5.0 SUMMARY OF RISK ASSESSMENTS

Baseline human health and ecological risk assessments were conducted to determine if residual petroleum at the NMCB Building Expanded Area would pose unacceptable risk to human health or the environment if no cleanup actions were to take place. Contaminant concentrations reported in Section 4 were used to calculate risks and hazards. Hazards calculated for human exposures to chemicals in soil were found to be greater than target health goals. Target health goals established for free-product petroleum sites at the former Adak Naval Complex are the following:

- Human health cancer risk (CR) of 1×10^{-5}
- Human health hazard index (HI) of 1 based on non-total petroleum hydrocarbon (TPH) compounds
- Human health HI of 1 based on TPH
- Ecological HI of 1

5.1 HUMAN HEALTH

Alaska DEC provides guidance for four methods of determining cleanup levels (beginning with Method One) that increase in level of effort and site-specificity. Method Four uses risk assessment to determine site specific cleanup levels (ADEC 2000c). Sufficient site information is available to determine Method Four cleanup levels and the results are summarized below. Details are provided in Appendix C of the FFS report (URS 2005a).

Previous investigations have identified chlorinated solvents and petroleum compounds in soil and groundwater at concentrations above regulatory levels at the site resulting from spills, leaks, or work practices associated with vehicle maintenance, woodworking, and machine shop activities and likely leakage from subsurface fuel lines. The risk assessment, conducted according to the risk assessment procedures specified by Alaska DEC (2000c), evaluated whether potential health risks were present if people encountered these chemical-impacted materials in their environment. Risks and hazards were estimated for each complete, significant exposure pathway. Exposure pathways were determined to be complete and significant based on the site-specific human health conceptual site model (CSM). The human health CSM for the NMCB Building Expanded Area is depicted on Figure 5-1. This section provides a summary of the human health risk assessment conducted for this site. The complete, detailed human health risk assessment is included as Appendix C of the FFS report (URS 2005a).

5.1.1 Human Health Risk Assessment Procedures

A baseline risk assessment typically consists of four major steps: (1) data evaluation, (2) exposure assessment, including development of a CSM, (3) toxicity assessment, and (4) risk characterization and calculation of cleanup levels. A final step is a qualitative analysis of the major uncertainties involved in risk assessment calculations. Details of the procedures used to calculate the health risks are summarized below.

Data Evaluation

At step one, the data applicable to human health exposures are selected and compared to de minimis health-based screening levels. Chemicals with concentrations greater than the de minimis levels are selected as "COPCs" for evaluation in the risk assessment. Nineteen chemicals were selected as COPCs in groundwater:

- 1,2-Dichloroethane
- cis-1,2-Dichloroethene
- 2-Methylnaphthalene
- 1,2,4-Trimethylbenzene
- 1,3,5-Trimethylbenzene
- Benzene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Carbazole
- Dibenzofuran
- Ethylbenzene
- Naphthalene
- n-Propylbenzene
- Toluene
- Trichloroethene
- Xylenes
- DRO
- GRO

The following 15 chemicals were selected as COPCs in soil:

- 2-Methylnaphthalene
- 1,2,4-Trimethylbenzene
- 1,3,5-Trimethylbenzene

- Benzene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Dibenz(a,h)anthracene
- Ethylbenzene
- Indeno(1,2,3-cd)pyrene
- Naphthalene
- Xylenes
- DRO
- GRO
- RRO

Exposure Assessment

Once COPCs are selected, the second step in risk assessment is an evaluation of the exposure pathways by which people could encounter chemicals. The exposure assessment identifies the populations potentially exposed to chemicals at the site, the means by which exposure occurs, and the amount of chemical received from each exposure medium (i.e., the dose). Only complete exposure pathways are quantitatively evaluated. Complete pathways consist of four elements: (1) a source and mechanism of chemical release, (2) a retention or transport medium (e.g., groundwater), (3) a point of potential human contact with the affected medium, and (4) a means of entry into the body at the contact point. Figure 5-1 presents the CSM, which depicts the complete pathways for this site.

Residential land use, including permanent or temporary living accommodations, childcare facilities, schools, playgrounds, and hospitals are prohibited at the NMCB Building Expanded Area by the Interim Conveyance Document. Thus, no residential populations would be exposed to chemicals at the site. Because there is no exposure to surface soil (site is either paved or covered in gravel) and chemicals in groundwater are moving away from the residential areas, off-site populations would not be exposed to chemicals migrating from the site to the residential areas.

Current and future human exposures to chemicals in soil and groundwater at the NMCB Building Expanded Area were therefore evaluated for potential construction workers who could be involved in tasks requiring subsurface intrusion and building workers occupying the buildings. The following exposure pathways were selected for quantitative evaluation under current and future conditions:

- Construction workers potentially disturbing soil in the course of construction activity could be exposed through incidental ingestion, dermal contact, and inhalation of fugitive dust and volatile chemicals in soil (to a depth of 15 feet).

- Construction workers conducting intrusive subsurface work could be exposed to chemicals in shallow groundwater (less than 15 feet bgs) through dermal contact and inhalation of volatile chemicals.

- On-site building workers occupying the site building could be exposed to volatile chemicals in soil and groundwater by inhalation of chemicals migrating through the soil into the building.

Recreational exposure to surface water and sediment of Sweeper Cove was considered a potentially complete, but insignificant pathway. Therefore, this pathway was not quantitatively evaluated in the risk assessment. Recreational activities at this area are expected to be limited because the shoreline in the NMCB Building Expanded Area is very rocky and access is very limited due to a large berm and riprap; thus, it is not considered an appealing recreational area. There are other shoreline areas near NMCB Building Expanded Area and closer to the residential areas that are attractive beaches with no riprap and are more likely to be visited by community members than the shoreline area around NMCB Building Expanded Area. For this reason, human contact with sediment is expected to be limited and only possible during low tide. At the request of Alaska DEC, detected chemicals in sediment were compared to the State of Texas' sediment protective concentration levels for protection of direct human contact with sediment (www.tnrc.state.tx.us/permitting/trrp.htm#topic3).

Detected concentrations of chemicals in sediment were compared to the State of Texas criteria because these are the only published criteria for recreational exposures according to the ADEC. None of the detected chemicals in sediment were present in concentrations greater than the State of Texas' sediment protective concentration levels. Therefore, in addition to the fact that contact with sediment is expected to be very minimal, chemicals in sediment are not present in concentrations that are a health concern for recreational exposures, even if fairly prolonged contact is assumed (see further discussion in uncertainty section). The small number of surface samples with detected GRO exhibited concentrations below the drinking water standard, and marine waters cannot be used for drinking. In summary, exposures to petroleum compounds in surface water and sediment of Sweeper Cove do not present a health concern for recreational populations.

Ingestion of groundwater is considered an incomplete pathway for all receptors. Institutional controls are currently in place for groundwater, which restrict the use of groundwater as drinking water. In addition, salt water intrusion makes the groundwater at the NMCB Building Expanded Area an unlikely potential future drinking water source.

The exposure factors used in the risk calculations for on-site building worker exposures to volatile chemicals in indoor air are summarized on Table 5-1; and the exposure factors used in the risk calculations for construction worker exposures to groundwater and soil are summarized on Tables 5-2 and 5-3, respectively.

Toxicity Assessment

The third step in risk assessment is an evaluation of the toxicity of the COPCs by an assessment of the relationship between the dose of a chemical and the occurrence of toxic effects. Chemical toxicity criteria, which are based on this relationship, consider both cancer effects and effects other than cancer (noncancer effects). Tables 5-4 and 5-5 present the cancer and noncancer criteria, respectively. The toxicity criteria are combined with the exposure factors when quantifying potential health risks for each COPC. The toxicity criteria are required in order to quantify the potential health risks due to the COPCs. Benzene, 1,2-dichloroethane, ethylbenzene, trichloroethylene, and the PAHs were evaluated for cancer effects; and the other chemicals (where toxicity information exists) were evaluated for noncancer effects.

Note, only noncancer toxicity criteria are available for the petroleum groups. Carcinogenic effects are not evaluated for the petroleum ranges. Rather, the individual carcinogenic compounds present in petroleum (i.e., benzene) are evaluated separately.

