SNC·LAVALIN

LEMON CREEK SPILL RESPONSE ENVIRONMENTAL IMPACT ASSESSMENT

Prepared For:

Executive Flight Centre Fuel Services Ltd.
BC Ministry of Environment

Reviewed By:

Tara Siemens Kennedy, M.E.T, PChem., CSAP
Senior Project Specialist, Environmental Toxicology

Patricia Carmichael, M.Sc., P. Geo., CSAP
Senior Project Hydrogeologist

Cory Bettles, M.Sc., R.P.Bio., CFP
Practice Lead, Aquatic Biodiversity

ENVIRONMENT & WATER

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SNC-LAVALIN INC.
8648 Commerce Court
Burnaby, British Columbia
Canada V5A 4N6
Tel.: 604-515-5151
Fax: 604-515-5150

RECOMMENDED CITATION

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EXECUTIVE SUMMARY

Introduction

On July 26, 2013, at approximately 16:00 Pacific Time, an Executive Flight Centre Fuel Services Inc. (EFC) owned and operated tanker truck hauling Jet A-1 fuel on the Lemon Creek Forest Service Road rolled down an embankment into Lemon Creek, which resulted in a spill (the incident). A confirmed total of approximately 32,850 L of Jet A-1 fuel (the product) was discharged to Lemon Creek. Lemon Creek flows in a west-northwesterly direction to the Slocan River. The spill release point on Lemon Creek was approximately 4 km from the confluence with the Slocan River (the incident site).

The Environment & Water business unit of SNC-Lavalin Inc. (SNC-Lavalin) was retained by EFC as Environmental Consultant for the incident. Part of the scope of work included the development of the Spill Response Environmental Impact Assessment (EIA) document, requested by the Kootenay-Boundary and Okanagan Regional Environmental Protection Division of the BC Ministry of Environment (MoE).

SNC-Lavalin assessed the following environmental aspects, following the incident:

- Air quality (results appended);
- Incident site soil;
- Surface water;
- Water supply;
- Sediment;
- Agricultural soil;
- Agricultural vegetation;
- Fisheries and aquatic resources; and
- Terrestrial and wildlife resources.

EFC engaged Quantum Murray LP (QMLP) to contain, recover, and clean-up the residual product. Polaris Applied Sciences Ltd. (Polaris) was retained by EFC to conduct the Shoreline Clean-up Assessment Technique program, which was used to prioritize and focus remedial activities in order to achieve the MoE shoreline treatment endpoints.

Product Description

Jet A-1 fuel is a liquid mixture primarily composed of kerosene, which is made up of a mixture of hydrocarbons. Hydrocarbons potentially associated with the product released into Lemon Creek include: ethylbenzene, toluene, xylenes, trimethylbenzene, and polycyclic aromatic hydrocarbons, including naphthalene, 2-methylnaphthalene, acenaphthene, fluorene, phenanthrene and fluoranthene. In addition to these individual parameters, the following general hydrocarbon compounds are associated with Jet A-1 fuel: volatile petroleum hydrocarbons (VPH) (C_6-C_{10}); light extractable petroleum hydrocarbons (LEPH) (C_{10}-C_{19}); petroleum hydrocarbon Fraction 1 (F1) (C_6-C_{10}) and PHC Fraction 2 (F2) (C_6-C_{16}). Based on current analytical results of soil, sediment and surface water samples collected along Lemon Creek and the Slocan River, benzene was not detected.

The components of Jet A-1 fuel are generally highly volatile, relatively insoluble and less dense than water; therefore, following a spill, most of its components disperse on the surface of the water and tend to volatilize quickly. Some components would accumulate in slower moving reaches of surface water and settle into sediments. The components of the product can exhibit moderate to rapid biodegradation. Plant uptake and bioaccumulation in the aquatic food web are not considered to be a significant fate processes for the product. Kerosene-based jet fuels are categorized as non-persistent oil.

Bedrock was observed and encountered on the south side (below the road down to the creek) and the bottom of Lemon Creek during the soil remediation excavation; therefore there was no opportunity for a large mass of the product to migrate into the underlying bedrock and impact groundwater beneath the creek. Due to its volatility, it is predicted that 30% to 35% of the volume released would volatilize in one day and 100% would have volatilized in 9 to 12 days. Residence times in the atmosphere would be relatively short due to indirect photo degradation reactions. In water, hydrolysis is not likely to be an important degradation process.

Product Recovery

A confirmed total of 2,150 L of product was recovered from the incident site with a vacuum truck. A remedial excavation of the incident site resulted in approximately 1,600 tonnes of soil being removed. At the time of this report, an estimated 20,000 kg of contaminated absorbent material and vegetation was contained and removed from the area. It is our understanding (at the date of this report) that QMLP continues to collect contaminated absorbent material from specific areas influenced by the incident. All waste was disposed of at licensed waste facilities.

Contaminant Concentration Characterization

The contaminants of concern were assessed by analysis of soil, groundwater, surface water, sediment, and vegetation, which were compared to the standards or guidelines contained in provincial regulations.

SNC-Lavalin personnel collected 384 samples between July 28 and August 8, 2013. The total number of samples analyzed by medium was as follows:

- 64 soil samples;
- 199 surface water samples;
- 8 water supply samples (drilled or dug wells etc);
- 76 sediment samples;
- 1 sample of the product recovered from Lemon Creek in a vacuum truck;
- 19 agricultural soil samples; and
- 17 vegetation samples.

Data collected to date indicates that current concentrations of parameters associated with the Jet A-1 fuel are less than the laboratory detection limit in surface water and groundwater (from select domestic and agricultural wells), and that concentrations of the product-associated parameters are less than the applicable provincial standards in sediment, as well as in soil from the incident site. Concentrations of parameters associated with the product were mainly non-detect with all concentrations well below the applicable provincial standards in agricultural soil. Concentrations in agricultural vegetation samples were either below laboratory detection limits or similar to the concentrations found in background vegetation samples.

Fisheries and Aquatic Resources Impact Assessment

In total, 261 fish were recovered from, and vast numbers of deceased benthic invertebrates were observed, in Lemon Creek and Slocan River. Of the fish mortalities collected, the majority were Mountain Whitefish (n=155), followed by Torrent Sculpin (n=26), and Rainbow Trout (n=19). The number of deceased fish is likely higher than the numbers physically removed by crews deployed during the emergency response due to: the fast-flowing waters of Lemon Creek and Slocan River, the large extent of area to cover (longitudinal and lateral habitats on Lemon Creek and Slocan River) as well as the delayed timing (first couple of days immediately post-spill) to commence fish salvage protocols. Length-frequency data for the three most common fish species collected during the fish carcass salvages suggest that the juvenile life-stage were the most affected based solely on deceased specimens collected in the field. A greater percentage of 'older' (i.e., > 2+) sculpins were affected relative to salmonid and cyprinid species. Of the deceased fish specimens collected, a small number of Species at Risk Act (SARA)-listed species (Umatilla Dace: n=3; Shorthead Sculpin: n=2; Shorthead/Columbia Scuplin: n=1) made up approximately 2% of the collected total. As Shorthead Sculpin and Umatilla Dace appear to be locally abundant, impacts to populations of these species are likely small. Impacts to populations of Columbia Sculpin, which although low, may be stable in tributaries such as the Slocan River, is problematic to quantify.

Terrestrial and Wildlife Resources Impact Assessment

Fourteen deceased wildlife specimens were collected from the study area and submitted for necropsy analysis and the results confirmed a Jet-A1 fuel-related mortality for two songbird species (northern waterthrush and American dipper). The other twelve specimens (nine bird species and three non-avian species) showed no visual or olfactory evidence of fuel exposure. For three of the nine bird species and the three non-avian species, the advanced state of decomposition of the carcasses prevented the determination of cause of death. Where determined, non-fuel related causes of death included trauma, drowning and nematode parasites. Based on these results, it is likely that twelve of the fourteen specimens died of causes unrelated to the spill.

Monitoring Phase Requirements

Water and Sediment Quality Monitoring Programs have been developed to monitor, assess and document the distribution and concentrations of residual contaminants associated with the incident in water and sediment following flushing/clean-up efforts completed as part of the post-spill response.

A Biological Monitoring Program (EMP) has been developed to ensure that the potential short-term, intermediate and prolonged effects to human and environmental health are effectively assessed, mitigated if necessary, and monitored for recovery.

Although it is clear fish mortalities were the result of acute toxic exposure to Jet A-1 fuel, any chronic effects (presumed low) or the magnitude of the acute impact is unknown. Thus, post-incident monitoring of key aquatic indicators is proposed to evaluate the magnitude of impact, identify any potential chronic effects, and assess aquatic health recovery based on firm endpoints.

Necropsies will continue to be performed on terrestrial wildlife specimens collected during the emergency response phase. Further, field observations for other deceased wildlife specimens will continue through the implementation of all biological and physical field monitoring programs.

Conclusions

All shoreline treatment endpoints outlined by MoE have been met in all waterways with the exception of the lower section of Lemon Creek, which continues to be under assessment. Any residual product in Slocan River is not recoverable with the available technology and will naturally attenuate over time.

Post-incident monitoring programs have been developed and will be used to confirm the results presented in this report and to ensure effective assessment of any short, medium, and long-term effects.

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DEFINED TERMS

°C – degree Celsius

AL – CSR Agricultural land use

ALS – ALS Canada Ltd., Burnaby, BC

AMEC – AMEC Environment and Infrastructure

API – American Petroleum Institute

atm-m^3/mol – atmospheres by cubic metre per mole

ATSDR – Agency for Toxic Substances and Disease Registry

AW – Aquatic Life

BAF – Bioaccumulation Factor

BC – British Columbia

BCF – Bioconcentration Factor

BCWQG – *British Columbia Approved Water Quality Guidelines (Criteria), updated 2013, includes [A Compendium of Working Water Quality Guidelines for BC, 2006]* (BCWQG). British Columbia Ministry of Environment (MoE), April 2013.

BETX – benzene, ethylbenzene, toluene, and xylenes

BF – backfill

BG – background

bgs – below ground surface

CALA – Canadian Association for Laboratory Accreditation Inc.

CANUTEC – Canadian Transport Emergency Centre

CCME – Canadian Council of Ministers of the Environment

CDC – Conservation Data Centre

CEQG – Canadian Environmental Quality Guidelines

CL – CSR Commercial land use

COSEWIC – Committee on the Status of Endangered Wildlife in Canada

CSR – *Contaminated Sites Regulation*, B.C. Reg. 375/96, including amendments up to B.C. Reg. 6/2013

CWS – Canada Wide Standards

DW – Drinking Water

DEFINED TERMS (Cont'd)

dw1 – dry warm

EC – Environment Canada

EERO – MoE Environmental Emergency Response Officer

EFC – Executive Flight Centre Fuel Services Inc.

EIA – Environmental Impact Assessment

EPA – U.S. Environmental Protection Agency

EPH – extractable petroleum hydrocarbons

$EPHw_{10\text{-}19}$ – extractable petroleum hydrocarbons in water

EXC – Excavation

F1 – PHC fraction C_6-C_{10}

F2 – PHC fraction $C_{>10}$-C_{16}

F3 – PHC fraction $C_{>16}$-C_{34}

F4 – PHC fraction $C_{>34}$-C_{50}

FR – farm

FRP – facility response plan

FSR – Forest Service Road

GPS – Global Positioning System

GR/G – grass

HEPH – heavy extractable petroleum hydrocarbons

hPa – hectopascal

ICH – Interior Cedar – Hemlock

ID – identification

IHA – Interior Health Authority

ISQG – Interim Sediment Quality Guidelines

IW – irrigation water

DEFINED TERMS (Cont'd)

JP-8 – jet propellant 8 (military grade, kerosene-based jet fuel)

KA/K – kale

kg – kilogram(s)

km – kilometre(s)

km/h – kilometre per hour

L – litre(s)

LEPH – light extractable petroleum hydrocarbons

LEPHw – light extractable petroleum hydrocarbons in water

LNAPL – light non-aqueous phase liquid

log K_{ow} – logarithm base 10 of octanol-water partition coefficient

LW – livestock water

LW – Livestock Water

m – metre(s)

m/m – metre per metre

m^3 – cubic metre(s)

MAH – monocyclic aromatic hydrocarbon

Maxxam – Maxxam Analytics, Burnaby, BC

MFLNRO – BC Ministry of Forests, Lands and Natural Resource Operations

mg/kg – milligram per kilogram

mL – millilitre(s)

mm – millimetre(s)

MoA – BC Ministry of Agriculture

MoE – BC Ministry of Environment

MoFR – BC Ministry of Forests and Range

MoTI – BC Ministry of Transportation and Infrastructure

DEFINED TERMS (Cont'd)

MSDS – Material Safety Data Sheet

MTBE – methyl tertiary-butyl ether

MU – mushroom

nm – nanometre(s)

OF – organic farm

ORC – Outdoor Recreation Council

PAH – polycyclic aromatic hydrocarbon

PEL – Probably Effects Level

Perry's Bridge – Perry's Back Road Bridge

PHC – petroleum hydrocarbon

PL – CSR Parkland land use

POD – point of diversion

Polaris – Polaris Applied Sciences, Inc.

PVC – Polyvinyl chloride

QA – quality assurance

QC – quality control

QMLP – Quantum Murray LP

R – residential

RISC – Resource Information Standards Committee

RPD – relative percent difference

SARA – Species at Risk Act

SC – Swiss chard

SCAT – Shoreline Clean-up Assessment Technique

SED – sediment

SNC-Lavalin – SNC-Lavalin Inc.

DEFINED TERMS (Cont'd)

SS – surface soil

SW – surface water

the incident – on July 26, 2013, an EFC owned and operated tanker truck hauling Jet A-1 fuel on the Lemon Creek Forest Service Road rolled down an embankment into Lemon Creek, which resulted in a spill

the product – Jet A-1 fuel released into Lemon Creek on July 26, 2013

the Project – Lemon Creek Spill Response Project

TMB – trimethylbenzene

U.S. – United States of America

UTM – Universal Transverse Mercator

UWR – ungulate winter range

VEG – kale and grass

$VHw_{6\text{-}10}$ – volatile hydrocarbons in water

VOC – volatile organic compound

VPH – volatile petroleum hydrocarbon

VPHw – volatile petroleum hydrocarbons in water

VRI – Vegetation Resources Inventory

WB – Winlaw Bridge

WHA – Wildlife Habitat Area

WL – CSR Wildlands land use

wwt – wet weight

µg/g – microgram per gram

µg/L – microgram per litre

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1.0 INTRODUCTION

The Environment & Water business unit of SNC-Lavalin Inc. (SNC-Lavalin) was retained by Executive Flight Centre Fuel Services Inc. (EFC) as Environmental Consultant for the Lemon Creek Spill Response (the Project), north of Winlaw, British Columbia (BC). Part of the scope of work includes the development of this Spill Response Environmental Impact Assessment (EIA) document[1], requested by the Kootenay-Boundary and Okanagan Regional Environmental Protection Division of the BC Ministry of Environment (MoE) in a memorandum dated July 27, 2013[2]. This EIA addresses the following:

- Background of events leading to the spill (Incident summary);
- Description and estimate of spilled materials, including total volume released and volume of product contained/ recovered;
- Chemical characterization and environmental fate of spilled material;
- Regulatory consultation;
- Impacted areas, including site maps;
- Extent and duration of impact;
- Characterization of contaminant concentrations in receiving environment;
- Description of Quality Assurance/Quality Control protocols used;
- Comparison of monitoring results to appropriate guidelines, objectives and standards;
- Description of short and long-term potential impacts to receiving environment;
- Assessment of effectiveness of clean-up and mitigation; and
- Interim conclusions and recommendations.

This interim report will be submitted to MoE Environmental Emergency Response Officer (EERO) by September 30, 2013. A final report will be submitted to the EERO and regional manager within 30 days of completing the review of the draft report.

1 The level of detail of the EIA is pending discussion and consultation with the MoE.
2 BC MoE memorandum addressed to Kandis Lipsett, EERO dated July 27, 2013. Re: Assessment of Water Quality and Environmental Impacts Following Lemon Creek Jet Fuel Spill, July 26, 2013.

1.1 Incident Summary

On July 26, 2013, at approximately 16:00 Pacific Time, an EFC owned and operated tanker truck hauling Jet A-1 fuel on the Lemon Creek Forest Service Road (FSR) rolled down an embankment into Lemon Creek, which resulted in a spill (the incident). A confirmed total of approximately 32,850 L of Jet A-1 fuel (the product) was discharged to Lemon Creek. Lemon Creek flows in a west-northwesterly direction to the Slocan River, south of Slocan City. The spill release point (approximately 49°42’05” N, 117°25’26” W) on Lemon Creek was approximately 4 km from the confluence with the Slocan River (the incident site). The Slocan River flows in a south-southwest direction into the Kootenay River, which passes Brilliant Dam and joins the Columbia River near Castlegar, BC. An overview of the area investigated following the incident as wells as the location of the incident site are shown on Drawing 614668-102-IA. Photographs taken during the incident investigation are appended.

First responders (fire and police), MoE, and the Canadian Transport Emergency Centre (CANUTEC) were notified following the incident. The Lemon Creek Forest Service Road was closed, local residents were evacuated, and a local state of emergency was declared.

On July 27, 2013, the Interior Health Authority (IHA) issued a “Do Not Use” water order for any users drawing water from Lemon Creek, Slocan River, and Kootenay River downstream of the incident site to confluence of the Kootenay and Columbia Rivers. A recreational ban was also implemented, which banned swimming and watercraft in the “Do Not Use” water restriction area. A Transport Canada Vessel Restriction Advisory was issued to ban watercraft and boat use.

EFC engaged Quantum Murray LP (QMLP) to contain, recover, and clean-up the residual product. On July 27, 2013, QMLP recovered 2,135 L or water and fuel from the tanker truck and subsequently removed the truck from Lemon Creek. Removal of the trailer resulted in additional water contaminated with the product to be released onto Lemon Creek FSR, controlled by Ministry of Transportation and Infrastructure (MoTI). QMLP reported that approximately 100 m of heavy staining and moderate fuel odour was present on the road, which would require remediation. A small amount of engine oil was released from the fuel truck and was contained. No diesel was released from the saddle tanks on the fuel truck.

As of July 31, 2013, QMLP had dispatched 45 responders, 12 boats, 1 vacuum truck with pup trailer, and 700 m of river containment booms. Large containment booms were established at the confluence of the Slocan and Kootenay Rivers, near Brilliant Dam, near the Winlaw Bridge and near Perry’s Back Road Bridge (Perry’s Bridge). Following satisfactory water quality observations, the Slocan Kootenay River confluence and Brilliant Dam booms were removed on August 7, 2013 and the Perry’s Bridge and Winlaw Bridge booms were removed on August 10, 2013. QMLP responders proceeded down Lemon Creek and Slocan River recovering and cleaning-up the product trapped in vegetation and debris. Flushing techniques were used to release product from streambanks and vegetation to make it accessible for recovery. Accessible product was recovered using a vacuum truck. A report summarizing QMLP’s remedial work is appended.

