Terrestrial Ecological Evaluation

Burrows Island Light Station
Skagit County, WA

September, 2013

Washington State Department of Ecology
Toxics Cleanup Program
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Lacey, WA 98504-7106

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Terrestrial Ecological Evaluation

History and Location:

Burrows Island Light Station is located on Burrows Island, located one quarter mile off the coast of the town of Anacortes, Washington (Figure 1). It is a small complex of buildings, which include the lighthouse, a boathouse and a duplex residence. Coordinates for the lighthouse (proper) are 48° 28' 40" N and 122° 42' 48" W. The remainder of the island is densely forested. There are no permanent or part time residents at the Light Station.

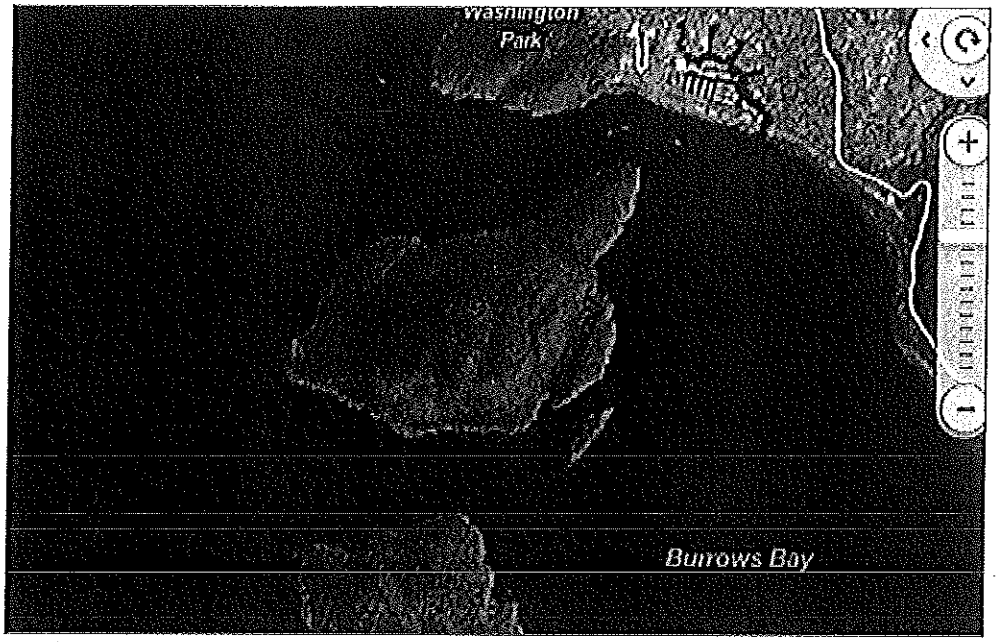

Figure 1: Location of Burrows Island.

Remediation to Date:

There is lead contaminated soil around the lighthouse and the duplex residence. There are two small areas of slightly elevated lead contaminated soil located on two corners of the boathouse. This soil contamination is a result of weathering of the lead based paint exterior surfaces of the structures over the years. In 2005, the Coast Guard began remediation of the lead contamination at the site. The remediation consisted of encapsulation of the exterior surfaces of the structures and excavation and removal of lead contaminated soil around the structures. Much of the excavation and removal of the contaminated soil was done by hand due to the remote location of the site and difficulty in accessing the site with construction equipment and means of transport.

Previous environmental work at the Light Station includes:

- 1980 - PCB spill; remediation consisted of removal of 140 cubic yards of PCB contaminated soil.
- 2000 - UST removal; 300 gallon diesel tank removed from area close to residence.
- 2005 - LBP encapsulation on structures and 150,000 pounds of lead contaminated soil removal in areas around the duplex residence.

Site Characterization:

A site investigation report was completed in August of 2009 (Final Site Investigation Report Burrows Island Light Station Skagit County, Washington) (EERG, 2009). The investigation report includes site diagrams that indicate sampling locations. Those sampling locations have been summarized in Figures (2a through 2d) (EERG, 2009). Results for the samples can be found in (Table 1).