Risk Characterization

The last step in human health risk assessment is a characterization of the health risks. The exposure factors, media concentrations, and toxicity criteria are combined to calculate health risks. Health risks are calculated differently for chemicals that cause cancer and for chemicals that cause noncancer effects. The calculation of CR assumes that no level of the chemical is without some risk, whereas for chemicals with noncancer effects, a "threshold" dose exists. Risks (for cancer) and hazards (for noncancer effects) are calculated for a reasonable maximum exposure (RME) scenario for each pathway, a calculation that overestimates risks for the majority of the population in order to ensure that public health is protected. CR estimates represent the potential for cancer effects by estimating the probability of developing cancer over a lifetime due to site exposures. Noncancer hazards assume there is a level of chemical intake that is not associated with an adverse health effect even in sensitive individuals. Alaska DEC (2000c) risk assessment guidelines require that noncarcinogenic effects of the TPH compounds (i.e., DRO and GRO) be evaluated separately from the non-TPH compounds. Therefore, in the summarizing step of the risk characterization section, a HI is presented for each, the non-TPH compounds and the TPH compounds. The results of the risk characterization for each population are discussed separately below:

On-Site Building Worker

Risks and hazards for the individual COPCs for on-site building worker exposures to volatile chemicals in indoor air are presented in Table 5-6. In addition, the exposure point concentrations (EPCs) used to calculate risks and hazards are also presented on Table 5-6. Health risks for the on-site worker inhaling vapors in indoor air did not exceed Alaska DEC target health goals—with an estimated total non-TPH hazard index of 0.03 and TPH hazard index of 0.01 for the non-cancer chemicals and CR of 2×10^{-7}.

These risks and hazards for on-site building worker exposures were estimated using EPA-approved modeling (Johnson-Ettinger model; Johnson *et al*. 1999, Johnson and Ettinger 2000) to predict indoor air concentrations based on groundwater data collected in the vicinity of the building. While volatile chemicals are also selected as COPCs in soil, the majority of the data collected in the vicinity of the building had volatile concentrations less than Alaska DEC Method Two. Therefore, only groundwater data was used to model indoor air concentrations. The model may underestimate indoor air concentrations if the soil type under a building is more permeable to vapors than sand or if the possibility of "preferential pathways" exists. The data for the NMCB Building Expanded Area do not indicate that very permeable soil types or preferential pathways are a concern. The much more likely scenario in the case of petroleum compounds is that the model over-predicts vapor concentrations. The developers of the indoor air model state that their model generally over-predicts, rather than under predicts, indoor air concentrations for most scenarios. Their opinion is that the Johnson-Ettinger model likely over-predicts for hydrocarbon scenarios due to the importance of *in situ* biodegradation.

Because of the tendency for the model to over-predict indoor air concentrations and because risks and hazards calculated for the indoor air pathway were approximately two orders of magnitude below target health goals, the potential for petroleum contamination in groundwater to pose a health concern via the indoor air pathway is highly unlikely. Because of the cleanup activities that have already occurred at the NMCB Building Expanded Area and the selected remedial alternative for the site (specifically, the free-product recovery efforts), indoor air concentrations are expected to decrease over time and result in even lower risk.

Construction Worker

Risks and hazards for the individual COPCs for construction worker exposures to soil and groundwater are presented on Tables 5-7 and 5-8, respectively. In addition, the EPCs used to calculate these risks and hazards are also presented on Tables 5-7 and 5-8. Table 5-9 presents the cumulative risks and hazards from exposure to both groundwater and soil during construction. The cumulative risks and hazards for the construction worker scenario for the non-TPH chemicals were 1×10^{-5} and 1 (for cancer and noncancer effects), while the TPH chemical noncancer hazards were 2. Alaska DEC target health goals for cancer chemicals are no more

than a 1 x 10^{-5} chance of developing cancer and target health goals for non-cancer chemicals are a hazard quotient of 1. Therefore, the risks and hazards for the non-TPH chemicals were equal to, but did not exceed, target health goals. However, the hazards due to the TPH chemicals exceeded the target health goal of 1 for non-cancer chemicals.

Free-product recovery has been conducted at the NMCB Building Expanded Area site intermittently from September 1997 through July 2005. Between September 1997 and November 2004 approximately 201 gallons of free product have been recovered at the site. As discussed in Section 3.0 of the FFS report (URS 2005a), measurable thicknesses of free product have been observed in five monitoring wells at the NMCB Building Expanded Area site during groundwater monitoring activities conducted since January 2001.

While exposures to free product cannot be quantitatively evaluated in risk assessments, exposures to free product may represent an unacceptable health risk—although significant risks are unlikely because of the small and localized extent of the remaining product (see Figure 4-1). As of December 2004, the areal extent of free product was estimated to be approximately 24,000 ft^2. The current extent is expected to be much smaller based on additional free-product recovery activities conducted in 2005. In the event that free product is encountered by construction workers performing subsurface activities, the appropriate measures should be taken to minimize contact and exposure.

Because TPH chemicals in soil exceeded target health goals for construction worker exposures and because there is sufficient free product remaining at the site that direct contact with free product could constitute a health risk, action-based alternative cleanup levels (ACLs) were calculated for GRO and DRO in soil as allowed under 18 AAC 75.340. The proposed action-based ACLs are 1,700 mg/kg for GRO and 31,000 mg/kg for DRO. These action-based ACLs were calculated by defining a target health goal and then solving the basic risk assessment equations for concentration, rather than for risk or for hazard. The same site-specific information developed for calculating health risks was used in the action-based ACL calculations. Because only non-cancer health effects are a concern, the ACLs are protective of non-cancer health end points.

Site-specific cleanup levels for groundwater were not calculated. The proposed groundwater cleanup levels for NMCB Building Expanded Area are the Alaska DEC cleanup levels established for groundwater not currently used for, or not reasonably expected to be used for drinking water, because the water is not potentially potable (i.e., saltwater intrusion makes the water undrinkable). In addition, institutional controls are currently in place for groundwater, which restrict the use of groundwater as a drinking water source.

5.2 ECOLOGICAL

Ecological hazards to terrestrial and aquatic biota resulting from exposure to petroleum compounds in soil, marine sediment and marine surface water were estimated for each complete, significant exposure pathway. Exposure pathways were determined to be complete and significant based on the site-specific ecological CSM. The ecological CSM for the NMCB Building Expanded Area is depicted on Figure 5-2. Hazards above target health were only qualified for terrestrial wildlife exposed to petroleum hydrocarbons in surface soil. There were no hazards above target health goals for aquatic biota exposed to petroleum compounds in surface water or sediment at the NMCB Building Expanded Area. In addition, there are no threatened or endangered species affected by the petroleum release at this site. This section provides a summary of the ecological risk assessment conducted for this site. The complete, detailed ecological risk assessment is included as Appendix C of the FFS report (URS 2005a).

5.2.1 Ecological Risk Assessment Procedures

Ecological risk assessment procedures begin with determining whether a detailed ecological risk assessment of that site is required. A detailed ecological risk assessment of a given site is required whenever the potential for an ecological threat from chemicals exists. The decision on whether to perform a detailed ecological risk assessment or not is made during the problem formulation stage of the risk assessment process. Before a decision can be made on the need for a detailed ecological risk assessment of a given site, a determination is made regarding the following:

1. The presence of sensitive environments, critical habitats, or sensitive species at a site

2. The presence of complete exposure pathways which result in the exposure of ecological receptors to site contaminants

If it is determined that no sensitive environments, critical habitats or sensitive species are present at a given site, and complete exposure pathways cannot be identified, Alaska DEC guidance permits the ecological risk assessment process for that site to be terminated.

5.2.2 Problem Formulation

An ecological checklist (found in Appendix B of the Alaska DEC Risk Assessment Procedures Manual and included in Appendix C-II of the FFS [URS 2005a]) was completed, describing the location and characteristics (e.g., environmental setting, land use, environmental fate-and-transport, and ecological receptors) of specific environments within the boundaries of the NMCB

Building Expanded Area site. Through this exercise, it was determined that critical habitat for anadromous salmonids is present at the site.

An ecological CSM was also prepared, describing the completeness and significance of exposure pathways by which ecological receptors may potentially be exposed to site contaminants. The CSM (included as Figure 5-2) revealed that the following complete exposure pathways exist at the NMCB Building Expanded Area and result in the ecologically significant exposure of ecological receptors to site contaminants:

1. Aquatic receptors may be exposed to site contaminants in marine waters and sediments

2. Terrestrial receptors may be exposed to site contaminants in surface soil 0 to 6 feet bgs

Based on this assessment, potential ecological threat exists to ecological receptors from petroleum products released at the NMCB Building Expanded Area. Therefore, an ecological effects evaluation that quantitatively described the potential ecological risk associated with exposure to site contaminants was conducted. Details of this evaluation are provided in Appendix C of the FFS report (URS 2005a).

