Washington as permitted by Ecology depends on whether benzene, a known carcinogen, is present. In soil, the allowable concentration of gasoline is 30 milligrams per kilogram (mg/kg) (also referred to as parts per million (ppm)) if benzene is present, and 100 ppm if not. In groundwater, the allowable limit is 0.8 milligrams per liter (mg/l) (also analogous to ppm) if benzene is present, and 1 ppm if not. Of the 40 borings where contamination was observed, contamination was greater than the allowable limits in 22 of them. For groundwater samples in particular, contamination was greater than the allowable limit in 13 of the 23 monitoring wells sampled. The concentration of gasoline contamination observed in groundwater ranged from 0.8 to 120 ppm.

Petroleum contamination exceeding regulatory limits was observed at three main source areas. The areas are:

- Brumfield-Twidwell
- Whitney's Inc. / Key Bank
- Tony's Short Stop

The contamination at these areas appeared to be migrating from the source properties listed above to the subsurface beneath adjacent streets and other properties. Additionally, the contamination from these sites appeared to have come together and mixed, making identification of sources difficult.

GPR was used at the Brumfield-Twidwell and Whitney's Inc. sites. Several possible USTs were identified, and subsequent excavation revealed one UST under the concrete floor of the Whitney's Inc. site. The tank was empty. At the time of the investigation it was not yet known if any products had been removed from the tank after its last use, or if the tank had leaked.

Water contamination exceeding regulatory limits was also found in 2 of the 12 baseflow sample collection locations within the City's stormwater and sanitary sewer systems. The concentration of the contamination was 1.2 ppm and 1.8 ppm, and was located in the City's stormwater system, downgradient of the three source areas listed above. Hydrocarbons were also found at concentrations less than the regulatory limits in the City's abandoned sewer system. Because contamination in the utilities was expected to be diluted by water, samples were analyzed using special "low level" detection techniques. The City's storm drains empty to the Chehalis River. Despite the diluted nature of the contamination, overall contamination loading to the environment could be quite high due to the continual high volume of water impacted by the low level concentrations of hydrocarbons that have been found to flow into the river from these utilities. In July 2006, Ecology sampled four locations (three stormwater locations and one abandoned sewer system location). All three stormwater baseflow samples exceeded the groundwater cleanup level for gasoline (0.8 ppm) and benzene (0.005 ppm). The concentrations detected were: 1.5 ppm, 0.93 ppm and 1.0 ppm for gasoline-range hydrocarbons and 0.032 ppm, 0.045 ppm and 0.064 ppm for benzene. All three samples also exceeded the surface water cleanup level for benzene of 0.023 ppm.

In a few groundwater and base flow sample locations, Ecology also ran analyses for volatile organic compounds (VOCs) by Method SW 8260. The original reason for these tests was due to the suspicion that groundwater had also been contaminated as the result of improper disposal of paint and cleaning solvents in underground heating oil tanks. Not only did this testing confirm the presence of solvent related VOCs, but had the added benefit of revealing low levels of gasoline range petroleum hydrocarbons other than BTEX. This was helpful in the base flow sampling as the lower detection limit of SW 8260 demonstrated that gasoline was entering the system, even though BTEX and gasoline might be non-detects. (It also indicates that other contaminants, such as substituted BTEX compounds and naphthalene are migrating, even though WTPHG and SW 8021 indicate lack of contamination.)

LESSONS LEARNED

A great deal was learned from this investigation. Some of the findings are discussed below.

SOURCES AND PREFERENTIAL PATHWAYS

It was originally thought that there were several, less-contaminated source areas that were contributing to regional contamination problems. However, using interviews, GPR, soil borings and chemical analyses, it was found that the petroleum hydrocarbon contamination largely came from three primary source areas listed above that had either LUSTs or leaking pipes connected to USTs. It was also discovered that contamination was moving between these sites, and off site, within stormwater and abandoned sewer pipe. However, it was difficult to ascertain the contribution to movement from the trench backfill around the utilities.