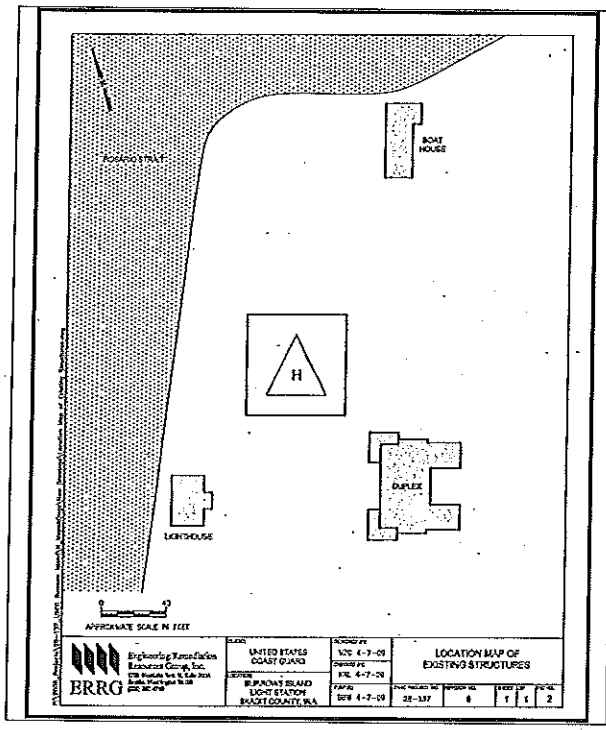

Figure 2(a): Diagram of facilities on Burrows Island

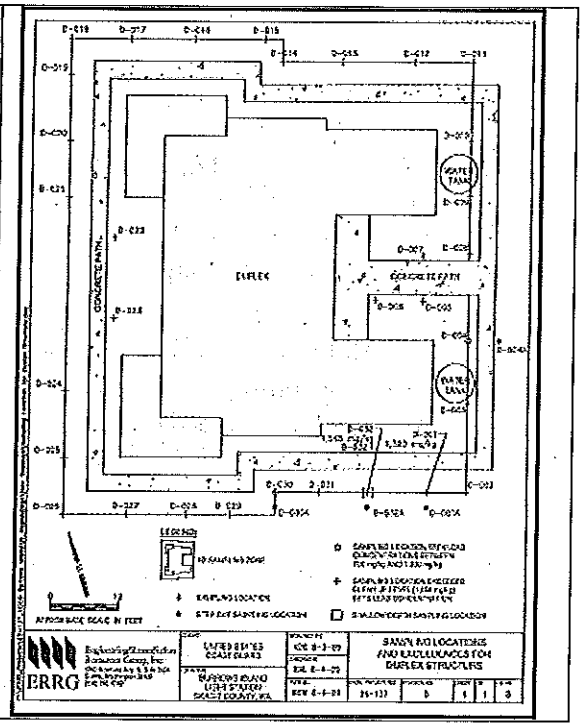

Figure 2(b): Diagram of Duplex and Sampling locations

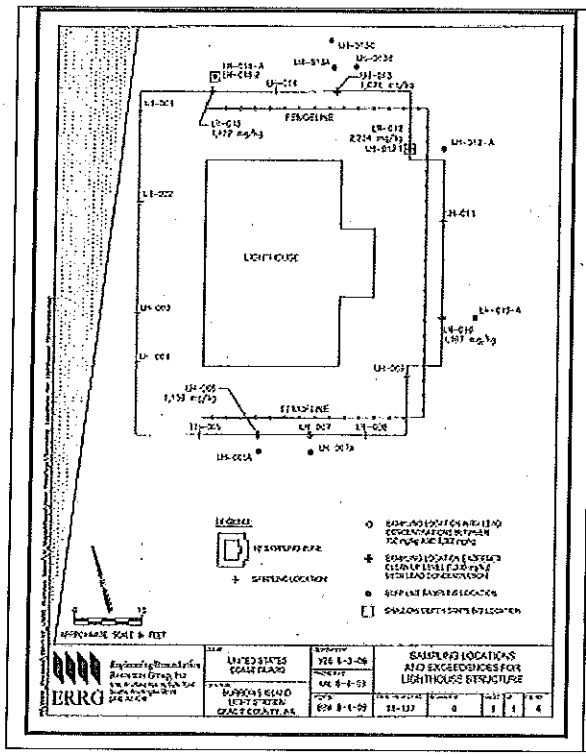

Figure 2(c): Diagram of Lighthouse and sampling locations

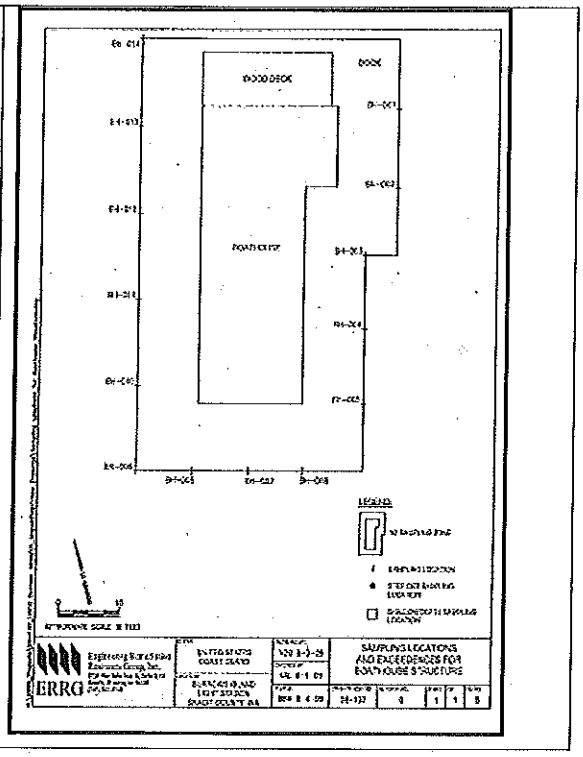

Figure 2(d): Diagram of Boathouse and sampling locations

Terrestrial Ecological Evaluation Process

Washington State's Model Toxics Control Act (MTCA) (Ecology, 2007), Washington Administrative Code (WAC) 173-340, applies to all facilities where there has been a release or threatened release of a hazardous substance that may pose a threat to human health or the environment. Soil contamination shall be evaluated for both human health and ecological threats, and those remedies selected to address soil contamination shall be protective of both human health and ecological receptors. The Terrestrial Ecological Evaluation (TEE) is a process that evaluates threats posed by contaminants to ecological receptors and is included in MTCA, specifically, WAC 173-340-7490 through 7494. The goals and procedures of the Terrestrial Ecological Evaluation are to:

- Determining whether a release of hazardous substances to soil may pose a threat to the terrestrial environment.
- Characterizing existing or potential threats to soil biota and terrestrial plants and animals exposed to hazardous substances in soil.
- Establishing soil concentrations that are protective of soil biota and terrestrial plants and animals, and;
- Developing and evaluating cleanup action alternatives and selecting a cleanup action protective of soil biota and terrestrial plants and animals.

A summary of the TEE process includes the following steps:

- Characterization of the site
- Exclusion evaluation, if no exclusion applies, then;
    - Selection of the appropriate evaluation method (simplified or site-specific TEE)
    - Conduct TEE, and then if required:
        - Selection of clean-up actions.
        - Implementation of cleanup actions, and;
        - Compliance monitoring requirements.

If the site may be excluded from the TEE process, then no further evaluation of ecological risk is necessary as long as the specific exclusion and its application to the site under investigation have been addressed. If the site cannot be excluded from the TEE process, a simplified or site-specific TEE is required. If cleanup actions/alternatives are required to meet requirements, the selection, implementation, and the compliance requirements of those cleanup actions shall also be included.

The TEE process is required at all MTCA sites where there has been a release or threatened release of a hazardous substance that may pose a threat to human health or the environment. This applies to sites that have formal Ecology oversight and also to those sites requiring a No Further Action (NFA) determination under the Voluntary Cleanup Program (VCP).

Exclusion Evaluation:

There are four primary criteria for excluding a contaminated site from further evaluation under the TEE process. As discussed earlier in this document, the site may be excluded from the TEE process and no further evaluation of ecological risk is necessary as long as the specific exclusion and its' application to the site under investigation have been addressed. If the specifics of the site have met one of the exclusionary criteria, neither a simplified nor site – specific TEE would be required.

The four TEE exclusionary criteria are:

- Contamination below the point of compliance.
- Incomplete exposure pathway.
- Type of contamination and proximity to ecological receptors, and;
- Concentrations below background levels.

Contamination below the Point of Compliance:

To qualify for an exclusion based on "contamination below the point of compliance," all soil contaminated with hazardous substances is (or will be) located below the established point of compliance. This means all soil contamination shall be below the standard point of compliance (ground surface to a depth of 15 feet), or below the conditional point of compliance (ground level to a depth of 6 feet). In making this demonstration, the following shall be considered:

- Depth to which soil macro-invertebrates are likely to occur.
- Depth to which soil turnover is likely to occur due to the activities of soil invertebrates.
- Depth to which animals likely to occur at the site are expected to burrow.
- Depth to which plant roots are likely to extend, and;
- The presence of a manmade subsurface biological barrier (such as a geomembrane cap or cobble barrier designed to limit penetration by plant roots and burrowing animals).

