Closure Plan for the
Miramichi Pulp and Paper Mill Basins

Project Number: 324-B04 BY3B34

Submitted to: **N.B. Department of Transportation and Infrastructure**
Kings Place
P. O. Box 6000
Fredericton, NB
E3B 5H1

Prepared by: **NATECH Environmental Services Inc.**
In association with:
Craig Hydrogeologic Inc.
P. Riebel Consulting
Intrinsik Inc.

Date: **January 30, 2015**

REGISTERED PROFESSIONAL ENGINEER
Province of New Brunswick
#M6778
Vincent J.M. Balland
V. Balland
Signature
2015 Jan. 30
Date
Province du Nouveau-Brunswick
INGÉNIEUR IMMATRICULÉ

NATECH

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1. INTRODUCTION

The City of Miramichi on the Miramichi River Estuary has been the site of pulp mills since the 1900s. Miramichi Pulp and Paper, REPAP and UPM-Kymmene were the most recent operators of the pulp mill on the NW Miramichi River. Since the early 1970s, effluent from the process was treated in large aerated stabilization basins (ASBs), prior to discharge into the river. Other process by-products, mainly wood ash, were stored in so called ash basins (ABs) located adjacent to the ASBs on the property. In 2007, the UPM-Kymmene pulp mill operation terminated and most mill structures were demolished or decommissioned. The wastewater treatment basins remain but have been dormant since 2007. Figures 1-1 and 1-2 show the location of the lagoons and related infrastructure.

The property is now owned by the Province of New Brunswick through Provincial Holdings Limited. The basins contain large qualities of fibre sludge and wood ash, some of which shows elevated concentrations of hydrocarbons, metals, and dioxins and furans. Consequently, the property has been classified as a contaminated site, and requires remediation.

Vandalism has been has been an ongoing problem, and there are environmental concerns with the presence of the waste material (electrical wires, transformers, aerators). There is also the danger of an uncontrolled massive discharge of sludge and water from the basins in the event that the stop logs or the berms deteriorate and give way. Odour complaints were received in the spring of 2014. There is an ongoing requirement for site maintenance, liability for public and environmental safety, odour concerns, public perception issues, and the missed development potential of the property.

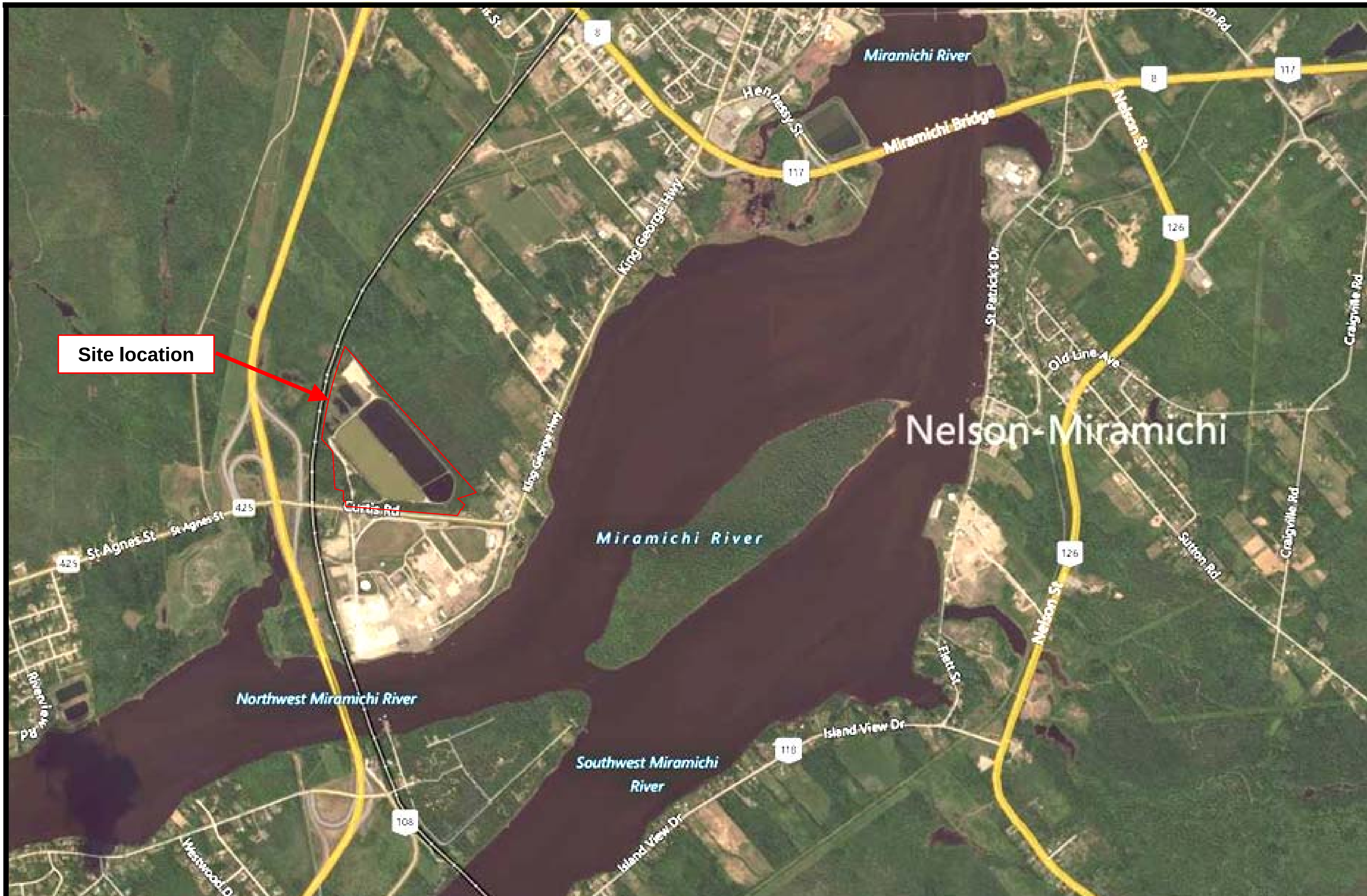
The objective of this work was to establish a Closure Plan for the property, including the basins. NATECH Environmental Services Inc., in association with Craig Hydrogeologic