Another effect that was observed during the investigation was that present and past building foundations, and other buried man-made features, may produce unexpected changes regarding where contaminants are found, and how they travel. For example, at the Whitney's Inc./Key Bank site, Ecology observed floating free-petroleum products in a groundwater monitoring well at a depth of about 15 feet bgs. Approximately 10 feet away, very little contamination of soil and groundwater was observed at similar depths. This is a common occurrence in urban environments where the subsurface has been altered by past activities.

ABANDONED USTS

Through the use of interviews, GPR, and soil borings we discovered one UST that had been abandoned at the Whitney's, Inc. site. Upon beginning the contaminated soil removal at Brumfield Twidwell, another previously unknown UST was discovered. This is common in urban settings, where many USTs, some buried decades ago, are abandoned in place. In many cases there are no records of the USTs, or the records have long since been lost. Most of these historical USTs are expected to eventually leak if product remains inside them.

UST PIPING

Although USTs are often the largest source for leaking petroleum compounds, leaks also often occur from underground piping that is connected to the tanks and to above-ground fuel pumps. Tanks are connected to gasoline and diesel pumps using metal pipe, and older systems using single-wall piping would often leak or corrode at joints, valves or corners, releasing petroleum contaminants into the subsurface. While observing the excavation of LUSTs at the Tony's Short Stop site, Ecology observed some of the worst leaks coming from underground piping rather than from LUSTs.

INDEPENDENT INVESTIGATIONS

All three of the facilities cited had tank closures and limited site assessments performed that were focused on each individual property without Ecology or the individual property owners viewing the investigations in an area-wide perspective. In all three cases, sources of past and continuing leakage were missed, the extent of contaminant migration beyond the property boundary was not determined, and the impact of releases on other properties and utility infrastructure not investigated. This is commonly the case where LUST sites are investigated and remediated, especially when done on an independent and individual basis.

UTILITIES

This study identified that underground utilities in Montesano, both active and abandoned, are acting as preferential pathways for contaminant flow. Although the concentration of contaminants was low in water samples collected from the stormwater and abandoned sewer system, the overall loading to surface waters such as the Chehalis River could be high due to the relatively fast flow of impacted water through the utilities and the on-going nature of the infiltration of contaminants. Although it was difficult to conclude that trench backfill was also a significant preferential pathway, it is suspected that contamination may be moving more easily through these trenches.

IMPLICATIONS FOR LARGER URBAN AREAS

In Washington State, Montesano is a small-scale example of the problems that can occur when USTs leak. Larger, more established communities such as Seattle, Tacoma, Everett and Olympia are expected to have similar contaminant migration problems. Substantial data have been collected in Tacoma, in particular, in large part because of the active stormwater source control program operated by the City of Tacoma. Multiple buried LUSTs are either known or suspected of existing within the downtown and port areas of Tacoma. The presence of gasoline and several solvents and metals has been documented in multiple locations in both groundwater and baseflow samples. A similar investigative approach as that taken in Montesano would be appropriate for larger urban areas such as Tacoma.

IMPLICATIONS FOR PROPERTY VALUES

The presence of contamination at a site will lower real property values. In addition, the uncertainty surrounding the amounts, types and extent of contamination on neighboring properties will often have a chilling effect on property transactions. Buyers are less willing to purchase a site with the potential for contamination to migrate onto the site from off-site sources or that has contaminant sources that can affect other sites. Regional studies such as that performed at Montesano can provide a comprehensive overall view of how widespread or localized the contamination may be. At the very least, LUST investigations where there are clusters of current and/or historical UST facilities should take into account the fact that there may be multiple sources of contaminants in the general area, rather than investigating only one particular facility of interest.

IMPLICATIONS FOR PUGET SOUND SURFACE WATER AND SEDIMENT

In December 2005, Governor Christine Gregoire launched the 2020 Action Agenda, requiring a scientifically based set of actions to protect and recover the environmental health of Puget Sound. Among other threats, contaminants released by LUSTs can pose a risk to the waters of the Puget Sound. In most cases, contaminated stormwater is thought of as being the result of what runs off of streets and yards or is illegally dumped. The contaminated groundwater infiltration pathway is often not considered. However, as evidenced in Montesano, contamination may flow off of source properties, especially when it encounters preferential pathways such as utility corridors. Eventually, the contamination is expected to discharge to surface waters when it reaches streams or Puget Sound. Identifying the sources of contamination, how much contamination is present, and how this contamination migrates from upland areas towards coastal areas will be an important step in the protection of human health and the environment in Puget Sound.