5.2.3 Screening Level Ecological Risk Assessment

Ecological risk at the site was estimated only for contaminants in surface soil, marine sediment and marine surface water. A screening level ecological risk assessment was conducted to determine whether any of the contaminants detected in these media on site might present an unacceptable risk to ecological receptors. Hazard quotients were derived for the detected contaminants; chemicals with hazard quotients greater than or equal to 1.0 were retained as COPCs.

Two surface soil contaminants were identified as COPCs:

- DRO
- GRO

Two marine sediment contaminants were identified as COPCs:

- 3- and 4-methylphenol
- DRO

No contaminants were identified as COPCs in marine surface water because no contaminants were present in concentrations exceeding the risk-based screening concentrations. The results of the screening level ecological risk assessment to identify COPCs are presented in Table 5-10 for soil, Table 5-11 for marine sediment, and Table 5-12 for surface water. COPCs identified during the screening level risk assessment were forwarded to the baseline ecological risk assessment.

5.2.4 Baseline Ecological Risk Assessment

In the risk characterization phase of a baseline risk assessment, hazard quotients are calculated in a similar manner as in a screening level risk assessment. However, the 95 percent upper confidence limit (UCL95) of the COPC is compared to the respective RBSC rather than the maximum detected concentration. For sediment, the most recent data from each sampled location was used in the calculation of the UCL95s to represent the most current conditions. That is, if a sediment location was sampled during the recent August 2003 sediment sampling investigation, then only the recent result was included in the UCL95 calculations.

The risk characterization phase of the baseline ecological risk assessment did not identify any chemicals detected in marine sediment as having the potential to pose a significant, unacceptable risk to benthic biota (i.e., all hazard quotients less than 1.0). The only potentially significant ecological risk which could be quantified during the baseline ecological risk assessment was exposure of terrestrial wildlife to GRO in soil (hazard quotient of 3.9). No other chemicals of concern (COCs) were identified in soils of the NMCB Building Expanded Area site in the baseline risk assessment of terrestrial wildlife.

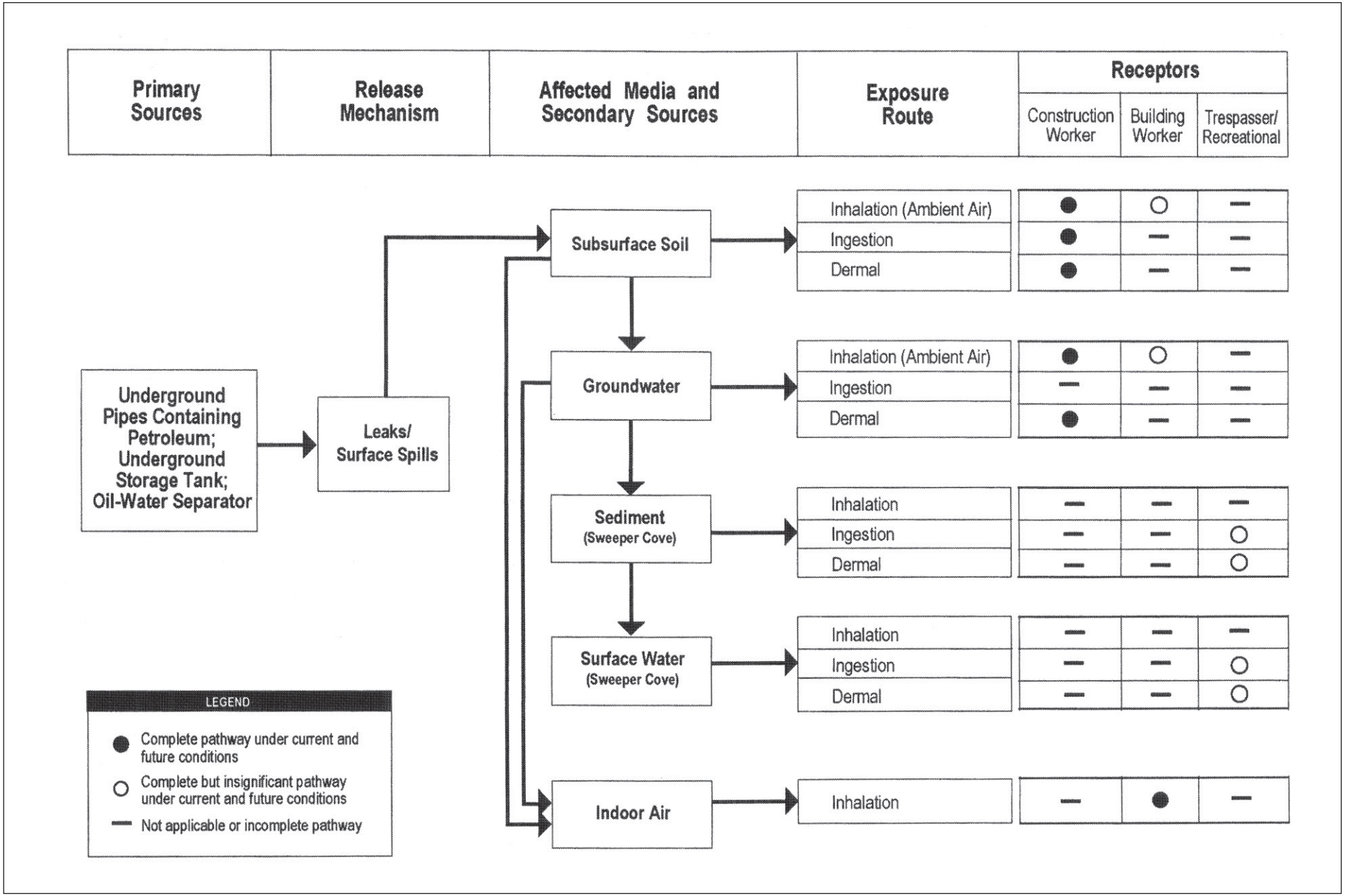
The results of the baseline ecological risk assessment to identify COCs are presented in Table 5-13 for soil, and Table 5-14 for marine sediment.

5.2.5 Conclusion

Site COPCs in marine surface water and marine sediments do not pose significant quantifiable risks to any ecological receptor. As discussed above, the most recent sediment data from each sampled location was used in the calculation of the UCL95s. The use of one data point for a single location in a statistical analysis is appropriate to avoid providing more statistical weight to one location. Furthermore, the detection limits were generally higher in the older data and tend to overestimate the concentration data. Although there is some uncertainty in whether Sweeper Cove is depositional or erosional, using the current sediment data gives the best approximation of current conditions without statistical bias. Collection of additional sediment samples is not considered necessary because newer samples are unlikely to result in different conclusions than those reached using the 2003 sediment data.

Based on the 2003 sediment investigation, marine sediments do not pose significant risk. Based on our experience, accretion of new sediments typically provides a natural "cap" and overall environmental improvement with very little vertical transfer due to "bioturbation." Additional free-product recovery has occurred at the site since the most recent sediment samples were collected. Therefore, it is likely that collection of new sediment samples would show either similar results to those presented in the Baseline Ecological Risk Assessment or even a decrease in ecological hazard, particularly since 3- and 4-methylphenol (the chemical of most potential ecological concern) has a relatively short half-life in marine environments. Therefore, it is unlikely that the measured concentrations of the chemical would remain stable, even if the sediments at the site were physically stable. The hazard quotient resulting from the 2003 sediment data are indicative of conditions that pose no significant ecological risks to benthic biota in Sweeper Cove in the vicinity of NMCB Building Expanded Area (i.e., hazards were approximately one order of magnitude below target health goals).

Based on these data, a potential ecological threat only exists to terrestrial wildlife from GRO in soil at the NMCB Building Expanded Area site. The ecological RBSC for soils of 1,840 mg/kg was selected as the ACL for GRO. However, the human health ACL for GRO of 1,700 mg/kg was lower than that determined for the ecological risk assessment. As such, the human health ACL is considered to be protective of ecological receptors.