Inc., P. Riebel Consulting and Intrinsik Inc., were asked by the NB Department of Transportation and Infrastructure to prepare the following closure plan.

An initial Closure Plan was proposed in 2010 by Environmental Planning Specialists Inc. (EPS) when the site was still owned by UPM-Kymmene, and while UPM was going through the Environmental Impact Assessment process to close the entire mill property. The EPS Closure Plan was not accepted by the NB Department of Environment at the time, as it was not clear whether ecological receptors may be affected by the contamination present in the sludge (some of the contaminant concentrations exceeded the soil/sediment quality screening criteria).

To prepare this revised Closure Plan, the following tasks were carried out:

- ❑ Former sediment quality data (from EPS) were compiled and compared to the latest relevant soil/sediment quality guidelines.
- ❑ Additional sediment/water quality samples were collected to fill in information gaps.
- ❑ The volume of sediments in the lagoon cells was determined using a bathymetric survey.
- ❑ An extensive Ecological Risk Assessment was carried out.



Closure Plan for the
Miramichi Pulp and Paper Mill Basins
Location Map

NATECH

Environmental Services Inc.
2492 Route 640, Hanwell, N.B., E3E 2C2
Ph: (506) 455-1085 Fax: (506) 455-1088

DATE: 2014/09/10	FILE: MLC-14-01
SCALE: As Shown	FIGURE: 1-1

Closure Plan for the
Miramichi Pulp and Paper Mill Basins
Aerial View from 2012

NATECH Environmental Services Inc.
2492 Route 640, Hanwell, N.B., E3E 2C2
Ph: (506) 455-1085 Fax: (506) 455-1088

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2. APPROACH

The following methodology was used to prepare the Closure Plan:

- An information review was carried out. The reference documents that were obtained and examined are listed in section 7.0.
- A bathymetric survey of the volume of accumulated sediments was carried out in the spring of 2014 (see Section 3.1).
- A meeting was held with the New Brunswick Department of Environment and Local Government (NBDELG) to determine their information requirements necessary to justify the choice of the closure option chosen and confirm its environmental feasibility.
- Photographs of the lagoons were taken at different times of the year (see Appendix A).
- Sediment and water samples were taken in the spring of 2014 to fill in information gaps in former sediment data available from 2009. The laboratory reports are provided in Appendix B (under Attachment B of that report).
- A Screening Ecological Risk Assessment was carried out by Intrinsik during the summer of 2014. The relevant soil/sediment quality screening guidelines were obtained from regulators and the sediment quality data were compared to these guidelines. The Screening Ecological Risk Assessment report is provided in Appendix B.
- An Ecological Risk Assessment was carried out by Intrinsik. A food chain accumulation model was setup and run for the site for any parameters of concern that exceeded the screening guidelines. This Ecological Risk Assessment report is provided in Appendix C.

- Three options for remediation were envisioned initially (following the principles of Risk Based Corrective Action):
  - Option A: Ecological remediation, as described in the EPS 2010 "Ecological Closure Plan".
  - Option B: A conventional cap and close approach to brown field remediation for all areas that show contamination levels posing a risk to the ecological receptors.
  - Option C: A long term controlled natural remediation approach that allows the natural degeneration of contaminants, with a strong monitoring component. Two ways to accomplish this were examined: keeping water in the basins, or draining them

  The advantages and disadvantages of each option were examined.

- The Closure Plan was prepared, based on the current characteristics of the site and the results of the Ecological Risk Assessments. The plan includes a strong monitoring component to validate the modeling approach used. The intent of the plan is to be as cost-effective as possible while protecting ecological receptors that may inhabit the property now or in the future.

3. RESULTS

3.1 Bathymetric and Topographic Surveys

Sludge depths in the three ASBs were determined using a boat equipped with a GPS and a 200 kHz echo sounder. Approximately 15,000 valid survey points were obtained. A few areas were too shallow to be surveyed with the boat and the sludge elevation in these areas was estimated.