On July 28, 2013, SNC-Lavalin was retained by EFC to assess and monitor the impact of the Jet 1A fuel spill on Lemon Creek and the Slocan River, during the spill response efforts and following remediation. SNC-Lavalin collected water, sediment, and soil samples, along with the recovery of deceased fish and wildlife carcasses. SNC-Lavalin also monitored air quality in the vicinity of the incident and assessed fish and wildlife habitat. Collected samples were submitted to Canadian Association for Laboratory Accreditation Inc. (CALA) certified laboratories for analysis. Laboratory analytical results were submitted to the Medical Health Officer and IHA to inform decisions regarding the “Do Not Use” order placed on water use in the vicinity of the incident. In addition, SNC-Lavalin personnel collected soil and vegetation from agricultural land, in coordination with the BC Ministry of Agriculture (MoA). SNC-Lavalin’s water, soil, sediment, vegetation, fish, and wildlife monitoring, sampling, and assessment program will be discussed in greater detail in this report. A report summarizing the air quality assessment program is appended.

QMLP and SNC-Lavalin completed a soil excavation from the incident site on July 31, 2013. Hawkeye Holdings of Kelowna, BC, sub-contracted by QMLP, transported approximately 1,600 tonnes of soil to Envirogreen Technology, a licensed waste disposal facility near Princeton, BC.

On August 1, 2013, EFC engaged Polaris Applied Sciences, Inc. (Polaris) of Kirkland, Washington to conduct a Shoreline Clean-up Assessment Technique (SCAT) program. SCAT was used to provide operational focus to the response team and prioritize areas for clean-up. By August 10, 2013, Polaris had completed over 200 km of detailed primary and secondary shoreline assessments. A report and drawings detailing Polaris’s SCAT program are appended.

On August 6, 2013, IHA lifted the “Do Not Use” water restriction on the Kootenay River, while the restriction remained in place for Lemon Creek and Slocan River. The water restriction was lifted from Slocan River, south of the Winlaw Bridge, on August 8, 2013. On August 9, 2013, all remaining water restrictions were lifted.

QMLP completed the in-stream remediation activities prescribed by Polaris’ SCAT specialists by August 24, 2013. QMLP personnel remained at Lemon Creek to monitor residual product collection with the remaining containment booms at the mouth of Lemon Creek.

The preceding information was gathered from the updates provided by EFC on the Lemon Creek Response website (www.lemoncreekresponse.ca) and the QMLP Emergency Response Management Workbook (appended).

1.2 Environmental Context

The incident occurred in the Wildlands area of BC. Wildlands are those lands that are not used for an approved purpose and are not designated as another land use (i.e., industrial, commercial, agricultural or residential/urban parkland). Wildlands are primarily used for supporting natural ecosystems (i.e., ecological land reserves, national and provincial parks, protected wetlands or woodlands, native forests, tundra and alpine meadows). In addition to Wildlands, the area investigated following the incident included both residential and agricultural land use. The following sections describe the environmental conditions of the incident site and surrounding area.

1.2.1 Hydrogeological Setting

Lemon Creek flows in a west-northwesterly direction to the Slocan River which flows to the south-southwest. For approximately 1.5 km downgradient of the incident site, the creek flows within a relatively narrow incised channel which is characteristic of channels cut into bedrock. Bedrock outcrop was observed along the bank and creek bottom at the incident site. There was about 0 m to 0.3 m of surficial sands and gravels overlying the bedrock near the creek's edge. The final 2 km of Lemon Creek is underlain by sands and gravels that are tens of metres thick, defined as an alluvial fan deposit, which serves as an aquifer. Drawing 614668-005 illustrates the approximate limits of the alluvial fan and flood plain. The alluvial fan deposit slopes to the west at a topographic gradient of approximately 0.02 m/m. Further to the south of Lemon Creek, it appears to be underlain by finer soils (i.e., silts with sand and clay) that are possibly floodplain deposits associated with the Slocan River.

Groundwater levels measured in the existing registered water wells at the time of completion, according to water well logs obtained from the BC MoE Water Resources Atlas[3] database, indicate the water table under static conditions was located at a depth of approximately 5.0 m bgs and suggests a flow direction to the west-southwest, similar to fan topography. This suggests that the alluvial fan aquifer may be recharged by Lemon Creek during varies times of the year, specifically at high stage levels such as, spring freshet and that Lemon Creek may be recharged by the aquifer during times of low stage levels. Similar hydraulic conditions are expected for the Slocan River and adjacent floodplain area throughout the year.

According to the MoE database, a number of domestic use groundwater wells are located along Lemon Creek (mainly within the alluvial fan/floodplain of the creek at its confluence with Slocan River) and along Slocan River. In addition, a number of points of diversion (POD) were registered in the database. Through recent site reconnaissance, these PODs and other unidentified PODs and shallow dug wells have been located along the bank and within 20 m of the shoreline of these water bodies.

[3] http://webmaps.gov.bc.ca/imf5/imf.jsp?site=wrbc

1.2.2 Hydrological Setting

According to Aquatic Resources Limited (2010), Lemon Creek is a straight-channel fifth-order stream, approximately 26 km long, with un-confined later channel movement, de-coupling between the hillslope and the channel, and occasional islands. Its watershed consists of a 380 km tributary system. Bankfull widths range from approximately 19 to 28 m. In 1999, Lemon Creek had a gradient of approximately 2% to 6% and the average water depth was 0.198 m with a velocity of 0.28 m/s (Aquatic Resources Limited, 2010).

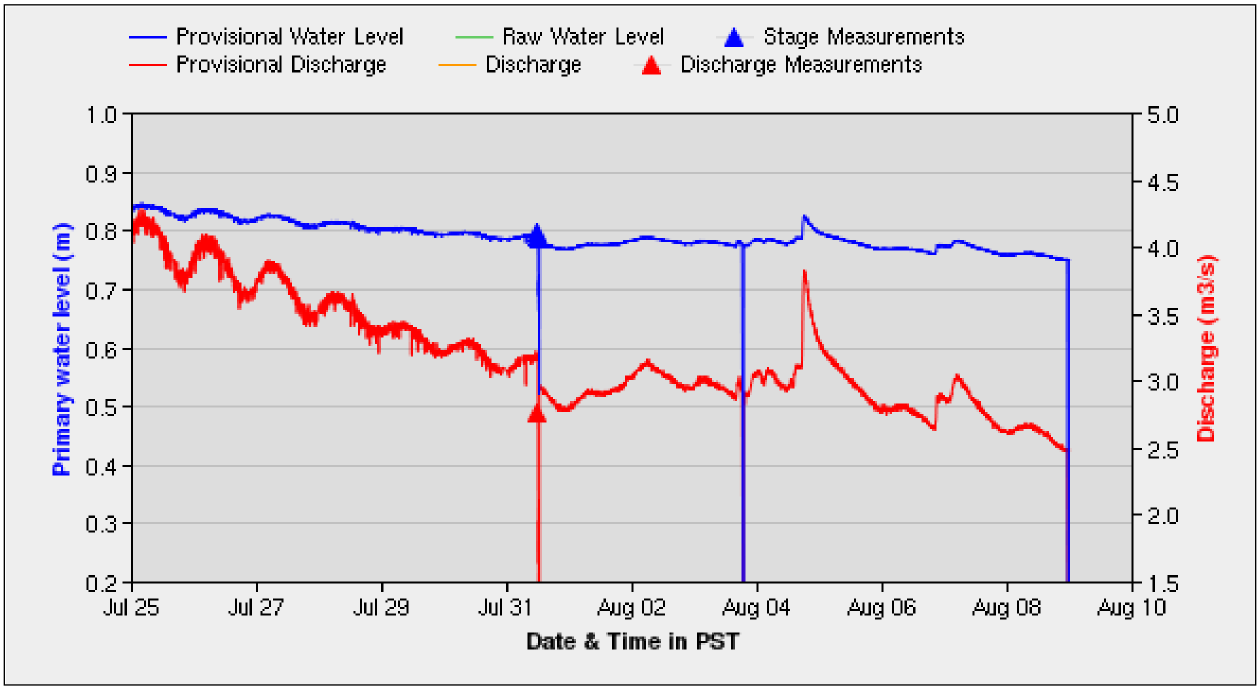
Streambed material consists of cobbles (dominant) and boulders (sub-dominant). Riffles consist of approximately 40% sands and gravels, 47% small and large cobbles, and 13% small and medium boulders (Aquatic Resources Limited, 2010).

Aquatic Resources Limited (2010) reported instream vegetation consisting of vascular plants, while the sloped banks were vegetated with a mature mix of conifers and deciduous trees. Crown closure was between approximately 1% and 20%. Large woody debris was abundant and clumped together.

1.2.3 Lemon Creek Hydrometrics

Hydrometric data for Lemon Creek for two weeks following the incident is provided in Figure 1. The data was collected from the closest station to the incident at Lemon Creek above South Lemon Creek (station number 08NJ160; located at 49°41’51” N, 117°27’00” W), approximately 2 km downstream of the incident site, by Environment Canada Wateroffice (EC, 2013a).

Figure 1: Hydrometric data for Lemon Creek July 26 to August 9, 2013 (Lemon Creek above South Lemon Creek Monitoring Station)



The hydrometric station provides both continuous gauge recorded water level and discharge data, as well as manually collected data. The gauge recorded water level was 0.818 m at the approximate time of the incident with a discharge of 3.69 m^3/s. The latest manual water level measurement obtained was 0.788 m on July 31, 2013. The latest manual discharge measurement of 2.76 m^3/s was conducted on July 31, 2013 with a mean water level of 0.775 m.

On August 6, 2013, SNC-Lavalin personnel monitored water temperature of surface water between approximately 1.1 km upstream of the incident site on Lemon Creek and Passmore, BC. A summary of the monitoring data is provided in Table A.

Table A: Surface Water Temperature Data August 6, 2013

Monitoring Location	Location Description	Water Temperature (°C)	Reference Drawing
SW13-300	Lemon Creek – approximately 1.1 km upstream of incident site	9.93	614668-005
SW13-1	Lemon Creek – pool just upstream of incident site	15.2	614668-005
SW13-5	Lemon Creek – near Russell Hubert's property at 7803 Lemon Creek Road	16.3	614668-005
SW13-406	Lemon Creek – near property, west of Highway 6, downstream of Russell Hubert's property	17.7	614668-005
SW13-12	Slocan River – upstream of Lemon Creek confluence. Pool near Mon Amie Road	23.1	614668-005
SW13-4	Slocan River – West side of Perry's Bridge	21.8	614668-006
SW13-2	Slocan River – East side of Perry's Bridge	20.7	614668-006
SW13-7	Slocan River – West side of Winlaw Bridge	23.1	614668-008
SW13-22	Slocan River – East side of Winlaw Bridge	24.2	614668-008
SW13-8	Slocan River – West side upstream of Valhalla Bridge #8	22.7	614668-002

Surface water temperatures ranged from approximately 10°C to 24°C with the highest water temperatures observed near Winlaw Bridge and the lowest temperatures recorded upstream of the incident site on Lemon Creek.

1.2.4 Ambient Weather Conditions

The ambient temperature, precipitation, and wind velocity for two weeks following the incident are summarized in Table B. Mean daily temperatures ranged from 18.4°C to 24.5°C with the highest maximum daily temperature of 35.0°C recorded on July 26, 2013. The lowest minimum daily temperature of 10.2°C was recorded on July 30, 2013. Within two weeks following the incident, the highest precipitation event occurred on August 1, 2013 with 4.8 mm of rain. Wind gusts ranged between <31 km/h to 52 km/h and the highest wind gust occurred on August 6, 2013 from the northeast. The weather data was collected by Government of Canada (2013) at the Nelson CS monitoring station (49°29'29" N, 117°18'19" W; Elevation 534.90 m), approximately 25 km south of the incident site and the nearest station with wind data.

Table B: Weather Data July 26 to August 9, 2013 (Nelson CS Monitoring Station)

Date (2013)	Maximum Temperature (°C)	Minimum Temperature (°C)	Mean Temperature (°C)	Total Precipitation (mm)	Approximate Direction of Maximum Wind Gust	Speed of Maximum Wind Gust (km/h)
July 26	35.0	14.0	24.5	0.0	West	33
July 27	30.5	14.7	22.6	0.0	West	33
July 28	29.8	10.8	20.3	0.2	Northeast	32
July 29	29.6	12.5	21.1	1.4	n/a	<31
July 30	30.5	10.2	20.4	0.0	n/a	<31
July 31	32.0	11.5	21.8	0.2	Southwest	32
August 1	24.6	15.3	20.0	4.8	Northeast	32
August 2	21.6	15.2	18.4	2.2	n/a	<31
August 3	28.2	16.0	22.1	0.0	South	33
August 4	26.5	13.8	20.2	0.0	South	35
August 5	28.6	15.4	22.0	0.0	Northeast	35
August 6	29.1	12.4	20.8	0.0	Northeast	52
August 7	29.5	13.5	21.5	0.0	n/a	<31
August 8	30.8	12.6	21.7	0.0	n/a	<31
August 9	32.8	15.2	24.0	0.0	n/a	<31

n/a: not applicable. Wind gust below detection limit

SNC-Lavalin staff reported lightning on August 3, 2013 and a thunderstorm and rain on August 4, 2013 near the confluence of Slocan River and Lemon Creek.

2.0 DESCRIPTION OF SPILLED MATERIAL

Approximately 32,850 L of Jet A-1 fuel was released into Lemon Creek on July 26, 2013. This was a high volume, rapid release into a generally rapid or high velocity flowing system. A confirmed total of 2,150 L of product was recovered from the incident site with a vacuum truck operated by QMLP, the contents of which were then disposed of at a licensed waste facility.

Following a remedial excavation of the incident site, QMLP transported approximately 1,600 tonnes of soil to Envirogreen Technology, a licensed waste disposal facility near Princeton, BC. The soil contained less than 3% Jet A-1 fuel.

At the time of this report, QMLP contained an estimated 20,000 kg of contaminated absorbent material and vegetation in two bins, approximately 30 m^3 and 40 m^3 in size. The bins were shipped to Newalta, a licensed waste facility near Winfield, BC, for disposal. It is our understanding that QMLP continues to collect contaminated absorbent material from specific areas influenced by the incident.

2.1 Chemical Characterization of Spilled Material

Jet A-1 fuel is a liquid mixture primarily composed of kerosene and contains aliphatic and aromatic petroleum hydrocarbon (PHC) parameters comprised of six to sixteen carbon atoms (in the C_6-C_{16} carbon range). The exact composition of kerosene depends on the crude oil from which the fuel was refined; as a result, the physical and chemical properties of jet fuel are variable. In general, kerosene is composed of at least 70% paraffinic (aliphatic alkanes; saturated straight-chain hydrocarbons) and naphthenic (cycloalkanes; saturated cyclic hydrocarbons) compounds, with less than 5% olefinic (alkenes; unsaturated straight-chain and cyclic hydrocarbons) and up to 25% aromatic hydrocarbons (fully unsaturated cyclic compounds), most of which are monoaromatics (single-ring) (ATSDR, 1998; API, 2010; EC, 2013b). The individual components of kerosene generally boil between 150°C and 290°C at atmospheric pressure (API, 2010).

Based on the material safety data sheet (MSDS) for the fuel that was contained in the tanker at the time of the spill and analytical results from worst-case locations, characterization indicates the following regulated PHC parameters are potentially associated with the fuel released to Lemon Creek: ethylbenzene, toluene, xylenes, and polycyclic aromatic hydrocarbons (PAHs), including naphthalene, 2-methylnaphthalene, acenaphthene, fluorene, phenanthrene and fluoranthene. In addition to these individual parameters, the following general hydrocarbon compounds are associated with Jet A-1 fuel: volatile petroleum hydrocarbons (VPH) (C_6-C_{10}); light extractable petroleum hydrocarbons (LEPH) (C_{10}-C_{19}); PHC Fraction 1 (F1) (C_6-C_{10}) and PHC Fraction 2 (F2) (C_6-C_{16}). Trimethylbenzene (TMB) compounds, which are not regulated in soil or water, also have the potential to be present in the product. Based on current analytical results of soil, sediment and surface water samples collected along Lemon Creek and the Slocan River, benzene was not detected.

2.2 Environmental Fate and Transport of Spilled Material

Kerosene's environmental fate is based on the individual components of the mixture. Methods for examining the environmental fate of jet fuels as a whole product are limited; instead the fates of individual hydrocarbon components are examined. Dissolution, adsorption, volatilization, and degradation are the primary factors affecting the transport and fate of Jet A-1 fuel in the environment. Environmental transport may lead the fuel to be present in the following compartments: soil, sediment, air, groundwater, surface water and biota (plants and animals). The fate of the spilled material is dependent on environmental conditions (e.g., climate, soil type). In addition to the physical-chemical properties of Jet A-1 fuel, organism-specific mechanisms (e.g., metabolism, excretion) determine the degree of uptake and accumulation of the spilled material in plants and animals.

2.2.1 Environmental Partitioning

The environmental fate of kerosene is dependent on the physical and chemical characteristics of the components of kerosene. In general, aromatic compounds tend to be more water soluble than aliphatics with the same carbon number, whereas aliphatics tend to be more volatile (EC, 2013b). Components of kerosene with the lowest molecular weight tend to be more soluble and volatile than those with relatively higher molecular weights.

Based on environmental partition modelling reported by Environment Canada (2013b), heavier alkanes and cycloalkanes (i.e., carbon numbers greater than approximately C_{12}) in aviation fuels released solely to water are predicted to partition mostly to sediment, whereas lighter alkanes are predicted to partition mostly to water and partially to sediment. Monoaromatics with approximately six carbon atoms will partition between air and water, whereas heavier monoaromatics and cyclalkane monoaromatics will partition mostly to water and partially to sediment, up to approximately C_{12}; those greater than C_{12} mostly adsorb to sediment. Diaromatics and cycloalkane diaromatics lighter than approximately C_{12} are found mostly in water and those heavier are mostly in sediment. Three-ring aromatics are predicted to partition between both water and sediment.

Since aviation fuels are less dense than water (0.75-0.85 g/mL), they tend to spread across and float on the surface of the water as light non-aqueous phase liquid (LNAPL) (EC, 2013b). Due to their relatively high vapour pressures (> 10 hPa 37.8°C; API, 2010) and Henry's Law Constants (0.01 to 29 atm-m^3/mol; EPA, 2011) most components of kerosene will volatilize.

While two-ring PAHs can have moderate to high volatility, PAHs with three or more rings found in the product tend to be relatively non-volatile and poorly soluble in water; as such, they tend to sorb to particulate matter in aquatic systems which allows them to settle into bottom sediments (CCME, 1999a).