REFERENCES

Montesano Groundwater Investigation of Leaking Underground Storage Tanks, October 2004 and March 2005, Ecology/Pamela B. Marti, January 2006.

Montesano Groundwater Investigation of Leaking Underground Storage Tanks, October 2005 and March 2006, Ecology/Pamela B. Marti, January 2007.

Groundwater Investigation: Downtown Montesano, August 5, 2005, GeoEngineers.

Additional Groundwater Investigation: Downtown Montesano, August 15, 2006, GeoEngineers.

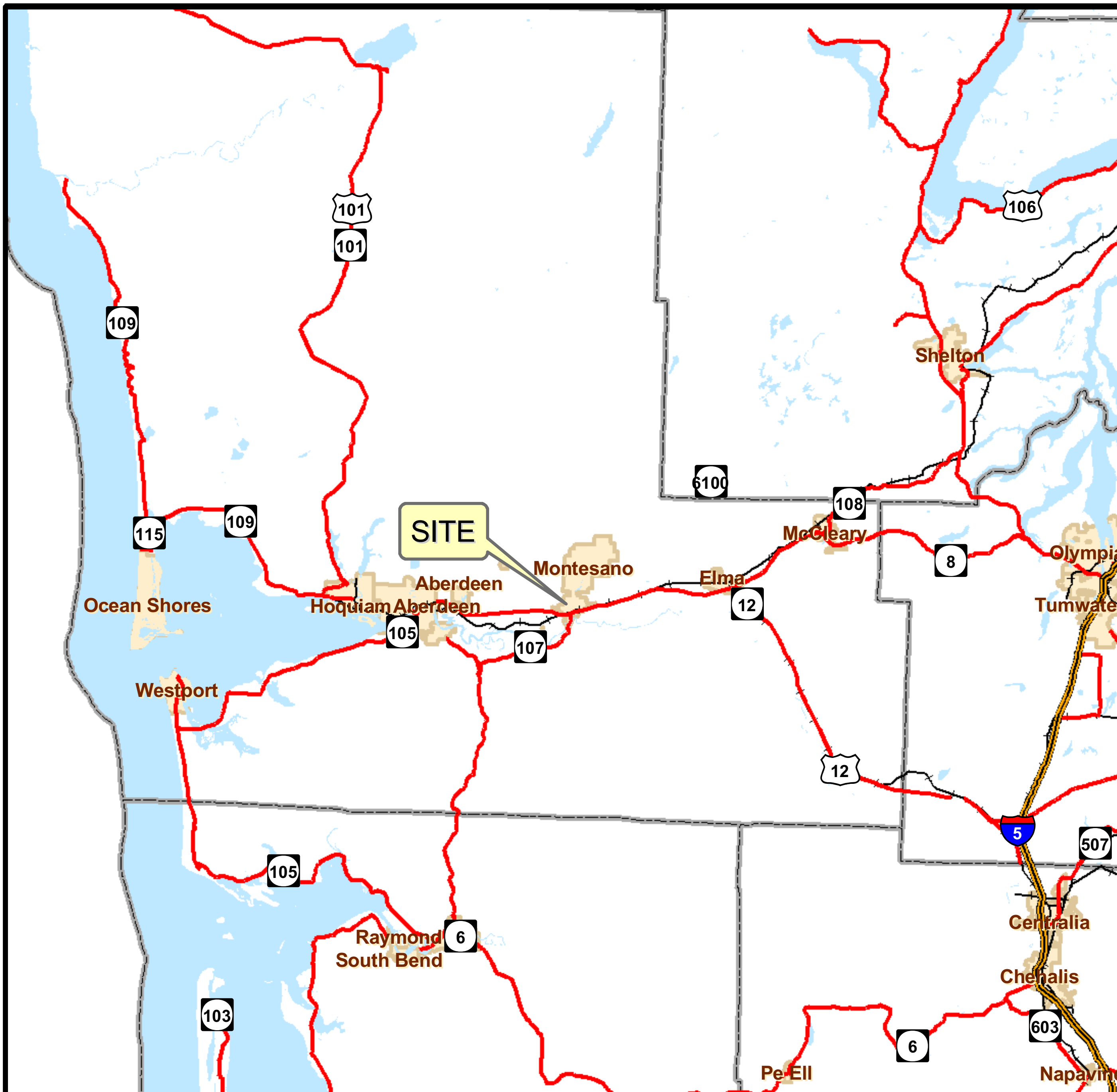
Report Addendum: Additional Groundwater Investigation, August 29, 2006, GeoEngineers.