It has been determined that the contamination is found mainly at the surface and that the receptors of interest (plants, soil biota, and wildlife) could come in contact with the contaminant. Therefore, the site is not excluded under this condition.

Incomplete Exposure Pathway:

To qualify for an exclusion based on "incomplete exposure pathway," all soil contaminated with hazardous substances is (or will be) covered by buildings, paved roads, pavement, or other physical barriers that will prevent plants or wildlife from being exposed to the soil contamination. These barriers may include engineered caps with geo-textile membranes or other engineered barriers which break the exposure pathway between the ecological receptors and the soil contaminants.

It has been determined that no institutional controls or future use will be implemented that would create an incomplete exposure pathway that that the receptors of interest (plants, soil biota, wildlife) could come in contact with the contaminant. Therefore, the site is not excluded under this condition.

Type of Contamination and Proximity to Ecological Receptors:

To qualify for an exclusion based on "type of contamination and proximity to ecological receptors," the site must be located on or near a limited amount of undeveloped land. This exclusion would be based on one of the following two points:

- For sites contaminated with hazardous substances other than those specified below; there must be less than 1.5 acres of contiguous undeveloped land on the site or within 500 feet of any area located on the site, or;
- For sites contaminated with one of the below substances; there must be less than one-quarter acre of contiguous undeveloped land on the site or within 500 feet of any area located on the site:
    - aldrin
    - benzene hexachloride
    - chlordane
    - chlorinated dioxins or furans
    - DDT, DDE, or DDD
    - dieldrin
    - endosulfan
    - endrin
    - heptachlor or heptachlor epoxide
    - hexachlorobenzene
    - PCB mixtures
    - pentachlorobenzene
    - pentachlorophenol
    - toxaphene

It has been determined that the contaminant of concern is lead, and that there is more than 1.5 acres of contiguous undeveloped land on or within 500 feet of the site (Figure 3). As a result, the receptors of interest (plants, soil biota, and wildlife) could come in contact with the contaminant. Therefore, the site is not excluded under this condition.

Figure 3: Location of Lighthouse and immediate surrounding area.

Concentrations below Background Levels:

To qualify for an exclusion based on "concentrations below background levels," concentrations of all hazardous substances in soil should not exceed natural background levels based on the determining compliance methodology found in MTCA.

The statewide and regional 90th percentile (natural background level) for lead is:

Statewide	17 ppm
Puget Sound	24 ppm

The sampling indicates concentrations of lead in the soil are above both statewide and regional 90th percentile levels. Therefore, the site is not excluded under this condition.

Summary: It has been determined that the site does not qualify for exclusion

Selection of an Appropriate Evaluation Method:

Since it was determined that none of the above-mentioned exclusionary criteria apply, either a simplified or site-specific terrestrial ecological evaluation is required. MTCA specifically refers to the process of determining the type of evaluation that is required (simplified or site-specific) as "Applicability of a Simplified Terrestrial Ecological Evaluation." The specific regulation that refers to this process can be found in WAC 173-340-7492; Applicability of a Simplified Terrestrial Ecological Evaluation. WAC 173-340-7492 lists four criteria that are to be used in that determination. If any of the below criteria apply to the site, then a site-specific terrestrial ecological evaluation is necessary. Those criteria are:

- Natural areas.
- Vulnerable species.
- Extensive habitat, and;
- Risk to significant wildlife populations.

Natural Areas:

If the site is located on, or directly adjacent to an area where management or land use plans will maintain or restore native or semi-native vegetation, then a site-specific terrestrial ecological evaluation is necessary. Examples of these areas include:

- Green-belts.
- Protected wetlands.

- Forestlands.
- Riparian areas.
- Locally designated environmentally sensitive areas.
- Open space areas managed for wildlife, and;
- Some parks and outdoor recreation areas.

Native Vegetation: Means any plant community native to the state of Washington. The following sources shall be used in making this determination: *Natural Vegetation of Oregon and Washington*, J.F. Franklin and C.T. Dyrness, Oregon State University Press, 1988; and *Vascular Plants of the Pacific Northwest* (5 Volumes), A. Cronquist, 1955-1969.

Semi-native Vegetation: Means a plant community that includes at least some vascular plant species native to the state of Washington. The following shall not be considered semi-native vegetation:

- Areas planted for ornamental or landscaping purposes.
- Areas planted for cultivated crops, and;
- Areas significantly disturbed and predominantly covered by noxious, introduced plant species or weeds (e.g., Scotch broom, Himalayan blackberry or knap-weed).

It does not appear that management or land use plans have been established that would maintain or restore native or semi-native vegetation at this site. Therefore, a site-specific TEE is not necessary doe to these criteria.

Vulnerable Species:

If the site is used by vulnerable species, a site-specific terrestrial ecological evaluation is necessary. Examples of listed vulnerable species are:

- A threatened or endangered species protected under the Federal Endangered Species Act.
- A wildlife species classified by the Washington State Department of Fish and Wildlife as a "priority species" or "species of concern" under Title 77 RCW, and;
- A plant species classified by the Washington State Department of Natural Resources Natural Heritage Program as "endangered," "threatened," or "sensitive" under Title 79 RCW.

Note: For plants, "used" means that a plant species grows at the site or has been found growing at the site. For animals, "used" means that individuals of a species have been observed to live, feed or breed at the site.

The Washington State Department of Fish and Wildlife has classified the following priority species to use this specific area:

- Bald Eagle (*H. leucocephalus*)
- Pinto Abalone (*H. kamtschatkana*)
- Red Sea Urchin (*S. franciscanus*)
- Peregrine Falcon (*F. peregrinus*)

The above information can be found on the Washington Department of Fish and Wildlife Priority Habitats and Species on the Web at:

www.wdfw.wa.gov/mapping/phs/

Under the above criteria, a site-specific TEE is required because individuals of the species have been observed to live, feed, or breed at the site.

Extensive Habitat:

If there is at least ten acres of native vegetation on or within 500 feet of any area of contaminated soil, a site-specific TEE is necessary. This total (ten acres) is applicable whether or not the native vegetation has been fragmented into smaller areas. "Any area of contaminated soil" means that the ten acres "on or within 500 feet of any area of contaminated soil" is not limited to the property that the source of the contamination is located on. It appears a site-specific TEE is required because there are more than 10 acres of native vegetation on or within 500 of contaminated soil (Figure 4).