The reference used to tie in all the elevations surveyed was the invert of the inlet structure in Cell 1 (where the process water from the mill used to enter the treatment plant) shown at an elevation of 12.65 m (41.5 ft) on a drawing from Sandwell (Drawing No. D06-1-6 Rev. D dated July 21, 1970). Based on this reference elevation, the water level surveyed on May 15, 2014 was 12.15 m geodetic in ASB 1, 11.85 m in ASB 2, and 11.80 m in ASB 3. The observed water levels are lower than the design water level of 12.50 m (41 ft) shown on the Sandwell drawing. The difference is due to the deterioration of the stop logs in the outlet structure, which apparently occurred in the spring of 2014, prior to the bathymetric survey.

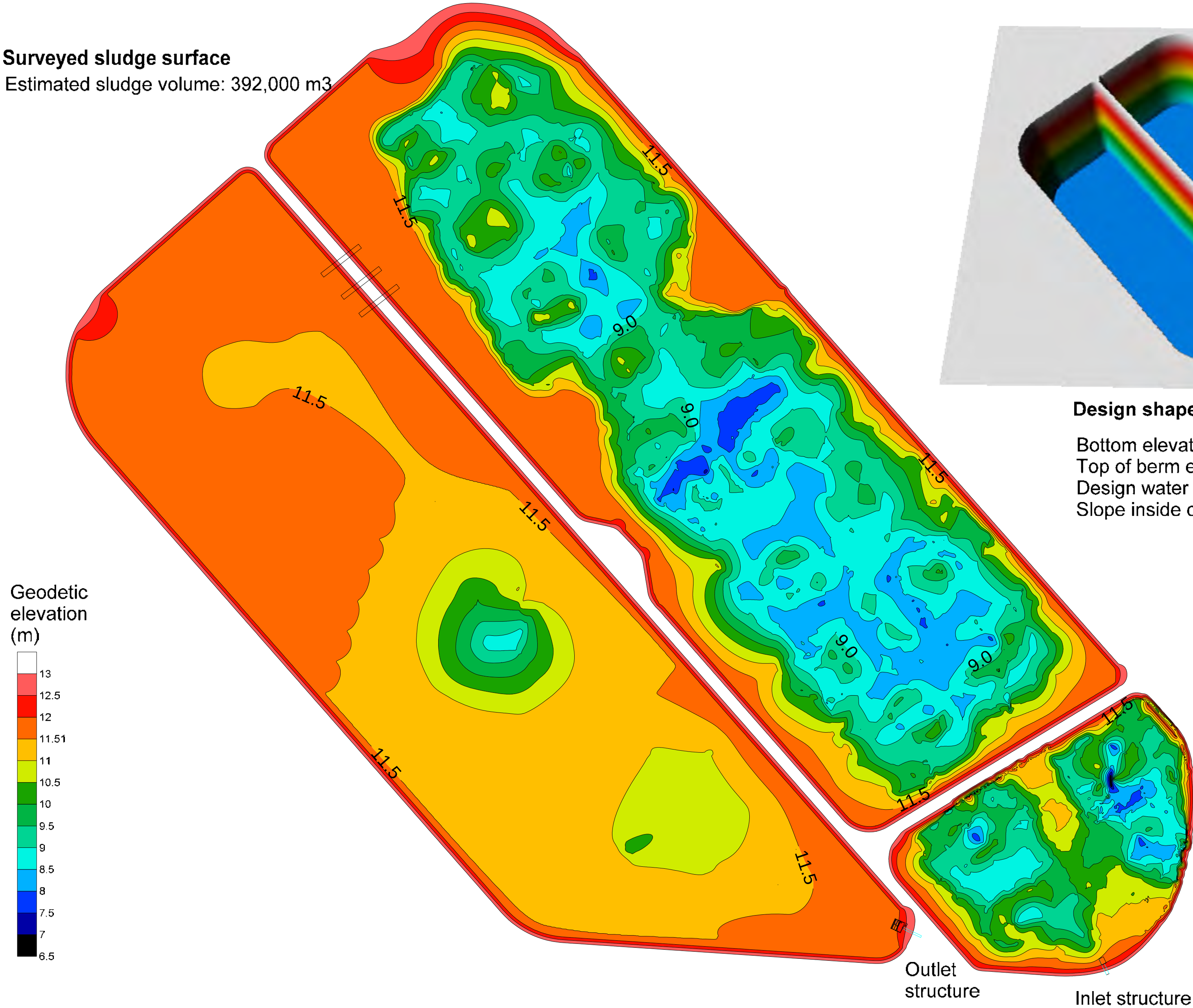
A digital terrain model was employed to calculate the sludge volumes, based on individual survey points. The amount of sludge accumulated is calculated by determining the difference between the surveyed sludge/water interface and the design lagoon bottom shape. The elevation of the bottom of the cells was assumed to be 7.92 m (26 ft) based on the Sandwell drawing.