LIMITATIONS

This report has been prepared for use by Washington State Department of Ecology. GeoEngineers has performed this study of the Montesano, Washington area in general accordance with the scope and limitations of our proposal dated March 14, 2007 and the terms of our subcontract with SAIC. GeoEngineers is working in collaboration as Science Application International Corporation's (SAIC's) teaming partner on this project under Ecology's "Hazardous Substances Site Investigation & Remediation for the Toxics Cleanup Program Contract # C0700034.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with the generally accepted environmental science practices for Phase I ESAs in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

Any electronic form, facsimile or hard copy of the original document (email, text, table, and/or figure), if provided, and any attachments are only a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.



Data Sources: Interstates, state routes, and roads from TIGER 2000.
County boundaries, cities, and waterbodies from Department of Ecology.

All locations are approximate.

Lambert Conformal Conic
Washington State Plane North
North American Datum 1983

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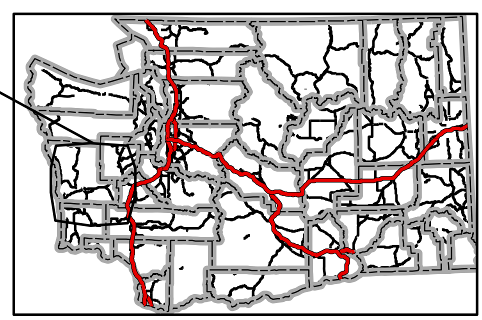

Note: This drawing is for informational purposes. It is intended to assist in showing features discussed in an attached document.

