Draft for Peer Review

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Public Health Assessment (Initial Release)

Evaluation of Exposures to Contaminants in Soil, Sediments, and Groundwater,
Bremerton Gasworks Superfund Site
Bremerton, Kitsap County, Washington

February 14, 2012

Prepared by

The Washington State Department of Health
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Washington State Department of Health

Foreword

The Washington State Department of Health (DOH) prepared this health consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services responsible for health issues related to hazardous substances.

The purpose of a health consultation is to assess the health threat posed by hazardous substances in the environment. If needed, a public health assessment will recommend steps or actions to protect public health. Health consultations are initiated in response to health concerns raised by residents or agencies about exposure to hazardous substances.

This Public Health Assessment was prepared in accordance with ATSDR methodologies and guidelines. ATSDR reviewed this document and concurs with its findings based on the information presented. The findings are relevant to conditions at the site during the time this report was written. It should not be relied upon if site conditions or land use changes in the future. The glossary in Appendix A defines technical terms.

Use of trade names is for identification only and does not imply endorsement by DOH, the Centers for Disease Control and Prevention (CDC), ATSDR, the Public Health Service, or the U.S. Department of Health and Human Services.

For additional information, please contact us at 1-877-485-7316 or visit our web site at www.doh.wa.gov/consults.

For persons with disabilities this document is available on request in other formats. To submit a request, please call 1-800-525-0127 (voice) or 1-800-833-6388 (TTY/TDD).

For more information about ATSDR, contact the CDC Information Center at 1-800-CDC-INFO (1-800-232-4636) or visit the agency's web site at www.atsdr.cdc.gov.

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Summary

Introduction

Past releases of polycyclic aromatic hydrocarbons (PAHs), petroleum hydrocarbons, and metals from the Bremerton Gasworks Superfund site in Kitsap County, Washington have occurred. These releases resulted in contamination of soil, groundwater, and sediment along the shoreline of the Washington Narrows. The Bremerton Gasworks Superfund site centers around a former manufactured gas plant (MGP) that operated from 1930 to 1963. Other past and current industrial activities adjacent to the former MGP may have also contributed to contamination. These activities include but are not limited to fuel storage and distribution; marine salvage and repair; boat part and pier float fabrication; electroplating; sheet metal duct work; concrete fabrication; possible landfill activity; etc.

The U.S. Environmental Protection Agency (EPA) is developing plans for a remedial investigation (RI) and feasibility study (FS) for cleanup. Through this process, EPA will determine the site boundary by investigating all sources and extent of contamination. For this public health assessment, the term 'site' refers to upland, shoreline, and waterway areas near the former MGP. This includes nearby locations of current and past industrial activities that may have contributed to contamination.

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Conclusion 1. Trespassing on the site could result in physical injury. This is an urgent public health hazard. Actions to remove or prevent these hazards have been recommended.

Basis for Decision. Several physical hazards are present at the site.

- The bluff at the end of Pennsylvania Avenue is very steep and has a well used path. This path leads to an area where a rope is necessary to go down to the shoreline. One of the owners, as well as Kitsap Public Health District, has cut this rope to discourage trespassers.
- At the bottom of the path, debris from former waste dumping is emerging from the bluff and shoreline sediment. Of concern is a rusted metal tank located adjacent to the path and hidden by brush. A person could very easily fall in or on the tank and become seriously injured.
- Two large former ballast tanks are abandoned on the shoreline. These tanks are heavy, anchored to the shoreline with an old rope, and do not move. It is not known what was in these tanks. Access at low tide could result in injury if a person tried to climb these tanks. They may even become trapped if entry is achieved.

Next Steps. To protect residents, visitors, and trespassers, DOH recommends that

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- A sign be installed at the end of Pennsylvania Avenue prohibiting beach access.
- The rusted tank at the foot of the bluff be removed or fenced within three months.
- The submarine ballast tanks be removed by the owner in collaboration with EPA and Washington State Department of Natural Resources (DNR).

Conclusion 2. **R**esidents, visitors, or trespassers touching or accidentally ingesting sediments for more than a year could harm the health of children or adults.

Basis for Decision. PAHs were found in sediments near seeps and a former pipe that led to the beach. Playing at the beach, touching, or accidentally ingesting these sediments could result in an increased risk for developing cancer. The risk estimates exceed EPA's range of acceptable estimated cancer risk.[1] For residents, we estimate 5 additional cases of cancer will develop for every 1,000 people exposed over a lifetime. Visitors and trespassers also exceed the acceptable range of cancer risk. Further information is needed to know how widespread the contamination is along the shoreline.

Next Steps. To protect residents and visitors, DOH recommends that

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- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

Conc[redacted]

Basis for Decision. The City of Bremerton has never had public drinking water wells in the vicinity of the site. Thus, the people in residences and businesses in the area are not drinking groundwater contaminated by releases at the site.

Next Steps. No further action is necessary.

Conclusion 4. DOH cannot conclude if trespassers are touching contaminated soils at the site. The nature and extent of soil contamination are not known. Future land use may lead to contact with the soil. More soil sample data will be collected during EPA's upcoming RI.

Basis for Decision. Most of the former MGP footprint and industrial locations are now covered by asphalt. People are not able to contact most of the contaminated soils. However, a small portion of the former MGP is not covered. Trespassers may come into contact with contaminated soils in this area. More sampling and information on future land use is needed to fully assess if current or future health threats exist.

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[1] EPA's acceptable increased risk of developing cancer ranges from developing one additional cancer case in 10,000 people exposed to one additional case for every 1,000,000 people exposed (1×10^{-4} to 1×10^{-6}).

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Next Steps. DOH recommends that

- Site access be restricted and signed appropriately.
- Nature and extent of contamination in surface soils be characterized.
- Future land use be determined based on risks of disturbing remaining contaminants or recontamination of remediated areas.

Conclusion 5. DOH cannot conclude if people are being exposed to contaminants from eating fish or shellfish harvested at the site. Shellfish and fish tissue data are needed to assess any potential health threat.

Basis for Decision. Though uncommon, residents reported stories of people fishing off the bluff along the site. Commercial shellfish harvest in the area and recreational shellfish harvest on nearby public beaches have been closed for many years. DOH closed these areas because of combined sewer overflow releases and its use as an active harbor. The intertidal area near the site is not expected to reopen for shellfish harvest. However, the site is situated within the Suquamish Tribe's usual and accustomed (U&A) subsistence fish and shellfish harvest areas. Sediments are contaminated at the site (see conclusion #2) a

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- People refrain from eating fruit grown at the site until more is known about the contaminants in the soil and berries.
- More sampling of soil where berries grow and berries be analyzed for contaminants of concern.

For More Information

A copy of this public health assessment report will be provided to EPA, Washington State Departments of Ecology and Natural Resources (DNR), current and past owners, current tenants, City of Bremerton, the Suquamish tribe, and Kitsap Public Health District and the Kitsap Regional Library in downtown Bremerton.

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A copy of this public health assessment report will be placed on the DOH web site assessment webpage: http://www.doh.wa.gov/consults. If you have any questions about this health consultation contact Rhonda Kaetzel at 360-236-3357 or 1-877-485-7316 at Washington State Department of Health.

For more information about ATSDR, contact the Center for Disease Control and Prevention (CDC) Information Center at 1-800-CDC-INFO (1-800-232-4636) or visit the agency's web site at www.atsdr.cdc.gov.

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Purpose and Statement of Issues

The purpose of this public health assessment is to 1) determine whether chemical releases from of the Bremerton Gasworks Superfund site pose a public health threat, 2) recommend appropriate actions to protect public health, and 3) identify data gaps where additional sampling may be needed to better assess health risks. The Bremerton Gasworks Superfund site centers around a former manufactured gas plant (MGP) that operated from 1930 to 1963. Other past and current industrial activities adjacent to the former MGP may have also contributed to contamination.

The Washington State Department of Health (DOH) prepared this public health assessment under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). This health assessment is mandated by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. On September 15, 2011, the U.S. Environmental Protection Agency (EPA) proposed to place the Bremerton Gasworks site in Bremerton, Washington on the National Priorities List (NPL) in accordance with Section 105 of CERCLA 42 U.S.C. 9605. The NPL is EPA's list of the nation's most contaminated hazardous waste sites, also known as Superfund sites. ATSDR is required to conduct a health assessment for all sites proposed for inclusion on the NPL. On May 10, 2012,

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It lies along the south shoreline of the Port Washington Narrows less than a half mile west of the Warren Avenue Bridge. The site has a gentle north-facing slope with bluffs approximately 40–50 feet above sea level. The Port Washington Narrows connect Dyes Inlet to Sinclair Inlet. Sinclair Inlet drains into in the Puget Sound.

The formal boundaries of the site have yet to be determined by EPA. Data collected during the remedial investigation (RI) and cleanup feasibility study (FS) will help determine all the sources, nature, and extent of contamination. In addition to the operations at the former MGP, other past and current industrial activities may have contributed to the contamination at the site. **For this assessment, the term 'site' refers to the upland, shoreline, and waterway areas near the former MGP footprint. It also includes nearby locations of current and past industrial activities.**

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Figure 1. Bremerton Gasworks Superfund area including site-related parcels (A–F), former manufactured gas plant boundary, and state aquatic lands in Bremerton, Kitsap County, Washington.

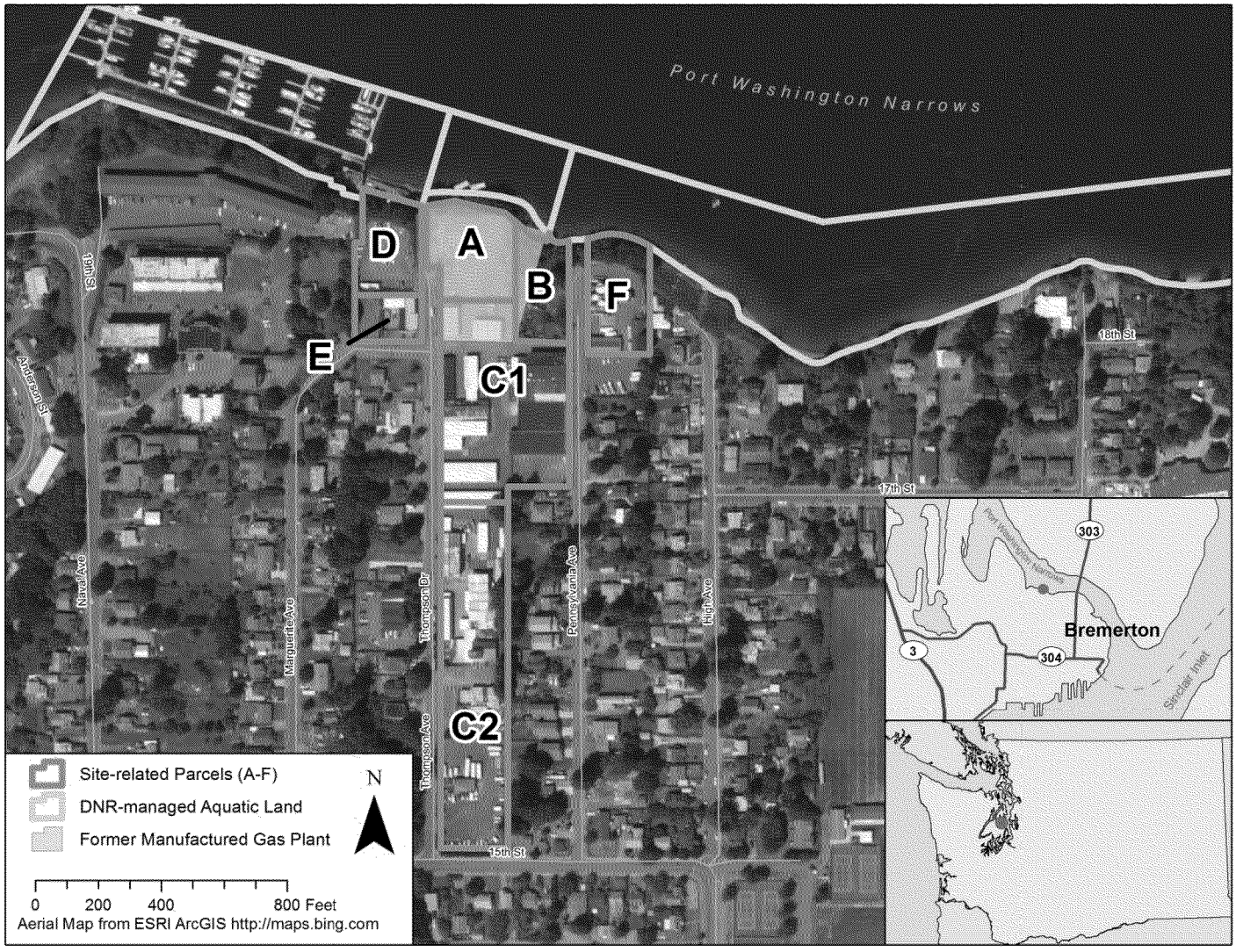

Table 1 provides a list of parcels with known past or current business operations that may have contributed to contamination.