Sedimentation can also occur when oil droplets reach a higher density than water after interacting with mineral matter in the water column. This interaction sometimes occurs on the shoreline or very close to the shore. Once oil is on the bottom, it is usually covered by other sediment and degrades very slowly. Although there is the potential for sedimentation to occur, given the conditions in the area of the spill, including fast moving water with very little particulate/fines in the water column, as well as the nature of the jet fuel, there is considered to be low potential for significant sedimentation to have occurred. The limited sediment contamination measured is further evidence that significant sedimentation has not occurred.

2.2.2 Plant Uptake of Volatiles

Select mono- and poly- aromatic compounds found in the product with relatively long atmospheric life spans (e.g., naphthalene, toluene, and their derivatives) can sorb to the surfaces of plant matter or they can penetrate the plant surface. These gaseous pollutants can be taken up by the lipophilic parts of plant leaves and other above-ground parts via a direct air-to-leaf transfer. Gaseous pollutants primarily enter leaves via their stomata, but can also be absorbed through the epidermis of the above-ground parts of plants. This uptake is dependent on several factors, including plant type and duration of exposure (Keymeulen, et al., 1993). Plants can eliminate volatile compounds through volatilization and transpiration. A survey of aromatic hydrocarbons concentrations in plants by Gorna-Binkul, et al. (1996) has found that these compounds tend to accumulate in oil-containing plant structures such as the wax layers of leaves and fruit; therefore penetration of such compounds into internal structures is likely to be reduced in plants with thicker waxy cuticles (Ugrekhelidze, et al., 1997).

In a study completed by Bakker, et al. (2000) examining 7 PAHs in vegetation, the PAH-profiles of plant samples appeared to shift to higher contributions of gaseous PAHs with increasing distance from a refinery; the authors concluded that particle-bound PAHs are deposited closer to the source, with the gaseous PAHs predominating with distance from the source.

In studies where vegetable plants were exposed to large concentrations of aromatic hydrocarbons (for example, Collins et al., 2000) of about 1 mg/m^3 (0.313 parts per million [ppm]) in a controlled environment (over 80 days of dosing), the increase of the contaminant in plant matter beyond background levels is about 40%.

There is the potential for vapours (monocyclic aromatic hydrocarbon [MAHs] and semi-volatile PAHs) to be taken up by plants; however, given the conditions at the incident site, including high temperatures, dispersion of the product in surface water, relatively short potential duration of exposure of plants to volatiles, and significantly lower levels of vapours of aromatic compounds expected in ambient air at Lemon Creek compared to the lab experiments, it is expected that the amount of increase for any of those compounds in edible plant tissue is negligible. It is noted that the results of the agricultural sampling program, which included the collection of vegetable and grass tissue samples, as well as soil samples from several properties in the area of the spill, indicated that plant uptake did not occur.

2.2.3 Bioaccumulation

Bioaccumulation information specific to Jet A-1 fuel as a whole product was not available for review; however, studies with JP-8, another kerosene based jet fuel, in flagfish, rainbow trout, and golden shiners suggest that the potential for bioaccumulation and biomagnification is low (ATSDR, 1998).

Since the individual components of the product will partition to different environmental media based on their physical and chemical properties, the bioaccumulation potential of the individual components should be investigated.

Aquatic organisms are able to bioaccumulate some hydrocarbon fractions, mainly those containing high molecular weight PAHs, but when the source of contamination is removed, the organisms are able to depurate; in general, lower molecular weight aliphatics and aromatics do not readily bioaccumulate (ATSDR, 1999).

For aquatic organisms, the bioconcentration factor (BCF) is the ratio of a contaminant concentration in biota to its concentration in the surrounding water. The bioaccumulation factor (BAF) is the ratio of the contaminant in an organism to the concentration in the ambient environment, where the organism can ingest the contaminant in food, in addition to exposure from the surrounding water. The octanol-water partition coefficient (K_{ow}) represents the ratio of the solubility of a compound in octanol (representative of lipids in biota) to its solubility in water. The *Canadian Environmental Protection Act* (1999) Persistence and Bioaccumulation Regulations define a substance as bioaccumulative when its BCF or BAF value is greater than or equal to 5,000 or its log K_{ow} value is greater than or equal to 5.

As indicated by ethylbenzene's BCF of 15.5 for goldfish and 37.5 for edible fish tissue, it is not likely to bioconcentrate in fish (CCME, 1999b). Toluene has calculated BCF values ranging from 15 to 70 in fish and 380 for algae, which indicates that it is not likely to bioconcentrate in aquatic organisms (CCME, 1999c). Xylenes have BCF values of approximately 250, indicating that bioconcentration potential is relatively low (CCME, 2004).

The product consists mainly of low molecular weight PAHs (i.e., those with three or fewer aromatic rings), which tend to have log K_{ow} values between 3.37 and 4.46. Bioaccumulation of PAHs in water tends to be greatest for substances with log K_{ow} values between 5.0 and 5.6; values outside of this range exhibit less bioaccumulation. In sediment, substances with log K_{ow} values of approximately 5 or more exhibit the highest bioaccumulation. Substances with lower log K_{ow}, such as those found in the product, tend to be eliminated more readily, thus limiting bioaccumulation potential (CCME, 1999a).

Trimethylbenzene isomers have experimental and estimated BCF and BAF values ranging from 120 to 220 and would not likely bioconcentrate or bioaccumulate in the aquatic food web (Royal Society of Chemistry, 2013).

2.2.4 Degradation

The three main environmental degradation pathways for chemicals in the environment include photolysis, hydrolysis, and biodegradation. The consequences of these degradation pathways on the product are discussed below.

2.2.4.1 Photolysis

Chemicals can be photodegraded either directly or indirectly. Direct photodegradation involves the sufficient absorption of light energy at wavelengths between 290 and 800 nm, which results in a photochemical transformation. Saturated (i.e., paraffinic and naphthenic) and MAH compounds do not show absorbance in the 290 to 800 nm wavelength range. PAHs, although found in low concentrations in kerosene, can absorb 290 to 800 nm light wavelengths and could potentially undergo photolysis reactions (API, 2010). Photolysis is dependent on environmental conditions that control the penetration of light into the compound, such as the depth of contamination in soil or water.

The components of kerosene that are not subject to direct photolysis (i.e., paraffinic, naphthenic, olefinic, and monoaromatic compounds) may be photodegraded indirectly, resulting in relatively short residence times in the atmosphere (API, 2010). These reactions are predominantly the result of daytime hydroxyl radical reactions that oxidize both the paraffinic and olefinic fractions of Jet A-1 fuel, resulting in chemical lifetimes on the order of a few hours. During summer daytime conditions with high temperatures and correspondingly clear skies, the concentrations of hydroxyl radicals are at the highest predicted levels, resulting in the efficient atmospheric degradation of most compounds found in Jet A-1 fuel. During night-time, in the absence of hydroxyl radicals, ground-level ozone acts as an oxidant for the degradation of the olefinic fraction of jet fuel vapours. Mono and polyaromatic compounds are longer-lived species in the atmosphere due to increasing difficulty in oxidizing molecules with aromatic structures.

2.2.4.2 Hydrolysis

The components of kerosene generally do not possess the functional groups required to undergo hydrolysis; therefore, this is not expected to be an important degradation pathway (API, 2010).

2.2.4.3 Biodegradation

Provided there are sufficient nutrients present for the microbial communities, the components of kerosene can be significantly biodegraded to carbon dioxide and water, especially under aerobic conditions (API, 2010). Lower molecular-weight linear alkanes are most readily biodegraded; however, they tend to partition to air where they are subject to photolysis. Higher molecular-weight polycyclic aromatics and substituted aromatics tend to adsorb to organic material in soil or sediment; biodegradation can be limited due to the reduced bioavailability of adsorbed material. In general, increased molecular weight, branching, presence of aromatic and cyclic structures, and substitutions result in a decreased rate and possible extent of biodegradation, when compared to smaller, straight-chain molecules. Following a spill, the microbial community composition in the impacted area may change to select for microbes that can degrade the introduced compounds (API, 2010).

2.2.5 Degradation/Transformation Products

The degradation or transformation products of Jet A-1 fuel are specific to the individual components of the fuel, the degradation pathways involved, and the environmental conditions present when degradation occurs.

Biodegradation of organic compounds, such as PHC F1 and F2, can result in complete mineralization of the reactants (i.e., production of carbon dioxide and water) (The Petroleum HPV Testing Group, 2009).

Reactions of PAHs in the atmosphere can result in the formation of oxy-, hydroxyl-, nitro-, and hydroxynitro-PAH derivatives (ATSDR, 1995). The most common products formed from the photooxidation of PAHs in water are peroxides, quinines, and diones. Photolysis would likely account for most of the transformation of PAHs in shallow, fast-moving, clear water. Microbial degradation is the main degradation pathway for PAHs in soil and sediment, resulting in the formation of *cis*- and *tran*-dihydrodiols (ATSDR, 1995).

Ethylbenzene in the presence of hydroxyl radicals in the atmosphere, water, sediment, or soil can generate acetophenone, whereas atmospheric ethylbenzene exposed to nitrogen radicals and oxides can form ethyl phenols and *p*-nitroethylbenzene, respectively (ATSDR, 2010). Aerobic transformation of ethylbenzene in water, sediment, or soil ultimately results in ring cleavage to form straight chain carboxylic acids (e.g., fumaric and acetoacetic acid). Xylenes in the presence of atmospheric hydroxyl radicals can be ultimately degraded to carbon dioxide and water. Hydroxyl radical reactions are the prevailing atmospheric degradation pathway for xylenes (ATSDR, 2007). Atmospheric toluene is readily degraded by hydroxyl radicals, which results in ring cleavage and the formation of simple hydrocarbons (ATSDR, 2000). Since volatilization is the dominant pathway for xylenes, toluene, and ethylbenzene, degradation products in surface water and soil are not likely significant.

2.2.6 Persistence

Persistence is a complex characteristic of oil related to viscosity, adhesiveness, and evaporative character that accounts for oil's duration in the environment before degrading. The persistence of petroleum-based oils is very important in assessing the environmental risk of an oil discharge and often affects the resources needed for spill recovery and remediation. The U.S. Environmental Protection Agency (EPA) requires the use of oil persistence levels in developing oil discharge response plans. To our knowledge, no BC Provincial or federal agency in Canada has similarly applicable requirements. For example, according to EPA Facility Response Plan (FRP) regulatory requirements, the determination of on-water oil recovery capacities, planning distance, and planning volume calculations all require information about an oil's level of persistence. This EPA definition of oil persistence and its determination and use is detailed here for reference purposes. Despite its importance, oil persistence is not defined consistently nor easily categorized.

According to the U.S. EPA (2009), non-persistent (Group 1 oils) and persistent (Group 2–5 oils) as defined as such:

Non-Persistent Oils or Group 1 Oils

1) A petroleum-based oil that, at the time of shipment, consists of hydrocarbon fractions:
    - At least 50% of which by volume, distil at a temperature of 340°C; and
    - At least 95% of which by volume, distil at a temperature of 370°C
2) A non-petroleum oil, other than an animal fat or vegetable oil, with a specific gravity less than 0.8.

Persistent Oils

3) A petroleum-based oil that does not meet the distillation criteria listed above under "Non-persistent oils or Group 1 oils," is further classified based on specific gravity as follows:

   - Group 2 – specific gravity less than 0.85;
   - Group 3 – specific gravity equal to or greater than 0.85 and less than 0.95;
   - Group 4 – specific gravity equal to or greater than 0.95 and less than 1.0; or
   - Group 5 – specific gravity equal to or greater than 1.0.

4) A non-petroleum oil, other than an animal fat or vegetable oil, with a specific gravity of 0.8 or greater. These oils are further classified based on specific gravity as follows:

   - Group 2 – specific gravity equal to or greater than 0.8 and less than 0.85;
   - Group 3 – specific gravity equal to or greater than 0.85 and less than 0.95;
   - Group 4 – specific gravity equal to or greater than 0.95 and less than 1.0; or
   - Group 5 – specific gravity equal to or greater than 1.0.

Jet A-1 fuel falls under the category of non-persistent oils (Group 1). Group 1 oils, when spilled in water (e.g., rivers) will partition as: 80% lost through natural dissipation, 10% recoverable floating oil, and 10% oil on shore (EPA, 2009). In terms of a relative ranking for different fuel spills on the basis of acute toxicity and persistence, Table C provides findings from the Washington Department of Ecology. Jet A fuel has the lowest acute toxicity and a low persistence in the environment (persisting on the order of days to weeks).

Table C: Relative Ranking Scores of Acute Toxicity and Persistence for Various Types of Oil Spills

Oil Class	Acute Toxicity[a]	Persistence[b]
Kerosene-type Jet Fuel	1.4	1
Gasoline	5	1
No. 2 Fuel Oil	2.3	2
Bunker C	2.3	5

[a] Ranks for acute toxicity are based on a scale of 0–5 (0 is least harmful, 5 represents the most harmful effect).

[b] Ranks for persistence are based on an integer scale of 1–5, where the anticipated persistence levels are classified as 1: days-weeks, 2: 1 month to 1 year, 3: 1–2 years, 4: 2–5 years, and 5: 5–10 years or more.

2.2.7 Environmental Fate and Transport Summary

Following a release of Jet A-1 fuel, the individual components will disperse and partition according to their individual physical-chemical properties. Since the product is highly volatile and LNAPL, most of its components would disperse on the surface of the water and tend to volatilize quickly; combined with the fact that bedrock was observed and encountered on the south side (below the road down to the creek) and the bottom of Lemon Creek during the soil remediation excavation, there was no opportunity for a large mass of the product to migrate into the underlying bedrock and impact groundwater beneath the creek. Due to its volatility, it is predicted that 30% to 35% of the volume released would volatilize in one day and 100% would have volatilized in 9 to 12 days[4]. Residence times in the atmosphere would be relatively short due to indirect photo degradation reactions. In water, hydrolysis is not likely to be an important degradation process.

As the liquid product migrated downstream, some LNAPL and related contaminants would tend to accumulate in slower moving reaches of the creek and/or river and come into contact with in river-bank sediments. Some components, such as three-ring PAHs and longer chain PHCs, may bind to organic material (i.e., organic carbon – wood debris, leaves, peat, etc.), partition to the sediment and eventually be biodegraded.

The constituents of the product can exhibit a moderate to rapid rate of biodegradation and are considered at least inherently biodegradable. Plant uptake and bioaccumulation in the aquatic food web are not considered to be significant fate processes for the product. Kerosene-based jet fuels are categorized as non-persistent oil.

4 SNC-Lavalin, Jet A1 Fuel Spill at Lemon Creek, BC – Air Quality Assessment (Appended).

3.0 REGULATORY CONTEXT

The following is a review of the relevant legislation, regulations, standards, guidelines, and protocols applicable at the time this report was prepared.

3.1 Legislation and Regulations

Provincial and federal legislation and regulations that are applicable to the incident are as follows:

Provincial (BC)

- *Water Act*. RSBC 1996. c. 483. More specifically, subsection 79(1) states that a person must not introduce, allow to be introduced or cause to be introduced a contaminant, in such amounts to cause significant adverse impact on the quality of groundwater in the well or the existing uses made of the groundwater well.
- *Fish Protection Act*. SBC 1997. c. 21
- *Wildlife Act.* RSBC 1996. c. 488
- *Environmental Management Act*. [EMA] 2003 including *Hazardous Waste Regulation*. [HWR] 2009. B.C. Reg. 63/88. Includes amendments up to B.C. Reg. 63/2009, April 1, 2009, *Spill Reporting Regulation*. 2008. B.C. Reg. 263/90. Included amendments up to B.C. reg. 376/2008, December 9, 2008, and *Contaminated Sites Regulation*. [CSR] 2010. B.C. reg. 375/96. Includes amendments up to B.C. Reg. 6/2013, January 6, 2013.

Federal

- *Fisheries Act.* R.S.C. 1985 c. f-14. Of particular importance, subsection 35(1) of the *Fisheries Act* prohibits the harmful alteration, disruption or destruction of fish habitat and Subsection 32 prohibits the unauthorized killing of fish by means other than fishing. Subsection 36(3) prohibits the deposit of deleterious substances and Environment Canada is responsible for administering this subsection. Under the *Fisheries Act,* a deleterious substance is defined as any substance, if added to water, makes the water deleterious to fish or fish habitat.
- *Canadian Environmental Protection Act*, 1999. S.C. 1999. c33;
- *Species at Risk Act* (SARA). S.C. 2002. C. 29;
- *Migratory Birds Convention Act* (MBCA), 1994. S.C. 1994, c.22; and
- *Migratory Birds Regulations*, C.R.C., c. 1035 (current to 2013-09-16).

3.2 Standards and Guidelines

3.2.1 Characterization of Contaminant Concentrations

The contaminants of concern were assessed by analysis of soil, groundwater, surface water, sediment, and vegetation, which were compared to the standards or guidelines contained in provincial regulations. The regulations used for the characterization of contaminants were as follows:

- CSR;
- *BC Water Quality Guidelines (*Criteria) Reports. Approved Water Quality Guidelines 2006 Edition, updated 2013. Available on-line at: http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html#approved; and
- *British Columbia Approved Water Quality Guidelines (Criteria), updated 2013, includes [A Compendium of Working Water Quality Guidelines for BC, 2006]* (BCWQG). British Columbia Ministry of Environment (MoE), April 2013. BC Ministry of Environment Environmental Protection Division Science and Information Branch. Available on-line at: http://www.env.gov.bc.ca/wat/wq/BCguidelines/working.html.

3.2.1.1 Incident Site Soil

The incident site is located on BC Wildlands and the soil analytical results were compared to CSR Wildlands standards. The site-specific factors used for determining the matrix standards for this site included: intake of contaminated soil, groundwater used for drinking water, toxicity to soil invertebrates and plants, groundwater flow to surface water used by freshwater aquatic life, and groundwater used for livestock watering (whichever is most stringent).

For Wildlands, Parkland (PL) standards apply from 0 m to 3 m depth, and for greater than 3 m, Commercial (CL) Standards apply, as defined in the CSR. Note that soil impacts did not extend greater than 1 m bgs.

3.2.1.2 Surface Water

Surface water analytical results were compared to BCWQG for aquatic life, livestock, and drinking water and the CSR Schedule 6 Generic Numerical Groundwater standards for the point of exposure water uses (i.e., aquatic life, drinking water, irrigation and livestock watering). In addition, the CSR Schedule 6 VPHw and LEPHw aquatic life standards divided by 10 were referenced as suggested in BC MoE Technical

Guidance 15 (TG15): Concentration Limits for the Protection of Aquatic Receiving Environments (March 2013, effective April 2013).

3.2.1.3 Water Supply

Water supply analytical results were compared to CSR Schedule 6 water quality standards for the protection of irrigation water, livestock water and drinking water.