U.S.NAVY	**Figure 5-1** **Human Health Conceptual Site Model** **NMCB Building Expanded Area**	Adak Island, AK DECISION DOCUMENT

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Primary Source	Primary Release Mechanism	Secondary Source	Secondary Release Mechanism	Tertiary Source	Tertiary Release Mechanism	Exposure Medium	Exposure Route	Potential Ecological Receptors									
								Terrestrial Biota				Aquatic Biota					
								Plants	Invertebrates	Birds	Mammals	Macrophytes	Plankton	Invertebrates	Fish	Birds	Marine Mammals
AGS Pipes, Fuel Dispensers, Oil/Water Separators, and/or Unknown	Spills/Leaks of Chemicals into Soil	On-Site Surface Soil	Dust Generation and Volitilization		Particulate and Volatile Emissions	Air	Inhalation	—	○	○	○	—	—	—	—	○	○
						On-Site Surface Soil (0-6 feet bgs)	Incidental Ingestion	—	●	●	●	—	—	—	—	○	○
							Dermal Contact/ Root Uptake	●	●	●	●	—	—	—	—	○	○
							Food Web	—	○	○	○	—	—	—	—	—	—
USTs, BGS Pipes, and/or Unknown		On-Site Subsurface Soil				On-Site Subsurface Soil (>6 feet bgs)	Inhalation	—	—	—	—	—	—	—	—	—	—
							Incidental Ingestion	—	—	—	—	—	—	—	—	—	—
							Dermal Contact	—	—	—	—	—	—	—	—	—	—
Storm and Wastewater Discharge	Spills/Leaks of Chemicals into Airport Ditch System, Sweeper Cove		Leaching and Infiltration	Groundwater	Discharge to Surface Water	Sweeper Cove East Canal Surface Water	Ingestion	—	—	○	○	—	—	●	●	●	●
							Dermal Contact	—	—	○	○	●	●	○	○	○	○
							Food Web	—	—	○	○	—	—	○	○	○	○
			Slope Erosion			Sweeper Cove East Canal Sediment	Incidental Ingestion	—	—	○	○	—	—	●	●	●	●
							Dermal Contact/ Root Uptake	—	—	○	○	●	—	●	●	○	○
			Sedimentation, Sorption				Food Web	—	—	○	○	—	—	○	○	○	○

LEGEND

- ● Potentially Complete Pathway
- ○ Minor or Insignificant Pathway
- — Incomplete Pathway
- AGS Above Ground Surface
- AST Aboveground Storage Tank
- BGS Below Ground Surface
- FCT Field Constructed Tank
- UST Underground Storage Tank

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Figure 5-2
Ecological Conceptual Site Model for the NMCB Building Expanded Area

Adak Island, AK
DECISION DOCUMENT

Table 5-1
Assumptions for Worker Exposure to Chemicals in Groundwater Through the Vapor Intrusion Pathway

Equations:

Chemical intake (mg/kg-day) = CA * SIF

$$SIF_{inh} = \frac{CF1 \bullet InhR \bullet EF \bullet ED \bullet ET}{BW \bullet AT}$$

Where:

SIF_{inh} (m^3-mg/ug-kg-day) = summary intake factor for inhalation of vapors from affected media

Parameter	Definition	Value	Units	Source
CA	Chemical concentration in air	chemical specific	ug/m^3	Calculated using the Johnson-Ettinger (1991) Model to estimate chemical movement from affected media (i.e., soil or groundwater) to air.
CF1	Conversion factor	1.00E-03	mg/ug	Not applicable
InhR	Inhalation rate	1.3	m^3/hour	Default value (USEPA 1997a)
EF	Exposure frequency	250	days/year	Default value (USEPA 1991)
ET	Exposure time	8	hours/day	Site-specific
ED	Exposure duration	25	years	Default value (USEPA 1991)
BW	Body weight	70	kg	Default value (USEPA 2002c)
ATnc	Averaging time for noncarcinogenic effects	ED x 365 days/year	days	Default value (USEPA 1991)
ATca	Averaging time for carcinogenic effects	25,550	days	Default value (USEPA 1991)

Notes:
hr - hour
kg - kilogram
m^3 - cubic meter
mg - milligram
ug - microgram
USEPA - United States Environmental protection Agency

Table 5-2
Construction Worker Exposures to Groundwater, Exposure Assumptions and Intake Equations

Equations:

$$\text{Chemical intake (mg/kg-day)} = CW * SIF$$

$$SIF_{derm} = \frac{CF1 \cdot CF2 \cdot SA \cdot EF \cdot ET \cdot ED \cdot PC}{BW \cdot AT}$$

$$SIF_{inh} = \frac{CF1 \cdot InhR \cdot EF \cdot ED \cdot VFw}{BW \cdot AT}$$

Where:

SIF_{derm} (L-mg/ug-kg-day) = summary intake factor for dermal contact with groundwater
SIF_{inh} (L-mg/ug-kg-day) = summary intake factor for inhalation of groundwater vapors

Parameter	Definition	Value	Units	Source
CW	Chemical concentration in	chemical specific	ug/L	analytical data
CF1	Conversion factor	1.00E-03	mg/ug	not applicable
CF2	Conversion factor	1.00E-03	L/cm^3	not applicable
SA	Skin surface area	3300	cm^2	default value, USEPA 2002c
PC	Dermal permeability constant	chemical specific	cm/hr	USEPA 2003b
InhR	Inhalation rate	20	m^3/day	default value, USEPA 2002c
VFw	Volatilization factor for water	0.01	L/m^3	site-specific, USEPA 1999
EF	Exposure frequency	190	days/year	site-specific
ET	Exposure time	8	hours/day	site-specific
ED	Exposure duration	1	years	site-specific
BW	Body weight	70	kg	default value, USEPA 2002c
ATnc	Averaging time (noncarcinogen)	ED x 365 days/year	days	default value, USEPA 2002c
ATca	Averaging time (carcinogen)	25,550	days	default value, USEPA 2002c

Notes:

cm - centimeters
cm^2 - centimeters squared
cm^3 - cubic centimeters
hr - hour
kg - kilograms
L - liters
m^3 - cubic meters
mg - milligrams
µg - micrograms
USEPA - United States Environnmental Protection Agency

Table 5-3
Construction Worker Exposures to Soil, Exposure Assumptions and Intake Equations

Equations:

$$\text{Chemical intake (mg/kg-day)} = CS * SIF$$

$$SIF_{ing} = \frac{IR \cdot CF \cdot EF \cdot ED}{BW \cdot AT}$$

$$SIF_{derm} = \frac{CF \cdot SA \cdot AF \cdot ABS \cdot EF \cdot ED}{BW \cdot AT}$$

$$SIF_{inh} = \frac{InhR \cdot EF \cdot ED \cdot (1/PEF)}{BW \cdot AT}$$

Where:

SIF_{ing} (day^{-1}) = summary intake factor for ingestion of soil
SIF_{derm} (day^{-1}) = summary intake factor for dermal contact with soil
SIF_{inh} (day^{-1}) = summary intake factor for inhalation of fugitive dust

Parameter	Definition	Value	Units	Source
CS	Chemical concentration in soil	chemical specific	mg/kg	analytical data
IR	Ingestion rate	330	mg/day	default value, USEPA 2002c
CF	Conversion factor	1.00E-06	kg/mg	not applicable
SA	Surface area	3300	cm^2	default value, USEPA 2002c
AF	Soil to skin adherence factor	0.3	mg/cm^2-day	default value, USEPA 2002c
ABS	Absorption factor	chemical specific	unitless	USEPA 2003b
InhR	Inhalation rate	20	m^3/day	default value, USEPA 2002c
PEF	Particulate emission factor	5.09E+08	m^3/kg	site-specific, USEPA 2002c
EF	Exposure frequency	190	days/year	site-specific
ED	Exposure duration	1	years	default value, USEPA 2002c
BW	Body weight	70	kg	default value, USEPA 2002c
ATnc	Averaging time (noncarcinogen)	ED x 365 days/year	days	default value, USEPA 2002c
ATca	Averaging time (carcinogen)	25,550	days	default value, USEPA 2002c

Notes:
cm^2 - centimeters squared
kg - kilograms
m^3 - cubic meters
mg - milligrams
USEPA - United States Environmental Protection Agency