Table 1. Parcel identification and industrial activities in the area of the Bremerton Gasworks Superfund site, Bremerton, Kitsap County, Washington.

Parcel	Parcel Number	Current Owner	Current Activity	Past Activity
A	3711-000-001-0409 address not available	McConkey	Storage (vehicles and implements)	Gas production, former product dock, metal fabrication (cutting fitting, welding, electroplating, sandblasting, and painting)
B	3741-000-022-0101 address not available	Sesko	Vacant	Gas production, bulk fuel distribution, former product dock, industrial and/or municipal landfill, metal salvage and repair of ship parts
C	**C1** 3711-000-001-0607 1723 Pennsylvania Ave.	Penn Plaza Storage LLC (McConkey)	Storage; light industrial activity (e.g., welding)	Gas production, storage, industrial activities (sheet metal shaping, pipe fitting, plumbing storage and supply, pier manufacturing, welding, building and repair of boat parts, electrical contracting , manufacture of granite countertops, etc)
	C2 142401-2-025-2008 1512 and 1550 Thompson Dr.	Penn Plaza Storage LLC (McConkey)	Storage; light industrial activity (e.g., welding)	Fabrication of concrete blocks, sewer pipes, and manholes; concrete storage; concrete covering of pier floats
D	3711-000-010-0002 1805 Thompson Dr. Bldg B	Seven JS Investments LLP	Marina parking lot and upland boat storage	Marina parking lot and upland boat storage; former product pipeline; former product dock
E	3711-000-009-0005 1701 Thompson Dr.	Pipeworks Mechanical & Service, Inc.	Vacant	Bulk fuel distribution, furniture fabrication, marine propeller electrical repair part supplier
F	3741-000-001-0007 1702 Pennsylvania Ave.	Pacific Northwest Energy Company Corporation (SC Fuels)	Bulk fuel distribution (diesel)	Bulk fuel distribution, former product pipeline and dock

Note: Site boundary has not yet been determined by the U.S. Environmental Protection Agency; operation information from site documents (Anchor 2011 (1), Ecology and Environment 2009 (2), Hart Crowser 2007(3) and current owners; parcel information from Kitsap County Assessor (http://kcwppub3.co.kitsap.wa.us/ParcelSearch/).

Residential areas border these parcels on the east, west, and south. Thompson Drive and Pennsylvania Avenue are owned and operated by the City of Bremerton. A combined storm sewer overflow outfall runs from Pennsylvania Avenue and discharges approximately 30 yards offshore of the site. The site is located within the Suquamish Tribe's usual and accustomed fishing and shell fishing area (U&A). Within the U&A, the tribe has treaty-reserved fishing and shell fishing rights. The tribe co-manages fishery resources with the State of Washington.

The intertidal and subtidal lands in this area are state-owned aquatic land managed by the Washington State Department of Natural Resources (DNR). This includes the land along the shoreline that is exposed and submerged with the ebb and flow of tides. The shoreline is mostly accessible when water is at 4 feet above mean lower low water [2] (+4) and below.

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Current Conditions and Operations

The following bullets describe known current uses on the parcels listed in Table 1 and shown in Figure 1. A brief description of parcel conditions that limit or impact human exposure to site contaminants is also provided. Access to parcels A, B, and C1 are within a fence with locked entrance.

1. **Parcel A:** Paved area used for vehicle and implement storage (0.83 acres). The shoreline banks are steep and have large concrete retaining blocks along the water's edge. The bluffs have discarded creosote-treated wood pilings lying against the slopes underneath the brush. At the edge of the bluff, a strong creosote-like odor can be detected.
2. **Parcel B**: Area is vacant, unpaved, and largely overgrown with brush (0.6 acres). The southern edge of the parcel has two cement foundations (see historical operations below). The contain standing water/dried mud that once supported ten above ground storage tanks (ASTs). There is a fence along Pennsylvania Avenue and access is through parcel C1. Jersey barriers (modular concrete road barriers) separate parcel B from parcels A and C1. Along the west side of the parcel, a former unpaved access road leads toward the shoreline. Unrestricted foot access from the shoreline in this area shows indications of trespasser habitation.
3. **Parcel C1**: Area is paved with seven buildings used for storage and light industrial activities (2.1 [redacted] and
4. [redacted] 2.47
5. [redacted]
6. [redacted]

- [redacted]

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Bremerton Gasworks (Former MGP): The former MGP operations are a source of primary concern at the site. The former MGP covered **parcel A, the west of parcel B, and north of parcel C1** (Figures 1–3). Under several different owners, this plant provided manufactured gas to City of Bremerton customers for lighting, heating, and cooking. The MGP structures were originally constructed to extract gas from coal using the carbureted water gas process (3). This process injected steam through an incandescent bed of coke or coal. The water gas produced was then fed into a carburetor where it was enriched with light hydrocarbons. It is unknown what fuel was used to enrich the water gas. However, petroleum oil-based feed stocks commonly used included naptha; gas oils (diesel, heating, and fuel oils); and residual oils.

It was reported in 1942 that wood chips were used to remove the tar from the end product (3;4). The "tar-laden wood chips" and the "soot from the water gas machine" were disposed of at the edge of the plant near the oil storage tanks. These byproducts were used to fill a gully on what is presumed to be parcel B. The tar emulsion was dumped in shallow pits dug at random in the ground. It is not known when these practices started or ended.

[2] Mean lower low water (MLLW) is the average height of the lower low waters over a 19-year period. Lower low water is the lower of the two low waters tides of the day.

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Figure 2 demonstrates actual structure configuration and boundaries of the former gasworks plant on a historical photo from the 1950s. Figure 3 provides a more detailed, close-up view of the former structures. These structures included a coal storage area; water gas generator; winch; gas holder and gas tanks; diesel, oil, and gasoline tanks; purifiers and scrubbers; tar well; residue cistern; and numerous underground pipes. Figure 2 shows three piers servicing the area.

Figure 2. Historical aerial photo of the Bremerton Gasworks Superfund site area in Bremerton, Kitsap County, Washington

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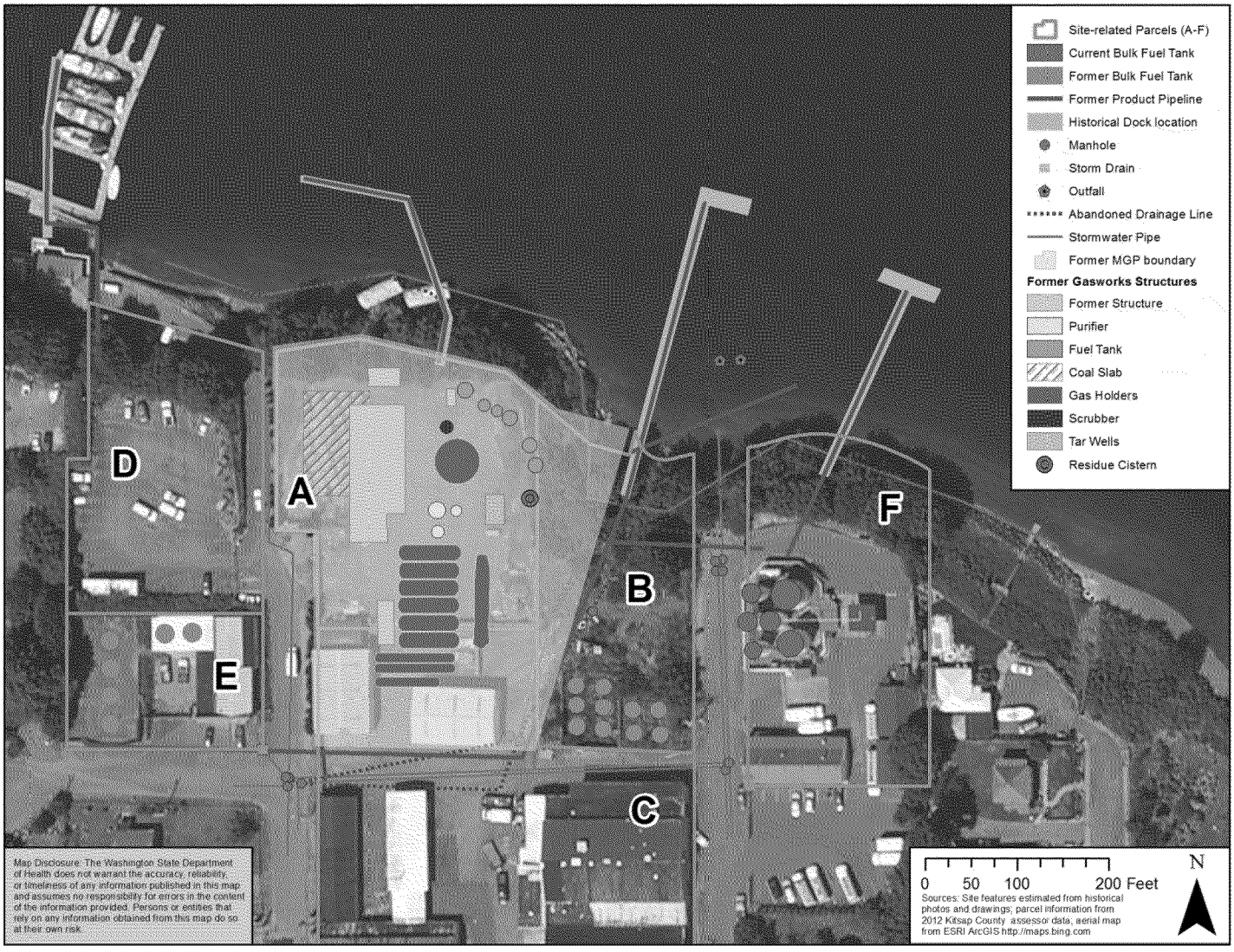
Figure 3. Former structures of the manufactured gas plant and bulk fueling facilities near the site, Bremerton, Kitsap County, Washington.



Landfill Activity. Historical photos indicate the shoreline of **Parcel B** has significantly changed over time. These changes clearly demonstrate that this area has been filled. Most fill activities occurred between 1963 and 1971 (3). No records were available to identify sources of the fill material. The bluff at the end of Pennsylvania Avenue is very steep and has a well used path. This path leads to an area where a rope is necessary to go down to the shoreline. At the bottom of the path, debris from former waste dumping is emerging from the bluff and shoreline sediment. Of concern is a rusted metal tank located adjacent to the path and hidden by brush. A person could very easily fall in or on the tank and become seriously injured.

Bulk Fuel Facilities. Three bulk fuel facilities operated separately from the MGP and stored petroleum fuels in ASTs. Product arrived by barge then transferred to ASTs via above and below ground pipelines then distributed from the ASTs (3;5). Use of the three or four former piers was consolidated over time and two or more facilities shared a single pier in later years. All former piers have been removed. It is unknown if the underground distribution pipelines still exist or if product still remains in them. The facilities were or are located on:

- **Parcel B.** Fuel facility was located adjacent to the former MGP. Ten ASTs were on site through the 1940s. Ownership and specific facility operations are unknown. The tanks were removed by
- **Parcel E.** [illegible] built by At[illegible] Co[illegible] (CO), were operated by several [illegible] 1942 [illegible] When A[illegible] fo[illegible]s on [illegible] (2;[illegible] Th[illegible] 19[illegible] who [illegible] of USTs o[illegible] arcel.
- **Par**[illegible] AS[illegible] y SC Fuels. Th[illegible] has [illegible] 19[illegible] 7 to [illegible] A[illegible] cts [illegible] waste oil ([illegible] Eco[illegible] om

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Penn Plaza Storage LLC. This storage facility is located on parcels A, C1, and C2. Much of the property has storage units that contain personal or industrial items. Some industrial activity by tenants has occurred or is occurring on these parcels. Historical operations include:

- Metal fabrication (cutting, fitting, welding, sandblasting, painting, and manufacturing of containment vessels) (Lee Fabricators).
- Electroplating operation
- Sheet metal operation
- Electrical contractor
- Building and repairing ship parts
- Boat repair
- Concrete float (pier) fabrication
- Concrete fabrication and storage (blocks, sewer pipes, and manholes)

Several sources may have contributed to contamination present on the shoreline. These include

- Known and unknown effluent drain pipes from the former MGP.