3.2.1.4 Sediment

Sediment analytical results were compared to BC CSR Schedule 9 Sediment Criteria for freshwater sensitive and typical contaminated sites ($SedQC_{SS}$/ $SedQC_{ST}$).

3.2.1.5 Agricultural Soil

Agricultural soil analytical results were compared to CSR Agricultural Land Use Standards. Matrix standard pathways included: intake of contaminated soil, groundwater used for drinking water, toxicity to soil invertebrates and plants, and groundwater flow to surface water used by freshwater aquatic life (whichever is most stringent).

3.2.1.6 Agricultural Vegetation

In the absence of applicable standards or guidelines from Provincial regulators, agricultural vegetation analytical results were compared to background vegetation samples.

3.2.2 Terrestrial Wildlife

The general process of conducting a species inventory according to Resources Information Standards Committee (RISC) standards was used, including selection of inventory intensity, sampling design, sampling techniques, and statistical analysis, as described in the following document:

- Ministry of Environment, Lands and Parks (MoELP). 1998. Species Inventory Fundamentals. Standards for Components of British Columbia's Biodiversity No. 1. Version 2.0. Prepared by MoELP Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Committee.

4.0 CHARACTERIZATION OF CONTAMINANT CONCENTRATIONS

Samples of soil from the incident site, surface water, sediment, water supply points (i.e., PODs and wells), recovered product, agricultural soil, and vegetation collected from areas of potential impact were submitted for analysis of PHCs present in the product, as previously described. It is noted that additional parameters beyond those found in Jet A-1 fuel have been included in the chemistry tables, as several of the standard laboratory analyses include parameters not present in the Jet A-1 fuel.

4.1 Incident Site Soil Investigation and Remediation Excavation

There were two areas that required soil remediation at the incident site on Lemon Creek; 1) in the creek along the south bank, where the major jet fuel spill occurred, and 2) approximately 130 m along the forest service road above, where the product leaked from the tanker, following its extraction from Lemon Creek. Field observations indicated that there was approximately 0 m to 0.3 m of overburden on bedrock on the south side of the creek. All overburden was removed in this area as part of the remedial excavation. The road was comprised of hardpan, underlain by large cobbles and gravels and then bedrock. Hydrocarbons were limited to surficial impacts along the roadway and confirmatory results indicated that impacts did not reach bedrock.

On July 28, 30, and 31, 2013, investigation of the incident site was conducted by SNC-Lavalin to identify worst-case areas of soil contamination based on visual observations (i.e., staining) of hydrocarbons. A remedial excavation was conducted between July 30 and 31, 2013, with confirmatory soil samples collected from the limits of the excavation to confirm the removal of the soil contamination associated with the spill. QMLP was the Prime Contractor for the excavation and further details are appended in the QMLP report titled Emergency Response Management Workbook. Waste manifests for the soil removed from the incident site were not available at this time of this report[5]. Soil impacts were limited to the upper 1 m of ground surface and 1,600 tonnes of excavated soil was transferred Envirogreen Technology's facility located at the Similco Mine Site, approximately 18 km south of Princeton, BC by trucks operated by Hawkeye Holdings of Kelowna, BC. The excavated soil contained less than 3% Jet A-1 fuel. Backfill was obtained from a MoTI source. Table D, below, as well as the attached Soil Sample Log (Table 1) summarizes the general locations of the samples collected during the incident site soil investigation and remedial excavation. Attached Drawings 614668-100-IA and 614668-102-IA depict the locations of the soil samples. Photographs of the incident site and remedial excavation are appended.

[5] Please contact QMLP for copies of the waste manifests

Table D: Incident Site Soil Investigation Sample Summary

Sample Location	Sample ID*	Reference Drawing
Lemon Creek – Spill Area – Forest Service Road – Surface Soil Investigation	SS13-01 to -5, -7, -9, -11, -13 to -23 and -DUPA	614668-100-IA
Lemon Creek – Spill Area – Forest Service Road – Remedial Excavation	EXC13-1, -2, -4, -6, -8, -10, -12, -14, -16, -18, -20, -22, -25, -26 to -32, -34 to -37, -40 to -55, -DUPB, - DUPC and -DUPD	614668-101-IA
Backfill Sample	BF13-2	Not shown on the drawings, refer to Soil Sample Log (Table 1)

*refer to Soil Sample Log (Table 1) for sample descriptions and location of the samples.

Incident site soil investigation and confirmatory soil samples were analysed for moisture content, benzene, ethylbenzene, toluene and xylenes (BETX), VPH, extractable petroleum hydrocarbons (EPH), LEPH, heavy extractable petroleum hydrocarbon (HEPH), F1 minus BETX, F2 to F4, methyl tertiary butyl ether (MTBE), and PAHs (naphthalene, 2-methylnaphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(b,j)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene).

Surface soil samples SS13-01, -02, -03, -9, -15 and -16 were also analyzed for the following volatile organic compounds (VOCs): bromodichloromethane; bromoform; bromomethane; carbon tetrachloride; chlorobenzene; chloroethane; chloroform; chloromethane; dibromochloromethane; 1,2-dichlorobenzene; 1,3-dichlrobenzene; 1,4-dichlorobenzene; 1,1-dichloroethane; 1,2-dichloroethane; 1,1-dichloroethylene; cis-1,2-dichloroethylene; trans-1,2-dichloroethylene; dichloromethane; 1,2-dichloropropane; cis-1,3-dichloropropene; trans-1,3-dichloropropene; 1,1,1,2-tetrachloroethane; 1,1,2,2-tetrachloroethane; tetrachloroethylene; 1,1,1-trichloroethane; 1,1,2-trichloroethane; trichloroethylene; trichlorofluoromethane; 1,2,4-trimethylbenzene; 1,3,5-trimethylbenzene; and vinyl chloride. Surface soil samples SS13-9, 15, and 16 were also analysed for glycols (propylene glycol, ethylene glycol, and diethylene glycol).

Surface soil and remedial excavation confirmatory soil samples collected on July 28, 2013 through July 31, 2013 were sent to Maxxam Analytics in Burnaby, BC (Maxxam) for analysis. The results of the incident site soil investigation and remedial excavation are presented in Table 1a and Table 1b and summarized on attached Drawing 614668-109-IA and 614668-110-IA.

4.2 Surface Water Investigation

During the period of July 28th to August 8th, 2013, surface (and select sub-surface) water sampling was completed daily at designated and incidental sampling stations located in the following four general geographic areas:

- Lemon Creek: at and downstream of the accident site (approximately 4 km);
- Slocan River: upstream, at, and downstream of the confluence with Lemon Creek to the confluence with Kootenay River;
- Kootenay River: upstream, at, and downstream of the confluence with the Slocan River; and
- Columbia River: downstream of the confluence with the Kootenay River.

Locations were chosen based on visual evidence of hydrocarbons (i.e., worst case locations); proximity to POD and/or water wells (i.e., areas of greatest concern); and also from other locations that were easily accessible. Designated and incidental water sampling sites included: domestic water intake areas (PODs); shallow dug/drilled water wells located close to the Slocan River and Lemon Creek; identified recreational use areas (i.e., beaches and local swimming areas); agricultural water intakes (i.e., irrigation and livestock water intakes/PODs); and, select sites downstream of the Lemon Creek spill site area on Lemon Creek. Designated sites were sampled daily, and both designated and incidental sampling stations were established, where possible, at access points (i.e., bridges, beaches, irrigation spots and points of diversion) to ensure the safety of personnel collecting the samples yet robust enough to cover the range of water users. Samples were collected both from shore and from boats. A summary of the surface water samples collected is presented in Table E below and shown on the attached Drawing 614668-102-IA through 614668-107-IA.

Table E: Surface Water Investigation Sample Summary

Sample Location	Sample ID	Reference Drawing
Slocan River – North of confluence of Lemon Creek	SW13-12, RR, TT, VV	614668-102-IA, -103-IA and -104-IA
Lemon Creek and confluence of Slocan River	SW13-1, -3, -5, -13, -23, -300 and -406	614668-102-IA, -103-IA and -104-IA
Slocan River – south of Lemon Creek and north of Winlaw	SW13-2, -4, -6, -7, -22, -500, -501, -502, -503, -505, -600, -601, -A, -AA to -OO, -QQ, -WW, -XX, -YY and -Z	614668-102-IA through 614668-107-IA
Slocan River – south of Winlaw	SW13-8 to -11 and -PC	614668-102-IA
Kootenay River	SW13-14 to -19, -PP, -KR1, -KR2, -400, -401 and -402	614668-102-IA
Columbia River	SW13-20 and -21	614668-102-IA
Winlaw Bride Foam	WB-01	614668-102-IA and -107-IA

Water samples were analysed for BETX, VHw, VPHw EPHw, LEPHw, HEPHw, F1 minus BETX, F1 to F4, MTBE, and PAHs. Select water samples were also analysed for VOCs.

Surface water samples collected on July 28, 2013 from SW13-01 to 04 and July 29, 2013 from SW13-03 to 11, A, and Z were sent to Maxxam for analysis. All other surface water samples were submitted to ALS for analysis. The results of the surface water investigation are presented in Table 2a and 2b and summarized on attached Drawings 614668-111-IA through 614668-115-IA.

On August 4, the results indicated, with one exception (SW13-WW had a surface water aquatic life exceedence[6] for LEPH of 320 µg/L versus the guideline of 50 µg/L), water quality meets numeric standards for all water uses, and chemical parameters were generally less than detection limits. At surface water location SW13-03, at the confluence of Lemon Creek and the Slocan River, ethylbenzene was measured above BCWQ drinking water (DW) guideline on one occasion (July 28, 2013); this guideline is an aesthetic objective derived to be protective of taste and odour concerns. A subsequent sample collected on August 3, did not contain detectable hydrocarbon parameters. No other exceedances of the CSR DW standards were measured during the surface water investigation.

[6] BCWQ guidelines do not exist for LEPH or VPH for the protection of aquatic life (AW); as such, 1/10th of the CSR AW standard is applied as suggested in MoE Technical Guidance 15 (TG15): Concentration Limits for the Protection of Aquatic Receiving Environments. However, the method detection limit (MDL) for LEPH was above the suggested criterion of 50 ug/L and therefore, there may be other AW exceedences that were not identified.

4.3 Water Supply Investigation

A limited water supply sampling program was undertaken during the spill response phase of the program. The wells sampled were either identified as shallow dug/drilled wells or points of diversion located close to Lemon Creek and the Slocan River, or, complaints had been received by the well owners regarding the detection of odours in their water supply. A shallow dug well located nearest the incident site and on the Lemon Creek alluvial fan, as well as six (6) other water supply wells, were sampled between July 28 and August 5, 2013. The sample locations are summarized in Table F below.

Table F: Water Supply Investigation Sample Summary

Sample Location	Sample ID	Reference Drawing
Lemon Creek – shallow well	DW13-01	614668-102-IA, -103-IA and -104-IA
Slocan River – south of Winlaw	DW13-02	614668-102-IA, -103-IA and -107-IA
Lemon Creek and confluence of Slocan River	DW13-03	614668-102-IA, -103-IA and -104-IA
Passmore Drinking Water Well	DW13-04	614668-102-IA, -103-IA and -107-IA
Winlaw Mobile Park	DW13-05	614668-102-IA, -103-IA and -107-IA
Slocan River north of Perry's Bridge – shallow well	DW13-A	614668-102-IA, -103-IA and -105-IA
Slocan River south of Lemon Creek and north of Winlaw	DW13-C	614668-102-IA, -103-IA and -107-IA

Water supply samples were analysed for BETX, VHw, VPHw, EPHw, LEPHw, HEPHw, MTBE, F1 minus BETX, F1 to F4, and PAHs. Water supply samples DW13-01 and DW13-02 were also analysed for VOCs.

Water supply samples DW13-01 and 02, collected on July 28 and 29, 2013, respectively, were sent to Maxxam for analysis. All other drinking water samples were submitted to ALS for analysis. The results of the drinking water investigation are presented in Table 3a and 3b and summarized on Drawing 614668-116-IA to 614668-118-IA.

Analytical results were non-detect indicating that hydrocarbon impacts had not occurred. In addition, IHA sampled eight (8) water supply wells and two (2) PODs, almost all within 30 m of Lemon Creek and the Slocan River between August 12 to August 14, 2013 and analytical results were also non-detect. The analytical results are not presented in this report; however the location of the water supply wells and the PODs, identified as IH-1 through IH-8, are shown on the attached Drawings.

4.4 Sediment Investigation

On July 29 and between August 1 and 4, 2013, sediment samples were collected at all designated and at select incidental surface water sampling locations. Seventy-six samples were collected along the shoreline of the Slocan River where hydrocarbons were observed (i.e., worst case locations) and in other locations where the shoreline was accessible and submitted for analytical testing of chemicals associated with Jet A-1 fuel. Sediment samples could not be collected from Lemon Creek due to the coarse nature of the material comprising the alluvial fan; as such, there are limited to no fine-grained sediments to act as on-going sources of hydrocarbons (via sorption) in this area. A summary of the sediment samples collected is presented in Table G and shown on attached Drawing 614668-102-IA through 614668-107-IA .

Table G: Sediment Investigation Sample Summary

Sample Location	Sample ID	Reference Drawing
Slocan River – north of confluence of Lemon Creek	SED13-114 and -115	614668-102-IA, -103-AI and -104-IA
Lemon Creek and confluence of Slocan River	SED13-300 and -302 to -306	614668-102-IA, -103-AI and -104-IA
Slocan River – north of Perry's Bridge	BEACH1, -3, -6 and -7 SED13-108, -116, -117, -A and -02 to -06	614668-102-IA, -103-AI and -105-IA
Slocan River – south of Perry's Bridge and north of Winlaw	BEACH2, -4 and -8 SED13-Z, -07, -100 to -107, -109 to -113 and -22A	614668-102-IA, -103-AI, -106-IA and -107-IA
Slocan River – south of Winlaw	BEACH5 SED13-08 to -11 and -109	614668-102-IA, -103-AI, -107-IA
Kootenay River	SED13-16A to -19A	614668-102-IA
Columbia River	SED13-20A and -21A	614668-102-IA

Sediment samples were analysed for BETX, VPH, EPH, LEPH, HEPH, F1-BETX, F1 to F4, MTBE, and PAHs. Select sediment samples (SED13-02, 13-04, 13-06 through 13-11) were also analysed for VOCs.

Sediment samples collected on July 29, 2013 from SED13-02 to 11, A, and Z were sent to Maxxam for analysis. All other sediment samples were submitted to ALS for analysis. The results of the sediment investigation are presented in Table 4a and 4b and summarized on Drawings 614668- 119-IA through 614668-123-IA.

One exceedence (2-methylnaphthanlene) was measured in one sediment sample collected north of Perry's Bridge. Approximately two thirds of the samples were non-detect and only a single sediment sample contained concentrations in excess of the CSR Schedule 9 Sediment Criteria, indicating that the product had minimal impacts to sediment.

4.5 Recovered Product Investigation

On July 31, 2013, SNC-Lavalin collected one sample of the product recovered from Lemon Creek by a vacuum truck operated by QMLP. The sample (VACTRUCK) was analysed for EPH (C_{10}-C_{19}; C_{19}-C_{32}) and PAHs. The results of the recovered product investigation helped to determine the chemical constituents of the product.

The recovered product sample was submitted to ALS for analysis. The results of the recovered product investigation are presented in Table 5, attached to the main text of this report.

4.6 Agricultural Soil Investigation

Between August 4 and 6, 2013, SNC-Lavalin personnel sampled exposed surface soils from six farms, two residences, and two background locations in the vicinity of the incident, as shown in Table H below. The locations of agricultural soil samples are shown on Drawing 614668-108-IA.

Table H: Agricultural Soil Investigation Sample Summary

Sample Location	Farm Type	Sample ID
150 Sunset Crescent Road – Goose Creek	Background mixed vegetable farm (approximately 25 km south and at least 6 km west of spill site)	BG13-1-01
Slocan, BC – Steen Icelandic Horses	Background mixed vegetable farm (approximately 8 km north of spill site)	BG13-2-01
Slocan Valley, BC – Larson Farm	Cattle Farm	FR13-1-01, -02 and -03
1920 Glade Road, Castlegar, BC – Glade Mountain Farm	Organic mixed vegetable farm	OF13-1-01 and -02

Sample Location	Farm Type	Sample ID
2989 Slocan Valley East Road, Slocan Park, BC – Chicken Lips Organic Farm	Organic poultry farm	OF13-2-01 and -02
5361 Filipoff Road, Winlaw, BC – Crooked Horn Farm	Organic mixed vegetable and mushroom farm	OF13-3-01, -02 and -03
6868 Fern Road, Winlaw, BC – Ravine Creek Farm	Organic mixed vegetable farm	OF13-4-01, -02 and -03
7381 Avis Road, Winlaw, BC – Bee Green Farm	Organic mixed vegetable farm	OF13-6-01
7803 Lemon Creek Road – Russell Hubert Property	Residential mixed garden	R13-1-02
West of Highway 6, downstream of Russell Hubert – Brian's Property	Residential grazing field	R13-2-02, -2-GR1 and -2-GR2

Agricultural soil samples were submitted for analysis of moisture content, BETX, styrene, VPH, EPH, LEPH, HEPH, silica gel EPH, F1 minus BETX, F1 to F4, silica gel F4, MTBE, and PAHs.

Agricultural soil samples from Larson Farm, Glade Farm, Chicken Lips, Bee Green, Russell Hubert Property, Brian Property, and select samples from Ravine Creek were also analysed for silica gel EPH. Select soil samples from Brian Property were also analysed for F2 minus naphthalene and F3 minus PAHs. The soil sample from Bee Green was also analysed for F4 silica gel.

The agricultural soil samples were submitted to ALS for analysis. The results of the agricultural soil investigation are presented in Table 6.

Concentrations of parameters associated with the product were mainly non-detect with all concentrations well below the applicable provincial standards in agricultural soil.

4.7 Agricultural Vegetation Investigation

On August 4 and 6, 2013, SNC-Lavalin personnel collected vegetation samples, including edible plant tissue, from six farms, two residences, and two background locations in the vicinity of the incident, as shown in Table I. The locations of agricultural vegetation samples are shown on Drawing 614668-108-IA.

