DEW Line Cleanup Project - Phenols in Wastewater

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1. Wastewater and the DEW Line Cleanup Project

Many activities generate wastewater during the remediation phase of the Distant Early Warning (DEW) Line Cleanup (DLCU) project, including cleaning of barrels and POL storage tanks, washing heavy equipment and dewatering contaminated soil excavations.

Maximum allowable concentrations (MACs) of contaminants in wastewater are outlined in the site-specific contract specifications for each DEW Line site undergoing remediation. The specifications require that “wash water, meltwater collection, rinsewater resulting from the cleaning of fuel tanks and pipelines, and/or any other liquid effluent stream” must meet site-specific guidelines before being discharged to land (Section 01560). ESG staff collects a representative sample of wastewater and submit it for analysis to ensure that the MACs are not exceeded for contaminants listed in the specs. If the concentration of a parameter in the wastewater sample collected exceeds the MAC, the contractor is advised that the wastewater cannot be discharged in its current state.

Typically, the specifications require that “wash water, meltwater collection, rinsewater resulting from the cleaning of fuel tanks and pipelines, and/or any other liquid effluent stream” meets the following guidelines prior to its discharge to land (Section 01560.4.1):

Parameter	Maximum Allowable Concentration	Units
pH	6-9	pH units
Total arsenic (As)	0.100	mg/L
Dissolved cadmium (Cd)	0.010	mg/L
Total chromium (Cr)	0.100	mg/L
Dissolved cobalt (Co)	0.050	mg/L
Dissolved copper (Cu)	0.200	mg/L
Dissolved lead (Pb)	0.050	mg/L
Total mercury (Hg)	0.6	µg/L
Dissolved nickel (Ni)	0.200	mg/L
Total zinc (Zn)	1.000	mg/L
Oil & grease	None visible and/or 5	mg/L
PCBs	50* 5**	µg/L
Phenols	20	µg/L

*When discharging the water to barren land.
**When discharging the water to vegetated land.

The MACs included in the specifications for wastewater discharge during DLCU remediation activities are based on the following two documents: the 1991 CCME Interim Irrigation Criteria, used for nine inorganic elements (i.e. arsenic, cadmium, chromium, cobalt, copper, lead, mercury, nickel and zinc); and the 1976 Environment Canada "Guidelines for Effluent Quality and Wastewater Treatment at Federal Establishments", from which the MAC for phenols (i.e. 20 µg/L) was adopted (EC 1976).

A review of the analytical results of wastewater samples collected during DLCU project remediation work from 2002 to 2006 was conducted to determine whether the MAC for phenols currently included in the specifications is appropriate.

This document was prepared to provide:

- background information on phenols, including their chemical properties and common uses;
- an explanation of the fate of phenols in the environment, including degradation pathways, half-lives and toxicity;
- additional information on the prevalence of phenol concentrations above 0.020 mg/L in wastewater generated during remediation work undertaken with the DLCU project; and
- a summary of existing numerical criteria and guidelines for phenolic compounds in water and soil for several jurisdictions.

These factors, along with the unique nature of the work completed as part of the DLCU project were considered to determine the most appropriate course of action regarding the MAC for phenols in wastewater included as part of the specifications used by the contractors conducting remediation work at the DEW Line sites.

2. Background Information on Phenols

The term phenol is used to describe any of a group of related acidic compounds that are hydroxyl derivatives of aromatic hydrocarbons based on the chemical formula C_6H_5OH (BC, 2002). Phenols and phenolic substances are aromatic hydroxyl compounds classified as *monohydric* (e.g. phenols, cresols [methylphenols], xylenols [dimethylphenols]), *dihydric* (e.g. catechols [*o*-dihydroxybenzenes], resorcinols [*m*-dihydroxybenzenes]) or *polyhydric* (i.e. with three or more hydroxyl groups), depending on the number of hydroxyl groups attached to the aromatic benzene ring (CCME, 1999b). Synonyms for the base compound phenol include carbolic acid, hydroxy benzene, oxybenzene, phenic acid, phenyl hydroxide, phenylic acid and phenyl hydrate (CCME, 1999a). It is a white crystalline solid that melts at 43°C and boils at 182°C. Phenol is soluble in most organic solvents. The solubility in water is limited at room temperature; but above 68°C it becomes entirely water soluble. Phenol is moderately volatile at room temperature (WHO, 1994).