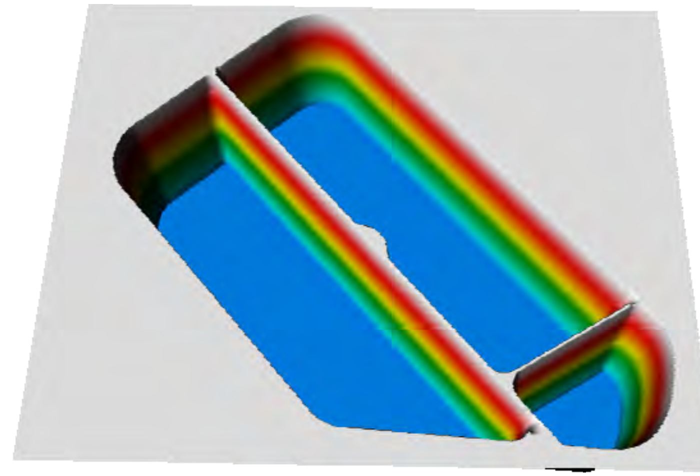
Figure 3-1 shows contours of the sludge deposits in the three ASBs. The total volume of sludge is estimated to be 392,000 m^3.

Recent Lidar survey data were obtained as well for the property and are shown on Figure 3-2. Drainage channels/ditches for surface water are apparent on the figure.

Surveyed sludge surface

Estimated sludge volume: 392,000 m3





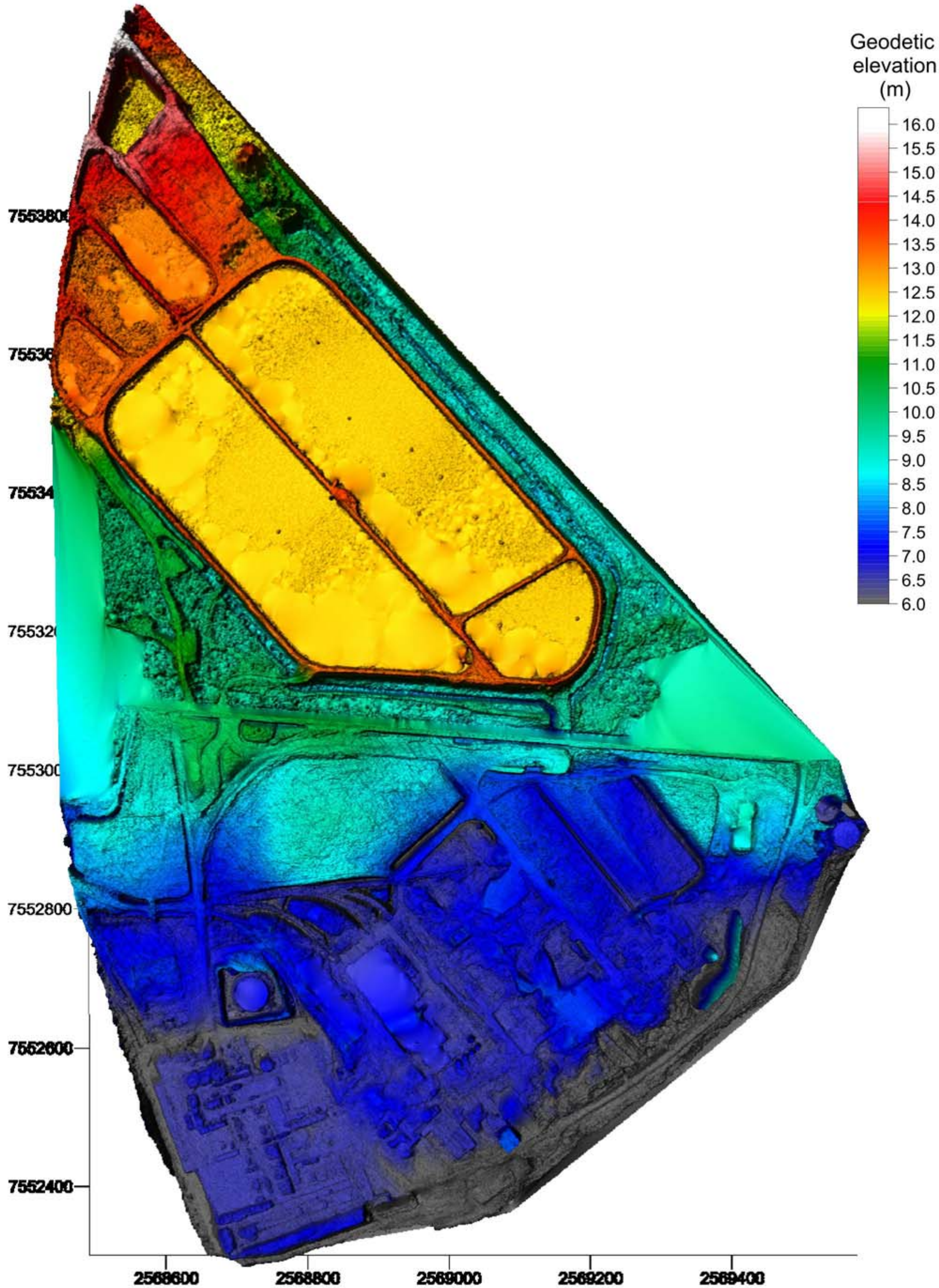
Design shape (from drawings)