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- Unknown effluent drain pipes from other industrial operations.
- Contaminated groundwater released from underground seeps.
- Surface water runoff.
- Combined sewer overflow releases.
- Product and or fuel spills from vessels.
- Releases from industrial and municipal waste from Parcel B
- Boats (i.e., in the adjacent marina, traveling in the Narrows, abandoned on shoreline)
- Unknown chemicals in the two abandoned ballast tanks
- Creosote-treated pilings from former piers

Environmental Investigations

The following environmental investigations have occurred at the site and are listed in chronological order. Data from some of these investigations were used to evaluate the nature and extent of contamination (see section below on page 20):

In 1992, Ecology inspected Lee Fabricators, a former metal fabrication business in operation since 1986 on **pa** [redacted] Dyes Inlet [redacted]

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In 19 [redacted] **and C2** (3 [redacted] on the C [redacted] list:

- [redacted] rums
- [redacted] or from diesel used as a releasing agent from the molds.
- At Lee Fabricators, Ecology again noted uncontrolled accumulation of sandblast grit in storm water runoff and improper storage of waste oil.
- During electroplating operations at an unknown location, illegally discharged substances were disposed of into storm drains.

In 1995, DNR observed unpermitted building of ship parts and reclamation activities on **parcels A and B**. DNR requested that Ecology perform a Site Hazard Assessment {Ecology, 1995 5 /id}. Unrelated to these activities, a black gooey substance with a creosote odor was identified on the bluff of **parcel B**. PAHs and metals were determined to be contaminants of concern based on one sediment and three soil samples. Ecology added the site to the state's Hazardous Site List.

In 1998, Ecology performed an initial investigation at **parcel F**, the current bulk fuel facility located on Pennsylvania Avenue (6). Groundwater and soil samples confirmed the presence of non-halogenated solvents and petroleum products above cleanup levels. Pacific Northwest Energy Company entered Ecology's Voluntary Cleanup Program (FS ID 2788449) in 2001. They exited the program in 2009. DOH did not have any site documents at the time of this review. Three leaded and unleaded 10,000-gallon USTs and a 5,000-gallon waste oil UST were removed from the facility in the early 2000 (3;6).

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In 2006, EPA awarded the City of Bremerton a Brownfields Assessment grant. At that time, the city and owners wanted to develop **parcels A and B** as a public access marina (2). Soil contamination has migrated from the soil into the groundwater beneath the site (2). Contamination of the sediments in the Washington Narrows was also identified. Contaminants of concern included PAHs, metals, total petroleum hydrocarbons (TPH), and TPH-associated non-chlorinated solvents. Several waste barrels from these remedial sampling efforts are still located on **parcels A and B**.

In 2010, Kitsap Public Health District investigated reports of an oily sheen on the shoreline of **parcels A and B**. The release was from an old pipe filled with what appeared to be leftover coal tar product and contaminated sediment. The Coast Guard located the pipe two feet under the surface then cut and plugged the end. They excavated approximately 4,000 square feet of contaminated sediment. The Coast Guard and EPA's Superfund Technical Assessment and Emergency Response Team (START) collected and analyzed 30 sediment samples. They identified high PAH contamination covering about 100 square feet extending out 60 feet below the high tide line. (1). The depth of contamination was not determined. EPA entered into an Agreed Order with a former owner, Cascade Natural Gas Corporation, to stop the release. The release came from what appeared to be an abandoned sewer storm water outfall pipe. It was once connected to, or may still be connected to, an abandoned vault. The vault likely received discharge from [redacted] ved appr[redacted] five feet a[redacted] abso[redacted] PA's NPL [redacted] in depth remedial inves[redacted]).

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Clim[redacted] nate is cha[redacted] m dry s[redacted] dram[redacted] nter temp[redacted] F and s[redacted] F (Nati[redacted] Washington State). Precipitation is seasonal with two thirds of the rain falling between November and March. Rain is characterized as frequent and low-intensity with long-duration patterns. Precipitation in the Puget Sound Lowlands, which includes the Bremerton area, averages about 43 inches per year. Snow is rare. Winter storms can be associated with high winds and prevailing winds are from the south/southwest. Storm surges in low-lying coastal areas occur, especial when aligned with higher tides.

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Figure 4. Contaminated sediments at low tide during October 2010 resulting in emergency action removal of product pipe and sediments Bremerton, Washington (photo courtesy of Kitsap Public Health District).

Geology and Marine Water Resources. The surface geology of the Puget Sound Lowlands consists mainly of glacial, alluvial, and marine sediments. Little bedrock is exposed. The typical soil in the area is Alderwood, formed from glacial till (5). Surface water and storm water can flows to the city storm drain which flows into the Narrows. Or, it can flow from parcels C1 and A onto parcel B then directly onto the shoreline.

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The Port Washington Narrows, north of the property, is a 3-mile channel connecting Dyes Inlet to Sinclair Inlet. Sinclair Inlet drains into Puget Sound. This channel is considered a harbor area. This is a relatively deep, narrow channel with strong tidal currents and bluff-backed beaches. Tidal flows drive strong currents through the Narrows at approximately 4 knots. Daily cycle of tides in all of Puget Sound includes two unequal high tides and two unequal low tides. From day to day the height and time of the tide varies depending on the lunar cycle. The lowest and highest tides occur near the summer and winter solstices. The lower low tides of late fall and early winter occur near midnight. Low tides permitting access to the shoreline during the day occur about 60% of the year (218 out of 365 days) [3] mostly between March and September. At this location, tides usually range from -3 feet below to +14 feet above the average of the lowest tides recorded at the closest tide station (Tracyton, Dyes Inlet, 2011 NOAA data).

Groundwater. Sand and gravel deposited during the last ice age compose the aquifers in the area. Based on topography and local drainage patterns, shallow-seated groundwater flows to the north or northeast (5). From previous reports, depth to groundwater is estimated at 10 to 20 feet deep.

The City of Bremerton has never had public drinking water wells in the vicinity of the site. Thus, the people in residences and businesses in the area are not drinking water contaminated by releases at the site. Wher[redacted]s not know[redacted] water[redacted]s from [redacted] water. The other 40% is supplied by 13 [redacted] wells [redacted] to [redacted] ply in [redacted] No [redacted] are [redacted] ne site a[redacted] are [redacted] ay. [redacted] e w[redacted] no[redacted] d to [redacted] e u[redacted] n t[redacted] ter [redacted] e Area. [redacted] r n[redacted] nati[redacted] n B[redacted] ton' [redacted] sou[redacted] se[redacted] 's [redacted]

Fish. [redacted] nu[redacted] h c[redacted] on [redacted] Pu[redacted] nd are presun[redacted] be [redacted] ngt[redacted] Narr[redacted]s. T[redacted] nts [redacted] vift[redacted] the[redacted] W[redacted] Na[redacted]s a[redacted] ren[redacted] ning. Loca[redacted] sidents have c[redacted] fis[redacted] m b[redacted]s i[redacted] ys a[redacted] fro[redacted] his [redacted] frequ[redacted]

DOH[redacted]
based [redacted]

- Chinook salmon – no more than 1 meal per week (all of Puget Sound).
- Resident juvenile Chinook salmon (blackmouth salmon) – no more than one meal per month (all of Puget Sound).
- Puget Sound rockfish – no more than one meal per week from Bremerton area and most of Puget Sound. Do not eat Puget Sound rockfish from Sinclair Inlet.
- Yelloweye and canary rockfish – Do not eat.
- English sole and other flatfish – no more than one meal per week from Port Orchard Passage and no more than one meal per month from Sinclair Inlet.

No Puget Sound meal limits have been set for other species of salmon (coho, chum, pink, or sockeye).

[3] Access to the shoreline occurs when the water is less than four feet above mean lower low water (4+ tide). Mean lower low water is the average of the lowest low tides recorded at a tide station. The closest NOAA tide station is at Tracyton, Dyes Inlet, Estimates are days in 2011with 4+ tides or lower that occur between 7 a.m. and 7 p.m.

[4] http://www.ci.bremerton.wa.us/display.php?id=733

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Bivalves (Clams, Oysters, and Mussels). Shellfish bivalve species known to the area include oysters, mussels, and a variety of clams. DOH and Kitsap Public Health District regularly test shellfish and water for fecal and biological toxins. DOH has closed commercial harvest in the area and recreational harvest on nearby public beaches for many years because of combined sewer overflow outfalls. **Do not eat shellfish from the Bremerton Area.** Several starfish, small crabs, clam shells, and other invertebrates were observed at low tide during the site visit in July 2012.

Crab and Shrimp. Dungeness crab (*Cancer magister*) live in the subtidal sediments of the Port Washington Narrows. Spot (*Pandalus playceros*), coonstripe (*P. danae and P. hypsinotus*) and pink shrimp (*P. eous and P. jordani*) are known to Puget Sound and probably present in the Narrows. DOH has a crab advisory for the Bremerton area. Advisories assume that an adult meal size equals 8 ounces (227 grams) of uncooked crab. **Do not eat Dungeness and red rock crab from the Bremerton area.**

Demographics

The site is located in an urban area of Bremerton. Nearby, there are industries, residences, businesses, schools, and the Port of Washington Marina. Bremerton is the largest city on the Kitsap peninsula. It's the home to the Puget Sound Naval Shipyard and U.S. Navy base.

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Exposure Evaluation

The exposure evaluation consists of three components

1. understanding the nature and extent of environmental contamination at and around the site;
2. identifying exposure pathways by evaluating who may be or has been exposed to site contaminants; and
3. identifying uncertainties and data gaps to be filled that would help understand exposures to people.

Nature and Extent of Contamination

DOH used environmental data collected during several investigations to evaluate the nature and extent of contamination at the site. Figure 4 demonstrates the sample locations of data available from the site. See the section on Environmental Investigations section (page 16) for details of these investigations. Tables 2, 3, and 4 summarize detected compounds in sediment, surface soil, and groundwater respectively.

Sediments. Sediment samples from the shoreline have been taken during four investigations.

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- In March 1995, one sediment sample (depth unknown) was analyzed for metals, and SVOCs during an investigation by Ecology (5;7). These data were not used in the current evaluation. They do not represent current conditions but do identify locations of high contamination not well characterized recently.
- In June 2008, five sediment samples (depth unknown) were analyzed for metals, SVOCs, and TPH-Dx (2) during the EPA Brownfield assessment.
- In October 2010, 31 sediment samples (30 cm deep) were analyzed for metals, SVOCs, VOCs, and TPH during the emergency action removal of the leaking pipe (8). Of these, nine were covered by the interim action placement of a clay mat and rocks.
- In November 2010, samples of removed materials including three sediment samples (30 cm deep) and two samples of sediment/product in the pipe were analyzed for metals, SVOCs, VOCs, and TPH. These data were not used in the current evaluation but identify contaminants of concern.

In general, PAHs are elevated on the shoreline and the extent and depth are not well characterized. Several compounds were analyzed with high detection limits. Limited data suggest that metals are not of concern, but more information is needed. Table 2 summarizes detected compounds in sediment used in this evaluation.

Soils. [redacted]

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Exposure Pathway section (page 29), the only people that would be exposed to chemicals in subsurface soils would be occupational exposures during excavation work. These workers are protected under the Occupational and Safety Health Administration (OSHA). Therefore, these exposures are not evaluated here.

Groundwater. During the Brownfield assessment in June 2008, six groundwater samples were analyzed for metals, SVOC, VOC, and TPH-Dx (2;9;10). Table 4 summarizes detected compounds in groundwater. As noted below in the Exposure Pathway section, people are not drinking this contaminated groundwater. However, this water can be discharging into the narrows.