Table 5-4
Carcinogenic Toxicity Criteria for the Chemicals of Potential Concern

Chemical	Oral Cancer: Slope Factor $(mg/kg\text{-}day)^{-1}$	Inhalation Cancer: Slope Factor $(mg/kg\text{-}day)^{-1}$	Tumor Type	EPA Cancer Classification[a]	Reference
1,2-Dichloroethane	0.091	0.091	Lung papillomas in mice	EPA Group B2 carcinogen	USEPA 2003a
1,2,4-Trimethylbenzene	None	None	NA	EPA Group D carcinogen	USEPA 2002a
1,3,5-Trimethylbenzene	None	None	NA	EPA Group D carcinogen	USEPA 2002a
2-Methylnaphthalene	None	None	NA	Not classified	NA
Benzene	0.055	0.029	Leukemia (human)	EPA Group A carcinogen	USEPA 2002a
Benzo(a)anthracene	0.73	0.31	Forestomach, larynx, and esophagus tumors (oral); Pharynx, larynx tumors (inhalation)	EPA Group B2 carcinogen	USEPA 2003a (oral) USEPA 1994 (inhalation)
Benzo(a)pyrene	7.3	3.1	Forestomach, larynx, and esophagus tumors (oral); Pharynx, larynx tumors (inhalation)	EPA Group B2 carcinogen	USEPA 2003a (oral) USEPA 1994 (inhalation)
Benzo(b)fluoranthene	0.73	0.31	Forestomach, larynx, and esophagus tumors (oral); Pharynx, larynx tumors (inhalation)	EPA Group B2 carcinogen	USEPA 2003a (oral) USEPA 1994 (inhalation)
Carbazole	0.02	0.02	Lesions on liver and stomach in mice	EPA Group D carcinogen	USEPA 1997b
Dibenzo(a,h)anthracene	7.3	3.1	Forestomach, larynx, and esophagus tumors (oral); Pharynx, larynx tumors (inhalation)	EPA Group B2 carcinogen	USEPA 2003a (oral) USEPA 1994 (inhalation)
Dibenzofuran	None	None	NA	EPA Group D carcinogen	USEPA 2002a
cis-1,2-Dichloroethene	None	None	NA	EPA Group D carcinogen	USEPA 2002a
Ethylbenzene	None	0.0039	Renal and testicular cancer (male rates)	EPA Group D carcinogen[b]	USEPA 2002a

Table 5-4 (Continued)
Carcinogenic Toxicity Criteria for the Chemicals of Potential Concern

Chemical	Oral Cancer: Slope Factor $(mg/kg\text{-}day)^{-1}$	Inhalation Cancer: Slope Factor $(mg/kg\text{-}day)^{-1}$	Tumor Type	EPA Cancer Classification[a]	Reference
Indeno(1,2,3-cd)pyrene	0.73	0.31	Forestomach, larynx, and esophagus tumors (oral); Pharynx, larynx tumors (inhalation)	EPA Group B2 carcinogen	USEPA 2003a (oral) USEPA 1994 (inhalation)
Naphthalene	None	None	NA	EPA Group D carcinogen	USEPA 2002a
n-Propylbenzene	None	None	NA	EPA Group D carcinogen	USEPA 2002a
Toluene	None	None	NA	EPA Group D carcinogen	USEPA 2002a
Trichloroethene	0.02-0.4[c]	0.02-0.4[c]	Kidney tumors	EPA Group B1 carcinogen	USEPA 2001
Xylenes	None	None	NA	EPA Group D carcinogen	USEPA 2002a
DRO aliphatics	None	None	NA	Not classified	ADEC 2000a
DRO aromatics	None	None	NA	Not classified	ADEC 2000a
GRO aliphatic	None	None	NA	Not classified	ADEC 2000a
GRO aromatics	None	None	NA	Not classified	ADEC 2000a
RRO aliphatic	None	None	NA	Not classified	ADEC 2000a
RRO aromatics	None	None	NA	Not classified	ADEC 2000a

Table 5-4 (Continued)
Carcinogenic Toxicity Criteria for the Chemicals of Potential Concern

Notes:
[a] EPA's Weight-of-Evidence Classification System:
Group A - human carcinogen (sufficient evidence in humans)
Group B1 - probable human carcinogen (limited human data available)
Group B2 - probable human carcinogen (sufficient evidence in animals, inadequate or no evidence in humans)
Group C - possible human carcinogen (limited evidence in animals)
Group D - not classifiable as to human carcinogenicity
[b] The IRIS file has not been updated yet to reflect the carcinogenicity of ethylbenzene. Therefore, the cancer classification will likely change.
[c] EPA recommends a range of cancer slope factors for trichloroethene from 0.02 $(mg/kg\text{-}day)^{-1}$ to 0.4 $(mg/kg\text{-}day)^{-1}$. The high end of the range, 0.4 $(mg/kg\text{-}day)^{-1}$, was selected as the slope factor because it is based on occupational studies.
mg/kg-day - milligram per kilogram per day
SF - slope factor
NA - not applicable
USEPA - United States Environmental Protection Agency

Table 5-5
Noncarcinogenic Chronic and Subchronic Toxicity Criteria for the Chemicals of Potential Concern

Chemical	Chronic RfD (mg/kg-day)	Toxic Endpoint	Critical Study	Chronic RfD UF[b]	RfD Source	Adjustment from Chronic to Subchronic	Subchronic RfD (mg/kg-day)	EPA Subchronic Source[d]
Inhalation Exposures								
1,2,4-Trimethylbenzene	0.0017	CNS symptoms	subchronic human occupational	3,000	NCEA	remove UF of 10 for subchronic to chronic	0.017	*NCEA (SRC TR-02-021/09-19-2002)*
1,2-Dichloroethane	0.0014	Gastrointestinal effects, liver/gallbladder effects	subchronic human occupational	3,000	NCEA	remove adjustment from 5 to 7 days[i], remove UF of 10 for subchronic to chronic	0.067	
1,3,5-Trimethylbenzene	0.0017	CNS symptoms	subchronic human occupational	3,000	NCEA	remove UF of 10 for subchronic to chronic	0.017	*NCEA (SRC TR-02-021/09-19-2002)*
2-Methylnaphthalene	none[c]	--	--	--	NCEA-S-1400 (April 2003)	insufficient information	--	
Benzene	0.009	Decreased lymphocyte count	subchronic human occupational	300	IRIS	no adjustment for subchronic warranted, primary study is already occupational	0.009	
Benzo(a)anthracene	none[e]	--	--	--	--	--	--	
Benzo(a)pyrene	none[e]	--	--	--	--	--	--	
Benzo(b)fluoranthene	none[e]	--	--	--	--	--	--	
Carbazole	none[e]	--	--	--	--	--	--	
Dibenz(a,h)anthracene	none[e]	--	--	--	--	--	--	
Dibenzofuran	0.004	NA	NA	NA	route-to-route extrapolation from the oral RfD[g]	--	--	
cis-1,2-Dichlorethene	none [a]	--	Inhalation hazards will not be quantified, uncertainties will be discussed.	--	--	insufficient information	--	
Ethylbenzene	0.29	Developmental toxicity	subchronic female rats	300	IRIS	Based on developmental effects during gestational exposures. No subchronic to chronic UF used; therefore, no subchronic value proposed.	0.29	
Indeno(1,2,3-cd)pyrene	none[e]	--	--	--	--	--	--	
Naphthalene	0.00086	Nasal effects	chronic mouse	3,000	IRIS	remove adjustment from 5 to 7 days[i]	0.0043	
n-Propylbenzene	0.097	Increased kidney weight	subchronic female rats	1,000	derived from ethylbenzene[h]	see description for ethylbenzene	0.097	
Toluene	0.11	Neurological effects	chronic human occupational	300	IRIS	no adjustment for subchronic warranted, primary study is already occupational	0.11	

Table 5-5 (Continued)
Noncarcinogenic Chronic and Subchronic Toxicity Criteria for the Chemicals of Potential Concern