Although phenols occur naturally in decomposing organic materials, animal wastes (or manures) and coal tar, the majority of phenols in the environment are anthropogenic (i.e. of human origin) (CCME, 1999a). Phenols are a major byproduct of the pulp and paper, mineral (non-metallic), chemical, steel and metal and petroleum industries (CCME, 1999b). They are also used as disinfectants, preservatives, dyes, biocides, pesticides and medical and industrial organic chemicals (CCME, 1999b). Potential sources of phenols in the environment include the production and use of phenol and its products, especially phenolic resins and caprolactam, exhaust gases, residential wood burning and cigarette smoke (WHO, 1994). Major anthropogenic sources of phenols in aquatic environments are industrial effluents and domestic sewage (CCME, 1999b).

Phenolic compounds are also present as additives in fuel, including surfactants and antioxidants. Fuel was required to perform many tasks at the DEW Line sites, including operating the generators, running equipment and vehicles and refueling aircraft. As a result, these fuels likely represent one source of phenols at DEW Line sites.

3. Environmental Fate of Phenols

The impact or fate of a chemical in the environment is in part determined by how long it persists in the environment, and how it is changed by organisms and/or physical processes.

Typically, phenols do not persist in the environment. Their environmental half-lives are short, rarely as long as a month. Some phenolic compounds photodegrade, especially in air. The microbial half life is short, typically measured in days under aerobic (i.e. with oxygen present) conditions. Once the discharge ceases, environmental levels drop rapidly because of bacterial breakdown. The half life of phenols in fish is less than one day, and phenols do not bioaccumulate; hence, the presence of high phenol levels in fish tissues indicates chronic or current exposure (BC, 2002).

3.1. Biodegradation of Phenols

Phenols present in soil, sediment and water are biodegraded by bacteria rapidly (typically within two to five days) under both aerobic and anaerobic conditions (CCME, 1999a). The rate of biodegradation is determined by several factors including the phenol concentration, temperature, soil depth, nutrient presence and concentration, presence of other contaminants and number of bacteria (WHO, 1994). Studies suggest rapid aerobic degradation of phenol in sewage (typically greater than 90 percent with a retention time of eight hours); complete degradation of phenols in soil in two to five days; complete biodegradation of phenols in freshwater in less than one day; and 50 percent biodegradation in seawater in nine days (WHO, 1994).

3.2. Phenols in Water

Phenols present in water may in the presence of sunlight (under experimental conditions) be oxidized to carbon dioxide; react with nitrate ions to form dihydroxybenzenes, nitrophenols, nitrosophenol and nitroquinone; react with nitrous acid to form cyanide; and form chlorophenols in chlorinated drinking water (WHO, 1994). The Canadian Council of Ministers of the Environment (CCME, 1999b) reports that photo-oxidation, oxidation and microbial degradation are expected to be the major attenuation processes of phenols in the aquatic environment. The mean half life of phenols in water is 55 hours. (CCME, 1999b) A major biotic process for the removal of phenols from the water column is microbial degradation, with the complete biodegradation of phenols in as little as 70 hours (CCME, 1999b).

3.3. Phenols in Soil

A report by the World Health Organization (WHO) in 1994 suggested that no data had been found indicating the presence of phenols in soil because of the speed of their biodegradation, volatilization or transport to groundwater and/or air. Phenols in soil are readily adsorbed to clays, but sorption to organic matter has been found to be low (CCME, 1999a). Since phenols are soluble in water and moderately volatile, they are mobile in soils and may leach easily, potentially contaminating groundwater (CCME, 1999a). In areas with low hydraulic conductivity, phenolic compounds are readily degraded by soil microflora, with a half life of one to six days (CCME, 1999b).

3.4. Phenols in Biota

The WHO (1994) report includes the results of studies that suggest that phenols may be taken up and stored in the cuticle membranes of various plants, including the fruits of tomato and green pepper plants, rubber leaves and soybean roots. However, bioaccumulation of phenols is not expected to be significant because of its low octanol-water partition coefficient.

3.5. Toxicity of Phenols in Terrestrial and Aquatic Animals

In a 1994 report, the WHO reports that phenols have moderately acute toxicity for animals with the oral LD_{50} ranging from 300 to 600 mg phenol/kg body weight, and the LC_{50}

for rats by inhalation is more than 900 mg phenol/m^3 (WHO, 1994). The most important effects reported in short-term animal studies were neurotoxicity, liver and kidney damage, respiratory effects and growth retardation (WHO, 1994). A 1979 study by Kao and Bridges reported that “following oral administration of phenol (25 mg/kg body weight) in sheep and pigs, a high proportion of the dose is rapidly excreted through urine (in three hours, 85 percent in sheep and 84 percent in pigs was recovered). Less than 0.5 percent was excreted in feces, suggesting that a considerable amount of phenol was absorbed.” (CCME, 1999a) The 1994 WHO report indicates that there have been no long-term general toxicity studies in animals (WHO, 1994).