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Figure 5. Sample locations from previous investigations at the Bremerton Gasworks Superfund site, Bremerton, Kitsap, Washington

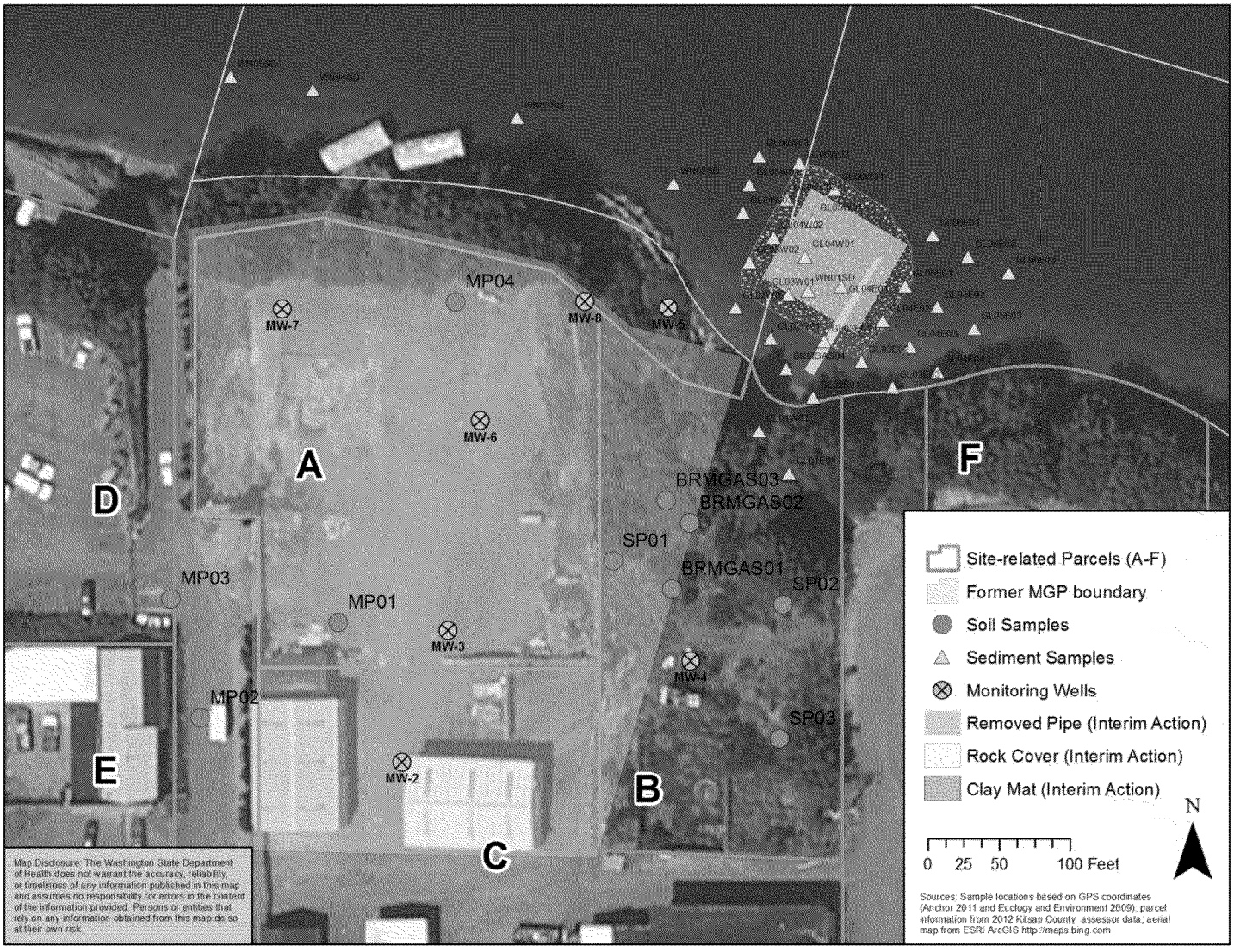

Table 2. Chemical concentration (mg/kg) of **intertidal sediment samples** and health-based comparison values, Bremerton Gasworks Superfund site, Kitsap County, Washington.

Chemical [a]	Number Detected / Total Sampled [b]	Soil CV [c,d] (mg/kg) (ppm)	Type of CV	Range of Concentrations Measured Greater than CV (mg/kg) [e]	Number Detected (and non-detected) greater than CV
Semivolatile Organic Compounds					
~Benz(a)anthracene	28/36	[0.48]	[CREG/RPF]	0.16–69	26 (7)
~Benzo(a)pyrene	26/36	0.096	CREG	0.26–76	26 (10)
~Benzo(b)fluoranthene	32/36	[0.12]	[CREG/RPF]	0.13–110	32 (4)
~Benzo(k)fluoranthene	18/36	[9.6]	[CREG/RPF]	0.19–60	2 (5)
~Benzo(g,h,i)perylene	11/36	[11]	[CREG/RPF]	0.16–32	2 (5)
~Chrysene	29/36	[0.96]	[CREG/RPF]	0.17–80	27 (6)
~Dibenz(a,h)anthracene	5/36	[0.0096]	[CREG/RPF]	0.047–15	5 (31)
~Fluoranthene	34/36	[1.2]	[CREG/RPF]	0.34–110	31 (2)
~Indeno(1,2,3-cd)pyrene	20/36	[1.4]	[CREG/RPF]	0.15–72	9 (14)
~Total cPAH BaP-EQ [f]	**36/36**	**[0.096]**	**[BaP CREG]**	**0.93–351**	**36**
Acenaphthene	5/36	3,000	RMEG	0.024–15	
Acenaphthylene [Acenaphthene]	5/36	[3,000]	[RMEG]	0.048–15	
Anthracene	4/36	15,000	RMEG	0.034–15	
Biphenyl, 1,1'-	4/5	2,500	RMEG	0.024–0.1	
Bis(2-chloroethyl)ether	0/36	0.64	CREG	0.024–**15U**	0 (29)
Carbazole [Diphenylamine]	4/36	[1,300]	[RMEG]	0.024–15	
Chloroaniline, 4-	0/36	200	RMEG	0.024–**1500U**	0 (27)
Dibenzofuran	4/36	78	RSL	0.024–15	
Dinitro-2-methylphenol, 4,6-	0/36	200	iEMEG	0.048–**450U**	0 (6)
Dinitrophenol, 2,4-	0/36	100	RMEG	0.12–**450U**	0 (6)
Fluoranthene	34/36	2,000	RMEG	0.34–110	
Fluorene	4/36	2,000	RMEG	0.012–15	
Hexachlorobenzene	0/36	0.44	CREG	0.024-**15U**	0 (29)
Hexachlorocylclopentadiene	0/36	9	CREG	0.024-**15U**	0 (27)
Methylnaphthalene, 2-	4/36	200	RMEG	0.024–15	
Methylphenol, 4- (p-cresol)	1/5	310	RSL	0.017–0.024	
Naphthalene	5/36	1,000	RMEG	0.017–150	
Nitrolaniline, 4-	0/36	24	RSL	0.048–**2300U**	0 (31)
Nitroso-dimethylamine, N-	0/36	0.014	CREG	0.024–0.036	
Nitroso-di-n-propylamine, N-	0/36	0.10	CREG	0.024–**15U**	0 (31)
Pentalchlorophenol	0/36	1.8	cEMEG	0.024–**150U**	0 (31)
Phenanthrene [Fluoranthene]	19/36	[2,000]	[RMEG]	0.14–36	
Phthalate, Di(2-ethylhexyl)	1/36	50	CREG	0.024–**150U**	0 (6)
Phthalate, Diethyl	1/36	40,000	RMEG	0.024–15	
Pyrene	35/36	1,500	RMEG	0.50–160	
Trichlorophenol, 2,4,5-	0/36	0.64	CREG	0.0014–**150U**	0 (6)
Xylene, o- [Total Xylenes]	1/5	[10,000]	[cEMEG]	0.0014–0.0057	
Metals					
Aluminum	5/5	50,000	cEMEG	6020–9030	
Arsenic [g]	5/5	15	cEMEG	1.5–5.1	

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Barium	2/5	10,000	cEMEG	13.3–47	
Beryllium	5/5	100	cEMEG	1.9–2.7	
Cadmium	0/5	5	cEMEG	0.05U–0.5U	
Chromium [Hexavalent chromium]	5/5	50	[cEMEG]	16.6–21.2	
Cobalt	5/5	500	iEMEG	3.0–26.3	
Copper	5/5	500	iEMEG	8.6–71.7	
Iron	5/5	55,000	RSL	9,730–15,900	
Lead	5/5	250	MTCA	8.9–30	
Manganese	5/5	2,500	RMEG	135–180	
Mercury [Mercuric chloride]	1/5	[15]	[RMEG]	0.021JQ –0.1	
Nickel	5/5	1,000	RMEG	21.4–52.6	
Selenium	0/5	250	cEMEG	0.41JQ –3.5U	
Silver	0/5	250	RMEG	1.0U	
Thallium	0/5	0.78	RSL	2.5U	0 (5)
Vanadium	5/5	500	iEMEG	21.6–36.5	
Zinc	5/5	15,000	cEMEG	23.2–79.9	
Volatile Organic Compounds				–	
Acetone	1/5	45,000	RMEG	0.0066–0.028	
Benzene	1/25	13	CREG	0.0014–0.03	
Ethylbenzene	1/25	5,000	RMEG	0.0014–0.05	
Methylene chloride	19/25	300	RMEG	0.0013–1.0	
Naphthalene	1/25	1,000	RMEG	0.001–0.17	
Trichloropropane, 1,2,3-	0/25	0.023	CREG	**0.0013–0.05**	0 (20)
Xylene, m- and p- [Total Xylenes]	1/25	10,000	cEMEG	0.0014–1.0	
Total Petroleum Hydrocarbons					
Diesel Range	4/5	2,000	MTCA	25–245	
Gasoline Range	0/5	2,000	MTCA	5–450	
Heavy oil range	5/5	2,000	MTCA	21–615	

Source
Notes:
[a] Bolde
[b] Table includes detected chemicals and chemicals with detection limits above the CV. Compounds not detected not listed.
[c] ATSDR CVs based on child soil exposures were used for screening (CVs for sediment exposures have not been developed). To be conservative, soil CVs reflect residential exposures and are expected to overestimate sediment exposures on the shoreline.
[d] Surrogate compounds were selected for chemicals that have no CV. Selection is based on structural and physiochemical properties. Surrogates and values designated with brackets [ ].
[e] PAHs associated with carcinogenic effects (cPAHs) have a ~ preceding their name. For each sample, each PAH is multiplied by potency factor relative (RPF) to BaP as presented by EPA 2010 (11). These are summed and presented as the Total cPAH BaP Equivalent (BaP-EQ).
[f] Per ATSDR, CV is health-based for non-carcinogenic effects only, not carcinogenic effects. CREG CV is below background.

Table 2 Abbreviations:

ATSDR	Agency for Toxic Substances and Disease Registry
BaP	Benzo(a)pyrene
BaP-EQ	Benzo(a)pyrene equivalents
cEMEG	ATSDR Environmental Media Evaluation Guide based on chronic exposures (>365 days) based on MRL
cPAH	Polycyclic Aromatic Hydrocarbons that have carcinogenic adverse effects
CREG	ATSDR Cancer Risk Evaluation Guide
CV	Health-based comparison value (unless otherwise indicated)
EPA	U.S. Environmental Protection Agency
iEMEG	ATSDR Environmental Media Evaluation Guide based on intermediate exposures (90–365 days) based on MRL
J	Chemical positively identified but outside of quality control limits and considered an estimate
JQ	Chemical detected below the reporting limit but above the detection limit and considered an estimate
mg/kg	milligrams of chemical per kilograms of sediment
MRL	ATSDR Minimal Risk Level for non-carcinogenic adverse effects

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MTCA	Washington State Model Toxics Control Act cleanup regulation
ppm	parts per million
RfD	Oral reference dose developed by EPA for non-carcinogenic adverse effects
RMEG	ATSDR Reference Dose Media Evaluation Guide for non-carcinogenic adverse effects
RSL	EPA Regional Screening Level
U	Value undetected at the detection limit given

Table 3. Chemical concentrations in **surface soil** samples (0–5 feet bgs) and health-based comparison values, Bremerton Gasworks Superfund site, Kitsap County, Washington.