Table I: Agricultural Vegetation Investigation Sample Summary

Sample Location (Address)	Farm Type	Sample ID	Sample Type
150 Sunset Crescent Rd – Goose Creek	Background mixed vegetable farm (approximately 25 km south and at least 6 km west of spill site)	BG13-1-K9	Kale
Slocan, BC – Steen Icelandic Horses	Background mixed vegetable farm (approximately 8 km north of spill site)	BG13-2-SC	Swiss Chard
Slocan Valley, BC – Larson Farm	Cattle Farm	FR13-1-G1, -G2 and -G3	Grass
1920 Glade Rd, Castlegar, BC – Glade Mountain Farm	Organic mixed vegetable farm	OF13-1-KA1 and -KA2	Kale
2989 Slocan Valley East Road, Slocan Park, BC – Chicken Lips Organic Farm	Organic poultry farm	OF13-2-G1 and-G2	Grass
5361 Filipoff Rd, Winlaw, BC – Crooked Horn Farm	Organic mixed vegetable and mushroom farm	OF13-3-KA and -MU	Kale, Mushroom
6868 Fern Rd, Winlaw, BC – Ravine Creek Farm	Organic mixed vegetable farm	OF13-4-KA and -KA2	Kale, Kale roots
7381 Avis Rd, Winlaw, BC – Bee Green Farm	Organic mixed vegetable farm	OF13-6-KA	Kale
7803 Lemon Creek Rd – Russell Hubert Property	Residential mixed garden	R13-1-02VEG	Kale and Grass
West of Highway 6, downstream of Russell Hubert – Brian's Property	Residential grazing field	R13-2-GR2 and -GR3	Grass

Agricultural vegetation samples were submitted for analysis of PAHs and alkylated PAHs.

The agricultural vegetation samples were submitted to ALS for analysis. The results of the agricultural vegetation investigation are presented in Table 7, attached to the main text of this report.

There are no applicable federal or provincial guidelines or standards to compare concentrations of contaminants in plant tissue; therefore, concentrations of parameters associated with the product in agricultural plant tissue were compared to background vegetation samples. Concentrations of parameters associated with the product were either below the laboratory detection limit or detected at concentrations similar to those detected in background samples.

4.8 Investigation Summary

SNC-Lavalin personnel collected 384 samples between July 28 and August 8, 2013. The total number of samples analyzed by medium was as follows:

- 64 soil samples, including QA/QC duplicates;
- 199 surface water samples. The number represents the total of both surface and sub-surface samples, including foam samples, and includes samples taken near surface water intakes. The numbers include blanks and QA/QC duplicates;
- 8 water supply samples (drilled or dug wells etc);
- 76 sediment samples, including QA/QC duplicates;
- 1 sample of the product recovered from Lemon Creek in a vacuum truck;
- 19 agricultural soil samples, including two background samples; and
- 17 vegetation samples, including two background samples.

The field methods employed by the sampling teams during these investigations were in accordance with standard industry practices, as well as technical direction provided by MoE (e.g., memo dated July 27, 2013). Detailed descriptions of SNC-Lavalin's field work methodology for collection and handling of samples during the investigation are appended (Appendix V). Analytical results for soil, surface water, drinking water, sediment, recovered product, agricultural soil, and vegetation compared to applicable standards/guidelines are provided in Tables 1 to 7, following the main text of this report. Drawings showing the locations of samples and Laboratory Analytical Reports are appended.

Data collected to date indicates that current concentrations of parameters associated with the Jet A-1 fuel are less than the laboratory detection limit in surface water and groundwater (from select domestic and agricultural wells), and that concentrations of the product-associated parameters are less than the applicable provincial standards in sediment, as well as in soil from the incident site. Concentrations of parameters associated with the product were mainly non-detect with all concentrations well below the applicable provincial standards in agricultural soil. Concentrations in agricultural vegetation samples were either below laboratory detection limits or similar to the concentrations found in background vegetation samples.

5.0 REGULATORY CONSULTATION

A number of regulatory agencies have been involved in the Project, such as MoE, MoA, and IHA.

In a memorandum sent on July 27, 2013, MoE requested EFC to obtain assistance from qualified environmental professionals to assess the impacts related to the incident. To meet this requirement, EFC retained SNC-Lavalin to complete an initial monitoring and sampling program in all applicable environmental media, in addition to an environmental impact assessment and post-remediation monitoring. SNC-Lavalin adhered to MoE's recommended sampling parameters, methods, and locations. The draft analytical results of the program, including sample location plans, were released to the public on August 19, 2013.

The results of the air quality monitoring program are reported in Jet A1 Fuel Spill at Lemon Creek, BC – Air Quality Assessment, dated September 9, 2013 (appended). The results of the water, soil, sediment, and vegetation monitoring and sampling programs are reported herein.

On August 14, 2013, MoE released shoreline treatment endpoints in a document titled Lemon Creek Spill: Shoreline Treatment Endpoints. This document identified the endpoints for remediation activities along segments of oiled shoreline, which were used as the practical definition of "clean" for each segment. The oiled shoreline was divided into segments based on value of habitat or use and shoreline type. The shoreline treatment endpoints are presented in Table J.

Table J: Endpoints Targeted for Each Type of Shoreline and Water Use

Location	Type of Shoreline	Use	Endpoints	Authority
Lemon Creek Km 0 (incident site) to Km 2 downstream	Coarse sediment bank	Residential + drinking water	No sheen No consistent odour Surface water quality analysis satisfy BC WQG for aquatic health and drinking water	MoE + IHA
Lemon Creek Km 2 to Km 4 downstream to confluence with Slocan River	Coarse sediment bank	Residential + drinking water	No sheen No consistent odour Surface water quality analysis satisfy BC WQG for aquatic health and drinking water	MoE + IHA
Slocan River	Coarse sediment bank	Environmental use	No rainbow sheen	MoE

Location	Type of Shoreline	Use	Endpoints	Authority
Slocan River	Vegetated bank	Environmental use	No rainbow sheen	MoE
Slocan River	Log jammed	Environmental use	No free product No rainbow sheen	MoE
Slocan River	Fine sediment beach	Environmental use	No rainbow sheen	MoE
Slocan River (first 10 km)	Coarse sediment bank	Residential + recreational use	No sheen No consistent odour	MoE + IHA
Slocan River (first 10 km)	Vegetated bank	Residential + recreational use	No sheen No consistent odour	MoE + IHA
Slocan River (first 10 km)	All types of shoreline	Agricultural use	No sheen No consistent odour	MoE + IHA

Adapted from MoE (2013)

At the request of MoE, SNC-Lavalin prepared a Draft Lemon Creek and Slocan River Biological Monitoring Program, dated September 9, 2013 and a Draft Water and Sediment Quality Program, dated August 30, 2013. These proposed programs comprise the environmental monitoring plan, which will take effect following MoE's declaration that the cleaning efforts have achieved the desired endpoints and that the project transitions from remediation to recovery and monitoring.

At the request of BC MoA, in conjunction with Kootenay Organic Growers Society, SNC-Lavalin collected surface soil and vegetation, including edible plant tissue, samples from agricultural lands located in the vicinity of the incident. The results of the agricultural sampling program were released to the individual farms on as soon as the analytical results were available and were released to the public on August 30, 2013.

SNC-Lavalin collected samples representative of drinking water in the vicinity of the incident. Laboratory analysis results were submitted to the Medical Health Officer and IHA to inform decisions regarding the "Do Not Use" order placed on water use in the vicinity of the incident. All water restrictions were lifted by IHA on August 9, 2013.

6.0 ECOLOGICAL IMPACT ASSESSMENT

6.1 Fisheries and Aquatic Resources

The extent of damage to fisheries and aquatic resources that has been reported following accidental hydrocarbon spills is diverse and complex (Miller & Stout 1986; Crunkilton & Duchrow 1990; Lytle & Peckarsky 2001). This is because effects depend on the chemical characteristics of the petrochemical, the volume spilled, and the nature of the receiving water and its biota (Crunkilton & Duchrow 1990). Below, a brief synopsis of the primary watercourses influenced by the fuel spill is provided, followed by the aquatic field methods deployed during the emergency response phase, analysis of data, and the assessment and interpretation of the impact to the receiving aquatic environment.

6.1.1 Watershed Summary

6.1.1.1 Slocan River

The Slocan River is a 58 km-long, sixth-order stream that originates between the Valhalla and Selkirk Mountain Ranges and flows out of the south end of Slocan Lake before eventually joining the Kootenay River. Major tributaries include the Little Slocan River, Fitzstubbs Creek, and Lemon Creek. Rainbow trout from various hatcheries have historically been stocked in Slocan River between 1911 and 1991; however, no recent fish stocking has occurred (BC MoE 2013).

The Slocan River played a major role in the early 1900s as a means of transporting logs from mountain logging ventures to sawmills within the Columbia River basin (Beckham 1995). Certain areas surrounding the Slocan River are used as consumptive watersheds which supply water for domestic and agricultural purposes to residents within the valley. Commercial land use practices within the area include timber management, mining, outdoor recreation and commercial tourism (Silva Forest Foundation 1996).

At least 17 fish species have been documented in the Slocan River watershed (BC MoE 2013):

- Brook Trout
- Bull Trout
- Chub (general)
- Dace (general)
- Dolly Varden
- Kokanee
- Largescale Sucker
- Mountain Whitefish
- Northern Pikeminnow
- Peamouth Chub
- Pygmy Whitefish
- Rainbow Trout
- Redside Shiner
- Shorthead Sculpin
- Umatilla Dace
- Sucker (general)
- Westslope (Yellowstone) Cutthroat Trout
- Unidentified species

6.1.1.2 Lemon Creek

A major tributary to the Slocan River is Lemon Creek, a 26 km-long, fifth-order stream that flows in a west-northwesterly direction to the Slocan River just downstream of Slocan Lake. Major tributaries to the creek include South Lemon Creek, Crusader Creek, and Chapleau Creek. Rainbow trout fry have historically been stocked in Lemon Creek in 1939, 1950, and 1951 from the Nelson Hatchery; however, there are no reports of recent stocking (BC MoE 2013).

Lemon Creek is characterized as a fast flowing stream that has been recognized as one of the most important tributaries to the Slocan River (Slocan River Streamkeepers 2006). Lemon Creek is a cold-water stream that provides salmonids with optimal water temperatures to carry out all life history stages. Due to the physical characteristics of the creek, Lemon Creek is known to support a diverse benthic macro-invertebrate and fish community (Slocan River Streamkeepers 2006).

At least 12 fish species have been documented in the Lemon Creek watershed (BC MoE 2013):

- Brook Trout
- Bull Trout
- Dace (general)
- Longnose Dace
- Mountain Whitefish
- Northern Pikeminnow
- Rainbow Trout
- Sculpin (general)
- Shorthead Sculpin
- Slimy Sculpin
- Torrent Sculpin
- Umatilla Dace

6.1.2 SARA-Listed Fish Species

Three fish species documented in the Slocan River and its tributaries (Shorthead Sculpin, Columbia Sculpin and Umatilla Dace,) are currently listed provincially by the BC Conservation Data Centre and by the Federal Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Columbia Sculpin (*Cottus hubbsi)* is a SARA-listed species (Schedule 1, Special Concern; GoC 2013) and is also provincially Blue-listed (Special Concern [formerly Vulnerable]) (British Columbia Conservation Data Center [BC CDC] 2013). The species is endemic to the Columbia River basin inhabiting the Kootenay River and tributaries (including the Slocan River), the Kettle River, and tributaries below Slocan Lake. Their habitat includes riffles in streams less than 5 m wide up to widths as wide as the Columbia River mainstem (COSEWIC 2010a). Populations have been negatively impacted by unnatural fluctuation in water levels, flow, and temperature (DFO 2012).

Shorthead Sculpin (*C. confusus*) is a SARA-listed species (Schedule 1, Special Concern; GoC 2013) and is also provincially Blue-listed (BC CDC 2013). They have been recorded in the Slocan River, the mainstem and tributaries of the Columbia River, and the Kettle River. Shorthead Sculpin prefer small rivers with moderately cool water that contain riffles with suitable spawning gravels and that contain adequate cover (COSEWIC 2010b). They have small home ranges and are particularly sensitive to changes in water quality and habitat as a result of anthropogenic activities, such as urbanization and pollution (DFO 2011).

Umatilla Dace (*Rhinichthys umatilla*) is a SARA-listed species (Schedule 3, Special Concern; GoC 2013) and is also provincially Red-listed (Extirpated, Endangered, or Threatened) (BC CDC 2013). Umatilla Dace is a minnow species of great scientific interest as it is thought to be a hybrid of Speckled Dace (*Rhinichthys osculus*) and Leopard Dace (*Rhinichthys falcatus*) (COSEWIC 2010c). It is endemic to the Columbia River basin, particularly the upper and middle mainstem sections below the Arrow Lakes and large tributaries which include the Kootenay River, the lower Slocan River and the Similkameen River. As a benthic, riverine species they prefer silt free sections with large gravels to boulder-sized substrates where they can find shelter during the day. The conversion of riverine habitat to reservoirs has resulted in the loss of suitable habitat that is required for the survival of the species (COSEWIC 2010c).

6.1.3 Comparative Incidents

Spills of chemicals harmful to the environment are not uncommon in North America. Three spills in recent history that have some similarity to the Lemon Creek incident are the light crude oil spill on the Pine River near Chetwynd, BC in 2000, the aviation kerosene spill in Roaring Run Creek near Ebensburg, Pennsylvania in 1982, and a 25,500 liter diesel fuel spill in a small trout stream (Cayuga Inlet) in central New York, USA in 1997.

A light crude oil spill occurred 80 km upstream from Chetwynd, BC on the Pine River in August, 2000 as a result of a ruptured of a pipeline. The incident recorded a spill of nearly one million liters of light crude oil into the Pine River. The spill resulted in the mortality of wildlife and fish, as well as the contamination of the water supply for the city of Chetwynd. Unlike the Lemon Creek spill, light crude oil is more hazardous to the environment than a Jet A-1 fuel. The nature of light crude oil is more persistent and requires more effort to remove from the system. Named by the Outdoor Recreation Council (ORC) in 2001 as the most endangered river in BC (Outdoor Recreation Council Endangered Rivers list 2001), the Pine River Spill is considered to likely be the most expensive oil spill in Canadian history (McCubbing et al., 2006).

In October 1982, a pipeline ruptured approximately 150 m north of Roaring Run Creek and 5 km south of the town of Ebensburg, Cambria County, Pennsylvania. The pipeline break was estimated to have released 200,000 liters of aviation kerosene into the aquatic environment. As a result, a comprehensive survey of the contaminated watershed was initiated to characterize the effects of the spill to aquatic biota and flora. In April 1983, results from short-term in-situ toxicity bioassays indicated that a fish restocking program could be launched. A fish study program conducted in May and October, 1983 concluded that previously contaminated sections of the stream had recovered and could support a diverse fish population. Several factors contributed to the relatively quick re-establishment of aquatic biota previously affected by the spill. These factors included: 1) a rapid and effective cleanup process, 2) access to an abundant source of uncontaminated dilution water, 3) an upstream source of benthic organisms for recolonization, and 4) immigration of fish from uncontaminated areas within the watershed (Guiney et al., 1987).

At 2:30 a.m. on 3 November 1997, three Conrail locomotive engines hauling 21 cars were derailed near West Danby, Tompkins County, New York, USA, spilling an estimated 26 500 L of diesel fuel into first order reach of the Cayuga Inlet, a tributary of Cayuga Lake. A fish kill of Rainbow Trout (*Oncorhynchus mykiss* Walbaum), White Sucker (*Catostomus commersoni* Lacepede), Blacknose Dace (*Rhinichthys atratulus* Agassiz) and Darters (*Etheostoma* spp.) estimated at 92% of total fish abundance was reported the following day. Despite efforts to clean up the spill with chemical containment booms, slicks of the diesel fuel were seen floating on the surface of Cayuga Lake 16 km downstream within 24 hours.

The Cayuga Inlet is one of the premier trout fishing streams in the area and holds a population of naturally breeding Rainbow Trout. As the Inlet is one of the few tributaries to the 170 km^2 Cayuga Lake where upstream migration of fish is not blocked by waterfalls, it is also an important spawning ground for Cayuga Lake Brown Trout (*Salmo trutta* Linnaeus) and Atlantic Salmon (*Salmo salar* Linnaeus). These fish were beginning their autumn run when the spill occurred. Amphibians, water birds, mink (*Mustela vison* Schreber) and other animals also use the Inlet and its riparian areas. Many of these animals ultimately depend on aquatic insects, snails and other aquatic invertebrates for food. Because of these food-web connections, an assessment of damage to the aquatic invertebrate community was conducted to gauge the magnitude of effects of this spill.

Immediately after the spill, invertebrate density below the spill was significantly lower than reference density. Three months after the spill, density up to 5 km below the spill was still far lower than reference density. A year after the spill, density was similar between reference and impact sites, suggesting that invertebrates had recovered numerically. Taxonomic richness up to 5.0 km below the spill was less than half the reference taxonomic richness and this difference persisted for at least 3 months. Some significant differences between reference and impact sites were observed after 15 months, but these differences could not be attributed to the spill. It was concluded that the diesel fuel spill significantly reduced the density of invertebrates (by 90%) and taxonomic richness (by 50%) at least 5.0 km downstream, but density recovered within a year. Throughout the study, however, the fauna immediately below the spill was species poor and significantly over-represented by a single dominant taxon, suggesting that 15 months was not sufficient for full community recovery from the spill.

6.1.4 Methodology

A fish carcass removal program was implemented immediately after the emergency spill response phase was initiated, with the main objectives to collect all encountered deceased specimens throughout the riverine environment influenced by the fuel, enumerate the specimens collected, and lower the risk of food web transfer of potentially contaminated specimens.

6.1.4.1 Fish Collection Area Delineation

The collection of deceased fish specimens was conducted between July 28 and August 8, 2013. The collection area included Lemon Creek downstream of the release site to the Brilliant Dam on the Kootenay River (Figure 614668-FW-003), which was divided into 4 areas:

1) Lemon Creek release site to the confluence with the Slocan River (approximately 4.9 km);
2) Slocan River from the Lemon Creek confluence to the Perry's Bridge near Appledale, BC (approximately 7.0 km);
3) Slocan River from Perry's Bridge to the confluence with the Little Slocan River (approximately 21 km); and,
4) Slocan River from the confluence with the Little Slocan River to the Brilliant Dam on Kootenay River (approximately 36 km).

The majority of the recovery effort, focused on Lemon Creek downstream of the spill site (Area 1) and the section of Slocan River immediately downstream of the confluence with Lemon Creek (Area 2). Decision to focus on these areas was based on initial field reconnaissance and refined through the evaluation of SCAT observations.

Lemon Creek downstream of the incident site consisted of two different reaches. The first reach, from the incident site downstream to the Highway 6 bridge, was characterized by fast-flowing waters, a confined channel, and relatively steep gradient (Appendix I – Photograph 1). Downstream of the Highway 6 bridge to the confluence with the Slocan River, the watercourse was less confined, with numerous bars and islands present, low gradient, and slower water velocities.

The Slocan River downstream of the confluence with Lemon Creek (Area 2) was characterized by multiple side channels, braided/anastamosed areas, and diverse fish habitats (e.g., pools, large woody debris, etc) (Appendix I – Photograph 2). Further (downstream) sections (e.g., Area 3) were more confined with likely less complex fish habitats (Appendix I – Photograph 3).