Bottom elevation: 7.92 m (26 ft)
Top of berm elevation: 13.41 m (44 ft)
Design water level: 12.50 m (41 ft)
Slope inside cells: 3 to 1

Water levels on May 16, 2014:
ASB1: 12.15 m
ASB2: 11.85 m
ASB3: 11.80 m

Benchmark for survey: invert of inlet structure at 12.65 m (41.5 ft)

Closure Plan for the Miramichi Pulp and Paper Mill Basins Bathymetric Survey done on May 16, 2014	NATECH **Environmental Services Inc.** 2492 Route 640, Hanwell, N.B. E3E 2C2 Ph.: (506) 455-1085 Fax: (506) 455-1088	DATE: 2014/05/27	FILE: MLC-14-01
		SCALE: NB Coordinates System (m)	FIGURE: 3-1



Closure Plan for the Miramichi Pulp and Paper Mill Basins LiDAR Data	NATECH Environmental Services Inc. 2492 Route 640, Hanwell, N.B. E3E 2C2 Ph.: (506) 455-1085 Fax: (506) 455-1088	DATE: 2014/11/18	FILE: MLC-14-01
		SCALE: NB Coordinates System (m)	FIGURE: 3-2

3.2 Sediment and Water Quality

Tables 3.1 lists the number of sediment samples taken in each cell by EPS in 2009. Additional sediment samples were taken by NATECH on July 15, 2014 to address gaps in the data, these samples are listed in Table 3.2. In particular, total organic carbon, PCBs, and chlorinated phenols had not been tested before. Also this time the hydrocarbon test was performed after a silica gel cleanup procedure in the laboratory, to prevent false positive readings due to wood fibre that may be present in the sediments.

The 2014 sediment quality laboratory reports are provided in Attachment B of the Screening Ecological Risk Assessment Report (Intrinsik, November 30, 2014), which is attached in Appendix B of this report. A comparison of the data to the applicable soil quality guidelines is provided in Attachment C of the same report from Intrinsik.

A few water samples were taken by NATECH in 2014 as well:

- One sample in each cell (7 samples in total) on May 15, 2014. The samples were analysed for general chemistry parameters and trace metals, and
- One sample in AB 3 and one in ASB 3 on July 15, 2014. These samples were analysed for dioxins and furans.

The 2014 water quality laboratory reports are provided in Attachment A of the Ecological Risk Assessment Report (Intrinsik, November 30, 2014), which is attached in Appendix C of this report. A comparison of the data to the applicable water quality guidelines is provided in Attachment B of the same report from Intrinsik.

Table 3.1. Summary of recent sampling information available - 2009 data from EPS - Number of sediment samples taken from each cell

Location	AB 1	AB 2	AB 3	AB 4	ASB 1	ASB 2	ASB 3
Parameters							
pH	1	1	2	2	4	12	12
PAHs	NS	NS	NS	NS	4	12	12
Hydrocarbons	1	1	2	2	4	12	12
Metals	1	1	2	2	4	12	12
Dioxins & furans	1	1	2	2	NS	6	6

NS = not sampled

Notes: the samples in the ABs were composite samples. For the ASBs: some additional, deeper samples were taken as well (not counted in this table).

Table 3.2. Summary of recent additional sampling information available - 2014 data from NATECH - Number of sediment analyses carried out each cell

Location	AB 1	AB 2	AB 3	AB 4	ASB 1	ASB 2	ASB 3
Parameters							
TOC	1	2	1	1	1	1	1
PAHs	1	2	1	1	1	2	1
Hydrocarbons	NS	NS	1	1	1	1	1
PCBs	NS	NS	1	NS	1	1	1
Chlorinated phenols	NS	NS	NS	NS	1	1	1

NS = not sampled

Notes: Each sample was a composite samples from three locations in the case of AB1, AB4, and ASB1, or four locations in the case of AB2, AB3, ASB2, and ASB3. An additional grab sample was taken in ASB2 at a location that was found to have elevated PAHs contamination in 2009 (Location T15).

3.3 Ecological Risk Assessment

Two stand-alone documents were prepared by a sub-consultant (Intrinsik) which specializes in ecological risk assessments. First Intrinsik carried out a *Screening Ecological Risk Assessment* for the site in the summer of 2014 (this report is attached in Appendix B and summarised in Section 3.3.1). Then in a subsequent study entitled *Ecological Risk Assessment*, Intrinsik investigated the potential for risk associated with the remaining chemicals of concern (COC) using their food-chain accumulation model (the complete Ecological Risk Assessment report including the modeling results is attached in Appendix C and summarised in Section 3.3.2).