Chemical [a]	Number Detected / Total Sampled [b]	Soil CV [c,d]	Type of CV	Range of Concentrations Measured Greater than CV (mg/kg)	Number Detected (and non-detected) greater than CV
Semivolatile Organic Compounds (ug/kg)					
~Benzo(a)anthracene	5/7	0.48	[CREG/RPF]	0.48–1.6	2
~Benzo(a)pyrene	5/7	0.096	CREG	0.57–2.5	2
~Benzo(b)fluoranthene	5/7	0.12	[CREG/RPF]	0.43–1.8	2
~Benzo(k)fluoranthene	5/7	9.6	[CREG/RPF]	–	
~Benzo(g,h,i)perylene	5/7	11	[CREG/RPF]	–	
~Chrysene	4/7	0.96	[CREG/RPF]	0.52–3.9	2
~Dibenzo(a,h)anthracene	5/7	0.0096	[CREG/RPF]	0.78–1.1 U	1(1)
~Fluoranthene	6/7	1.2	[CREG/RPF]	12 J	1
~Indeno(1,2,3-cd)pyrene	5/7	1.4	[CREG/RPF]	2.0	1
~Total PAH BaP Equivalents [e]	**6/7**	**0.096**	**CREG**	**0.3–13.6**	**3 [e]**
Acenaphthene	3/7	3,000	RMEG	–	
Acenaphthylene [Acenaphthlene]	3/7	[3,000]	[RMEG]	–	
Acetophenone	1/7	5,000	RMEG	–	
Anthracene	1/7	15,000	RMEG	–	
Biphenyl, 1,1'-	1/7	2,500	RMEG	–	
Carbazole [diphenylamine]	2/7	[1,300]	[RMEG]	–	
Dibenzofuran	1/7	78	RSL	–	
Fluoranthene	5/7	2,000	RMEG	–	
Fluorene	3/7	2,000	RMEG	–	
Methylnaphthalene, 2-	3/7	200	RMEG	–	
Naphthalene	1/7	1,000	RMEG	–	
Phenanthrene [fluoranthene]	5/7	[2,000]	[RMEG]	–	
Phthalate, Di(2-ethylhexyl)	6/7	50	CREG	–	
Pyrene	5/7	1,500	RMEG	–	
Trimethylbenzene, 1,2,4-	1/7	62	RSL	–	
Trimethylbenzene, 1,3,5-	1/7	780	RSL	–	
Metals (mg/kg)					
Aluminum	7/7	50,000	cEMEG	–	
Arsenic	7/7	15	cEMEG	–	
Barium	7/7	10,000	cEMEG	–	
Cadmium	2/7	5	cEMEG	–	
Chromium [Hexavalent chromium]	7/7	[50]	[cEMEG]	–	

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Cobalt	7/7	500	iEMEG	–	
Copper	7/7	500	iEMEG	–	
Lead	7/7	60	IEUBK	–	
Manganese	7/7	2,500	RMEG	–	
Nickel	7/7	1,000	RMEG	–	
Thallium	**4/7**	**0.78**	**RSL**	**2.2 JQ –4.1**	**2**
Vanadium	7/7	500	iEMEG	–	
Zinc	7/7	15,000	cEMEG	–	
Total Petroleum Hydrocarbons (mg/kg)					
Diesel Range	1/7	2,000	MTCA	–	
Heavy oil range	**3/7**	**2,000**	**MTCA**	**4,700**	**1**
Volatile Organic Compounds (ug/kg)				–	
Acetone	4/7	45,000	RMEG	–	
Benzene	2/7	13	CREG	–	
Ethylbenzene	2/7	5,000	RMEG	–	
Isopropylbenzene cumene	2/7	5,000	RMEG	–	
Tetrachloroethylene	1/7	300	RMEG	–	
Toluene	3/7	4,000	RMEG	–	
Trichlorobenzene, 1,2,3- [1,2,4-]	0/7	[500]	[RMEG]	–	
Trichlorobenzene, 1,2,4-	0/7	300	RMEG	–	
Trichlorofluoromethane	0/7	15,000	RMEG	–	
Xylene, o- [Total Xylenes]	2/7	10,000	cEMEG	–	

Source: [illegible]&E [illegible]

Notes:

[a] Bolde[illegible]hem[illegible]cted [illegible]entrations in s[illegible]at p[illegible]uld [illegible]ontact with E[illegible]atio[illegible]one in this rep[illegible]unti[illegible]atio[illegible]kten[illegible]ure [illegible]s available.

[b] Chem[illegible]s an[illegible]ot de[illegible]are [illegible]. Ho[illegible]tabl[illegible]hemi[illegible]th d[illegible]e C[illegible]

[c] ATSI[illegible]Vs [illegible]child [illegible]al sc[illegible]es.

[d] Surro[illegible] compounds we[illegible]or cl[illegible]at ha[illegible]no [illegible]base[illegible]stru[illegible]ical [illegible]s. Surrog[illegible]

[e] PAHs [illegible]otency factor [illegible]BaP-EQ).

[f] Per ATSDR, CV is health-based for non-carcinogenic effects only, not carcinogenic effects. CREG CV is below background.

Abbreviations:

ATSDR	Agency for Toxic Substances and Disease Registry
BaP-EQ	Benzo(a)pyrene equivalents
cEMEG	ATSDR Environmental Media Evaluation Guide based on chronic exposures (>365 days) based on MRL
cPAH	Polycyclic Aromatic Hydrocarbons that have carcinogenic adverse effects
CREG	ATSDR Cancer Risk Evaluation Guide
CV	Health-based comparison value (unless otherwise indicated)
EPA	U.S. Environmental Protection Agency
iEMEG	ATSDR Environmental Media Evaluation Guide based on intermediate exposures (90–365 days) based on MRL
J	Chemical positively identified but outside of quality control limits and considered an estimate
JQ	Chemical detected below the reporting limit but above the detection limit and considered an estimate
mg/kg	milligrams of chemical per kilograms of sediment
MRL	ATSDR Minimal Risk Level for non-carcinogenic adverse effects
MTCA	Washington State Model Toxics Control Act cleanup regulation
ppm	parts per million
RfD	Oral reference dose developed by EPA for non-carcinogenic adverse effects
RMEG	ATSDR Reference Dose Media Evaluation Guide for non-carcinogenic adverse effects
RSL	EPA Regional Screening Level
U	Value undetected at the detection limit given

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Table 4. Chemical concentrations in **groundwater** samples and health-based drinking water comparison values, Bremerton Gasworks Superfund site, Kitsap County, Washington.

Chemical [a]	Number Detected / Total Sampled [b]	Drinking Water CV (µg/L) [c,d]	Type of CV	Range of Concentrations Measured Greater than CV (mg/kg)	Number Detected (and Non-detected) greater than CV
Semivolatile Organic Compounds					
~Benz(a)anthracene	4/5	0.024	[CREG/RPF]	0.05 U–0.66	2
~Benzo(a)pyrene (BaP)	2/5	0.0048	CREG	0.05 U–1.1	2
~Benzo(b)fluoranthene	2/5	0.0060	[CREG/RPF]	0.05 U–0.59	2
~Benzo(k)fluoranthene	3/5	0.48	[CREG/RPF]	0.7	1
~Benzo(g,h,i)perylene	2/5	0.53	[CREG/RPF]	0.12–0.82	2
~Chrysene	3/5	0.048	[CREG/RPF]	0.068–1.1	2
~Dibenz(a,h)anthracene	1/5	0.00048	[CREG/RPF]	0.05U–0.5U	1
~Fluoranthene	4/5	0.060	[CREG/RPF]	0.12–3.7	4
~Indeno(1,2,3-cd)pyrene	2/5	0.069	[CREG/RPF]	0.090–0.40	2
~Total PAH B(a)P Equivalent	**4/5**	**0.0048**	**BaP CREG**	**0.61U–3.0**	**4**
Acenaphthene	2/5	600	RMEG	–	
Acenaphthylene [acenaphthene]	3/5	[600]	[RMEG]	–	
Acetophenone	1/5	1,000	RMEG	–	
Anthracene	4/5	3,000	RMEG	–	
Biphenyl, 1,1'-	1/5	500	RMEG	–	
Caprolactam	1/5	5,000	RMEG	–	
Carbazole [Fluorene]	2/5	[400]	[RMEG]	–	
Dibenzofuran	1/5	6	RSL	–	
Dimethylphenol, 2,4-	1/5	200	RMEG	–	
Fluoranthene	4/5	400	RMEG	–	
Fluorene	3/5	400	RMEG	–	
Methylnaphthalene, 2-	**5/5**	**40**	**RMEG**	**170**	**1**
Methylphenol, 4- (cresol, p-) [m-]	1/5	[500]	[RMEG]	–	
Phenanthrene [fluorene]	2/5	[400]	RMEG	–	
Phenol	1/5	3,000	RMEG	–	
Phthalate, Di(2-ethylhexyl)	2/5	2.5	CREG	–	
Phthalate, Diethyl	0/5	8,000	RMEG	–	
Phthalate, Butyl benzyl	1/5	2,000	RMEG	–	
Pyrene	4/5	300	RMEG	–	
Trimethylbenzene, 1,2,4-	**1/5**	**15**	**RSL**	**16**	**1**
Trimethylbenzene, 1,3,5-	**1/5**	**87**	**RSL**	**98**	**1**
Metals (ug/L)					
Arsenic	**6/6**	**0.023**	**CREG**	**0.39–4.1**	**5**
Barium	**6/6**	**2,000**	**cEMEG**	**2,370–5,840**	**3**
Beryllium	**4/6**	**4**	**MCL**	**6.4–13.6**	**3**
Cadmium	**3/6**	**1**	**cEMEG**	**1.8–3.9**	**3**
Chromium [hexavalent chromium]	**6/6**	**[10]**	**MCL**	**69.6–1,670**	**5**
Cobalt	6/6	100	iEMEG	–	
Copper	**5/6**	**100**	**iEMEG**	**111–293**	**2**

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Lead	**5/6**	**15**	**MCL**	**43.2–268**	**4**
Manganese	**6/6**	**500**	**RMEG**	**3,020–25,600**	**5**
Nickel	**6/6**	**200**	**RMEG**	**458**	**1**
Selenium	6/6	50	cEMEG	–	
Silver	1/6	50	RMEG	–	
Thallium	1/6	2	MCL	–	
Vanadium	**5/6**	**100**	**iEMEG**	**454–926**	**4**
Zinc	4/6	3,000	cEMEG	–	
Total Petroleum Hydrocarbons					
Diesel Range	**5/6**	**500**	**MTCA**	**510–5,500**	**2**
Volatile Organic Compounds					
Acetone	0/6	9,000	RMEG	–	
Benzene	**3/6**	**0.64**	**CREG**	**5.4–3,100**	**3**
Cyclohexane	1/6	13,000	RSL	–	
Ethylbenzene	1/6	700	MCL	–	
Isopropyl benzene (cumene)	1/6	1,000	RMEG	–	
Naphthalene	**3/6**	**200**	**RMEG**	**1,800**	**1**
Toluene	2/6	800	RMEG	–	
Trichloroethene	**2/6**	**0.76**	**CREG**	**25 U**	**0 (1)**
Xylene, o- [Total Xylenes]	2/6	[2000]	cEMEG	–	

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from ([illegible] **F)**
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[d] Surro [illegible] CV. Selection is b [illegible] ical [illegible] s. Surrog [illegible]
[e] PAHs [illegible] ulti [illegible] otency factor [illegible] (BaP-EQ).
[f] Per A [illegible]
Abbre [illegible]
ATSDI [illegible]
BaP-EQ Benzo(a)pyrene equivalents
cEMEG ATSDR Environmental Media Evaluation Guide based on chronic exposures (>365 days) based on MRL
cPAH Polycyclic Aromatic Hydrocarbons that have carcinogenic adverse effects
CREG ATSDR Cancer Risk Evaluation Guide
CV Health-based comparison value (unless otherwise indicated)
EPA U.S. Environmental Protection Agency
iEMEG ATSDR Environmental Media Evaluation Guide based on intermediate exposures (90–365 days) based on MRL
mg/kg milligrams of chemical per kilograms of sediment
MRL ATSDR Minimal Risk Level for non-carcinogenic adverse effects
MTCA Washington State Model Toxics Control Act cleanup regulation
ppm parts per million
RfD Oral reference dose developed by EPA for non-carcinogenic adverse effects
RMEG ATSDR Reference Dose Media Evaluation Guide for non-carcinogenic adverse effects
RSL EPA Regional Screening Level
U Value undetected at the detection limit given

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Exposure Pathways

In order for a chemical to harm human health, people must come into contact with the chemical. An exposure pathway describes how a chemical moves from a source and comes into contact with people. An exposure pathway is specific to when it occurred or will occur: the past, present, or future. An exposure pathway has five elements:

1. a source of contaminants;
2. a release mechanisms into water, soil, air, or the food chain
3. an exposure point or area
4. an exposure route (ingestion, dermal contact, or inhalation); and
5. a potentially exposed population.