Areas 1 and 2 were walked by the response team (between 2 and 3 field staff per team; up to three separate teams per area) to collect fish mortalities. Area 3 was monitored in select sections due to the lower likelihood of mortalities present and personnel safety (deeper waters). Area 1 was accessed by truck, while inflatable zodiac boats (Fraser River Rafting) were used to access Areas 2 and 3. A jet boat was used to monitor the Kootenay River to the Brilliant Dam (Area 4).

6.1.4.2 Data Collection

Carcasses were removed from stream margins by hand (with Nitrile gloves) or from deeper water using dipnets. The following information was collected for each carcass recovered:

1) Date and location (i.e., watercourse);
2) Fish species (if possible; dependant on the condition of carcass);
3) Length (fork or total depending on species; in mm);
4) Life history stage (young-of-year, juvenile, or adult); and,
5) General mesohabitat type where the fish was found (e.g., riffle, pool, run, etc.).

The location of most deceased fish specimens were marked with a global positioning system (GPS) to aid in digitally representing where specimens were collected; however, not all recovered fish had individual Universal Transverse Mercator (UTM) coordinates. As such, the total number of fish collected does not exactly match with the number of GPS points on the figures. Photographs were also taken of select fish mortalities and mesohabitats where specimens were collected.

Once information for each fish was recorded, deceased fish were placed in Ziploc baggies, labeled (date, location, watercourse, species, number of mortalities), and transported on ice in coolers until eventually frozen and stored at the Nelson MoE office. Carcass salvages continued until directed by MoE to cease salvage efforts on August 4, 2013; however, incidental fish mortality collections (e.g., as part of SCAT) were conducted up until August 8, 2013.

In addition to the fish carcass recovery, general notes on specific areas where product was observed were also recorded. The specific location was marked with a GPS and observations on the amount, mesohabitat type in which it was present (e.g., pool, eddy, etc.), and characteristics (presence of odour, colour) were documented.

Fisheries biologists also assisted Polaris with the SCAT program specifically tasked with locating residual product on the Slocan and Kootenay rivers in Areas 2, 3, and 4 on August 6, 7 and 8, 2013. This included identifying where product was observed and evaluating fish habitat quality and quantity where product was noted.

6.1.4.3 Specimen Analyses

Fish length data were used to create length-frequency histograms, which can provide insight into population dynamics (e.g., cohorts), as well as growth and mortality within a given population.

Two unidentified salmonids from the Slocan River near the confluence with Lemon Creek were sent to the Animal Health Centre at the Ministry of Agriculture in Abbottsford, BC on July 30th, 2013 for necropsy analysis to determine cause of death. An additional fourteen unidentified fish consisting of salmonids and cottids (i.e., sculpins), were subsequently sent for further analysis. Due to the advanced state of decomposition, only the two originally submitted fish were assessed successfully; the remaining fourteen samples were not assessed and were frozen for storage at the lab.

Three whole Mountain Whitefish samples from Lemon Creek were also sent to ALS Laboratories in Edmonton, AB for analysis of PAH's and alkylated PAH's in muscle tissue. Two samples were analyzed and one was archived (i.e., no analysis performed). Fish samples were collected from the exposure area for necropsy and PAH analysis; however, no live fish were collected from unaffected (i.e., reference areas) during the emergency response. As such, although lab results are presented, no comparison of results between impact and reference areas have been conducted as part of the impact assessment.

Select samples of unidentified dace (*Rhinichthys* sp.) and sculpin (*Cottus* sp.) specimens were sent to AMEC Environment and Infrastructure (AMEC) in Nelson, BC for identification of potential SARA-listed species (namely, Umatilla Dace and/or Shorthead Sculpin).

6.1.5 Results

6.1.5.1 Salvage of Deceased Fish Specimens

The fish carcass recovery was conducted on lower Lemon Creek, the Slocan River downstream of the confluence with Lemon Creek to the confluence with the Kootenay River, and the Kootenay River downstream to the Brilliant Dam (Figure 614668-FW-003). Table K summarizes the results of the salvage.

Table K: Fish Carcass Salvage Summary

Fish Species	Number of Individuals and Date Found											
	July			August								Total
	29	30	31	1	2	3	4	5	6	7	8	
Mountain Whitefish		7	27	11	58	3	49					155
Torrent Sculpin					4	9	10	2	1			26
Rainbow Trout		4	5		7		3					19
Salmonid (unidentified)	1				1		7					9
Sculpin (unidentified)					2	3	3	1				9
Unidentified species						1	6				1	8
Northern Pikeminnow	1					2	3					6
Torrent/Prickly Sculpin		2			1	1	2					6
Longnose Dace					2	2						4
Longnose Sucker		1	1		1	1						4
Redside Shiner							1				2	3
Umatilla Dace						1	2					3
Largescale sucker						1	1					2
Shorthead Sculpin				2								2
Sucker (unidentified)					2							2
Dace (unidentified)							1					1
Peamouth (chub)											1	1
Shorthead/Columbia Sculpin							1					1
Total	2	14	33	13	78	24	89	3	1	0	4	**261**

In total, 261 fish were recovered from Lemon Creek and Slocan River. Of the fish mortalities collected, the majority were Mountain Whitefish (n=155) (Appendix I – Photograph 4), followed by Torrent Sculpin (n=26), and Rainbow Trout (n=19) (Appendix I – Photograph 5). The number of deceased fish is likely higher than the numbers removed by crews deployed during the emergency response due to the fast-flowing waters of Lemon Creek and Slocan River and the large extent of area to cover (longitudinal and lateral habitats on Lemon Creek and Slocan River), as well as missing the first couple of days immediately post-incident to commence fish salvages.

In addition to the fish mortalities, extensive numbers of deceased benthic invertebrates were observed in both Lemon Creek and Slocan River (Appendix I – Photograph 6). Live fish were also observed in many of the same areas where fish mortalities were recorded/collected indicating that either not all of the fish in the two watercourses were acutely impacted, or that other fish from locations uninfluenced by the fuel (e.g., from Slocan River upstream of the confluence with Lemon Creek) had migrated into the affected reaches (areas) post-incident.

Figures 614668-FW-004.1 to 614668-FW-004.6 show the location of where most of the fish carcasses were recovered; however, not all recovered fish had individual UTM coordinates. As such, the total number of fish collected does not exactly match with the number of GPS points on the figures.

Approximately 17 fish were salvaged from Lemon Creek (Area 1). The following species of fish were confirmed deceased as a result of the incident:

- Mountain Whitefish (n=15); and,
- Shorthead Sculpin (n=2).

Similar to the Slocan River, the number of species may be higher, as fish may have drifted downstream due to the fast-flowing waters in Lemon Creek. Information from BC MoE indicates the presence of at least 12 fish species that inhabit Lemon Creek (BC MoE 2013). Species that were not collected during the salvages but that are present in Lemon Creek include Brook Trout, Bull Trout, Rainbow Trout, Longnose Dace, Northern Pikeminnow, Slimy Sculpin, Torrent Sculpin, Umatilla Dace, and unidentified suckers and sculpins.

The majority of fish (n=226) were collected from Area 2 of the Slocan River. The following species of fish were collected in Slocan River as a result of the incident:

- Longnose Sucker (*Catostomus catostomus*);
- Largescale Sucker (*Catostomus macrocheilus*);
- Mountain Whitefish (*Prosopium williamsoni*);
- Northern Pikeminnow (*Ptychocheilus oregonensis*);
- Peamouth (chub) (*Mylocheilus caurinus*);
- Rainbow Trout (*Oncorhynchus mykiss*);
- Redside Shiner (*Richardsonius balteatus*);
- Shorthead Sculpin (*Cottus confusus*);
- Torrent Sculpin (*Cottus rhotheus*);
- Umatilla Dace (*Rhinichthys Umatilla*);
- Unidentified Dace (*Rhinichthys sp*); and,
- Unidentified Sculpin (*Cottus sp.*).

It is possible that the number of species may be higher, as it was difficult to perform accurate species identification due to the rapid decay of carcasses. Information from BC MoE indicates the presence of at least 17 fish species that inhabit Slocan River (BC MoE 2013). Species that were not collected during the salvages but are likely present in Slocan River include Brook Trout, Bull Trout, Dolly Varden, Kokanee, Lake Chub, and Westslope Cutthroat Trout.

Approximately 18 fish carcasses were collected in Area 3 of the Slocan River, consisting of Sculpin (n=11), Dace (n=2), Redside Shiner (n=1), and 4 other unidentified fish species. No fish mortalities were observed in Area 4.

Fish were collected from a variety of mesohabitats in all watercourses, including pools, riffles, runs, bars, glides, side channels, and along watercourse margins. Of the fish that were salvaged that had mesohabitat notes, the majority of deceased fish were salvaged from shallow pools; however, fish may have washed downstream from other locations and habitats.

6.1.5.2 Length-Frequency Distribution

Length-frequency histograms were created for the three most common fish species collected during the fish carcass salvages on Lemon Creek and Slocan River (Mountain Whitefish [Figure 2], Torrent Sculpin [Figure 3], and Rainbow Trout [Figure 4]). Not all of the data are presented, as not all fish were measured for length. The data suggest that, with the exception of sculpins, rearing juvenile fish were the most severely affected. A greater percentage of 'older' (i.e., > 2+) sculpins were affected relative to Mountain Whitefish and Rainbow Trout.

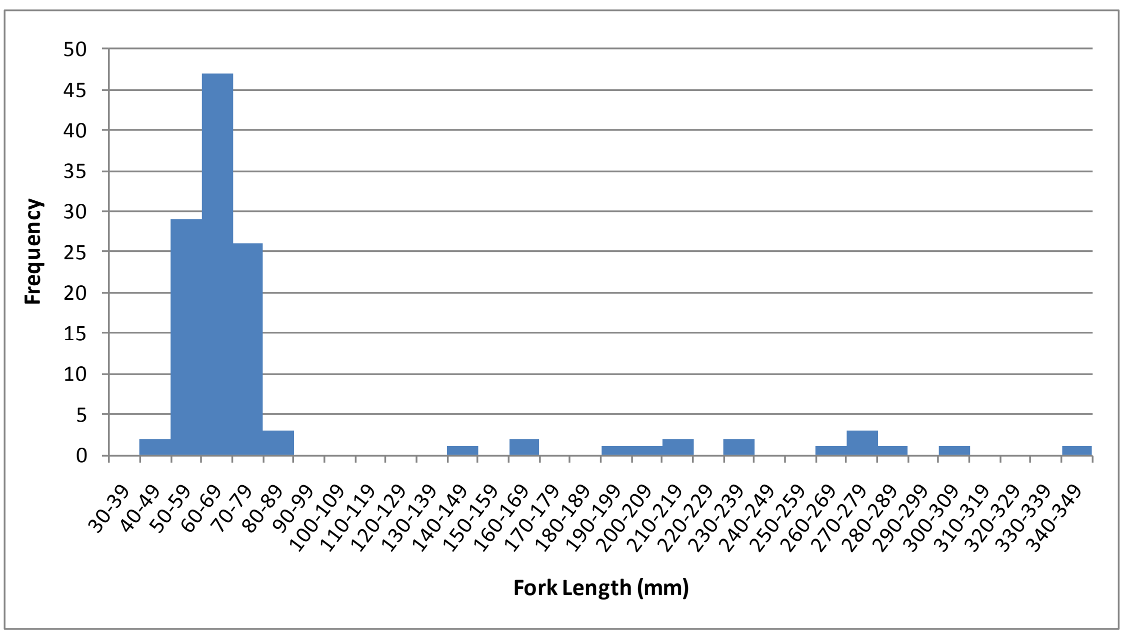


Figure 2: Length-frequency Histogram for Salvaged Mountain Whitefish (*Prosopium williamsoni*) (n=123)

The length-frequency data for Mountain Whitefish indicate a varied distribution of fish lengths; however, a small-sized class (40–89 mm) cohort is evident, with a few larger (i.e., >139 mm) fish. The majority of fish collected was within the 60–69 mm range. Most of the adult and sub-adult Mountain Whitefish (i.e., >139 mm) were collected from Lemon Creek. This may be attributed to habitat conditions in the creek, as less side channels and braided sections where juveniles would be more likely to rear were observed, relative to Slocan River (Appendix I – Photograph 1).

Data from McPhail (2007) indicate that Mountain Whitefish fry can attain lengths of 60-100 mm at the end of their first summer after hatching in the spring or early summer. This would suggest that the majority of Mountain Whitefish (87%) collected from Lemon Creek and Slocan River were young-of-year (0+).

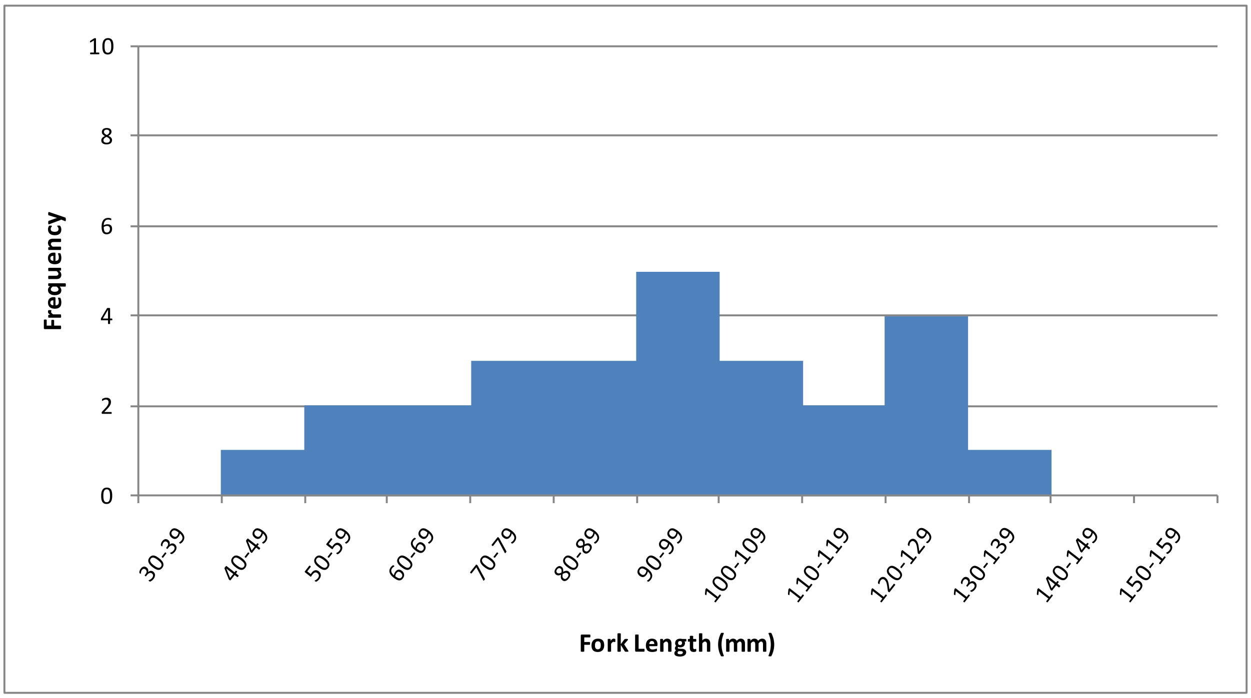


Figure 3: Length-frequency Histogram for Salvaged Torrent Sculpin (Cottus rhotheus) (n=26)

The length-frequency data for Torrent Sculpin indicate a relatively uniform distribution of fish lengths, with no cohorts evident. Of note is the absence of very small sized (<40 mm) fish; however, this may be attributed to the habitat where these fish were collected (predominantly runs and shallow pools). The majority of fish captured were within the 90-99 mm range.

Data from McPhail (2007) indicate that Torrent Sculpin fry can attain lengths of 20-30 mm by mid-July, after hatching in early spring. This suggests that all of the Torrent Sculpin species collected from Lemon Creek and Slocan River were likely at least 2 years old (1+).

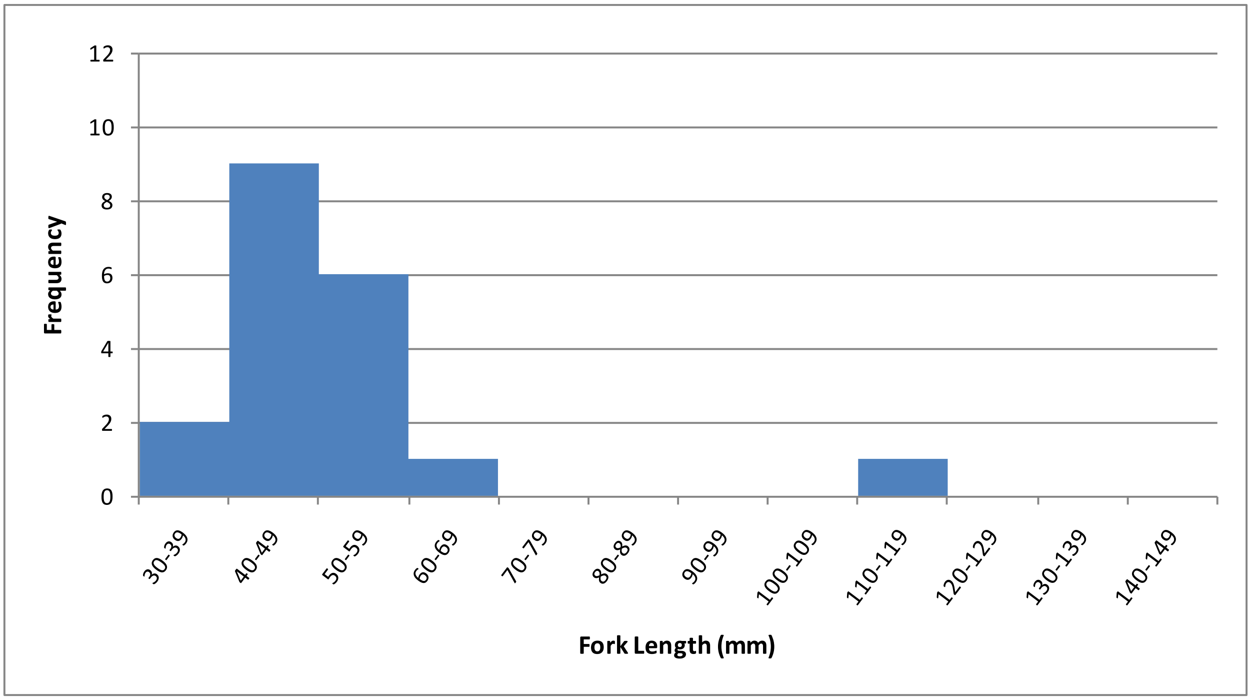


Figure 4: Length-frequency Histogram for Salvaged Rainbow Trout (Oncorhynchus mykiss) (n=19)

The length-frequency data for Rainbow Trout indicate a varied distribution of fish lengths, with one potential cohort evident: a small-sized class (30-69 mm). Although two larger (110 mm and 115 mm) Rainbow Trout were also collected, data from McPhail (2007) indicate that fry can attain lengths of 100-120 mm at the end of their first summer after hatching in late spring or early summer. This suggests that most, if not all, of the Rainbow Trout collected from Lemon Creek and Slocan River were young-of-year (0+).