Data summarized in the WHO report suggest that phenol is toxic to aquatic organisms with the lowest estimated LC_{50} or EC_{50} values for crustaceans and fish lying between 3 and 7 mg/L (WHO, 1994). Thus, fish (both freshwater and marine) were found to be the most sensitive species although the WHO concludes that phenol is not expected to significantly bioaccumulate in aquatic organisms (WHO, 1994).

The 1994 WHO report suggests that the limited exposure dataset for phenols does not allow any conclusions to be made regarding the level of risk to aquatic or terrestrial ecosystems. The report continues that for aquatic organisms, “it is reasonable to assume that these organisms may be at risk in any surface or sea water subject to phenol contamination, in spite of the rapid degradation of this compound.” (WHO, 1994)

4. Review of Phenol Concentrations in DLCU Project Wastewater Samples

A review was conducted of wastewater samples taken from DEW Line sites between 2002 and 2006 that exceeded the MACs. There were 76 wastewater samples from DEW Line sites undergoing cleanup activities with contaminant concentrations that exceeded their respective MACs for one or more parameters in that time. Of these samples, 16 (or 21 percent) contained phenols at a concentration above 0.020 mg/L. Thirteen of these 16 samples (81 percent) were collected from water in tanks, two were collected from contaminated soil excavations and one from the wastewater generated by the mobile lab at the DYE-M site, Cape Dyer, NU.

Depending on the site, the MAC for oil and grease is either 5 mg/L or ‘no visible sheen’. In all cases in which wastewater samples were analyzed for phenols and oil and grease (8 samples), the concentrations of both phenols and oil and grease exceeded their MACs of 0.020 mg/L and 5 mg/L, respectively. For sites where the oil and grease criterion was ‘no visible sheen’, six of eight samples (or 75 percent) that exceeded the phenol criterion of 0.020 mg/L were also observed to have a ‘visible sheen’.

Examining the data from a geographic perspective, 50 percent of the wastewater samples with phenol concentrations above 0.020 mg/L (eight of the 16) were collected at Cape Dyer, NU (DYE-M), with seven collected at the Lower Site Tank Farm and one from the mobile lab. Seven samples were collected from wastewater at Hall Beach, NU (FOX-M), with two collected from a contaminated soil excavation used to pool consolidated water from the barrel processing area and five from tanks. One sample of rinse water from barrel washing activities at Pelly Bay/Kugaaruk, NU (CAM-4) contained phenols above 0.020 mg/L.

The data on the sources of wastewater with excess phenols, along with the presence of elevated oil and grease concentrations in all wastewater samples with phenol concentrations above 0.020 mg/L, suggests that fuel at DEW Line sites is a probable source of the contamination. Typically, petroleum hydrocarbon (PHC) products were stored in large tanks on the sites and used to generate power as well as to fuel equipment and aircraft. Phenolic compounds are present in varying concentrations in surfactants and antioxidants added to the fuel during its manufacture (Chevron, 2006; Exxon, 2005).

Scientific studies by the CCME and province of British Columbia referenced earlier in this document suggest that the half life of phenols in water and soil is relatively short. The CCME reports that the mean half life of phenols in water is 55 hours (CCME, 1999b). Furthermore, these studies suggest that the main means of degradation of phenols in the environment are photo-oxidation, oxidation and microbial degradation.

Wastewater contained in tanks on the DEW Line accounted for most of the phenol MAC excesses. The phenol concentrations of these samples ranged from 0.030-2.440 mg/L, with an average concentration of 0.954 mg/L. The water in these tanks was not exposed to sunlight (therefore the phenols could not photodegrade), nor did it likely contain the microorganisms required for biodegradation (a biocide is added to the fuel to limit microbial growth and ensure proper performance of the fuel). Furthermore, wastewater samples are typically collected directly from tanks using the valve located near the bottom, which removes the possibility of exposure of the wastewater sample to sun or other microbes.