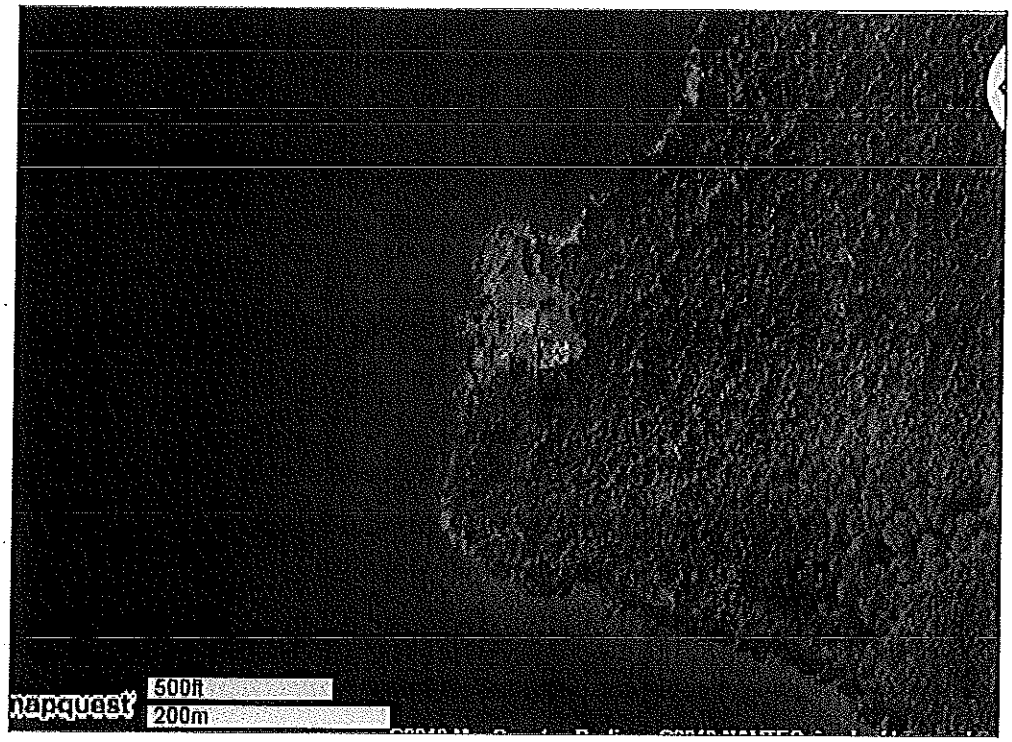

Figure 4: Lighthouse and surrounding vegetation.

Risk to Significant Wildlife Populations:

If the department determines the contamination may present a risk to significant wildlife populations, a site – specific terrestrial ecological evaluation is necessary. The department did not determine the contamination may present a risk to significant wildlife populations. Therefore, a site-specific TEE is not required under these criteria.

Summary: It has been determined that a site-specific TEE is required due to the vulnerable species and extensive habitat criteria.

The Site-Specific Terrestrial Ecological Evaluation:

It has been established that a site-specific TEE is required at this site. A site-specific TEE shall include the following steps:

- Problem formulation
- Selection of appropriate evaluation method(s)
- Conducting the evaluation
- Establish ecologically protective soil concentrations

Problem Formulation Step:

Contaminants of Ecological Concern:

The contaminants of ecological concern at the site are: Lead (Pb). The concentrations of Pb exceed the screening levels found in Table 5.1 (MTCA Table 749-3). The site Ecological Indicator Soil Concentration for Protection of Terrestrial Plants and Animals for lead are:

Contaminant	Plants (ppm)	Soil Biota (ppm)	Wildlife (ppm)
Lead	50	500	118

Exposure Pathways:

It appears there are only complete potential exposure pathways for exposure of plants or animals to the contaminants of concern (Pb). It does not appear that there are any man-made physical barriers, either currently existing or for future use within a timeframe acceptable to the department that would create an incomplete exposure pathway.

Terrestrial Ecological Receptors of Concern:

The identified current and potential terrestrial ecological receptor groups reasonably likely to live or feed at the site are the suggested receptor groups in WAC 173-340. The groupings represent taxonomically related species with similar exposure characteristics. These include:

- Soil-associated invertebrates (earthworms)
- Vascular plants
- Ground-feeding birds (robin)
- Ground-feeding small mammal predators (shrew)
- Herbivorous small mammals (vole)

Toxicological Assessment:

Lead in soil is relatively immobile and persistent whether added to the soil as halides, hydroxides, oxides, carbonates, or sulfates. When released to the soil, lead is normally converted from soluble lead compounds to relatively insoluble sulfate or phosphate derivatives. It also forms complexes with organic matter and clay minerals which limits its mobility. The efficient fixation of lead in soils limits the transfer of lead to aquatic systems. However, leaching of lead can be relatively rapid from some soils, especially at highly contaminated sites or landfills. Lead is most available from acidic sandy soils which contain little material capable of binding lead. Concentrations of lead in soil solution reach a minimum between pH 5 and 6 because metal-organic complexes form in this pH range. Only a small fraction of lead in lead-contaminated soil appears to be in water-soluble form (0.2-1%) (USEPA, 2005).

Plants: Lead is not considered to be an essential element for plant growth and development. Lead inhibits growth, reduces photosynthesis (by inhibiting enzymes unique to photosynthesis), interferes with cell division and respiration, reduces water absorption and transpiration, accelerates abscission or defoliation and pigmentation, and reduces chlorophyll and ATP synthesis (USEPA, 1979). The uptake of lead by plants depends on factors including cation exchange capacity, soil composition (e.g., organic matter content, calcium content), metal concentrations, precipitation, light, and temperature. Lead uptake by plants is favored at lower pH values and in soils with low organic carbon content (DeMayo et al. 1982) (USEPA, 2005).

Soil Invertebrates: Earthworms accumulate lead and are thus a useful bioindicator of lead pollution in soil. Total lead concentrations in soils almost always exceed concentrations in earthworms except where unique conditions, such as high levels of lead in soils combined with low pH and low calcium, cause earthworms to accumulate greater amounts of lead from the soil. BCFs (ratio of lead in worms to lead in the soil) range from 0.01 to 2.73, but are usually well below 1.0, indicating that there is no constant

relationship between the concentration of lead in soil and that found in earthworms (CSG, 1999) (Canada, 1999).

Birds and Mammals: Lead is not considered an essential element for birds or mammals. Lead can interfere with the synthesis of heme, thereby altering the urinary or blood concentration of enzymes and intermediates in heme synthesis or their derivatives. Thus, lead poisoning can lead to accumulation of non-heme iron and protoporphyrin-IX in red cell, an increase in delta-aminolevulinic acid (ALA) in blood and urine, an increase in urinary coproporphyrin, proporphyrin, and porphobilinogen, inhibition of blood ALA-dehydratase (ALA-D), and an increased proportion of immature red cell in the blood (reticulocytes and basophilic stippled cells) (USEPA, 2005).