Of note is the absence of large (>120 mm) fish; however, this may be attributed to the habitat where these fish were collected (predominantly runs and shallow pools where juveniles typically rear). The majority of fish captured were within the 40-49 mm range.

6.1.5.3 SARA Fish Species Identification

The results of the fish identification analyses performed by AMEC (Appendix VII) indicated that three SARA-listed species (GoC 2013) were collected during the carcass recovery program:

1) Shorthead Sculpin (Schedule 1, Special Concern);
2) Umatilla Dace (Schedule 3, Special Concern);

3) Columbia Sculpin (Schedule 1, Special Concern); and,
4) Columbia Sculpin was possibly the third species collected, but due to the condition that the carcass was recovered in, the specimen was identified as either Columbia Sculpin or Shorthead Sculpin. In certain cases, the state of the carcass completely prevented the identification to even the family level.

Of the 50 sculpin and dace samples submitted to AMEC, six fish were confirmed to be federally-listed by SARA as being Special Concern: three (potentially four, but was too decomposed to positively identify) Umatilla Dace (approximately 70mm, 85 mm, and 110 mm), two Shorthead Sculpin (approximately 65 mm and 100 mm), and one Shorthead or Columbia Sculpin (unknown length).

Being mid-summer spawners, length data indicated that the Umatilla Dace were at least 2 years old (1+), as they typically don't exceed 30 mm at the end of their first growing season. The 110 mm specimen was an adult, as adults rarely achieve fork lengths of more than 120 mm (McPhail 2007).

The 65 mm Shorthead Sculpin was likely an adult, as there are reports of sexually mature species around 45 to 46 m in the Slocan River (three years old [2+]) (McPhail 2007). The 100 mm specimen was an old adult, as literature indicates that the oldest Shorthead Sculpin in BC was 85 mm in length and in its seventh growing season (6+) (McPhail 2007).

Two of the three Umatilla Dace were collected in the Slocan River: one between Vallican and Lebahdo, and one between the Lemon Creek confluence and Perry's Back Bridge Road. The location of the third species recovered is unknown. The two Shorthead Sculpin were collected in Lemon Creek, downstream of the release site, while the Columbia/Shorthead Sculpin was salvaged from the Slocan River, also between Vallican and Lebahdo.

6.1.5.4 Fish Tissue

6.1.5.4.1 Necropsy

Results from the Animal Health Center necropsy on two unidentified fish species indicated that although fish tissues were too decomposed to determine cause of death, the fish likely died of acute toxin exposure or other abrupt change in environmental conditions (Appendix XI).

6.1.5.4.2 PAH/Alkylated PAH

Whole Mountain Whitefish samples collected from Lemon Creek were analyzed for a suite of PAHs and alkylated PAHs. Lab reports are provided in Appendix XI.

Of the 50 parameters analyzed, only two (C2 and C3 Naphthalene) were greater than the lab detection limit in the first fish sample and nine (Naphthalene and alkylated naphthalene, Biphenyl and Alkylated biphenyl, and Fluorene) in the second sample (Table L).

Table L: Fish Tissue Analytical Results (for Parameters Greater Than Lab Detection Limit)

Parameter (PAHs & Alkylated PAHs)	Concentration	
	FISH13-1-130808	FISH13-2-130808
Biphenyl	-	0.384 mg/kg *
C2 Naphthalenes	0.87 mg/kg *	1.38 mg/kg *
C3 Naphthalenes	0.71 mg/kg *	0.218 mg/kg
C4 Naphthalenes	-	0.079 mg/kg
Fluorene	-	0.028 mg/kg
C1 Biphenyls	-	0.154 mg/kg
1-Methylnapthalene	-	1.32 mg/kg *
2-Methylnapthalene	-	1.74 mg/kg *
Naphthalene	-	1.86 mg/kg *

*DLA: Detection Limit Adjusted For Required Dilution

Naphthalene and alkylated Naphthalene (C2 and C3) were the only parameters detected in both fish species. All of these parameters are found in Jet A-1 fuel (see Section 2.0). There are no provincial or federal fish tissue guidelines for naphthalene, biphenyl, or fluorene.

No fish from unaffected (i.e., reference) areas of Lemon Creek or Slocan River were collected. As such, no assessments can be made regarding whether naphthalene, biphenyl, or fluorene contributed to the mortalities of fish in either Lemon Creek or Slocan River. Typically, lower molecular weight PAH's (i.e., those with two to three benzene rings (such as naphthalene and fluorene) are acutely toxic to aquatic life, whereas higher-weight PAH's (i.e., those with four to seven benzene rings) are not (BC MoE 1993).

Naphthalene is a polycyclic aromatic hydrocarbon typically used in the manufacturing of polyvinyl chloride (PVC) plastics and is present in petroleum fuels and coal. It dissolves in water to a limited degree, biodegradation is typically rapid, and it has a low potential for bioconcentration (BCF of 1.6 to 3). It does not, however, bioaccumulate in fish tissue or the food chain (ATSDR 2005). Additional information on bioconcentration and bioaccumulation is provided in Section 2.2.3.

Naphthalene levels in water samples collected from Lemon Creek at the confluence with Slocan River on two dates (July 28 [12.0 µg/L]; July 31 [1.2 µg/L]) exceeded provincial water quality guidelines for the protection of aquatic life (1.0 µg/L; BC MoE 2007). Results from the same site on other dates, as well as from other water quality sites were below guidelines. Sediment samples did not exceed guidelines for the protection of aquatic life.

Biphenyl is polycyclic aromatic hydrocarbon typically used in the textile industry to dissolve dyes and is also a byproduct in the manufacture of aviation fuels. It dissolves poorly in water and attaches to solid materials and can be broken down by microorganisms to other chemicals. Biphenyl has high acute toxicity to aquatic organisms but low chronic toxicity, with a bioconcentration factor of 436, giving it a relatively low potential for bioconcentration (U.S. EPA 1995). Additional information on bioconcentration and bioaccumulation is provided in Section 2.2.3. Biphenyl was not tested in water or sediment in Lemon Creek or Slocan River.

Fluorene is a polycyclic aromatic hydrocarbon found naturally in the environment and can also result from the incomplete burning of coal, gas, oil and garbage. Fluorene is used in the making of plastics, dyes, and pesticides. Fluorene is easily biodegradable in soil and water with the presence of acclimated microbes; however, it is slow to biodegrade if exposed to pristine soil or water. It is insoluble in water and strongly adsorbs to sediment where it can be gradually biometabolized. Fluorene does not biomagnify; however, it has a moderate potential to bioaccumulate in benthic organisms and fish. Studies have shown that fluorine reduces reproduction of aquatic invertebrates and delays the emergence of midge larvae (U.S. EPA 2010). Additional information on bioconcentration and bioaccumulation is provided in Section 2.2.3.

Fluorene in water and sediment samples collected from Lemon Creek and Slocan River did not exceed guidelines for the protection of aquatic life (BC MoE 2006).

6.1.6 Analysis of Impacts

6.1.6.1 Effects of Jet A-1 Fuel on Fish/Aquatic Organisms

The impacts of jet fuel spills on the ecology of freshwater streams and river systems can be variable. Documented effects range from catastrophic fish kills and changes in fish distribution to initial mortality followed by no observed effects (Guiney 1978). The variability of these impacts reflects the different petroleum compounds found in the spilled substance as well as the response of the aquatic biota to the spill. Following a release of Jet A-1 fuel, the individual components will typically disperse and partition according to their individual physical-chemical properties. Due to the product being highly volatile and a light, LNAPL, most of its components would disperse on the surface of the water and tend to volatilize quickly. However, it can become bound up in fish habitat features such as under boulders, in tree root wads and other large, woody debris structures, and instream vegetation, which then has the potential, if not removed, to lead to chronic effects to fish and aquatic organisms.

As Jet A-1 fuel predominantly consists of kerosene, it is most likely that fish died from acute toxicity resulting from a disruption of biological membrane functions (e.g., gill damage), which can affect osmoregulation and gas exchange (American Petroleum Institute 2010; Steen et al. 2005). The acute toxic effects to fish in the Lemon Creek and Slocan River systems were immediate, with mortalities observed downstream of the spill site in Lemon Creek to just upstream of the confluence between Slocan River and Little Slocan River, particularly in juvenile Mountain Whitefish populations, the most common fish species enumerated. In total, 261 fish, representing at least 12 species, were collected from lower Lemon Creek and throughout Slocan River. In addition to the fish mortalities, extensive numbers of deceased benthic invertebrates were observed in both watercourses.

6.1.6.2 Impacts to Fish Species

The majority of observed fish mortalities occurred to the juvenile life-stage, which were recovered in shallower, lower-velocity areas of Slocan River downstream of the confluence with Lemon Creek, such as side channels, riffles, and shallow pools, where smaller fish are most likely to be rearing (McPhail and Troffe 1998). This habitat preference makes the life-stage particularly vulnerable in the event of a spill, as the product can become trapped in low velocity areas, thereby increasing the potential for exposure. As Jet A-1 fuel is a light-phase liquid, it likely remained on the water surface for a period of time (see Environmental Fate Section 2.2) after the release, thereby reducing minimizing the risk to acutely impact adult fish in deeper habitats.

6.1.6.2.1 Mountain Whitefish

Mountain Whitefish was the most abundant fish collected post-spill (n=155). Given the relatively large populations documented throughout the Columbia River watershed and the high recreational fishery catch quota (15/day), the overall impact to mountain whitefish as a result of the spill is likely low. However, given the impact appears to be fairly localized, it is possible that specific population(s) of mountain whitefish were more severely impacted. The length-frequency data obtained from the deceased fish collected on Slocan River and Lemon Creek indicate that most of fish were young of the year; however, a number of adults and sub-adults (n=16) were recovered, primarily from Lemon Creek.

6.1.6.2.2 Torrent Sculpin

Torrent Sculpin, the second-most populous species recovered (n=26), are abundant in the Slocan watershed and commonly caught in minnow traps or electrofishing studies (Lawrence and Keeler 2013). Based on length-frequency data collected, both juvenile and adult Torrent Sculpin were affected; however, impacts to both these life stages were expected as sculpin are sedentary with very small home ranges often not exceeding 150 meters, thus habitat preferences between juveniles and adults are typically similar (Hendricks 1997; McPhail 2007). Given that a small number of adults and juveniles were found deceased downstream of the spill site, it is unlikely that the overall population was severely impacted.

6.1.6.2.3 Rainbow Trout

Rainbow Trout was the third-most abundant species collected after the spill incident (n=19). It has been documented throughout the Slocan River and Lemon Creek watersheds and is one of the most sought after, yet ecologically important sportfish in the Slocan River system. Length-frequency data suggests that young-of-year (0+) rainbow trout were exclusively impacted, likely due to their habitat preference along stream margins (McPhail 2007). Deceased adult rainbow trout were not collected during the carcass recovery program. Assessments conducted on rainbow trout populations on the Slocan River have observed relatively high densities of fish in the upper Slocan River near the Lemon Creek confluence (Oliver 1999). As such, data recorded from the salvage recovery program appear to suggest that the impact sustained by rainbow trout population(s) in both the Slocan River and Lemon Creek is low.

6.1.6.3 Impacts to SARA-listed Fish Species

Columbia Sculpin are present in the lower Slocan River near the confluence with Kootenay River, but have not been reported in Lemon Creek (BC MoE 2013). Populations in the Columbia River are low due to dams and reservoirs and the Kootenay/Slocan population has been estimated at roughly 100 individuals; however, this value was not obtained quantitatively. Large tributary populations appear to be stable (COSEWIC 2010a).

Shorthead Sculpin are present in both Slocan River and Lemon Creek (BC MoE 2013). Populations appear to be locally abundant and stable within their range, and while no population estimates are available, the Kootenay/Slocan population is most dense in the Slocan River and Little Slocan River, with a Catch Per Unit Effort of 0.9 fish/minute for that area (COSEWIC 2010b).

Umatilla Dace are also present in both Slocan River and Lemon Creek (BC MoE 2013). Umatilla Dace population estimates are unknown; however, assessments indicate that this species is still present in locations where observed historically and is locally abundant (COSEWIC 2010c; McPhail 2007). More than 30 specimens were collected from the Slocan River just upstream of its confluence with the Kootenay River and near Vallican during 1984-87; however, no conclusions of the population stability can be inferred (COSEWIC 2010c).

Low numbers of SARA-listed species (Umatilla Dace: n=3; Shorthead Sculpin: n=2; Shorthead/Columbia Sculpin: n=1) were collected during the mortality recovery. As Shorthead Sculpin and Umatilla Dace appear to be locally abundant, impacts to populations of this species are likely small. Populations of Columbia Sculpin, which although low, may be stable in large tributaries such as the Slocan River, therefore impacts are difficult to estimate. However, only one Columbia Sculpin was collected and positive identification could not be confirmed.

6.2 Terrestrial and Wildlife Resources

6.2.1 Assessment Area

The study area for the proposed wildlife impact assessment extended downstream from the spill site for approximately 11 km (Drawing 614668-FW-003 *Study Areas*), including Lemon Creek to its confluence with the Slocan River (approximately 4 km, Area 1), and the Slocan River from its confluence with Lemon Creek to approximately 100 m below Perry's Bridge (approximately 7 km, Area 2). Laterally, the study area covered the creek/river shoreline within 10 m of the high water mark on either side of the respective watercourse. The study area for wildlife was initially broader and included Area 3 and Area 4 (refer to Drawing 614668-FW-003 *FW Study Areas*); however, the area was refined within the course of the spill response based on the wildlife findings and water quality results.

6.2.2 Methodology

Information and data were collected through a desktop review of available ecological databases and search engines, including local, regional and federal government sites and publicly available reports, as well as a field assessment to observe conditions within the area within which wildlife and vegetation had the potential to be affected by the spill (i.e., within the study area).

Primary data sources for the description of the receiving environment included the Conservation Data Centre (BC CDC) Species and Ecosystem Explorer database (CDC, 2013), iMap BC mapping tool (iMap, 2013), and Hectares BC database (Hectares BC, 2013). Other data sources included the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), the Ministry of Forests and Range (MoFR), as well as the SARA Public Registry and Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Terrestrial carcass searches were conducted between July 30 and August 4, 2013. The purpose of the carcass searches was to identify and collect potentially affected wildlife species (i.e., all specimens found dead), to remove them from the food chain. The collection of voucher specimen of deceased wildlife found within the study area was conducted to submit for analysis, as required. In addition, reconnaissance habitat assessments were completed during the carcass searches, which followed RISC standards for species inventories (encounter transects and presence/not detected surveys as per MoELP, 1998). The purpose of the assessments was to describe the wildlife habitats within the study area, identify the potential for species and ecosystems at risk, and record incidental wildlife observed. Prior to the assessments, locations of interest were marked on field maps.

Carcass searches and incidental wildlife documentation were conducted on foot and by raft. Transect surveys on foot were conducted on Lemon Creek and on the Slocan River, and typically involved slow walks (approximately 500 m per hour) along the shorelines, with particular focus on slow moving water, side channels, back eddies and wetland features. Where the shoreline was inaccessible (i.e., due to deep pools), spot-checks were made from the bank. Raft surveys were carried out on the Slocan River, and involved slowly floating down the river, and landing in areas of interest and areas that were inaccessible (or difficult to access) on foot. During the carcass searches, wildlife encounters and sign (such as tracks, burrows, nests, and scat) were recorded. Vegetation communities were documented at each location of interest. Data were recorded in field books, photo documented, and geo-referenced using handheld GPS units.

Information collected for each carcass recovered included: date; watercourse; species group (i.e., bird, mammal, reptile etc.) or species where possible (depending on condition of carcass); and GPS location. Specimens were placed in zip-lock bags, labelled, and transported in coolers on ice until eventually frozen and stored at the Nelson MoE office. Carcass searches continued until directed by MoE to cease on August 8.

6.2.3 Analysis

All collected wildlife specimens were sent to the Ministry of Agriculture's Animal Health Centre in Abbotsford for necropsy analysis to determine cause of death.

6.2.4 Baseline Conditions

The study area is located in the MoE Kootenay Region, Arrow-Boundary Forest District and Central Kootenay Regional District. The study area falls within the Interior Cedar - Hemlock (ICH) biogeoclimatic zone, and West Kootenay dry warm (dw1) subzone. The ICHdw subzone occurs at elevations from 450-1200 m (Braumandl et al, 2002), with the West Kootenay (dw1) subzone commonly found in the valley bottoms and lower slopes (Ketcheson et al, 1991). In general, the ICH zone is characterized by an interior, continental climate with predominantly easterly moving air masses that produce cool wet winters and warm dry summers (Ketcheson et al, 1991). The mean annual temperature is 6.1°C, and the mean annual precipitation is 798 mm, with approximately 30% falling as snow (Hectares BC, 2013). Based on available Vegetation Resources Inventory (VRI) information dating from 1990 to 2002, the age of the forest stands in the study area is between 70 to 150 years, with a range in tree height of 25 m to 37 m (iMap BC, 2013).

6.2.4.1 Vegetation

Vegetation species identified in the study area during the transect surveys are provided in Appendix VIII, Table 1. Dominant coniferous tree species observed in the riparian forests of the study area included interior Douglas-fir, western redcedar, western hemlock, lodgepole pine, western white pine, and western larch. Dominant deciduous tree species in the study area included black cottonwood and paper birch. While the riparian shoreline of Lemon Creek was conifer dominated, black cottonwood ecosystems were widespread in the Slocan River riparian areas.

The shrub layer in the study area was dominated by willows, Saskatoon, Sitka (or mountain) alder, beaked hazelnut, thimbleberry, oval-leaved blueberry, tall Oregon-grape, common snowberry, falsebox, kinnikinnick and twinflower, and the herbaceous vegetation included grasses, sedges (in wet areas), herbs, ferns and mosses. Some of the typical forest species included wild sarsaparilla, Queen’s cup, false Solomon’s seal, and foamflower; species of dry open habitats included wild strawberry, pearly everlasting and yarrow; and streamside and marsh habitats were frequented by beaked sedge, water sedge, bulrush, scouring rush and horsetail. At the time of the surveys, some of the shrub species (e.g., thimbleberry, blueberry, and Saskatoon) were bearing fruits.

6.2.4.2 Wildlife and Wildlife Habitat

Wildlife species observed in the study area during the transect surveys are provided in Appendix VIII, Table 2. Table 2 includes amphibians, reptiles, birds, mammals, and incidental terrestrial invertebrates.