Exposure pathways may be "completed", "potential" or "eliminated". A completed pathway has all five elements in place and occurring. A potential pathway has one or more of the elements unknown. If one of the five elements is not in place and occurring, the pathway is eliminated and not evaluated. Table 5 describes the completed, potential, and eliminated exposure pathways for the Bremerton Gasworks Superfund site.

DOH identified the following **completed pathways** at the site:

- Currently and in the past, residents, owners, and workers come in contact with contaminated sediment on the shoreline.
- Currently and in the past, inhalation of vapors from creosote-treated pilings on parcel A is occurring. Workers, site trespassers, and residents may potentially be exposed to chemicals being
- kers areas

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- Occ ave No osures hav ere is uncer to the is ted areas. The pas to with surf sur vate edi th am d. lth reported forci asse ve sit
- nia Avenue adjacent to parcel B. This location has not been tested for contaminants in soils. Some contaminants are known to accumulate in berries.
- Future use of the property may increase access to the shoreline. This would increase daily exposures of children and local residents to contaminants in surface soils and shoreline sediments.
- In the future, shellfish harvest could occur at low tide by residents, recreational visitors, and tribal subsistence harvesters. Eventually combined sewer overflows will be contained reducing fecal contamination in shellfish. Though unlikely, public beaches in the Narrows may be opened for shellfish harvest.
- Current and future use of the Narrows for fishing is unknown. Potential areas of sediment contamination may exist near former dock structures and seeps. Fish living nearby may be contaminated. Eating these fish could result in increased exposures of contaminants which accumulate in fish.

Some exposures are not occurring at the site or are extremely unlikely. DOH eliminated the following exposure pathways.

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- Currently, in the past, and in the future, contaminated groundwater at the site is not used as a drinking water source. Bremerton does not have source wells in the area. No private wells in the area exist. .No springs on site have been identified. No exposure is expected.
- In the past and currently people may not harvest shellfish near the site. For many years, area commercial harvest and recreational harvest on nearby public beaches have been closed by DOH. No exposure is expected.

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Table 5. Exposure Pathways for the Bremerton Gasworks Superfund site, Bremerton, Kitsap County, Washington

Pathway Name	Exposure Pathway Elements					Ti Fra
	Source	Media	Point of Exposure	Route of Exposure	Potentially Exposed Population	
Surface Soil	Past disposal of MGP waste; Leakage from storage tanks; Landfill debris from municipal and gasworks activities; Runoff from industrial activities.	Soil	Surface soil and on slope to shoreline	Ingestion; Dermal Contact	Trespassers; Site workers	Pas
						Pre t
					Local residents; Trespassers; Recreational visitors	Fut
Subsurface soil	Past disposal of MGP waste; Leakage from storage tanks; Landfill debris from municipal and gasworks activities; Abandoned product pipes	Subsurface Soil	Subsurface soils	Ingestion; Dermal Contact	Site workers	Pas
						Pre t
						Fut
Surface Water	Contaminated soils released into storm water runoff; waste product released into the Narrows	Surface Water	Storm water runoff	Ingestion; Dermal Contact	Trespassers	Pas
						Pre t
					Local residents; Trespassers;	Fut
Air	Release of volatiles from waste in surface soil and surface water runoff; Creosote- treated pilings on shoreline	Air	Air near or on property	Inhalatio n	Local residents; Trespassers; Recreational visitors; Tribal harvesters	Pas
						Pre t
						Fut
Public Water Supply	Past deposit of MGP waste in wells, soils; Leakage from storage tanks	Municipal Water Supply	Tap water	Ingestion	Past users of municipal water Supply	Pas
			None	None	None (different water source)	Pre t
						Fut
Private Water Supply	Past deposit of MGP waste in wells or soils; Leakage from storage tanks	Groundwater (Private Wells)	Well water	Ingestion	Past local residents with private wells	Pas
			None	None	None	Pre t
						Fut
Sediment	Seeps from contaminated groundwater; Release of product from abandoned pipes; Creosote-treated pilings; Surface runoff from facility; Fuel and oil spills from boats formerly docked in the area	Sediment	Sediments on shoreline	Ingestion; Dermal Contact	Trespassers	Pas
						Pre t
					Local residents; Trespassers; Recreational visitors; Tribal harvesters	Fut
Food Chain (Biota)	Past deposit of MGP waste in soils, water, or the narrows; Landfill debris from municipal and gasworks activities; Contaminated storm runoff from facility	Food	Blackberries	Ingestion	Local residents; Trespassers; Recreational visitors (exposure limited to late summer and fall)	Pas
						Pre t
						Fut
Food Chain	Seeps from contaminated groundwater; Release of	Food	None	None	None	Pas

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						Pre t
			Shellfish	Ingestion	Local residents; Trespassers; Recreational visitors; Tribal harvesters	Fut
Food Chain (Biota)	Seeps from contaminated groundwater; Release of product from abandoned pipes; creosote-treated pilings; Surface runoff from facility; Fuel and oil spills from boats formerly docked in the area	Food	None	None	None	Pas
						Pre t
			Fish	Ingestion	Local residents; Trespassers; Recreational visitors; Tribal harvesters	Fut

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Data Gaps

Additional data is necessary for a more definitive assessment of human exposures and possible health effects. Sampling should be focused on locations where people live, spend time, and play.

Sediment. The intertidal shoreline will be used in the future by residents, tribal members, or recreational visitors. The extent of contamination is not known. The surface sediment is well characterized near the mat and rocks placed in 2010 during the emergency action. A limited number of samples beyond this area have been taken. Sediment samples have only been taken between Thompson and Pennsylvania Avenues. The depth of contamination is not known. Nothing is known about the sediments further than approximately 120 feet offshore below the low-water mark. It is possible that effluent from the former MGP was released directly into the Narrows. Most effluent would have been carried away with the tide. Heavier residues from the gasification process may have drifted down into the sediments of the narrows. Contaminants in these sediments may impact shellfish and fish that may be harvested and eaten.

The nature of contamination has only been partially identified. Of the sediment samples taken, VOCs and SVOCs have been well characterized, though some had high detection limits. The PAH data for sediment samp[redacted]t the exten[redacted] conta[redacted] grou[redacted]

Surfa[redacted] [redacted]ntact with [redacted]ature and e[redacted]e expos[redacted] of Penns[redacted]th forme[redacted]

Subs[redacted] [redacted]n subsu[redacted] expos[redacted]ith MGP product residues. Residues were detected up to 35 feet below the surface. The extent of contamination is not well characterized.

Groundwater. People are not drinking the contaminated groundwater at the site (see exposure pathways section). Thus direct exposure to groundwater does not occur and more groundwater information will not help understand human exposures. Little information could be found regarding the relationship between the groundwater beneath the site and seeps or springs along the shoreline. Multiple anecdotal stories of seeps have been reported, some of which have been "oily." It is not clear where, or if, the contaminated groundwater is being released along the shoreline, thus the sources of contamination have not been identified.

Air. People walking on the shoreline or working at the site would be exposed to chemicals in the air. No air sampling has been conducted at the site. Creosote-like smells were observed along the shoreline. Sources for these smells should be identified and depending on the source, air sampling and analysis should be considered. Extensive wind movement along the Narrows will dilute chemicals in the air. It is unlikely that air would stagnate or remain in one location. However, exposure to chemicals in the air cannot be estimated at this time.

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Biota. The Suquamish tribe has U&A rights to harvest shellfish and fish in the Washington Narrows. During the site visit, clam shells and crab carcasses were observed on the beach during low tide. No information on the ecological sustainability of these and other species as a resource is available. No shellfish or fish chemical data in tissue is available. More information is needed to better understand exposures through consumption of fish and shellfish.

Nearby residents eat blackberries grown at the shoreline, particularly at the end of Pennsylvania Avenue. Concerns have been raised about potential contamination of berries. Berries have been shown to accumulate PAHs and some metals {2002 9 /id} which have been reported at the site. Neither soil samples nor berry samples have been sampled and analyzed, therefore exposures cannot be evaluated.

Other Contaminants. Other contaminants that were not analyzed for may be present at the site. Dioxin and furan compounds are oftentimes by-products from the combustion of fuel oils and gasification residues therefore sediments and soils should be analyzed for these contaminants-dioxins are considered carcinogenic at any detectable level. Because of the boat repair and part fabrication that occurred at the site, tributyltin should be analyzed for. Tributyltin was frequently used in marine paints.

Nearby Sources and Locations. Data from sampling done to determine the nature and extent of conta
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CVs are conservative and non-site specific and set to protect the most sensitive population, usually children. CVs are based on health guidelines with uncertainty or safety factors applied to ensure that they protect public health. C**hemicals detected below their CV** are not expected to result in health effects upon contact. These chemicals are not considered further in the public health assessment process. **Chemicals detected above their CV**, do not necessarily represent a health threat. These chemicals are identified for a detailed, site-specific evaluation to determine if health effects are expected to occur. CVs are not intended to be used as environmental clean-up levels.

CVs can be based on either carcinogenic or non-carcinogenic effects. Cancer CVs are calculated from EPA's oral cancer slope factor (CSF). CVs based on cancerous effects account for a lifetime exposure (70 years). They are based on an estimated excess lifetime cancer risk of one extra case per one million people exposed. Non-cancer CVs are calculated from ATSDR's Minimal Risk Levels (MRLs) or EPA's Reference Doses (RfDs). Some chemicals have both a cancer CV and non-cancer CV. When this happens, the lower of these values is used to be protective. Chemicals without a CV use a surrogate CV of a chemical that has similar structural and physiochemical features. CVs include Environmental Medial Evaluation Guidelines (EMEGs), Cancer Risk Evaluation Guidelines (CREGs), and Reference Dose

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Media Evaluation Guidelines (RMEGs), MTCA state cleanup levels, and EPA Regional Screening Levels (see definitions in the glossary in Appendix A).

Exposures to sediments are the only pathways evaluated with adequate data for initial screening. As a conservative approach, the screening analysis will compare sediment concentrations with soil CVs. Table 2 summarizes chemicals in sediment that exceed soil CVs. PAHs associated with carcinogenic effects (cPAHs) are of concern and will be evaluated further for resident, trespasser, and visitor exposures. Neither soil nor water exposures are evaluated further at this time. Soil data are not adequate to complete a full evaluation; more data are needed. Groundwater exposures are not occurring so they are not evaluated further. Though not evaluated further, Tables 3 and 4 summarize chemicals that exceed soil and water CVs respectively.

The PAH chemical class includes organic compounds. Most PAHs are fat-loving compounds, generated from the incomplete combustion of organic matter, including oil, wood, and coal. They are found in materials such as creosote, coal, coal tar, and used motor oil. Thus, their presence at the site near the former MGP in Bremerton is not surprising. Dietary sources make up a large percentage of PAH exposure in the U.S. population (8). Grains and smoked or barbequed meat and fish contain relatively high levels of PAHs. The majority of dietary exposure to PAHs for the average person comes from inges
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multiplied by the chemical's cancer potency factor. Cancer potency factors, also known as a cancer slope factors, are chemical specific. Some cancer potency factors are derived from human population data and others are derived from laboratory animal studies. Sometimes the doses in animal studies are much higher than encountered in the environment. Use of animal data requires extrapolation of the cancer potency from high dose studies down to low-level exposures. This process involves much uncertainty.