Chemical	Chronic RfD (mg/kg-day)	Toxic Endpoint	Critical Study	Chronic RfD UF[b]	RfD Source	Adjustment from Chronic to Subchronic	Subchronic RfD (mg/kg-day)	EPA Subchronic Source[d]
Xylenes	0.029	Hyperactivity, decreased body weight, and increased mortality	subchronic male rats	300	IRIS	remove UF of 3 for subchronic to chronic	0.09	
DRO aliphatics	0.29	hepatic and hematological changes	NA	NA	ADEC 2000a	The petroleum fraction RfD values presented in ADEC guidance were not adjusted because of their status in State guidance and because of insufficient information on how those values were derived.	0.29	
DRO aromatics	0.06	Decreased body weight	NA	NA	ADEC 2000a		0.06	
GRO aliphatics	5.3	Neurotoxicity	NA	NA	ADEC 2000a		5.3	
GRO aromatics	0.11	Hepatotoxicity and nephrotoxicity	NA	NA	ADEC 2000a		0.11	
RRO aliphatics	none [a]	--	--	--	--	--	--	
RRO aromatics	none [a]	--	--	--	--	--	--	
Oral Exposures								
1,2,4-Trimethylbenzene	0.05	Decreased body weight	subchronic rats	3,000	NCEA	remove UF of 10 for subchronic to chronic	0.5	*NCEA (SRC TR-02-021/09-19-2002)*
1,2-Dichloroethane	0.03	Increase in organ weights	subchronic rat	1,000	NCEA	remove adjustment from 5 to 7 days[i]	0.037	
1,3,5-Trimethylbenzene	0.05	Decreased body weight	subchronic rats	3,000	NCEA	remove UF of 10 for subchronic to chronic	0.5	*NCEA (SRC TR-02-021/09-19-2002)*
2-Methylnaphthalene	0.009	pulmonary alveolar proteinosis	chronic male mice	1,000	NCEA-S-1400 (April 2003)	no adjustment for subchronic warranted because no UF applied for subchronic to chronic.	0.009	
Benzene	0.004	Decreased lymphocyte count	subchronic human occupational	300	IRIS	no adjustment for subchronic warranted, primary study is already occupational	0.004	
Benzo(a)anthracene	none[e]	--	--	--	--	--	--	
Benzo(a)pyrene	none[e]	--	--	--	--	--	--	
Benzo(b)fluoranthene	none[e]	--	--	--	--	--	--	
Carbazole	none[e]	--	--	--	--	--	--	
Dibenz(a,h)anthracene	none[e]	--	--	--	--	--	--	
Dibenzofuran	0.004	NA	NA	NA	NCEA	insufficient information	0.004	

Table 5-5 (Continued)
Noncarcinogenic Chronic and Subchronic Toxicity Criteria for the Chemicals of Potential Concern

Chemical	Chronic RfD (mg/kg-day)	Toxic Endpoint	Critical Study	Chronic RfD UF[b]	RfD Source	Adjustment from Chronic to Subchronic	Subchronic RfD (mg/kg-day)	EPA Subchronic Source[d]
cis-1,2-Dichlorethene	0.01	Hemoglobin production in rats	subchronic rats	3,000	NCEA	remove UF of 10 for subchronic to chronic	0.1	*NCEA (SRC TR-02-017/09-24-2002)*
Ethylbenzene	0.10	Liver and kidney toxicity	subchronic mouse	1,000	IRIS	remove UF of 10 for subchronic to chronic	1	
Indeno(1,2,3-cd)pyrene	none[e]	--	--	--	--	--	--	
Naphthalene	0.02	Decreased body weight	subchronic rat	3,000	IRIS	remove UF of 10 for subchronic to chronic	0.2	
n-Propylbenzene	0.04	increased kidney weight	subchronic female rats	3,000	NCEA (99-010/07-26-99)	remove UF of 3 for subchronic to chronic	0.12	
Toluene	0.2	Changes in liver and kidney weights	subchronic rats	1,000	IRIS	remove UF of 10 for subchronic to chronic	2	*HEAST*
Trichloroethene	0.0003	CNS, liver and endocrine effects	subchronic mouse	3,000	USEPA 2001c	NCEA used EPA's maximum UF of 3,000 but considered the data sufficiently equivocal that even 5,000 might be appropriate. Therefore, data set too uncertain to adjust for subchronic.	0.0003	
Xylenes	0.2	Hyperactivity, decreased body weight, and increased mortality	chronic rat	1,000	IRIS	remove adjustment from 5 to 7 days[i]	0.25	
DRO aliphatics	0.1	hepatic and hematological changes	NA	NA	ADEC 2000a	The petroleum fraction RfD values presented in ADEC guidance were not adjusted because of their status in State guidance and because of insufficient information on how those values were derived.	0.1	
DRO aromatics	0.04	Decreased body weight	NA	NA	ADEC 2000a		0.04	
GRO aliphatics	5.00	Neurotoxicity	NA	NA	ADEC 2000a		5.00	
GRO aromatics	0.2	Hepatotoxicity and nephrotoxicity	NA	NA	ADEC 2000a		0.2	
RRO aliphatics	2	Hepatotoxicity	NA	NA	ADEC 2000a		2	
RRO aromatics	0.3	Hepatotoxicity and nephrotoxicity	NA	NA	ADEC 2000a		0.3	

Table 5-5 (Continued)
Noncarcinogenic Chronic and Subchronic Toxicity Criteria for the Chemicals of Potential Concern

Notes

[a] The chemical was administered by gavage in the critical study upon which the oral RfD is based. Because of the "low" confidence rating of the oral RfD, no chronic inhalation value, based on route-to-route extrapolation, is proposed.

[b] EPA indicates that there are generally 5 areas of uncertainty where an application of a UF may be warranted:

1 variation between species (applied when extrapolating from animal to human)
2 variation within species (applied to account for differences in human response and sensitive subpopulations)
3 use of a subchronic study to evaluate chronic exposure
4 use of a LOAEL, rather than a NOAEL
5 deficiencies in the data base

[c] No inhalation criteria are available for this chemical and NCEA specifically states the route-to-route extrapolation from oral to inhalation is not recommended for this chemical (NCEA-S-1400, April 2003).

[d] If a subchronic value was obtained from a published source, rather than calculated, the source is listed in this column.

[e] This chemical is not a concern based on noncancer health effects. Therefore, there are no noncancer toxicity criteria for this chemical.

[f] No inhalation criteria are available for this chemical.

[g] Although route-to-route extrapolation is not generally recommended, no information is available to discount the use of the oral RfD in estimating inhalation exposures to dibenzofuran. In addition, as only the dermal and inhalation pathways are evaluated for groundwater exposures, if inhalation exposures were not evaluated, then exposures to dibenzofuran would not be quantified because there is no dermal permeability constant with which to evaluate dermal exposures in groundwater. Therefore, the oral RfD was also used as the inhalation RfD.

[h] NCEA derived the oral RfD for these chemicals by dividing the RfD for ethylbenzene by 3 to account for differences in toxicity between these structurally related chemicals. Therefore, this approach was used to estimate an inhalation RfC (ethylbenzene's inhalation RfC was divided by 3).

[i] EPA adjusted the 5-day per week exposure of the NOAEL to a 7-day NOAEL to account for continuous exposure (chronic), rather than subchronic, exposures.

CNS: central nervous system
DRO: diesel-range organics
EPA: Environmental Protection Agency
GRO: gasoline-range organics
HEAST: Health Effects Assessment Summary Table
IRIS: EPA's Integrated Risk Information System (on-line data base) (USEPA 2003a)
LOAEL: lowest-observed-adverse-effect-level
mg/kg-day: milligram per kilogram per day
NA: Not available
NCEA: EPA's National Center for Environmental Assessment
NOAEL: no-observed-adverse-effect-level
RfD: Reference Dose
RRO: residual-range organics
UF: Uncertainty factor

Table 5-6
Summary of EPCs and Total RME Risks and Hazards for the Building Worker

Chemicals of Potential Concern	EPC for Indoor Air[c] ug/L (ug/m^3)	Inhalation of Indoor Air	
		Hazard Index	Cancer Risk
1,2-Dichloroethane	5.4 (0.001)	0.00004	2E-09
cis-1,2-Dichloroethene	78.8 (0.063)	a	a
1,2,4-Trimethylbenzene	523 (0.41)	0.01	NA
1,3,5-Trimethylbenzene	182 (0.20)	0.007	NA
2-Methylnaphthalene	63 (0.0032)	a	NA
Benzene	72.2 (0.078)	0.0005	5E-08
Ethylbenzene	217 (0.263)	0.00005	2E-08
Naphthalene	316 (0.0175)	0.0001	NA
Toluene	193 (0.223)	0.0001	NA
Trichloroethylene	6.6 (0.012)	0.00006	1E-07
Xylenes	1,403 (1.56)	0.003	NA
Benzo(a)anthracene	d	b	b
Benzo(a)pyrene	d	b	b
Benzo(b)fluoranthene	d	b	b
Carbazole	d	b	b
Dibenzofuran	29.3 (2.4 x 10^{-8})	0.0000000003	NA
n-Propylbenzene	54 (0.076)	0.0005	NA
Non-TPH Total Hazard/Risk	--	0.03	2E-07
DRO (C9-C24 aliphatics)	d	b	b
DRO (C9-C24 aromatics)	d	b	b
GRO (C6-C8 aliphatics)	5,545 (275)	0.003	NA
GRO (C6-C8 aromatics)	3,960 (13.2)	0.007	NA
TPH Total Hazard/Risk	--	0.01	NA