Three amphibian and reptile species were observed including western toad, Columbia spotted frog and common garter snake. The two amphibian species were observed in pools along the Slocan River, on the right and left banks east of Slocan Island. Common garter snakes were common throughout the study area, particularly on gravel bars and in adjacent forest edge habitat along the Slocan River.

The study area has a broad diversity of habitats for birds, including riverine, riparian, wetland (marsh), and forest edge habitats. Fifty-two resident or migratory bird species were observed in the study area, including: passerines (songbirds); woodpeckers, dabbling and diving ducks; shorebirds; riverine birds and raptors. Most notable raptor species were osprey, bald eagle and golden eagle. Ospreys and eagles were mostly observed along the Slocan River, and one osprey nest with young was detected on the right bank south of Perry's Bridge. Riverine birds included belted kingfisher and American dipper, while water dependent swallows included bank swallow, tree swallow and barn swallow. Other water (and wetland) birds included common merganser, mallard, gadwall, common goldeneye, Canada goose, great blue heron, and ring-billed gull, as well as shorebirds such as spotted sandpiper and least sandpiper. Corvids were common in all open habitats, and included common raven, American crow and black-billed magpie. Woodpeckers observed in the open mixed forested habitats included pileated woodpecker, hairy woodpecker, downy woodpecker and northern flicker, and other forest dwelling songbirds included hermit thrush, varied thrush, veery, ruffed grouse, winter wren, and red-breasted nuthatch. Migratory songbirds observed in riparian habitats and along forest edge included: cedar waxwing, evening grosbeak, western wood-pewee, willow flycatcher, common yellowthroat, song sparrow, fox sparrow, vesper sparrow, American goldfinch, American robin, eastern and western kingbirds, Cassin's vireo and warbling vireo. A few active songbird nests were observed along the Slocan River: one eastern kingbird nest with two chicks was identified within 100 m (downstream) of Perry's Bridge (right bank); one cedar waxwing nest was identified on the east side of Slocan Island (as it was raided by a common garter snake); and one unidentified stick-nest was observed near the confluence of Lemon Creek and Slocan River. Various songbird pairs and/or adults with fledged young were observed (e.g., common yellowthroat, cedar waxwing, eastern kingbird and Cassin's vireo), suggesting nesting and/or rearing activity was still in progress at the time of the survey.

A variety of small, medium and large mammals were detected in the study area, along Lemon Creek and/or the Slocan River. Mammal species observed or identified through sign (e.g., tracks, scat, and burrows) included: white-tailed deer and/or mule deer, elk, beaver, river otter, mink, red squirrel, black bear and grizzly bear. Deer tracks were common along the river banks of the Slocan River, and were also occasionally detected on Lemon Creek. A beaver was observed on the left bank of the Slocan River, about 200 m upstream of Perry's Bridge. Various haul-outs were also identified in this area. Mink and river otter tracks were identified along the shoreline of the Slocan River, in the areas east and southeast of Slocan Island. Red squirrels were observed on various occasions, in forest habitat along Lemon Creek and the Slocan River. Black bear scat was identified along Lemon Creek, while footprints of a juvenile grizzly bear were detected on the sandy shore of a side channel of Slocan River, on the east side of Slocan Island.

Based on the iMap BC (2013) database, Lemon Creek and the Slocan River are within known ungulate winter range (UWR). The lower reaches of Lemon Creek and the east and west sides of the Slocan River are UWR for mule deer, while the Slocan River floodplain is UWR for white-tailed deer. There is no established (or proposed) Wildlife Habitat Area (WHA) within the study area; however, the study area lies within a grizzly bear population unit (2012).

6.2.4.3 Species and Ecosystems at Risk

A search of the BC CDC, using BC Species and Ecosystem Explorer (BC CDC, 2013) was conducted to determine the potential presence of federally and provincially listed plant species, ecological communities and wildlife species within the study area. The search results are shown in Appendix IX, Tables 1, 2 and 3, and are based on the following search criteria: Arrow Boundary Forest District, Kootenay MoE region, Central Kootenay regional district, ICH biogeoclimatic zone (for plant communities: ICHdw1 subzone).

Based on the BC CDC database, 44 plant species, ten ecological communities and 40 terrestrial or amphibious wildlife species at risk could potentially occur in the study area.

No plant species or communities at risk were identified in the study area during the transect surveys. However, specific rare plant surveys were not completed; and therefore, the absence of species and communities at risk cannot be confirmed in the study area. Rare plant surveys would typically include a detailed characterization of the habitat types for each potentially occurring species, confirmation of suitable habitat types on the Site, complete coverage of suitable habitats during the growing season (i.e., seasonal coverage in spring, summer and fall, depending on species of interest) and verification of specimens with experts (particularly for species that are difficult to identify such as grasses, sedges, and mosses [Klinkenberg, 2011]).

One amphibian species, two bird species and one mammal species observed during the transect surveys are provincially Blue-listed: western toad, barn swallow, great blue heron, and grizzly bear. Western toad is also listed as Special Concern under the SARA. No other listed wildlife species were identified in the study area.

6.2.4.4 Invasive Plant Species

Spotted knapweed was observed throughout the study area, and appeared to be well established in drier locations along the creek and river banks and in upland habitats.

6.2.5 Results

6.2.5.1 Carcass Search

Table M lists 14 deceased wildlife specimens that were collected in the study area between July 27 and August 8, 2013, or received by third parties. Nine of the individuals were collected by SNC-Lavalin between the incident site and 100 m downstream of Perry's Bridge; the remaining five individuals were found by third parties (refer to comments in table). Recovery locations are included on Drawing 614668-FW-00X *Wildlife Mortalities*.

Table M: Wildlife Species and Number of Individuals Collected in the Study Area, July 27 to August 8, 2013

Wildlife Species	Number of Individuals and Date Found													Comment
	July				August								Total	
	27	29	30	31	1	2	3	4	5	6	7	8		
Non-avian														
Mouse sp.						1							1	Left bank, Lemon Creek downstream of Hwy 6 bridge, EM waypoint 60. Submitted for necropsy
Common garter snake						1							1	Slocan River left, DR 463834, 5505266. Submitted for necropsy.
Western toad parts								1					1	Western toad parts, MSt waypoint 58. Submitted for necropsy.
Total Non-avian	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**1**	**0**	**0**	**0**	**0**	**3**	
Avian (Birds)														
Grouse							1						1	Picked up at resident's home. Submitted for necropsy.
American dipper							1						1	Picked up at resident's home. Submitted for necropsy.

Wildlife Species	Number of Individuals and Date Found													Comment
	July				August								Total	
	27	29	30	31	1	2	3	4	5	6	7	8		
Mallard						1	1						2	Aug 2: gravel bar far from water, no sign of product on specimen (near BS13-02-130729); submitted for necropsy. Aug 3: in sloughed bank on Bob Kirk's property, product on specimen (462197 5500729); submitted for necropsy.
Unidentified songbird	2												2	Both songbirds were received by third party. Sparrow-like birds found dead on lawn at residence, on bank of Slocan River, Appledale, BC. Submitted for necropsy.
Unidentified songbird								1					1	Collected along Slocan River / Lemon Creek. Submitted for necropsy.
Unidentified songbird								1					1	Received by third party. Unknown origin, possibly from near Brilliant Dam. No sign of product on specimen. Submitted for necropsy.
Mallard wing and breast								1					1	Likely coyote kill, KT waypoint 315. Submitted for necropsy.
Northern waterthrush				1				1					2	Jul 31: Perry's back bridge raft launch, product on specimen. Submitted for necropsy. Aug 4: Lemon Creek / Slocan River. Submitted for necropsy.
Total Avian	**2**	**0**	**0**	**1**	**0**	**1**	**3**	**4**	**0**	**0**	**0**	**0**	**11**	
TOTAL	**2**	**0**	**0**	**1**	**0**	**3**	**3**	**5**	**0**	**0**	**0**	**0**	**14**	

6.2.5.2 Necropsy

The Animal Health Centre provided necropsy results for all fourteen specimens (Table N).

Table N: Results of Necropsy Analysis for Wildlife

Wildlife Species/Group	Necropsy Result
Non-Avian	
Mouse sp.	Post mortem change significantly hinders gross assessment of multiple tissues. There is no indication of a cause of death.
Common garter snake	Because of the degree of decomposition of the subcutis, liquefactive change within the viscera, a precise cause of death could not be determined.
Western toad parts	Post mortem change significantly hinders gross assessment of multiple tissues. There is no indication of a cause of death.
Avian (Birds)	
Northern waterthrush (2)	Jul 31: The history and post-mortem findings in this bird are consistent with exposure to, and ingestion of Jet A fuel. Aug 4: Final diagnosis is pulmonary congestion (suspected drowning). Carcass is wet; no fuel smell detected.
Unidentified songbirds (2)	Carcasses were skeletonised, fly blown and desiccated, making them unsuitable for further testing. There is no visual or olfactory evidence of fuel exposure.
Unidentified songbird	Cause of death could not be determined although exposure/hypothermia cannot be ruled out. No visual or olfactory evidence of fuel exposure.
Unidentified songbird	Carcass was skeletonised, fly blown and desiccated, making it unsuitable for further testing. There is no visual or olfactory evidence of fuel exposure.
Grouse	Final diagnosis was trauma (suspected predation). No visual or olfactory evidence of fuel exposure.
American dipper	Final diagnosis: The source of hemorrhage around the mouth is most likely coming from the congested lungs. The carcass is soaked in fuel.
Mallards (2)	Aug 2 (Duck A): Final diagnosis was Verminous vasculitis (suspected *Echinuria* sp); no visual or olfactory evidence of fuel exposure. Aug 3 (Duck B): Parts unsuitable for further diagnostic testing; no visual or olfactory evidence of fuel exposure.
Mallard wing and breast	Final diagnosis is suspected trauma. There is no visual or olfactory evidence of fuel exposure.

6.2.6 Analysis of Impacts

The findings from the Animal Health Centre confirmed a Jet-A fuel related mortality for two songbird species (northern waterthrush and American dipper). The other twelve specimens (nine bird species and three non-avian species) showed no visual or olfactory evidence of fuel exposure. Non-fuel related causes of death included trauma, drowning and nematode parasites. For three of the nine bird species and the three non-avian species, the advanced state of decomposition of the carcasses prevented the determination of cause of death. Based on these factors, it is likely that twelve specimens died of causes unrelated to the spill.

6.3 Effectiveness of Clean-up and Mitigation during Spill Response

According to QMLP and Polaris (SCAT) (Polaris 2010), all shoreline treatment endpoints outlined by MoE (Lemon Creek Spill: Shoreline Treatment End Points, dated August 14, 2013) have been met in all waterways with the exception of the lower section (200 meters) of Lemon Creek. Any residual product remaining in Slocan River is not recoverable with the available technology and will naturally attenuate over time.

7.0 MONITORING PHASE REQUIREMENTS

7.1 Water and Sediment Quality

Approximately 35,000 L of Jet A1 fuel was released into Lemon Creek on July 26, 2013. This was a high volume, rapid release into a generally rapid or high velocity flowing water system. Jet A1 fuel is highly volatile and a LNAPL; therefore, it dispersed on the surface of the water, and volatilized quickly. Combined with the fact that bedrock was observed and encountered on the south side (below the road down to the creek) and the bottom of Lemon Creek during the soil remediation excavation, there was no opportunity for a large mass of the fuel to migrate into the underlying bedrock and impact groundwater beneath the creek. Due to its volatility, it is predicted that 30% to 35% of the volume released volatilized in one day and 100% volatilized in 9 to 12 days[7].

As the liquid product migrated downstream, some LNAPL and related contaminants accumulated in slower moving reaches of the creek and/or river, and came into contact with river-bank sediments. Particular contaminants (e.g., PAHs) were bound to organic material (i.e., organic carbon - wood debris, leaves, peat etc.); if left in place, the sediment contamination would eventually biodegrade.

Results of samples collected and analyzed days post-spill indicates that current concentrations of parameters associated with the Jet-A1 fuel are less than the laboratory detection limit in surface water and groundwater (from select domestic and agricultural wells), and that concentrations of fuel associated parameters are less than the applicable provincial criteria in sediment, as well as in soil from the spill site. This indicates that these media are no longer impacted. However, seasonal monitoring is recommended to verify this finding.

Select existing sample locations, which are representative of worst case locations (i.e., areas of greatest concern) should be focused. Criteria to select these sites will consider:

- analytical exceedences;
- preliminary SCAT results;
- observations of hydrocarbons made at time of sampling; and/or,
- location in proximity to shallow water supply wells or points of diversion.

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7.2 Fisheries and Aquatic Resources

Acute toxicity endpoints for freshwater fish, freshwater invertebrate, and freshwater alga for Jet fuel/kerosene category have been well documented in literature (API 2010). The substances in the Jet fuel/kerosene were found to produce a similar range of toxicity for each of the three trophic levels (API 2010) and there is sufficient data on the ecotoxicity of jet fuel and kerosenes to demonstrate moderate acute toxicity to aquatic organisms. This is predicted because the majority of constituents in kerosenes are neutral organic hydrocarbons that act in a common mode of action termed "non-polar narcosis", which is brought about by disruption of biological membrane function (van Wezel and Opperhuizen 1995). Thus, it is anticipated that any chronic toxicity effects or impacts to species, populations, or communities of these organisms will be low. However, given the evidence of acute toxicity effects to fish and benthic invertebrates, and the uncertainty around the magnitude of the acute impact to both fish and aquatic resources, (1) warrants monitoring of fish tissue and concerns around human (and wildlife) health, (2) assessment of key fisheries indicators (e.g., species-level, population-level, community-level) to attempt to understand magnitude of impact; and (3) detection and identification of recovery process based on results from (1) and (2).

7.3 Terrestrial and Wildlife Resources

The number of deceased wildlife specimens collected in the study area (Lemon Creek and Slocan River) was very low (14 specimens). Necropsies have been performed on all 14 specimens collected (directly or through submission by third parties). As of October 17, 2013, only two of the mortalities (both songbird species) were confirmed to have been caused by the spill. Based on these results, monitoring for any wildlife species would be difficult to interpret considering the overall low number of mortalities. Also, establishing a benchmark to compare against would pose a challenge, as comparisons with reference streams would likely not lead to data robust enough for statistical analyses.

Therefore, as part of the biological Environmental Monitoring Program (EMP), we propose to continue performing necropsies on terrestrial wildlife specimens collected during the emergency response phase, to better understand any potential linkages between the spill and cause of death. Further, field observations will continue through the implementation of all biological and physical field monitoring programs. If any additional deceased wildlife specimens are observed in the field, they will be: identified to species; photo-documented; characterized for level of decomposition; geo-referenced (GPS); appropriately stored to preserve the specimens; and be considered further for causation of death screening (i.e., necropsy analysis). Specimens collected (and necropsy results received) after finalization of this Spill Response Impact Assessment document will be discussed with EFC and regulators prior to any further action taken.

8.0 CONCLUSIONS AND RECOMMENDATIONS

On July 26, 2013, at approximately 16:00 Pacific Time, an EFC owned and operated tanker truck hauling Jet A-1 fuel on the Lemon Creek FSR rolled down an embankment into Lemon Creek, which resulted in a spill. A confirmed total of approximately 32,850 L of Jet A-1 fuel was discharged to Lemon Creek. EFC retained SNC-Lavalin to conduct an assessment of the impacts to water, soil, sediment, vegetation, fisheries, and wildlife. Air monitoring was also completed by SNC-Lavalin and the report is appended.

Data collected to date indicates that current concentrations of parameters associated with the Jet A-1 fuel are less than the laboratory detection limit in surface water and groundwater, and that concentrations of the product-associated parameters are less than the applicable provincial standards in sediment, as well as in soil from the incident site. Concentrations of parameters associated with the product were mainly non-detect with all concentrations well below the applicable provincial standards in agricultural soil. Concentrations in agricultural vegetation samples were either below laboratory detection limits or similar to the concentrations found in background vegetation samples. Water and Sediment Quality Monitoring Programs have been developed to monitor, assess and document the distribution and concentrations of residual contaminants associated with the incident in water and sediment following flushing/clean-up efforts completed as part of the post-spill response.

In total, 261 fish were recovered from, and vast quantities of deceased benthic invertebrates were observed in Lemon Creek and Slocan River. Of the fish mortalities collected, the majority were Mountain Whitefish (n=155), followed by Torrent Sculpin (n=26), and Rainbow Trout (n=19). The number of deceased fish is likely higher than the numbers physically removed by crews deployed during the emergency response due to: the fast-flowing waters of Lemon Creek and Slocan River, the large extent of area to cover (longitudinal and lateral habitats on Lemon Creek and Slocan River) as well as missing the first couple of days immediately post-spill to commence fish salvage protocols. Length-frequency data for the three most common fish species collected during the fish carcass salvages suggest that the juvenile life-stage were the most severely affected based solely on deceased specimens collected in the field. A greater percentage of 'older' (i.e., > 2+) sculpins were affected relative to salmonid and cyprinid species. Of the deceased fish specimens collected, a small number of SARA-listed species (Umatilla Dace: n=3; Shorthead Sculpin: n=2; Shorthead/Columbia Scuplin: n=1) made up approximately 2% of the collected total. As Shorthead Sculpin and Umatilla Dace appear to be locally abundant, impacts to populations of these species are likely small. Impacts to populations of Columbia Sculpin, which although low, may be stable in tributaries such as the Slocan River, is difficult to quantify. Although it is clear the mortalities were the result of acute toxic exposure to Jet A-1 fuel, any chronic effects (presumed low) or the magnitude of the acute impact is unknown. Thus, post-spill monitoring of key aquatic indicators should be initiated to evaluate the magnitude of impact, identify any potential chronic effects, and assess aquatic health recovery based on firm endpoints.

Fourteen deceased wildlife specimens were collected from the study area and submitted for necropsy analysis and the results confirmed a Jet-A fuel related mortality for two songbird species (northern waterthrush and American dipper). The other twelve specimens (nine bird species and three non-avian species) showed no visual or olfactory evidence of fuel exposure. For three of the nine bird species and the three non-avian species, the advanced state of decomposition of the carcasses prevented the determination of cause of death. Where determined, non-fuel related causes of death included trauma, drowning and nematode parasites. Based on these results, it is likely that twelve of the fourteen specimens died of causes unrelated to the spill. As part of the biological EMP, necropsies will continue to be performed on terrestrial wildlife specimens collected during the emergency response phase. Further, field observations will continue through the implementation of all biological and physical field monitoring programs.

All shoreline treatment endpoints outlined by MoE have been met in all waterways with the exception of the lower section of Lemon Creek, which continues to be under assessment. Any residual product in Slocan River is not recoverable with the available technology and will naturally attenuate over time.

9.0 LIMITATIONS OF LIABILITY, SCOPE OF REPORT AND THIRD PARTY RELIANCE

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