Comparison of the mean concentration of phenols in wastewater samples that exceed the MAC outlined in the specs for the DLCU (0.954 mg/L or 0.954 ppm) with toxicity data suggests that maximum phenol concentration measured (2.44 mg/L or 2.44 ppm) is still below the LC_{50} for freshwater fish and crustaceans (3 -7 mg/L), the oral LD_{50} for rodents (300-600 ppm) and the dermal LD_{50} for rats and rodents (670-1,400 ppm) (WHO, 1994). This comparison of toxicity data, coupled with the brief duration of the discharges (typically one-time events), suggests that these discharges have a limited impact on the immediate area into which they are discharged. In addition, discharge is to the ground at least 30 m from natural drainage courses and at least 100 m from fish-bearing waters, thereby minimizing any impact on the most sensitive receptor (fish).

5. Phenols in Wastewater – The Way Ahead for the DLCU Project

Currently, MACs for contaminants in wastewater are outlined in the site-specific specifications for each DEW Line site being remediated. A maximum allowable concentration of 20 μg/L (0.020 mg/L) is used for phenols in wastewater.

The review of the specific circumstances where the MAC has been exceeded, in conjunction with a review of information on the actual environmental fate and impact of phenols, suggests that the appropriateness of a numerical value of 0.020 mg/L for the DLCU Project needs evaluation.

5.1. Current Guideline Values for Phenols

To determine whether the current MAC in the DLCU cleanup specifications is suitable, guideline values from several jurisdictions were examined for permissible concentrations of phenolic compounds in effluent, water and soil.

5.1.1. Phenols in Effluent/Water

Effluent is defined as “any wastewater discharged directly or indirectly to surface waters or to any storm sewer, and the runoff from land used for disposal of wastewater sludges, spray irrigation, or other wastes, but does not otherwise include land runoffs” (EC, 1976).

Table 1 summarizes effluent objectives for phenols from several federal and territorial guidelines:

Table 1: Summary of Guideline Values for Phenol Concentration in Effluents

	Effluent Objective
Northwest Territories Standards for Process Effluent Discharged to Municipal Sewage Systems – phenolic compounds[1]	1 mg/L
Northwest Territories Standards for Non-point Source Discharges[A] – phenolic compounds[1]	0.02 mg/L
Territory of Nunavut Standards for Process Effluent Discharged to Municipal Sewage Systems – phenolic compounds[2]	1 mg/L
Territory of Nunavut Standards for Non-point Sources Discharges – phenolic compounds[2]	0.02 mg/L
Guidelines for the Discharge of Treated Municipal Wastewater in the Northwest Territories[3]	-
Environment Canada Guidelines for Effluent Quality and Wastewater Treatment at Federal Establishments[4]	0.02 mg/L
Federal Discharge Guidelines for Wastewater at Point of Discharge[5] – monohydric and dihydric	0.02 mg/L
Pollution Prevention Abatement Handbook[6]	0.5–1.0 mg/L

A – A non-point source discharge is defined as a non-specific or diffuse source of effluent entering the environment. This includes run off from areas such as compounds, storage sites and storage yards.(NWT, 1998)
1 – NWT, 1998
2 – Nunavut, 2002.
3 – NWTWB, 1992. (Guidelines for the Discharge of Treated Municipal Wastewater in the Northwest Territories does not contain a numerical value for a permitted concentration of phenols in effluent.)
4 – EC, 1976.
5 – EC, 2000.
6 – WBG, 1998.

The 1998 'Guideline for Industrial Waste Discharges in the NWT" and the 2002 Nunavut 'Environmental Guideline for Industrial Waste Discharges' address the discharge of effluent from industrial operations (NWT, 1998 and Nunavut, 2002). These guidelines are intended for the discharge of waste into municipal systems as well as non-point source discharges from industrial sources to storm sewers, ditches and other areas for containment, routing and disposal (NWT, 1998 and Nunavut, 2002). The effluent quality objective for wastewater being discharged to municipal treatment systems (1 mg/L) is not applicable as DLCU-generated wastewater does not enter the municipal treatment stream and is not discharged continuously.

Wastewater generated and disposed of during DLCU remediation activities could be described as a non-point source discharge, and the 0.02 mg/L value utilized by Nunavut and the NWT (NWT, 1998 and Nunavut, 2002) would be applicable if this effluent was discharged either directly to a body of water or to a drainage course or ditch that would preferentially route this effluent to a water body. At DEW Line sites, however, the specifications stipulate that wastewater be discharged to land at least 30 m from natural drainage courses and at least 100 m from fish-bearing waters, reducing the risk to water-based receptors even further (Section 01560). A wastewater discharge event at DEW Line sites more closely approximates a soil irrigation process, than a non-point source discharge event as defined in the Nunavut and NWT guidance documents.