3.3.1 Screening Ecological Risk Assessment Summary

Intrinsik examined the relevant soil quality guidelines from several jurisdictions (federal, provincial, USEPA) to determine the most up-to date applicable ecological health-based guidelines. The sampling results (sediments in 2009, sediments and water in 2014) were compared to the guidelines, to determine which constituents exceeded the guidelines and required further assessment. The following is a summary of Intrinsik's conclusions:

- ❑ Many of the chemicals in the sediments were found to be below the ecological health-based guidelines and would not be expected to be of concern to wildlife receptors (PAHs, most hydrocarbons, most metals, phenols, and PCBs). Among these chemicals, some were well below the guidelines, others only exceeded the guidelines in localised areas of the seven basins, or only slightly exceeded the guidelines. These chemicals were not recommended for further study, as risks associated with exposure to these chemicals was considered to be low.

- For the remaining chemicals (a few metals, F3 petroleum hydrocarbons, and dioxins and furans), ecological health-based guidelines were exceeded to a greater degree. Since it was unclear whether the exceedances observed would pose a threat to the ecosystem (aquatic or terrestrial fauna and flora), further study was recommended for these substances (the fact that some parameters are over a guideline limit does not mean that there is a threat to the ecosystem).

3.3.2 Ecological Risk Assessment Summary

Intrinsik investigated the potential for risk associated with the remaining chemicals of concern (COC) using their food-chain accumulation model. Three potential future closure scenarios were examined in that study:

- Option 1) Keeping water in the four ash basins and draining the three aerated stabilisation basins only.

- Option 2) Keeping water in all the basins (only aquatic fauna and flora was considered).

- Option 3) Draining all the basins (only terrestrial fauna and flora was considered).

Option 1 was identified as the preferred option in principle, as it would provide a more diverse habitat for wildlife than Options 2 or 3, i.e., some wetlands with aquatic vegetation (ash basins and low sections of aerated basins), and some dry areas where grass, bushes trees would eventually be able to grow (most of the aerated basins). Leaving an elevated water level everywhere, as was the case until now, would require ongoing maintenance of the water level control structure and of the berms. Also the ponds would remain deep, which is a public safety concern, if someone was to fall in a basin or in the outlet structure.

Intrinsik concluded that:

- Draining Water from ASBs: "Three species of metals (aluminum, lead, vanadium) were in exceedance of freshwater aquatic life guidelines, based on single samples taken in May of 2014. Potential risk to aquatic life in the Miramichi River are uncertain due to the scarcity of water quality data available at this time. Monitoring of both the basins, as well as the receiving environment, should be undertaken to confirm whether there will be any risks to the receiving environment related to water release."
- Vegetation: "Vegetation growth and colonization in the ASBs appears robust and rapid, based on field photographic evidence from 2014. This information suggests that if the ASBs were drained, the basins would likely have rapid succession of vegetation. While the sediments may limit growth or colonization of some species, tolerant species appear to colonize the sediments/soils with relative ease, which is likely due to the nutrients present in the soil."

- Avian and Mammalian Risks:

  " For Scenario 1 (ABs retain water; ASBs are drained), risks for species using the aquatic environments within the ABs, such as the black duck and muskrat, were considered to be negligible. For the terrestrial habitat in the ASB area, risks for meadow vole, finch, robin and mink were negligible, with masked shrew exhibiting higher risk potential, related to cadmium exposures. Population level effects for shrew and other receptors are considered unlikely.

  For Scenario 2 (ABs and ASBs retain water), risks for species feeding in these aquatic environments, such as the black duck, the muskrat and mink, are considered unlikely.

For Scenario 3 (ABs and ASBs are drained), risks for species feeding in this terrestrial environment, such as the purple finch, American robin, meadow vole and mink, were considered negligible, whereas risks to the shrew were higher. Cadmium was the main COC driving shrew risk estimates, but population level impacts were not considered probable, based on the degree of exceedance and assumptions used in the assessment. Population level effects for other receptors are also considered unlikely".

- Fish: "In all scenarios, fish are assumed to be absent, and should not be allowed to inhabit these basins, without further assessment being conducted for piscivores."

No fish are present nor are they expected to be present in the basins. The basins are not natural aquatic life habitat, they are constructed industrial lagoons where aquatic life species tolerant of the lagoons' conditions have developed. The stop logs in the outlet structure prevent fish passage into the lagoons.

Intrinsik also listed the following risk management considerations:

- "The modelling results suggest that no risk management is necessary for the ash basins, if water is retained in these basins."

- "If water is drained from the aerated stabilization basins, the conclusions of the assessment indicate that risk management is not required to protect wildlife receptors, or vegetation. Since population level effects are considered unlikely based on the outcomes of the ERA, risk management concentrations for soil were not developed for any contaminants of potential concern or receptors. "

- "The model used in this ERA is based on standard equations and assumptions, and is a theoretical representation of risk, which has included conservative assumptions related to bioavailability of COPCs within food sources and soils. While management of soils in the ASBs is not recommended based on the outcomes of the ERA, it would be prudent to undertake some monitoring to validate risk assessment conclusions. It is recommended that an Adaptive Management Approach be implemented, if the desired option of draining the ASBs is put forth as the final selected option. This approach could include the following monitoring initiatives:

  Water monitoring for ASBs, and the Miramichi River (prior to release of any water), as discussed in Section 7.1, to confirm that the release of water from the ASBs will not pose a risk to the receiving environment of the Miramichi River.