With some exceptions, current regulatory practice assumes there is "no safe dose" of a carcinogen. In other words, any dose of a carcinogen will result in some additional cancer risk. The validity of "no safe dose" assumption for all cancer-causing chemicals is not clear. Some chemicals must exceed a certain dose threshold before initiating cancer. For such chemicals, cancer risk estimates are not appropriate. Unless a chemical has been shown to have a threshold, DOH assumes that no threshold exists.

[5] According to the National Cancer Institute (NCI) based on 2007–2009 incidence rates.

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DOH describes cancer risks estimated for site-related contaminants in qualitative terms. Terms used to describe the increased risk of developing cancer include moderate, low, very low, slight, and insignificant. To better understand these terms, consider how big the population size at the site must be to see additional cases of cancer. For example, a low cancer risk would be associated with one additional case in 10,000 people exposed over a lifetime (1×10^{-4}). A very low estimate reflects one additional cancer case in 100,000 people exposed over a lifetime (1×10^{-5}). DOH and EPA generally consider a cancer risk up to one additional case of cancer in 10,000 people to be an acceptable risk. Ecology considers cancer risk up to one additional case of cancer in 100,000 people to be acceptable risk.

Estimated Cancer Risk

Cancer risk estimates do not reach zero no matter how low the level of exposure to a carcinogen. Terms used to describe this risk are defined below as the number of excess cancers expected in a lifetime:

Term		Number of Excess Cancers
Moderate	approximately equal to	1 in 1,000
Low	approximately equal to	1 in 10,000
Very Low	approximately equal to	1 in 100,000
Slight	approximately equal to	1 in 1,000,000
Insignificant	less than	1 in 1,000,000

Because cPAHs in sediment exceed the soil c[illegible]
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First, each PAH is multiplied by its relative potency factor (RPF). This factor scales the concentration relative to the potency of BaP. These modified concentrations are then summed as the BaP-Equivalent (BEQ) concentration. In 2010, EPA released draft report updating the RPFs of selected cPAHs in mixtures (8;14). This report considered more recent data and a wider range of cPAH compounds. Cancer risk is then estimated using the current oral cancer slope factor for BaP.

Using the 95% upper confidence limit of the average sediment concentration (159 mg/kg cPAH BEQ) the following estimated cancer risk estimates were calculated for touching or accidently ingesting sediment from the shoreline at the site during daytime low tides:

- For every 1,000 local residents playing or recreating on the beach sediments at low tide during the day for a lifetime, there is an increased lifetime risk of developing *five additional cancer cases* (5.3×10^{-3});
- For every 1,000 people visiting the beach sediments during the three summer months for a lifetime, there is an increased lifetime risk of developing *two additional cancer cases* (2.2×10^{-3});
- For every 10,000 adults (ages 16 years and higher) trespassing onto the site and going onto beach sediments three days a week for a lifetime, there is an increased lifetime risk of developing *six additional cases of cancer cases* (5.5×10^{-4}).

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Evaluation of Health Outcome Data

Evaluation of health outcome data (e.g., mortality and morbidity) in public health assessments are completed per ATSDR guidance (REF). The main requirements for evaluating this type of data include

- a completed pathway,
- high contaminant levels to result in measurable health effects,
- sufficient number people in the completed pathway for effects to be measured, and
- a health outcome database in which disease rates for the population of concern can be identified.

This site does not meet the requirements for including an evaluation of these data. Although a completed exposure pathway exists, the exposed population is not sufficiently defined or large enough.

Child Health Considerations

DOH recognizes that infants and children may be more vulnerable to exposures than adults in communities with contamination issues. This vulnerability is a result of the following factors. Children are more [redacted]

- To bring food [redacted] taminated a[redacted] g in [redacted] to mouth ex[redacted]osures.
- To [redacted] ighe[redacted]s o[redacted] tam[redacted] aus[redacted] th[redacted] alle[redacted]
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Healt[redacted] s for childr[redacted] ss point[redacted] children as the most sensitive population being exposed. In addition, an age-dependent adjustment factor is used to protect children 2 years old and younger and 3–6 year olds. Because of child-specific behaviors, estimated cancer risks for child residents and visitors six years old and younger have exposures that contribute to two-thirds of the lifetime cancer risk (up to 78 years).

Community Health Concerns

The purpose of this section is to document and respond to current, specific community health concerns. DOH conducted two site visits, one in July and one in August 2012. DOH is working with EPA to develop a community involvement and communication plan. EPA and DOH conducted community interviews on September 18, 2012. This meeting provided an opportunity to meet with residents to discuss concerns regarding the site. On October 10, 2012, DOH, met with the mayor of Bremerton, Public Works Director, community outreach, and two city council members. Staff discussed the Public Health Assessment process and ways to best communicate results of the report. The community has been invited to previous meetings regarding site activities during the EPA Brownfields Assessment. EPA and the Coast Guard posted signs informing residents of actions that occurred during the emergency

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removal in 2010. The release into the Narrows at that time raised concerns of on-going contamination from the site.

Community members, owners, and other members of the public brought forward the following health-related concerns and questions:

1. Are the cancers that people have in the neighborhood caused by the release of chemicals from the site?

Cancer is a term used for diseases in which abnormal cells divide without control then invade other tissues. Cancer develops over many years and has many causes. Several factors, both inside and outside the body, contribute to cancer development. Often, doctors cannot explain why one person develops cancer and another does not. Likewise, we cannot determine if any cancers in the neighborhood were caused by a chemical released from the former MGP or other industrial operations. Each chemical is associated with a specific cancer. The individual chance that someone will develop cancer in response to a particular, single environmental exposure depends on 1) the potential of the chemical to cause cancer and 2) how long or how often that person was exposed. Each person is exposed differently.

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berries. DOH recommends collecting and eating berries from a number of locations, not just one.

We recommend that the soils the blackberries grow in be analyzed to see if contaminants are present and available for the plants to absorb. If contaminants are present, we recommend analyzing the blackberries at the bottom of Pennsylvania Avenue.

4. Can we eat the shellfish collected on the shoreline or fish caught near or at the site?

For many years, DOH has closed commercial shellfish harvest and recreational harvest on nearby publicly owned beaches. The closure is because of combined sewer overflow releases resulting in fecal contamination on beaches. We do not recommend eating shellfish harvested near the site. We do not know if chemicals from the site are in shellfish that live in the Narrows. However, chemicals have been found in the sediments these shellfish live in.

[6] Rate of developing cancer based on 2007-2009 incidence rates from National Cancer Institute (NCI).

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We also do not recommend eating fish caught near the site. We don't know how far away the contamination has moved from the site. We don't have any fish tissue data so we don't know if these chemicals are in the fish that live in the Washington Narrows.

To better address this question, we recommend

- Further sampling and analysis of the sediments to determine the extent of the contamination.
- Replacement of warning signs.
- Sampling and analysis of fish and shellfish expected to be harvested.

5. Is it safe for tenants of the Penn Plaza Storage to come onsite?

Yes. Most of the contaminants from the site are below the asphalt or underground and are not easy to come in contact with. The storage property is fenced and locked and most tenants use the buildings briefly for storage or for light industrial activities. Though accessible from the storage area, we recommend you do not enter the areas beyond your rented space. There are areas with contaminants on the s

6. A at ri

Durin our site visit, w l evidence o and f e by trespass rs on part of the site. Owne hav d t ser pas en syl nue h le the shore e. T via nd acc eas the are om o conta wit ues taminated nta ed water runo cre expos es t tant wne por seeps in the n t whe eless peopl lee

A foc ath is pres e e nsw ani wn he Pu alth Distri acces was obser easily trip onto or fall into the tank resulting in physical injury.

We recommend that a sign and fence prohibiting beach access be installed at the site. We recommend that physical hazards be reduced either with fencing or removal (for items such as the tank).

7. What are the big tanks on the shoreline near the site? Are they dangerous?

These tanks are former ballast tanks from a submarine that were used to allow the vessel to submerge and surface. DNR reported the presence of volatile organic compounds inside the tanks. Kitsap Public Health District did not detect these compounds in the tank in 2010. The tanks are accessible at low tide and tied to the shoreline with a rope. Access to the tanks presents a physical hazard. We recommend that these tanks be removed.

8. If the land is zoned residential or used as a park, what are the health risks for a resident or visitor?

The future use of the land has not been determined nor has the level of remediation that will occur to reduce risk. EPA is beginning its investigation to determine the nature and extent of contamination from

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the site. With more soil, sediment, and tissue data a more accurate assessment of health threats will be possible.

9. Is it safe to swim in the water near the site?

We do not recommend swimming in the Washington Narrows for several reasons:

- Cold water can quickly incapacitate the best of swimmers.
- Tidal currents are so swift in the narrows that swimmers cannot break free of the current. Swimmers can be easily carried into open waters.
- We do not know the extent of contamination in the water or sediments of the Washington Narrows. Contaminants from in sediments can be released into the water column.

We do not know if swimming in the Narrows will result in chemical exposures. More data is needed to determine if a health threat exists from this type of exposure.

10. Are there signs posted about health risks at the site?

Kitsap Public Health District posted signs warning people on the beach about the contamination on the shore
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DOH reached six conclusions in this public health assessment:

Conclusion 1. Trespassing on the site could result in physical injury. This is an urgent public health hazard. Actions to remove or prevent these hazards have been recommended.

Conclusion 2. **R**esidents, visitors, or trespassers touching or accidentally ingesting sediments for more than a year could harm the health of children or adults.

Conclusion 3. No one is drinking the contaminated groundwater located in the vicinity of the site. No harm is expected.

Conclusion 4. DOH cannot conclude if trespassers are touching contaminated soils at the site. The nature and extent of soil contamination are not known. Future land use may lead to contact with the soil. More soil sample data will be collected during EPA's upcoming RI.

Conclusion 5. DOH cannot conclude if people are being exposed to contaminants from eating fish or shellfish harvested at the site. Shellfish and fish tissue data are needed to assess any potential health threat.

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Conclusion 6. DOH cannot conclude if people are being exposed to contaminants in blackberries collected at the site. Neither soil samples near blackberry bushes nor blackberry chemical data are available to assess this potential health threat.

Recommendations

To protect residents, visitors, and trespassers, DOH recommends that

- Physical hazards be removed.
- Site access be restricted.
- Ongoing source(s) of contaminants be identified and removed or mitigated to reduce the potential of exposure.
- People safeguard their health by not walking or playing on the shoreline near the site.
- Parents monitor their children's behavior while playing outdoors to prevent them from going onto the shoreline.
- [redacted]

To pr[redacted]nd shellf[redacted] sampling an[redacted] plan.

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- [redacted]
- Owner removing the submarine ballast tanks in collaboration with EPA and Washington State Department of Natural Resources (DNR).
- EPA facilitating the maintenance of the capped area on the shoreline. The cap consists of an absorbent clay mat covered with large rocks. Maintenance should continue until the extent of contamination is known and a remedy is determined.
- EPA facilitating the removal of waste barrels found on Parcel A.
- EPA considering sampling plans to collect and analyzing fish, shellfish, and berries.

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Report Preparation

This Public Health Assessment for initial release on the Bremerton Gasworks Superfund site in Kitsap County, Washington was prepared by the Washington Department of Health (DOH) under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, and procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner (DOH). ATSDR has reviewed this document and concurs with its findings based on the information presented.

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Appendix A–Glossary

Acute	Occurring over a short time [compare with **chronic**].
Agency for Toxic Substances and Disease Registry (ATSDR)	The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services.

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Cancer Risk Evaluation Guide (CREG)	The concentration of a chemical in air, soil, or water that is expected to cause no more than one excess cancer in a million persons exposed over a lifetime. The CREG is a *comparison value* used to select contaminants of potential health concern and is based on the *cancer slope factor* (CSF).
Cancer Slope Factor (CSF)	A number assigned to a cancer causing chemical that is used to estimate its ability to cause cancer in humans.
Carcinogen	Any substance that causes cancer.
Chronic	Occurring over a long time (more than 1 year) [compare with **acute**].
Comparison Value (CV)	Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.
Contaminant	A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.
Dermal Contact	Contact with (touching) the skin (see route of exposure).
Dose (for chemicals that are not radioactive)	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.
Environmental Media Evaluation Guide (EMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The EMEG is a comparison value used to select contaminants of potential health concern and is based on ATSDR's minimal risk level (MRL).
Environmental Protection Agency (EPA)	United States Environmental Protection Agency.