The 1976 ‘Guidelines for Effluent Quality and Wastewater Treatment at Federal Establishments’ specifies that wastewater be treated so that effluents discharged be of minimum quality at the point of discharge to the receiving water body (EC, 1976). The intent of Environment Canada’s document entitled ‘An Approach for Assessing and Managing Wastewater Effluent Quality for Federal Establishments’ is to set out “a consistent approach to managing and monitoring wastewater effluents from federal facilities to ensure that receiving environments are not directly or indirectly adversely impacted” (EC, 2000). This document includes a value for phenols in wastewater at the point of discharge and outlines a framework under which “wastewater management and monitoring requirements are determined by the nature of the operations at the facility and the receiving water into which wastewater is discharged” (EC, 2000). Both of the Environment Canada documents specify that the phenol concentration in the wastewater not exceed a concentration of 0.02 mg/L at the point of discharge to the receiving water body. Again, since wastewater generated during cleanup activities on the DEW Line is discharged to land rather than a water body, the effluent quality objective stated in these two documents is not directly applicable to the DLCU Project.

The World Bank Group, in collaboration with United Nations Industrial Development Organization and United Nations Environment Program, publishes the Pollution Prevention Abatement Handbook, which includes guidelines for phenols in effluent discharge between 0.5 – 1.0 g/L. (Worldbank, 1998) They are designed to protect human health, reduce discharge of pollutants into the environment, follow regulatory trends, and promote good industrial practices. These criteria are developed with the assumption that there will be continuous industrial (i.e. high volume) discharge over periods of years. The DLCU Project, however, will only be periodically discharging very small volumes for a finite period of time.

Although, the wastewater generated and discharged during remediation work at the DEW Line sites can be defined as effluent, none of the effluent quality objectives listed in Table 1 above accurately describes the discharge scenario encountered during DEW Line Cleanup activities and therefore none of the guidelines listed are completely appropriate for evaluation of wastewater.

The CCME states that "**water quality objectives** should protect the existing and potential uses of a water body" (CCME 1991). Most water quality guideline values are designed to protect the intended use of the water as habitat for aquatic life (either freshwater or marine), for agricultural purposes (i.e. irrigation water or for watering of livestock) and/or for drinking water. Generally, toxicity data is used to determine these threshold values. A summary of guideline values for different phenol compounds in water in various jurisdictions is presented in Table 2 below.

Table 2: Summary of Guideline Values for Phenol Concentration in Waters

	Guideline Value for Phenol Concentration in Water				
	Protection of Aquatic Life		*Protection of Agricultural Water Uses*[A]		*Drinking Water*
	Freshwater	*Marine*	*Irrigation*	*Livestock*	
Canadian Drinking Water Quality Standards[1]	-	-	-	-	No recommended guideline
CCME Water Quality Guidelines[2,] - mono- and dihydric phenols	0.004 mg/L	-	-	0.002 mg/L	-
Yukon Territory[3] - non-chlorinated phenols (total)	0.010 mg/L	-	-	-	-

A – The 2005 CCME Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses includes a guideline value for phenols in livestock water but not for irrigation water (CCME 2005).

1 - The guideline value for phenols as reported in the Canadian Drinking Water Quality Standards is no longer required and has been archived. Health Canada reports that "guidelines are archived for parameters which are no longer found in Canadian drinking water supplies at levels that could pose a risk to human health" (Health Canada 2006). The Canadian Drinking Water Quality Standards include a guideline value of 0.060 mg/L for pentachlorophenol (Health Canada 2006).

2 – CCME, 2006b.

3 – YT, 2002b.

The Canadian Water Quality Guidelines for the Protection of Aquatic Life "help to protect all plants and animals that live in our lakes, rivers, and oceans by establishing acceptable levels for substances or conditions that affect water quality such as toxic chemicals, temperature and acidity" (www.ec.gc.ca). A guideline value for phenols for freshwater was established whereas no value was established for marine waters. The contract specifications for cleanup work at the DEW Line sites, state that wastewater generated on-site must be disposed of a minimum of 30 m from waterways and/or 100 m from water bodies known to contain fish. Thus, the likelihood of the discharged wastewater impacting aquatic life is minimal and as a result these CCME guideline values for phenols are not applicable to the DEW Line Cleanup Project.

"Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses help to protect sensitive crop species that may be exposed to toxic substances such as pesticides in irrigation water. They are based on maximum irrigation rates and the sensitivity of crops to pollutants. Similarly, the Canadian Water Quality Guidelines for Livestock Water are based on how livestock are affected by their drinking water and whether certain substances, such as toxic chemicals, accumulate in the animals' bodies." (www.ec.gc.ca) Both the irrigation and livestock guidelines are based on the toxicological data as well as information on the environmental fate and behaviour of the chemical (CCME 1993). The guidelines contain a value for phenols in water used for livestock but not for irrigation purposes. Irrigation criteria, if they existed, would be a more applicable choice, as DCLU-generated wastewater is discharged to land, which is typically vegetated. The water would not be consumed by wildlife in the area.

"The Yukon *Contaminated Sites Regulation* (CSR) contains standards to ensure that water at a site, or which flows from a site, is suitable for direct use and is clean enough to protect water uses on adjacent properties." (www.environmentyukon.gov.yk.ca). Similar to the CCME guidelines the aquatic life standards apply to either fresh or marine water that is used as habitat, irrigation water standards apply to water used to produce. A range of acceptable concentrations of specific phenolic compounds is included to ensure protection of aquatic life to take into account the varying conditions of the water including pH, temperature and compound isomer with the water assumed to be at 20^{o}C (YT 1996). The livestock guidelines for the various phenolic compounds and drinking water guidelines are in place "to protect against taste and odour concerns" (YT 1996). As stated previously, neither the aquatic life guidelines, the livestock watering guidelines nor the drinking water guidelines can be readily applied to the wastewater discharge scenario at the DEW Line sites.

Other MACs included in the contract specifications are based on the CCME water quality guidelines for irrigation water but this document does not include a value for phenols. Neither the CCME guidelines for the protection of freshwater aquatic life nor the CCME guidelines for the protection of the agricultural use of water for livestock watering are applicable to the land-based discharge of wastewater generated during remediation work on the DEW Line sites. Furthermore, guideline values for phenols included in the Yukon Territory's contaminated site regulation for similar situations do not apply for the reasons stated above. A guideline value for phenols in water used for irrigation purposes would be most protective of terrestrial ecosystem since wastewater discharged by DLCU activities could be used by terrestrial plants in the area to which it is discharged but neither the CCME nor the Yukon Territory guidelines contain this value.

5.2. Wastewater from the DLCU-A Summary and Recommendations

The potential impact of phenols entering the environment via wastewater discharged during DLCU remediation work is limited, as discharge typically occurs only a few times a season for less than five consecutive years. Discharge criteria for wastewater listed in the previous section specify that the concentration of the specific analyte in the effluent stream must fall below a certain numerical value at the point of discharge to the receiving water body. At DEW Line sites the specifications stipulate that wastewater be discharged to land at least 30 m from natural drainage courses and at least 100 m from fish-bearing waters (Section 01560). Thus, applying a water-based discharge criteria to the land-based effluent discharge that occurs as part of the DLCU is a conservative approach, since the most sensitive receptor to phenols are aquatic organisms.

The maximum phenol concentration in wastewater previously measured at a DEW Line site (2.44 mg/L or 2.44 ppm) falls below the LC_{50} for freshwater fish and crustaceans (3-7 mg/L), the oral LD_{50} for rodents (300-600 ppm) and the dermal LD_{50} for rats and other rodents (670-1400 ppm) (WHO, 1994). Studies have also shown that phenols in the soil rapidly biodegrade under both aerobic and anaerobic conditions (CCME, 1999b). Any phenol that enters the soil via the discharge event would have minimal impact on organisms in this media. Volatilization, adsorption and biodegradation processes significantly reduce the wastewater phenol concentration by the time it would reach any receiving water body.

The review of phenols in wastewater produced as part of the DLCU also indicated that when phenols are present at concentrations above 0.020 mg/L, oil and grease concentrations are above the MAC of 5 mg/L or visible sheen. Because the oil and grease concentration in the wastewater is above the MAC, the water must be treated prior to discharge. Typically, when this water was passed through an activated carbon filter, and/or absorbent material was used to remove a visible sheen, a decrease in phenol concentrations to below the MAC of 0.020 mg/L was also observed.

These factors indicate that currently there are no applicable numeric criteria for phenols, considering the unique nature of the work completed as part of the DLCU project. The contractual requirement to discharge wastewater to land at least 30 m from natural drainage courses and at least 100 m from fish-bearing waters can be considered protective to plant, fish, mammal and human receptors.

Therefore, the Environmental Sciences Group recommends that phenols be removed from the list of parameters for which wastewater generated by DLCU remediation work be analyzed, provided that the MAC for oil and grease continues to be implemented.

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