  Soil/sediment monitoring in each of the ASBs as water level decreases (or once it is lowered), to confirm that surface soil concentrations of metals and PCDD/F are less than or within the range of concentrations modelled in this assessment. Surface soil sampling could focus on the 0 – 5 cm profile, or at the deepest, 0 – 15 cm, as this would be the active foraging zone for insectivorous avian or mammalian species.

  Confirmatory sampling and analysis of soil invertebrates upon which insectivorous small mammal species or avian species could forage. The types of species collected should be based on the predominant foraging species present in the area, and samples should be depurated of soil, if at all possible, prior to analysis. The measured concentrations can be compared to the biota concentrations estimated in the model.

Outcomes of soil and soil invertebrate monitoring can be compared to modelled estimates, based on a calculated upper confidence limit of the mean (UCLM) Where measured UCLM are less than modelled values, no further study would be considered necessary. Where measured UCLM are higher than modelling values, additional lines of evidence may be recommended to further validate risk levels. These could include a habitat survey to confirm compatibility of habitat for shrew; abundance and diversity studies for insectivorous small mammals, or body burden analysis of organs or whole body, to confirm exposure levels to the COCs of interest".

4. CLOSURE PLAN

The preferred closure envisions that the property is ultimately restored to natural conditions, requiring little to no maintenance. The Ecological Risk Assessment determined that placing a soil barrier layer on top of the sediment is not necessary. A protective layer of leaf litter and humus is expected to develop within a short period of time. In order to achieve the desired restoration, it is recommended to carry out the following tasks:

- ❑ Drain the three aerated stabilization basins (ASBs) in a controlled fashion as much as possible without pumping. Draining by gravity and using a syphon is envisioned. Water level equalization may be required before draining the basins by breaching the berms.

- ❑ Leave the four shallow ash basins (ABs) in their current state (shallow water and well established wetland vegetation). It is anticipated that water levels may change if the adjacent ASBs are emptied.

- ❑ Remove man made structures (aerators, power lines, maintenance building. etc.). The inlet force main and the discharge pipe may be left buried in place. Any hazards to the public and wildlife should be addressed, including securing the outlet structure in ASB 3. The outfall pipe should remain in place, but the diffuser at the end should be removed, as it may become clogged with river sediment over time. This will decrease future maintenance requirements. The diffuser may also pose a navigational hazard.

- ❑ Monitor the water quality, prior to, during, and after the closure plan is implemented. Wildlife presence and health will be characterised as well.

- ❑ Standard erosion protection measures will be employed to minimise erosion from disturbed areas.

Before implementing the closure, a few tasks need to be carried out:

- A more detailed underwater survey of the outlet structure is required. The structural integrity of the structure needs to be assessed prior to working at the structure.

- An underwater inspection of the diffuser at the end of the outfall pipe in the Miramichi River is required. The assessment will assist contractors in the bidding process for removal of the diffuser.

- A CCME Environmental Risk Assessment should be conducted for the Miramichi River, based on the anticipated discharge rate and contaminant concentrations from the basins. The duration of the drainage process will be determined based on the results of this risk assessment.

- A detailed scope of work needs to be developed. This includes the preparation of engineered design drawings and a design brief, identifying precisely which tasks need to be done where and in which sequence. The document can be used for tendering purposes.

The following paragraphs explain the closure plan in more detail.

4.1 Aerated Stabilization Basins

Step 1: A sand filter has to be installed around the existing outlet structure in ASB 3 to filter any sediments that may potentially be entraining when draining the basins, and to ensure that the basins are drained slowly. The design of the sand filter will depend on the outcome on an underwater survey of the outfall. The filter will likely consist of a layer of heavy duty geo-textile, coarse angular stone (RipRap), and several layers of gravel and sand. Figure 4-1 shows a conceptual design of the filter, and Figure 4-2 illustrates the sequence of the different steps recommended. Some laboratory testing of the drainage behaviour may be required as part of the design.