Note:
NA - not applicable; these chemicals are not considered carcinogenic.
EPCs - exposure point concentrations
a - No toxicity criteria available to quantify exposures by this pathway.
b - Chemical is not considered volatile. Therefore, the inhalation pathway is incomplete.
c - The groundwater EPCs were used in the Johnson-Ettinger Model for Subsurface Vapor Intrusion to estimate indoor air concentrations. The resulting modeled indoor air concentrations are in parentheses after the groundwater EPCs.
d - The vapor intrusion pathway was not evaluated for these chemicals because this pathway is only complete for volatile chemicals.
DRO - diesel-range organics
GRO - gasoline-range organics
µg/L - micrograms per liter
µg/m^3 - micrograms per meter cubed
TPH - total petroleum hydrocarbons

Table 5-7
Summary of EPCs and RME Risks and Hazards for the Construction Worker From Soil

Chemicals of Potential Concern	EPC for Soil (mg/kg)	Total		Ingestion		Dermal		Inhalation	
		HI	CR	HI	CR	HI	CR	HI	CR
1,2,4-Trimethylbenzene	47	0.1	NA	0.0002	NA	NE	NA	0.1	NA
1,3,5-Trimethylbenzene	20	0.1	NA	0.0001	NA	NE	NA	0.1	NA
2-Methylnaphthalene	30.5	0.008	NA	0.008	NA	NE	NA	NE	NA
Benzene	3.2	0.10	4E-07	0.002	6E-09	NE	NE	0.09	4E-07
Ethylbenzene	9.4	0.004	7E-08	0.00002	NA	NE	NA	0.004	7E-08
Naphthalene	49	0.2	NA	0.0006	NA	NE	NA	0.2	NA
Xylenes	50.9	0.08	NA	0.0005	NA	NE	NA	0.08	NA
Benzo(a)anthracene	13.8	NA	5E-07	NA	4E-07	NA	1E-07	NA	2E-11
Benzo(a)pyrene	7.2	NA	3E-06	NA	2E-06	NA	7E-07	NA	9E-11
Benzo(b)fluoranthene	7.8	NA	3E-07	NA	2E-07	NA	8E-08	NA	1E-11
Dibenz(a,h)anthracene	1.8	NA	6E-07	NA	5E-07	NA	2E-07	NA	2E-11
Indeno(1,2,3-cd)pyrene	3.1	NA	1E-07	NA	8E-08	NA	3E-08	NA	4E-12
Non-TPH Total Hazard/Risk	--	0.6	5E-06	0.01	3E-06	NE	1E-06	0.5	4E-07
DRO (C9-C24 aliphatics)	4,438	0.1	NA	0.1	NA	0.03	NA	0.000004	NA
DRO (C9-C24 aromatics)	2,219	0.2	NA	0.1	NA	0.04	NA	0.00001	NA
GRO (C6-C8 aliphatics)	1,224	0.008	NA	0.0006	NA	NE	NA	0.08	NA
GRO (C6-C8 aromatics)	874	1	NA	0.01	NA	NE	NA	1	NA
RRO (C25-C36 aliphatic)	1,179	0.002	NA	0.001	NA	0.0004	NA	0.0000002	NA
RRO (C25-C36 aromatic)	393	0.04	NA	0.03	NA	0.01	NA	0.000004	NA
TPH Total Hazard/Risk	--	1	NA	0.3	NA	0.08	NA	1	NA

Notes:
CR - cancer risk
DRO - diesel-range organics
EPCs - exposure point concentrations
GRO - gasoline-range organics
HI - hazard index
mg/kg - milligram per kilogram
NA - not applicable; these chemicals are not considered carcinogenic or noncarcinogenic by this pathway.
NE - not evaluated; toxicity criteria are not available to quantify exposures by this pathway.
RRO - residual-range organics
TPH - total petroleum hydrocarbons

Table 5-8
Summary of EPCs and Total RME Risks and Hazards for the Construction Worker From Groundwater

Chemicals of Potential Concern	EPC for Groundwater (ug/L)	Total		Dermal		Inhalation	
		HI	CR	HI	CR	HI	CR
1,2-Dichloroethane	11.8	0.0005	4E-08	0.0003	1E-08	0.0003	2E-08
cis-1,2-Dichloroethene	58.2	0.0009	NA	b	NA	0.0009	NA
1,2,4-Trimethylbenzene	443	0.04	NA	b	NA	0.04	NA
1,3,5-Trimethylbenzene	151	0.01	NA	b	NA	0.01	NA
2-Methylnaphthalene	39.9	b	NA	b	NA	b	NA
Benzene	46.5	0.04	1E-07	0.03	1E-07	0.008	3E-08
Dibenzofuran	22.1	0.008	NA	b	NA	0.008	NA
Ethylbenzene	213.5	0.003	2E-08	0.002	NA	0.001	2E-08
Naphthalene	208	0.08	NA	0.01	NA	0.07	NA
Toluene	166	0.003	NA	0.0005	NA	0.002	NA
Trichloroethylene	11.8	0.09	3E-07	0.09	2E-07	0.0002	1E-07
Xylenes	1,299	0.08	NA	0.05	NA	0.02	NA
Benzo(a)anthracene	0.52	NA	5E-07	NA	5E-07	NA	a
Benzo(a)pyrene	0.4	NA	6E-06	NA	6E-06	NA	a
Benzo(b)fluoranthene	0.54	NA	8E-07	NA	8E-07	NA	a
Carbazole	19.4	b	NA	b	NA	a	NA
n-Propylbenzene	46	0.00001	NA	b	NA	0.00001	NA
Non-TPH Total Hazard/Risk	--	0.4	7E-06	0.2	7E-06	0.2	2E-07
DRO (C9-C24 aliphatics)	7,414	b	NA	b	NA	a	NA
DRO (C9-C24 aromatics)	3,707	b	NA	b	NA	a	NA
GRO (C6-C8 aliphatics)	5,462	0.002	NA	b	NA	0.002	NA
GRO (C6-C8 aromatics)	3,902	0.05	NA	b	NA	0.05	NA
TPH Total Hazard/Risk	--	0.05	NA	b	NA	0.05	NA

a - Chemical is not considered volatile; Pathway is only complete for volatile chemicals.
b - Toxicity criteria are not available to quantify exposures by this pathway.

Notes:
CR - cancer risk
DRO - diesel-range organics
EPCs - exposure point concentrations
GRO - gasoline-range organics
HI - hazard index
µg/L - micrograms per liter
NA - not applicable; these chemicals are not considered carcinogenic or noncarcinogenic by this pathway.
TPH - total petroleum hydrocarbons

Table 5-9
Summary of Total RME Risks and Hazards for the Construction Worker From Groundwater and Soil