Selection of Appropriate Evaluation Method:

It was determined during the problem formulation that further evaluation is necessary. As a result, the following methods are options for conducting the site-specific TEE:

- Table Values
- Soil Bioassays
- Wildlife exposure model
- Biomarkers
- Site – specific field studies
- Weight of evidence
- Literature surveys

It has been determined that the Table Values from WAC 173-340 (Table 749-3), should be used to evaluate risk associated with Pb exposure at this site.

Table Values:

At the discretion of the person conducting the evaluation, the screening values in Table 5.1 (MTCA Table 749-3) may be used as the cleanup level when terrestrial ecological risk drives the cleanup level.

Ecological Indicator Soil Concentration for Protection of Terrestrial Plants and Animals for lead are:

Contaminant	Plants (ppm)	Soil Biota (ppm)	Wildlife (ppm)
Lead	50	500	118

Confirmation samples appear to indicate the potential for unacceptable exposure to Pb plants, soil biota, and wildlife at surface locations (Table 1) (EERG, 2009):

Table 1: Sampling results of Lighthouse and surrounding area

Sample ID	Sample Date	Sample Locations	XRF Lead (ppm)	Laboratory Confirmation Sample Results (ppm)
BI-BH-001	1/28/2009	10 ft from Boathouse	135	
BI-BH-002	1/28/2009	10 ft from Boathouse	<LOD	
BI-BH-003	1/28/2009	10 ft from Boathouse	105	
BI-BH-004	1/28/2009	10 ft from Boathouse	94	
BI-BH-005	1/28/2009	10 ft from Boathouse	40	
BI-BH-006	1/28/2009	10 ft from Boathouse	60	
BI-BH-007	1/28/2009	10 ft from Boathouse	64	
BI-BH-008	1/28/2009	10 ft from Boathouse	262	59
BI-BH-009	1/28/2009	10 ft from Boathouse	50	
BI-BH-010	1/28/2009	10 ft from Boathouse	59	
BI-BH-011	1/28/2009	10 ft from Boathouse	168	
BI-BH-012	1/28/2009	10 ft from Boathouse	169	
BI-BH-013	1/28/2009	10 ft from Boathouse	222	
BI-BH-014	1/28/2009	10 ft from Boathouse	330	340
BI-D-001	1/28/2009	10 ft from Duplex	1320	
BI-D-001A	1/28/2009	15 ft from Duplex	351	
BI-D-002	1/28/2009	10 ft from Duplex	453	
BI-D-003	1/28/2009	10 ft from Duplex	670	
BI-D-004	1/28/2009	10 ft from Duplex	863	770
BI-D-004A	1/28/2009	15 ft from Duplex	234	
BI-D-005	1/28/2009	10 ft from Duplex	32	
BI-D-006	1/28/2009	10 ft from Duplex	578	
BI-D-007	1/28/2009	10 ft from Duplex	384	
BI-D-008	1/28/2009	10 ft from Duplex	<LOD	
BI-D-009	1/28/2009	10 ft from Duplex	104	
BI-D-010	1/28/2009	10 ft from Duplex	473	260
BI-D-011	1/28/2009	10 ft from Duplex	169	
BI-D-012	1/28/2009	10 ft from Duplex	256	
BI-D-013	1/28/2009	10 ft from Duplex	290	
BI-D-014	1/28/2009	10 ft from Duplex	577	
BI-D-015	1/28/2009	10 ft from Duplex	595	
BI-D-016	1/28/2009	10 ft from Duplex	185	
BI-D-017	1/28/2009	10 ft from Duplex	250	
BI-D-018	1/28/2009	10 ft from Duplex	253	
BI-D-019	1/28/2009	10 ft from Duplex	109	
BI-D-020	1/28/2009	10 ft from Duplex	262	210
BI-D-021	1/28/2009	10 ft from Duplex	135	
BI-D-022	1/28/2009	10 ft from Duplex	97	
BI-D-023	1/28/2009	10 ft from Duplex	54	
BI-D-024	1/28/2009	10 ft from Duplex	210	
BI-D-025	1/28/2009	10 ft from Duplex	213	
BI-D-026	1/28/2009	10 ft from Duplex	221	
BI-D-027	1/28/2009	10 ft from Duplex	572	
BI-D028	1/28/2009	10 ft from Duplex	357	
BI-D-029	1/28/2009	10 ft from Duplex	600	
BI-D-030	1/28/2009	10 ft from Duplex	744	
BI-D-030A	1/28/2009	15 ft from Duplex	404	
BI-D-031	1/28/2009	10 ft from Duplex	475	
BI-D-032	1/28/2009	10 ft from Duplex	1545	2300
BI-D-032A	1/28/2009	15 ft from Duplex	434	
BI-LH-001	1/28/2009	10 ft from Lighthouse	473	
BI-LH-002	1/28/2009	10 ft from Lighthouse	559	
BI-LH-003	1/28/2009	10 ft from Lighthouse	429	
BI-LH-004	1/28/2009	10 ft from Lighthouse	402	
BI-LH-005	1/28/2009	10 ft from Lighthouse	388	
BI-LH-006	1/28/2009	10 ft from Lighthouse	1139	

BI-LH-006A	1/28/2009	15 ft from Lighthouse	566	
BI-LH-007	1/28/2009	10 ft from Lighthouse	992	860
BI-LH-007A	1/28/2009	15 ft from Lighthouse	512	
BI-LH-008	1/28/2009	10 ft from Lighthouse	306	
BI-LH-009	1/28/2009	10 ft from Lighthouse	592	
BI-LH-010	1/28/2009	10 ft from Lighthouse	1107	
BI-LH-010A	1/28/2009	15 ft from Lighthouse	356	
BI-LH-011	1/28/2009	10 ft from Lighthouse	342	
BI-LH-012	1/28/2009	10 ft from Lighthouse	2334	2600
BI-LH-012A	1/28/2009	15 ft from Lighthouse	184	
BI-LH-013	1/28/2009	10 ft from Lighthouse	1071	
BI-LH-013A	1/28/2009	15 ft from Lighthouse	953	
BI-LH-013B	1/28/2009	15 ft from Lighthouse	270	
BI-LH-013C	1/28/2009	20 ft from Lighthouse	295	
BI-LH-014	1/28/2009	10 ft from Lighthouse	288	
BI-LH-015	1/28/2009	10 ft from Lighthouse	1472	1700
BI-LH-015A	1/28/2009	15 ft from Lighthouse	187	
BI-D-032.1	1/29/2009	10 ft from Duplex	554	
BI-LH-012.1	1/29/2009	10 ft from Lighthouse	395	
BI-LH-015.2 (1.5ft bgs)	1/29/2009	15 ft from Lighthouse	128	

Selection of Cleanup Actions:

The remaining cleanup action selected for this site (including the previous soil removal) is to treat the remaining lead in the soil. This alternative method would use processed fish bones (commercial name Apatite II) as a soil amendment to the lead contaminated soil. The Apatite II would become a source of calcium phosphate to the lead in the soil. Based on the results of another project where this method has been used, there is the anticipation that the lead would react chemically with the Apatite II and be chemically bound into the phosphate mineral called pyromorphite. This chemical reaction would transform the lead into a mineral that will not leach out of the soil. Reaction time is very rapid and the treatment should be effective immediately based on previous project results. A PBET (lead based bioaccessibility extraction test) will be performed to calculate bioavailability of the contaminant.