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Vicinity Map

FIGURE 1

Map Revised: July 20, 2007

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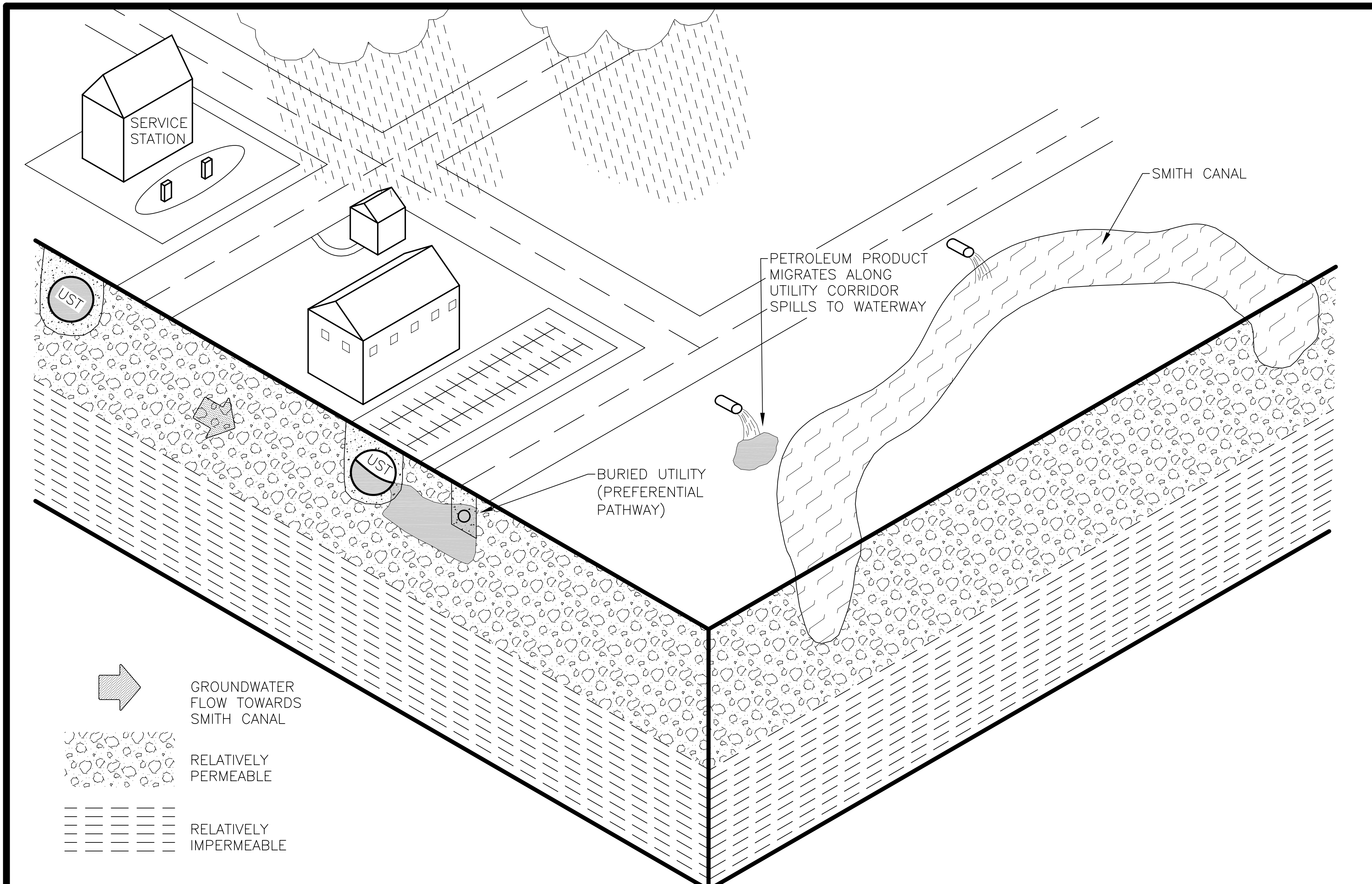

NOT TO SCALE

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CONCEPTUAL MODEL

FIGURE 2

Data Sources: Interstates, state routes, and roads from TIGER 2000.
County boundaries, cities, and waterbodies from Department of Ecology.

Lambert Conformal Conic
Washington State Plane South
North American Datum 1983

Note: This drawing is for informational purposes. It is intended to assist in showing features discussed in an attached document. All locations are approximate.

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Completed Boring Locations, First Phase

Figure 3

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Map Revised: August 28, 2007

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Data Sources: Interstates, state routes, and roads from TIGER 2000.
County boundaries, cities, and waterbodies from Department of Ecology.

Lambert Conformal Conic
Washington State Plane South
North American Datum 1983

Note: This drawing is for informational purposes. It is intended to assist in showing features discussed in an attached document. All locations are approximate.

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Feet

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Completed Boring Locations, Second Phase

Figure 4

Data Sources: Interstates, state routes, and roads from TIGER 2000.
County boundaries, cities, and waterbodies from Department of Ecology.

Lambert Conformal Conic
Washington State Plane South
North American Datum 1983

Note: This drawing is for informational purposes. It is intended to assist in showing features discussed in an attached document. All locations are approximate.

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Map Revised: August 28, 2007

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Office: TAC

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May 2005 Proposed Work and Baseflow Sample Locations

Figure 5

Figure 6. Sampling monitoring wells with low flow down-hole pump.

Figure 7. Free product gasoline found on groundwater.

Figure 8. Base flow sampling in the sewer systems.

Figure 9. Sampling with bailers in monitoring wells that contain free product.