	Total		Groundwater		Soil	
Chemicals of Potential Concern	**HI**	**CR**	**HI**	**CR**	**HI**	**CR**
1,2,4-Trimethylbenzene	0.1	NA	0.04	NA	0.1	NA
1,2-Dichloroethane	0.0005	4E-08	0.0005	4E-08	b	b
1,3,5-Trimethylbenzene	0.1	NA	0.01	NA	0.1	NA
2-Methylnaphthalene	0.008	NA	a	NA	0.008	NA
Benzene	0.2	5E-07	0.04	1E-07	0.1	4E-07
Benzo(a)anthracene	NA	1E-06	NA	5E-07	NA	5E-07
Benzo(a)pyrene	NA	8E-06	NA	6E-06	NA	3E-06
Benzo(b)fluoranthene	NA	1E-06	NA	8E-07	NA	3E-07
Carbazole	a	NA	a	NA	b	b
cis-1,2-Dichloroethene	0.001	NA	0.001	NA	b	b
Dibenz(a,h)anthracene	NA	6E-07	0.008	NA	NA	6E-07
Dibenzofuran	0.008	NA	0.008	NA	b	b
Ethylbenzene	0.008	9E-08	0.003	2E-08	0.004	7E-08
Indeno(1,2,3-cd)pyrene	NA	1E-07	b	b	NA	1E-07
Naphthalene	0.2	NA	0.1	NA	0.2	NA
n-Propylbenzene	0.00001	NA	0.00001	NA	b	b
Toluene	0.003	NA	0.003	NA	b	b
Trichloroethylene	0.09	3E-07	0.09	3E-07	b	b
Xylenes	0.2	NA	0.08	NA	0.08	NA
Non-TPH Total Hazard/Risk	1	1E-05	0.4	7E-06	0.6	5E-06
DRO (C9-C24 aliphatics)	0.1	NA	a	NA	0.1	NA
DRO (C9-C24 aromatics)	0.2	NA	a	NA	0.2	NA
GRO (C6-C8 aliphatics)	0.09	NA	0.002	NA	0.08	NA
GRO (C6-C8 aromatics)	1	NA	0.05	NA	1	NA
RRO (C25-C36 aliphatic)	0.002	NA	b	b	0.002	NA
RRO (C25-C36 aromatic)	0.04	NA	b	b	0.04	NA
TPH Total Hazard/Risk	**2**	NA	0.05	NA	1	NA

a - Toxicity criteria are not available to quantify exposures by this pathway.
b - Chemical was not selected as a COPC in this medium.

Notes:
Bolded values indicate exceedances over target health goals
COPC - chemical of potential concern
CR - cancer risk
DRO - diesel-range organics
GRO - gasoline-range organics
HI - hazard index
NA - not applicable; these chemicals are not considered carcinogenic or noncarcinogenic by this pathway.
RME - reasonable maximum exposure
RRO - residual-range organics
TPH - total petroleum hydrocarbons

Table 5-10
Results of the Screening Level Ecological Risk Assessment to Identify COPCs in Soil at NMCB Building Expanded Area

Chemical	Maximum Detected Concentration (mg/kg)	RBSC (mg/kg)	Hazard Quotient	Poses Potential Ecological Risk?	Rationale
1,3,5-Trimethylbenzene	0.047	280,000	0.00000017	**NO**	Site chemical concentration lower than RBSC
2-Methylnaphthalene	0.6	450	0.0013	**NO**	Site chemical concentration lower than RBSC
Anthracene	0.2	90	0.0022	**NO**	Site chemical concentration lower than RBSC
Benzene	80	240	0.33	**NO**	Site chemical concentration lower than RBSC
Benzo(a)anthracene	0.2	260	0.00077	**NO**	Site chemical concentration lower than RBSC
Benzo(a)pyrene	0.3	345	0.00087	**NO**	Site chemical concentration lower than RBSC
Benzo(b)fluoranthene	0.3	345	0.00087	**NO**	Site chemical concentration lower than RBSC
Benzo(g,h,i)perylene	0.4	490	0.00082	**NO**	Site chemical concentration lower than RBSC
Chrysene	1	260	0.0038	**NO**	Site chemical concentration lower than RBSC
Ethylbenzene	180	1,780	0.10	**NO**	Site chemical concentration lower than RBSC
Fluoranthene	0.6	145	0.0041	**NO**	Site chemical concentration lower than RBSC
Indeno(1,2,3-cd)pyrene	0.4	415	0.0010	**NO**	Site chemical concentration lower than RBSC
Naphthalene	0.5	4,240	0.0001	**NO**	Site chemical concentration lower than RBSC
Phenanthrene	0.2	90	0.0022	**NO**	Site chemical concentration lower than RBSC
Pyrene	0.4	140	0.0029	**NO**	Site chemical concentration lower than RBSC
Toluene	120	6,280	0.019	**NO**	Site chemical concentration lower than RBSC
Diesel range organics	43,000	20,100	2.1	**YES**	Site chemical concentration greater than RBSC
Gasoline range organics	27,000	1,840	15	**YES**	Site chemical concentration greater than RBSC
Residual range organics	580	>1,000,000	<0.00058	**NO**	Site chemical concentration lower than RBSC
Xylenes	920	3,780	0.24	**NO**	Site chemical concentration lower than RBSC

Notes:
COPC - chemical of potential concern
mg/kg - milligrams contaminant per kilogram of soil
RBSC - risk-based screening concentration

Table 5-11
Results of the Screening Level Ecological Risk Assessment to Identify COPCs in Marine Sediment at NMCB Building Expanded Area

Chemical	Maximum Detected Concentration (mg/kg)	RBSC (mg/kg)	Hazard Quotient	Poses Potential Ecological Risk?	Rationale
3- and 4-Methylphenol	0.9	0.67	1.34	**YES**	Site chemical concentration greater than RBSC
Anthracene	0.2	2.2	0.091	**NO**	Site chemical concentration lower than RBSC
Benzo(a)anthracene	0.4	1.1	0.36	**NO**	Site chemical concentration lower than RBSC
Benzo(a)pyrene	0.4	0.99	0.40	**NO**	Site chemical concentration lower than RBSC
Benzo(b)fluoranthene	0.5	2.3	0.22	**NO**	Site chemical concentration lower than RBSC
Benzo(g,h,i)perylene	0.2	0.31	0.65	**NO**	Site chemical concentration lower than RBSC
Benzo(k)fluoranthene	0.4	2.3	0.17	**NO**	Site chemical concentration lower than RBSC
Chrysene	0.8	1.1	0.73	**NO**	Site chemical concentration lower than RBSC
Fluoranthene	0.8	1.6	0.50	**NO**	Site chemical concentration lower than RBSC
Indeno(1,2,3-cd)pyrene	0.2	0.34	0.59	**NO**	Site chemical concentration lower than RBSC
Phenanthrene	0.2	1	0.20	**NO**	Site chemical concentration lower than RBSC
Phenol	0.15	0.42	0.36	**NO**	Site chemical concentration lower than RBSC
Pyrene	0.4	10	0.040	**NO**	Site chemical concentration lower than RBSC
Diesel range organics	95	90.6	1.05	**YES**	Site chemical concentration greater than RBSC

Notes:
COPC - chemical of potential concern
mg/kg - milligrams contaminant per kilogram of soil
RBSC - risk-based screening concentration

Table 5-12
Results of the Screening Level Ecological Risk Assessment to Identify COPCs in Marine Surface Water at NMCB Building Expanded Area

Chemical	Maximum Detected Concentration (µg/L)	RBSC (µg/L)	Hazard Quotient	Poses Potential Ecological Risk?	Rationale
Benzene	2	1,060	0.0019	**NO**	Site chemical concentration lower than RBSC
Ethylbenzene	3	6,400	0.00047	**NO**	Site chemical concentration lower than RBSC
Toluene	12	3,500	0.0034	**NO**	Site chemical concentration lower than RBSC
Gasoline range organics	67	114	0.59	**NO**	Site chemical concentration lower than RBSC
Xylenes	16	332	0.048	**NO**	Site chemical concentration lower than RBSC

Notes:
COPC - chemical of potential concern
µg/L - micrograms contaminant per liter of water
RBSC - risk-based screening concentration

Table 5-13
Results of the Baseline Ecological Risk Assessment to Identify COCs in Soil at NMCB Building Expanded Area

Chemical	Exposure Point Concentration (mg/kg)	RBSC (mg/kg)	Hazard Quotient	Poses Potential Ecological Risk?	Rationale
Diesel range organics	14,312	20,100	0.71	**NO**	Site chemical concentration less than RBSC
Gasoline range organics	7,261	1,840	3.9	**YES**	Site chemical concentration greater than RBSC

Notes:
COC - chemical of concern
mg/kg - milligrams contaminant per kilogram of soil
RBSC - risk-based screening concentration

Table 5-14
Results of the Baseline Ecological Risk Assessment to Identify COCs in Marine Sediment at NMCB Building Expanded Area

Chemical	Exposure Point Concentration (mg/kg)	RBSC (mg/kg)	Hazard Quotient	Poses Potential Ecological Risk?	Rationale
3- and 4-Methylphenol	0.36	0.67	0.5	**NO**	Site chemical concentration less than RBSC
Diesel range organics	51.3	90.6	0.6	**NO**	Site chemical concentration less than RBSC

Notes:
COC - chemical of concern
mg/kg - milligrams contaminant per kilogram of sediment
RBSC - risk-based screening concentration