A contractor will be transported to the project site along with the necessary materials and equipment to perform the soil stabilization. The Apatite II material will be transported to Burrows Island by barge or helicopter, along with tilling equipment. Areas to be treated shall be based on this site investigation report and reports completed by the Coast Guard in 2008. Tilling equipment will till the lead affected soil to a depth of six inches, blending in the Apatite II at the recommended application rate. Composite samples of the treated soil will be sent to a certified lab for TCLP or SPLP testing to demonstrate the effectiveness of the treatment. When the test results have demonstrated that the soil has been rendered non-hazardous, the soil surface will be graded and seeded with native grass to provide a surface cap to the treated soil.

Site work has been discussed with the State of Washington Fish and Wildlife biologist. Based on his direction, site work would be conducted after August 1st and prior to the following spring. Routing helicopters around the north side of the island would minimize impacts to fledgling eagles. Based on these recommendations the Coast Guard work should have no adverse effect on natural resources in the area.

Compliance Monitoring Requirements:

Following the selected cleanup action, composite samples of the treated soil will be sent to a certified lab for TCLP or SPLP testing to demonstrate the effectiveness of the treatment.

Soil Bioassays and the Wildlife Exposure Model:

Effectiveness of the cleanup action should normally be demonstrated with soil bioassays for plants and soil biota and the wildlife exposure model for wildlife. Ecology Publication No. 96-324 (Early Seedling Growth Protocol for Soil Toxicity Screening) (Ecology, 1996a) and Ecology Publication No. 96-327 (Earthworm Bioassay Protocol for Soil Toxicity Screening) (Ecology, 1996b) are the recommended resources for bioassay protocol. Bioaccumulation of the contaminants should be recorded at the same time so adjustments can be made (if needed) to BAF_{worm} and K_{Plant} to be used with the wildlife exposure model. However, it appears that because of the sensitive species that use this site a Net Environmental Benefit Analysis would be more appropriate.

Net Environmental Benefit Analysis:

It is recommended that a Net Environmental Benefit Analysis is conducted at this site in conjunction with the proposed cleanup action.

It appears that this site could constitute especially valuable habitat, whereas excessive soil removal could cause more harm than net benefit. A Net Environmental Benefit Analysis (NEBA) is the procedure of weighing the advantages of active cleanup (remediation) versus the impact that cleanup might have on potentially valuable ecological receptor habitat (Ecology, 2012). Terrestrial ecological evaluation procedures should not create an incentive to cause harm through the destruction of habitat. As a result, WAC 173-340-7490 (5): "Additional measures. The department may require additional measures to evaluate potential threats to terrestrial ecological receptors notwithstanding the provisions in this and the following sections (when based upon a site – specific review), the department determines that such measures are necessary to protect the environment." (Ecology, 2007).

Prior to performing a NEBA, the proposed area needs to be defined as "especially valuable habitat." (Ecology, 2012). "Especially valuable habitat" can be designated through the use of one of the below proposed methods:

Method 1: Site can be designated "especially valuable habitat" through several verifications:

- The site is used by a threatened or endangered species protected under the Federal Endangered Species Act, or;
- The site is used by a "priority species" or "species of concern" designated under Title 77 RCW, or;

- The site is used by a plant species classified as "endangered," "threatened," or "sensitive" under Title 79 RCW, or;
- Wetlands and Fish and Wildlife habitat conservation areas designated as critical areas under Chapter 36.70A.170 RCW. Other critical areas that might be found on the property, such as recharge areas, frequently flooded areas, geologically hazardous areas, steep slopes, and aquatic areas, are not immediately designated as "especially valuable habitat" unless they meet one of the previous criteria. These other types of critical areas must follow the Method 2 process.

Note: For animals, "used" means that individuals of a species have been observed to live, feed or breed at the site. For plants, "used" means that a plant species grows at the site or has been found growing at the site (Ecology, 2007).

Method 2: Site can be designated "especially valuable habitat" through several verifications:

- An experienced field biologist must visit the site and document that:
  - The site can be potentially used by a threatened or endangered species protected under the Federal Endangered Species Act, or;
  - The site can be potentially used by a "priority species" or "species of concern" designated under Title 77 RCW, or;
  - The site can be potentially used by a plant species classified as "endangered," "threatened," or "sensitive" under Title 79 RCW
- Additionally, the field biologist must document types of flora and fauna and signs of excessive uptake of the specific contaminants. This will help establish sustainability and whether or not native species occupy the habitat.
  - Document the species of plant, soil biota, and wildlife found at the specific site
    1. Differentiate between those that are native and those that are invasive
  - Document if native plant life is well-established (i.e. primary or secondary growth)
  - Document if plant life show signs of Pb uptake including (but not limited to) signs of:
    1. Wilting
    2. Chlorosis (pale, yellow or white plant tissue)
    3. Browning
    4. Excess mortality
    5. Reduced growth, photosynthesis, mitosis, or water absorption (dehydration)
  - Document any signs of Pb uptake in soil biota including (but not limited to):
    1. Limited numbers

- Document any signs of Pb uptake in wildlife including (but not limited to):
    1. Muscular incoordination
    2. Debility
    3. Slowness
    4. Jerkiness
    5. Falling
    6. Hyperactivity
    7. Fluffed feathers
    8. Drooped eyelids
    9. Seizures

If one of the above methods has been met, the Ecology Site Manager (or designee) should then visit the site to make a final determination as to whether or not the area appears to be established, sustainable, and native habitat. In granting the request of the proposed cleanup action (application of fish bones [Apatite II] as a soil amendment to the lead contaminated soil), the Ecology Site Manager (or designee) should consider the following factors prior to making the final decision (Ecology, 2012) that the proposed cleanup action sufficiently addresses ecological risk:

- The rarity of the habitat for the geographic area in which the site is located.
- The size of the habitat.
- Whether the habitat functions as a wildlife corridor.
- Whether the habitat functions as a refuge or feeding area for migratory species.
- The structural diversity of the habitat.
- Surrounding habitat and land uses.
- Whether the habitat is manmade or natural.
- Whether the cleanup would significantly disturb the ecological functions of the habitat.
- The level of human activity in the area.
- The length of time for recovery of the habitat after cleanup.