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Epidemiology	The study of the occurrence and causes of health effects in human populations. An epidemiological study often compares two groups of people who are alike except for one factor, such as exposure to a chemical or the presence of a health effect. The investigators try to determine if any factor (i.e., age, sex, occupation, economic status) is associated with the health effect.
Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].
Hazardous Substance	Any material that poses a threat to public health and/or the environment. Typical hazardous substances are materials that are toxic, corrosive, ignitable, explosive, or chemically reactive.
Ingestion	The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].
Ingestion Rate (IR)	The amount of an environmental medium that could be ingested typically on a daily basis. Units for IR are usually liter/day for water, and mg/day for soil.
Inhalation	The act of breathing. A hazardous substance can enter the body this way [see **route of exposure**].
Inorganic	Compounds composed of mineral materials, including elemental salts and metals such as iron, aluminum, mercury, and zinc.
Lowest Observed Adverse Effect Level (LOAEL)	The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.
Maximum Contaminant Level (MCL)	A drinking water regulation established by the federal Safe Drinking Water Act. It is the maximum permissible concentration of a contaminant in water that is delivered to the free flowing outlet of the ultimate user of a public water system. MCLs are enforceable standards.
Media	Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.
Minimal Risk Level (MRL)	An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see **reference dose**].

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Model Toxics Control Act (MTCA)	The hazardous waste cleanup law for Washington State.
No Observed Adverse Effect Level (NOAEL)	The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.
Oral Reference Dose (RfD)	An amount of chemical ingested into the body (i.e., dose) below which health effects are not expected. RfDs are published by EPA.
Organic	Compounds composed of carbon, including materials such as solvents, oils, and pesticides that are not easily dissolved in water.
Parts per billion (ppb)/Parts per million (ppm)	Units commonly used to express low concentrations of contaminants. For example, 1 ounce of trichloroethylene (TCE) in 1 million ounces of water is 1 ppm. 1 ounce of TCE in 1 billion ounces of water is 1 ppb. If one drop of TCE is mixed in a competition size swimming pool, the water will contain about 1 ppb of TCE.
Reference Dose Media Evaluation Guide (RMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The EMEG is a *comparison value* used to select contaminants of potential health concern and is based on EPA's oral reference dose (RfD).
Route of Exposure	The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

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Appendix B–Data Summary

Table B1. Sediment data from the Bremerton Gasworks Superfund Site, Bremerton, Kitsap County, Washington

Table B2. Soil data from the Bremerton Gasworks Superfund Site, Bremerton Kitsap County, Washington

Table B3. Groundwater data from the Bremerton Gasworks Superfund Site, Bremerton Kitsap County Washington

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Appendix C–Assumptions, Calculations, and Estimates of Health Risks for Exposure to Chemicals in Sediments

This appendix of the public health assessment (for initial release) for the Bremerton Gasworks Superfund Site provides the methodology and assumptions (Table C1) used to calculate exposure doses for people coming into contact with the intertidal sediment at the site. A summary of exposure doses and health risk calculations are summarized for carcinogenic risks (Table C2).

The following scenarios for sediment exposures have been defined for this site:

- Future hypothetical resident (adult and child) playing at the beach daily
- Visitor (adult and child) during the summer months (or frequency of 1–2 times per year)
- Trespasser (adult) on the sediments 3 days a week.

Data Compilation

For chemicals with samples detected below the reporting limit but above the detection limit, the estimated value was used. Estimated values were designated by a "J" flag. Compounds that were not detected (designated with a U flag) were assumed to be present at the detection limit.

When possible, exposure point concentrations for sediments were derived by using a conservative estimate of the mean concentration. This conservative estimate is typically the upper limit of a 95% confidence interval (95% UCL) of the average concentration. The 95% UCL was calculated by ProUCL 4.1.00[7] (15). The method of calculation was based on sample size, coefficient of variation, and the underlying distribution of the data. The sediment sampling source, location, number, and analytical data are listed in Appendix C and Table 2 in the main text.

At this time there is not sufficient soil data and no air or tissue data to estimate potential exposures. After these data gaps have been filled, these pathways can also be evaluated. All intertidal sediment samples from the Brownfield Assessment (2) and the Emergency interim action (1) were combined together to calculate the sediment exposure point concentration (C_s) for incidental ingestion and dermal contact at the beach. The data from the Ecology investigation in 1995 was not used as it is 15 years old.

It is important to point out that although residents have unrestricted access to the shoreline at this time, tidal fluctuations prevent access to sediments and decrease exposure frequency. Low tides permitting access to the shoreline during the day[8] occur about 60% of the year (218 out of 365 days) mostly between March and September. DOH assumed that a resident nearby could be exposed a maximum number of 218 days and likely will be exposed much less frequently

[7] http://www.epa.gov/osp/hstl/tsc/software.htm

[8] Estimated number of days with low tides permitting access to the shoreline during the day were assumed to occur between 7am and 7pm, includes +4 tides or less relative to the average of the lowest tides recorded at this tide station (mean lower low water), and are based on NOAA 2011 data from the Tracyton, Dyes Inlet, tide station.

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Sediment Exposure Dose Calculations

This section provides the assumptions and calculations used to estimate daily intakes for exposure to chemicals in sediments at the site. Exposure doses were calculated for incidental ingestion of sediment and dermal absorption of sediment adhered to skin. Inhalation of sediment particles was not considered as a route of exposure since inhalation of dust particles from wet sediments are not expected to occur. Volatile and semi-volatile organic chemicals in sediments have been identified as contaminants of concern.

The following equations were used to calculate exposures and risks:

Equation C1: Incidental Ingestion Route

Where,

The exposure factor (EF) will vary depending on the scenario (see scenario-specific calculations for EF in Table D1).

Equation C2: Skin Contact Route

Where,

Again, the exposure factor (EF) will vary depending on the scenario (see scenario-specific calculations for EF in Table D1).

Equation C3: Carcinogenic risks

If the carcinogenic risks are greater than in increased incidence of 1 cancer per 1 million people (1×10^{-6}) the exposure dose will be discussed further in the text.

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Table C1. Exposure assumptions used in exposure evaluation of people in contact with sediments at the former MGP in Bremerton Washington

Parameter and Abbreviation		Value	Units	Source
Exposure dose for ingestion route	D(ing)	Calc.	mg/kg-day	D(ing) = C*IR*CF*EF/BW
Exposure Dose for dermal route	D(der)	Calc.	mg/kg-day	D(der) = (C*AF*ABS*AD*CF*EF*SA)/BW
Concentration in sediment	Cs	Calc.	mg/kg	Mean chemical-specific concentration for sediment (95% UCL of the mean if adequate data available)
Conversion factor	CF	0.000001	kg/mg	Converts from kilograms soil to to milligrams soil
Age-specific body weight	BW	9.2	kg	Body weight, Child 0.5 to < 1 year (EFH)
		11.4		Body weight, Child 1 to < 2 years (EFH)
		17.4		Body weight, Child 2 to < 6 years (EFH)
		31.8		Body weight, Child 6 to < 11 years (EFH)
		56.8		Body weight, Child 11 to < 16 years (EFH)
		71.6		Body weight, Child 16 to < 21 years (EFH)
		64.8		Body weight, Child 11 to < 21 years (EFH)
		80		Body weight, Adult 21 to < 65 years (EFH)
		76		Body weight, Adult 65+ years (EFH)
Exposure factor (EF=F*ED/AT)	EF	0.60	unitless	Local resident (daily exposure at low tide)
		0.25		Visitor
		0.43		Trespasser
Frequency	F	218	days/year	Resident: low tides occur during the day for 60% of the year (218/365 based on NOAA 2011 data)
		~90		Visitor: summertime months (3 months a year)
		156		Trespasser: onsite 3 days a week
Age-specific exposure duration	ED	0.5	year	Child 0.5 to < 1 yr
		1		Child 1 to < 2 yr
		4		Child 2 to < 6 yr
		5		Child 6 to < 11 yr
		5		Child 11 to <16 yr
		5		Child 16 to <21 yr
		10		Child 11 to < 21 yr
		44		Adult 21 to < 65 yr
		14		Adult 65+
Averaging time	AT	28470	day	Tribal averaging time, number of days in lifetime (78 years*365 days per year)
Age-Dependent Adjustment Factor	ADAF	10	unitless	Children < 2 years old
		3		Children 2 to < 16 years old
		1		Young adults and adults 16 years and older
Cancer Risk	CR	Calc.	$(mg/kg\text{-}day)^{-1}$	Increased risk of getting cancer (CR=D*CSF*ED/78)
Cancer Slope Factor	CSF	7.3	unitless	For BaP used as a reference chemical for cPAHs, published by EPA
Ingestion parameters				
Incidental ingestion rate (central tendency)	IR	60	mg/day	Child 0.5 to < 1 year
		100		Child 1 to < 21 years

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		50		Adult 21 years and older
Incidental ingestion rate (upper percentile) [results not presented]		100		Adult and Child 0.5 years to < 1 year (EFH Table 5-1)
		200		Child 1 to < 21 years old (EFH Table 5-1)
Dermal parameters				
Absorption duration	AD	1	day	Fraction of day sediment is in contact with the skin (worst-case) RAGS E
Skin-sediment adherence factor	AF	0.07	mg/cm^2	Amount of sediment that adheres to skin, child 1-6 years (RAGS E)
		0.2		Amount of sediment that adheres to skin, child and adult (7-31 years) (RAGS E)
Dermal absorption factor	ABS	PAH 0.13	unitless	Chemical-specific, fraction of chemical that absorbs through the skin in 24-hours (EPA RSL; EPA RAGS E)
Surface area	SA	2900	cm^2	Surface area exposed, child 1-6 years (RAGS E)
		5700		Surface area exposed, child and adult 7-31 years (RAGS E)

Sources: Guidance for developing soil screening levels for Superfund sites Abbreviations not defined in the table:

ATSDR Agency for Toxic Substances and Disease Registry
BaP Benzo(a)Pyrene used as the reference compound for PAHs with carcinogenic effects (cPAH)
Calc. Calculated
cm centimeters
EFH EPA Exposure Factors Handbook 2011
EPA U.S. Environmental Protection Agency
mg milligram
NOAA National Oceanic Atmospheric Administration
kg kilogram
cPAH polycyclic aromatic hydrocarbons with carcinogenic effects
RAGS E
RSL EPA Regional Screening Levels

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Results

Table C2. Estimated cancer risks resulting from central tendency exposures to carcinogenic polycyclic aromatic hydrocarbons (cPAH)[a] in surface sediments near the former MGP from Bremerton, Kitsap County, Washington

Exposure Pathway	Age [b]	Concentration (mg/kg) [c]	Increased Cancer Risk		
			Incidental Ingestion	Dermal Contact	Total Cancer Risk
Resident (daily during low tides)	Young Child	159	1.7E-03	1.4E-03	3.1E-03
	Older Child		6.6E-03	7.5E-04	1.4E-03
	Young Adult to Adult		3.9E-04	3.7E-04	7.6E-04
	Lifetime		**2.7E-03**	**2.5E-03**	**5.3E-03**
Visitor (daily during summertime only)	Young Child	159	7.0E-04	5.9E-04	1.3E-03
	Older Child		2.7E-04	3.1E-04	5.8E-04
	Young Adult to Adult		1.6E-04	1.6E-04	3.2E-04
	Lifetime		**1.1E-03**	**1.1E-03**	**2.2E-03**
Trespasser (3 days per week)	Young Adult to Adult	159	2.8E-04	2.7E-04	5.5E-04

Notes:
a – Carcinogenic polycyclic aromatic hydrocarbons (cPAHs) classified by EPA as Group B2 Probable Human Carcinogens; calculations performed with EPA's slope factor 7.3 (mg/kg-day)-1. Concentrations of each PAHs multiplied by carcinogenic potency factors relative to Benzo(a)pyrene (BaP) according to EPA 2010 and summed/expressed as BaP equivalents (BEQ).
b – Age groupings are young (03.5 to < 6 years), older (6 to < 16 years old) and young adult/adult (16 years and older)
c – Concentration represents 95% upper confidence limit of the mean sediment samples
Abbreviations: MGP – manufactured gas plant; mg/kg – milligrams chemical per kilogram sediment

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