In summary, the proposed remaining cleanup action is an in-situ treatment involving the application of Apatite II to the remaining contaminated soil on site. Post application of the Apatite II, composite samples of the treated soil will be sent to a certified lab for TCLP or SPLP testing to demonstrate the effectiveness of the treatment (limiting the bioavailability of the lead). In addition, under WAC 173-340-7490(5) – Additional Measures, Ecology is requiring that a Net Environmental Benefit Analysis is performed to show that further removal of that contaminated soil could create an incentive to cause harm through the destruction of habitat (designated as "especially valuable" through either Method 1 or Method 2 as described above). A follow-up report documenting the findings of the NEBA is required prior to making a final determination.

Results of the Net Environmental Benefit Analysis:

Method 1 was chosen to designate the site as "especially valuable habitat" because the site is used by a "priority species" designated under Title 77 RCW. Those species include:

- Bald Eagle (*H. leucocephalus*)
- Pinto Abalone (*H. kamtschatkana*)
- Red Sea Urchin (*S. franciscanus*)
- Peregrine Falcon (*F. peregrinus*)

Because the site met the requirements of Method 1, the final determination regarding the proposed remaining cleanup action (treatment of contamination in place by tilling Apatite II to a depth of 6 ") was based on a site visit by a designee from the Ecology Site Manager. Those points that were factors in the final decision were:

- The rarity of the habitat for the geographic area in which the site is located.
- The size of the habitat.
- Whether the habitat functions as a wildlife corridor.
- Whether the habitat functions as a refuge or feeding area for migratory species.
- The structural diversity of the habitat.
- Surrounding habitat and land uses.
- Whether the habitat is manmade or natural.
- Whether the cleanup would significantly disturb the ecological functions of the habitat.
- The level of human activity in the area.
- The length of time for recovery of the habitat after cleanup.

Methods:

The site was evaluated (site visit) on 08/28/2013. Method used to evaluate contamination was soil sampling 4" bgs at seven [7] locations (see Figure 5 through 13) with a Thermo Niton XL3t 700 XRF gun and identification of both native and non-native plant species with field guides; *Wild Plants of the San Juan Islands* (Atkinson and Sharpe, 1993), *Northwest Weeds* (Taylor, 1990), *Trees of Washington* (Mosher and Lunnum, 2003), and *Burke Image Collection* (WTU Image Collection, 2013).

Soil Sampling:

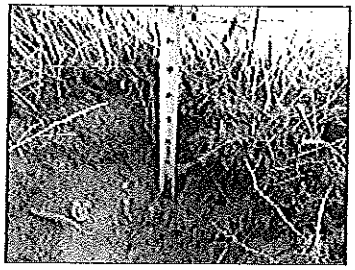

Figure 5: Soil Sampling at 4" bgs

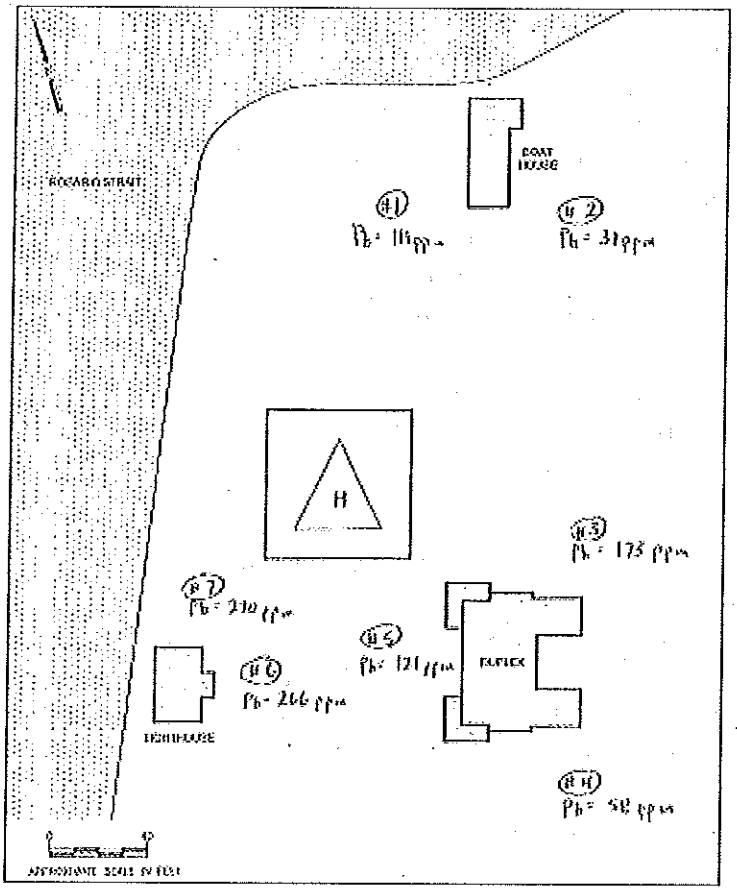

Figure 6: Locations of samples and Pb contaminant levels.

The seven locations chosen to test soil samples for lead were:

- SW and SE corner of Boat house app. 20' from the structure

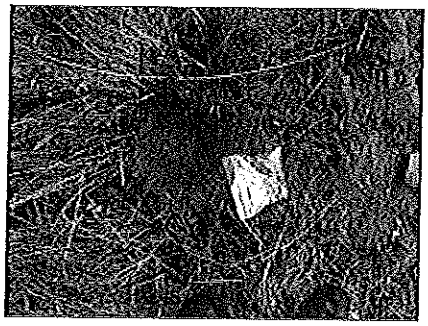

Figure 7: Pb = 111 ppm

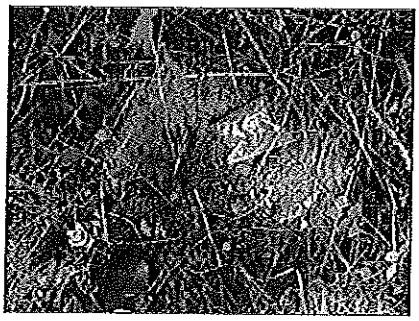

Figure 8: Pb = 31 ppm

- NE and SE end corner of Duplex app. 20' from the structure

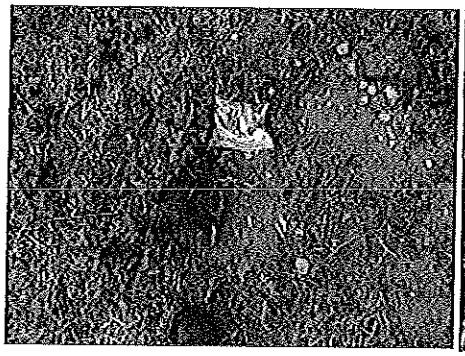

Figure 9: Pb = 173 ppm

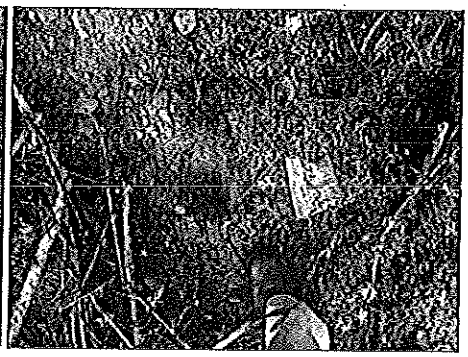

Figure 10: Pb = 58 ppm

- W end of Duplex app. 20' from the structure

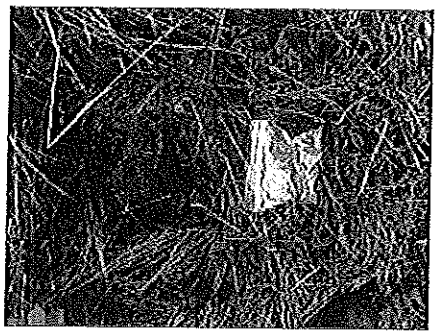

Figure 11: Pb = 124 ppm

- E end of Lighthouse app. 10' from structure

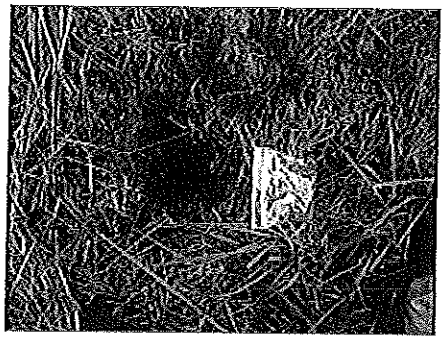

Figure 12: Pb = 266 ppm

- NE end of Lighthouse app. 10' from structure

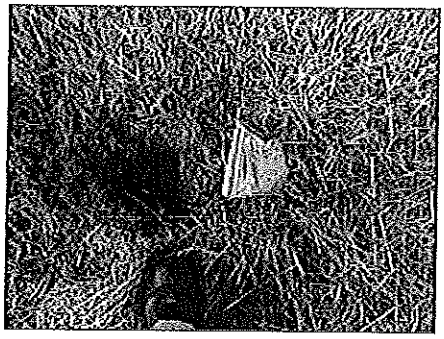

Figure 13: Pb = 270 ppm

Identification of both native and non-native plant species:

Native species identified to use the site were:

- Yarrow (*Achillea millefolium*)
- Sword fern (*Polystichum munitum*)
- Douglas fir (*Pseudotsuga menziesii*)
- Trailing Blackberry (*Rubus ursinus*)
- Oceanspray (*Holodiscus discolor*)
- Low Oregon grape (*Berberis nervosa*)
- Nootka rose (*Rosa nutkana*)
- Red Alder (*Alnus rubra*)
- Pacific Madrone (*Arbutus menziesii*)
- Rocky Mountain Juniper (*Juniperus scopulorum*)

Non-native species identified to use the site were:

- Canada Thistle (*Cirsium arvense*)
- Gumweed (*Grindelia spp.*)
- Himalayan Blackberry (*Rubus procerus*)
- Quackgrass (*Agropyron repens*)
- Cheatgrass (*Bromus tectorum*)
- Evening Primrose (*Oenothera biennis*)
- Common Dandelion (*Taraxacum officinale*)

Ecology Representative Evaluation:

- The rarity of the habitat for the geographic area in which the site is located:
  - This is an island with many native species found. In Washington State, this appears to be relatively rare habitat.
- The size of the habitat:
  - The contamination covers approximately 240' x 320'.
- Whether the habitat functions as a wildlife corridor.
  - Wildlife are known to use this area including invertebrates, vertebrates, mammals, and birds.
- Whether the habitat functions as a refuge or feeding area for migratory species.
  - It is not know if this habitat functions as a refuge or feeding area for migratory species.
- The structural diversity of the habitat.

- The structural diversity of the habitat is illustrated in the number of native plant species found.
- Surrounding habitat and land uses.
  - Surrounding habitat is a dense coniferous and deciduous forest.
- Whether the habitat is manmade or natural.
  - Much of the habitat is man-made. It is recommended that the Apatite II is tilled into the soil in the man-made/non-native species areas.
- Whether the cleanup would significantly disturb the ecological functions of the habitat.
  - It is recommended that the continued removal of soil would significantly disturb the ecological functions of the habitat. Tillage of Apatite II in the areas described in the Terrestrial Ecological Risk Assessment should significantly mitigate that disruption.
- The level of human activity in the area.
  - There is minimal human activity in the area. It is recommended that an Environmental Covenant be placed on this site to prevent future development.
- The length of time for recovery of the habitat after cleanup.
  - The length of time for recovery of the habitat after treatment and tillage of Apatite II to the recommended areas is minimal (< 1 yr) because the recommended areas for treatment are disturbed at present.

Final Recommendation

The final recommendation to be protective of ecological receptors at this site, will be to till (non-contaminated-i.e. make sure it is clean) Apatite II into the soil to a depth of at least 6" in all disturbed areas within 25 ft of all structures located within the complex. Areas that are, and will remain inaccessible (i.e. pavement walkways, rocky outcrops) and native vegetation will not be required to undergo this proposed treatment.

Native Vegetation includes:

- Yarrow (*Achillea millefolium*)
- Sword fern (*Polystichum munitum*)
- Douglas fir (*Pseudotsuga menziesii*)
- Trailing Blackberry (*Rubus ursinus*)
- Oceanspray (*Holodiscus discolor*)
- Low Oregon grape (*Berberis nervosa*)

- Nootka rose (*Rosa nutkana*)
- Red Alder (*Alnus rubra*)
- Pacific Madrone (*Arbutus menziesii*)
- Rocky Mountain Juniper (*Juniperus scopulor*)

Native Vegetation does not include:

- Canada Thistle (*Cirsium arvense*)
- Gumweed (*Grindelia spp.*)
- Himalayan Blackberry (*Rubus procerus*)
- Quackgrass (*Agropyron repens*)
- Cheatgrass (*Bromus tectorum*)
- Evening Primrose (*Oenothera biennis*)
- Common Dandelion (*Taraxacum officinale*)

In addition, if the helicopter pad (pad) is removed (prior to, or after treatment with Apatite II), it is recommended that any suspected contaminated soil is placed at the east end of the graded area of the pad and capped with at least 6" of soil from the site (that does not contain native species) of which the source of the soil is greater than 25 ft from any structure located on the site.

Following the selected cleanup action, composite samples of the treated soil will be sent to a certified lab for TCLP or SPLP testing to demonstrate the effectiveness of the treatment.

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