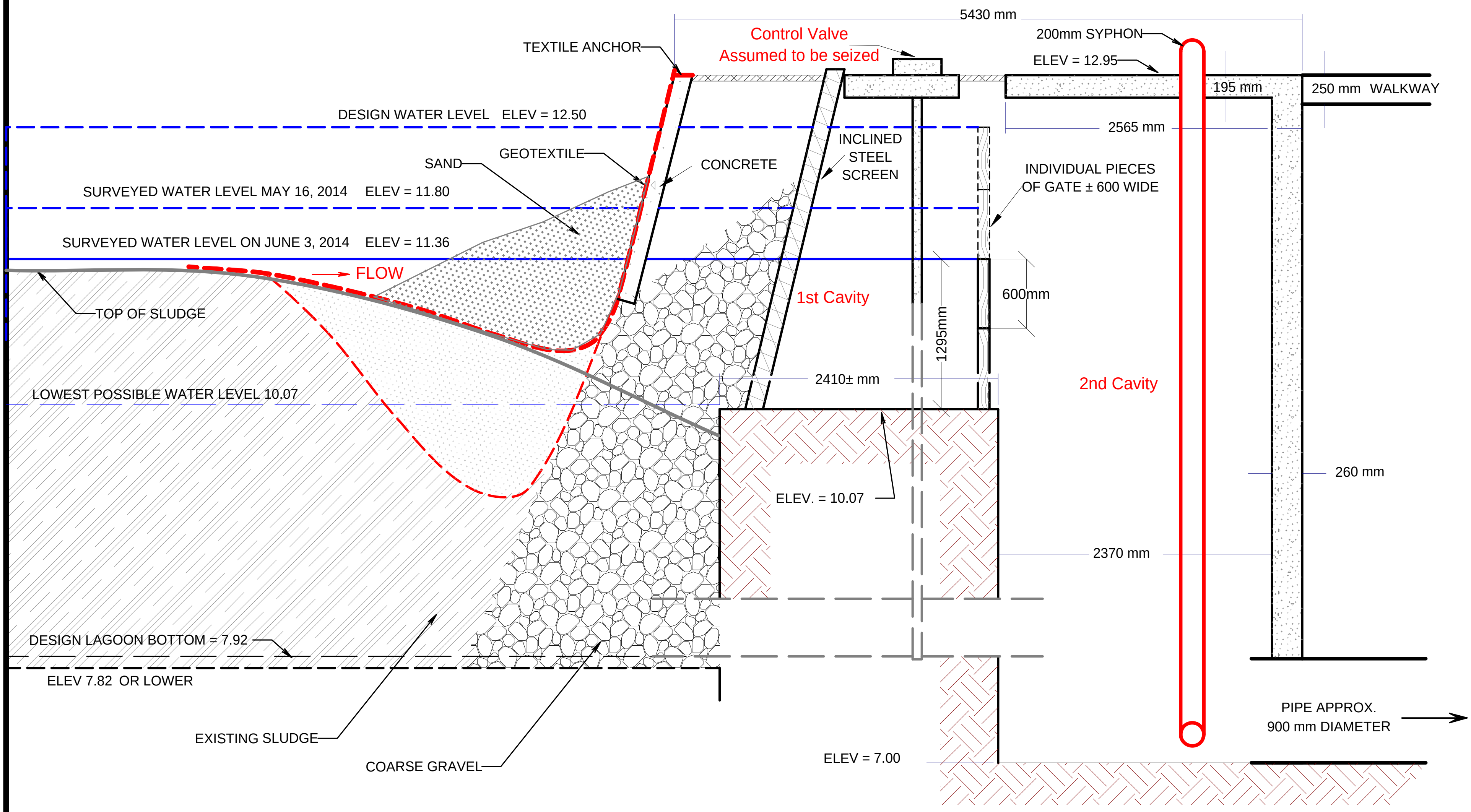
Steps 2 & 3: Prior to draining the basins, the water levels between the three basins should be equalized. This can be achieved by breaching the berms between ASB 1 and ASB 2, and between ASB 2 and ASB 3 to an elevation of 7.92 m.

Step 4: The basins will be drained gradually during the spring or summer by removing the stop logs. The drainage has to be carried out slowly to minimize the wash-out of sediments. In particular, wave action along the newly formed shore lines could lead to elevated concentrations of sediments in the water.

Step 5: A syphon will be installed between ASB 1 and ASB 3, draining into the outlet structure. The syphon will be employed to drain the remaining water that does not flow freely toward the outlet structure as low as possible. As the basins are draining over a period of several months, it is anticipated that vegetation will propagate, leading to shore line stabilization. Some water is likely to remain in the low areas of the basins. According to the results of the Ecological Risk Assessment this is not a concern, and possibly even desired from a wildlife management point of view.

Step 6: After draining the basins, a new outlet structure will be installed in ASB1. This structure will discharge to the surface water ditch. The structure will allow control of future water levels by using stop logs. The new structure will be significantly smaller than the existing outlet structure. The berm may not be restored to the full height, and may serve as a new spillway. The new outlet structure will be built with long-lasting materials, and allow to control water levels in the future. This way, if there was an ecological need to fill the ponds with water again in the future, it could still be done. There will always be precipitation falling over the footprint of the lined aeration basins that will need to be discharged (or they will fill up again), so the structure should be in place for the long-term. The area around the inlet of the structure should be kept free of sediment so that the piping does not clog. Once the vegetation is well established everywhere and if there is no need to fill the ponds again, the structure can be removed and the southern berm can be breached at that location. Then the site drainage would enter the surface ditches, and there would be no long term maintenance requirements.

SECTIONAL VIEW



Closure Plan for the Miramichi Pulp and Paper Mill Basins Outlet Structure	NATECH Environmental Services Inc. 2492 Route 640, Hanwell, N.B., E3E 2C2 Ph: (506) 455-1085 Fax: (506) 455-1088	Date: Date: 2014/11/18	Project No.: Nodu projet MLC-14-01
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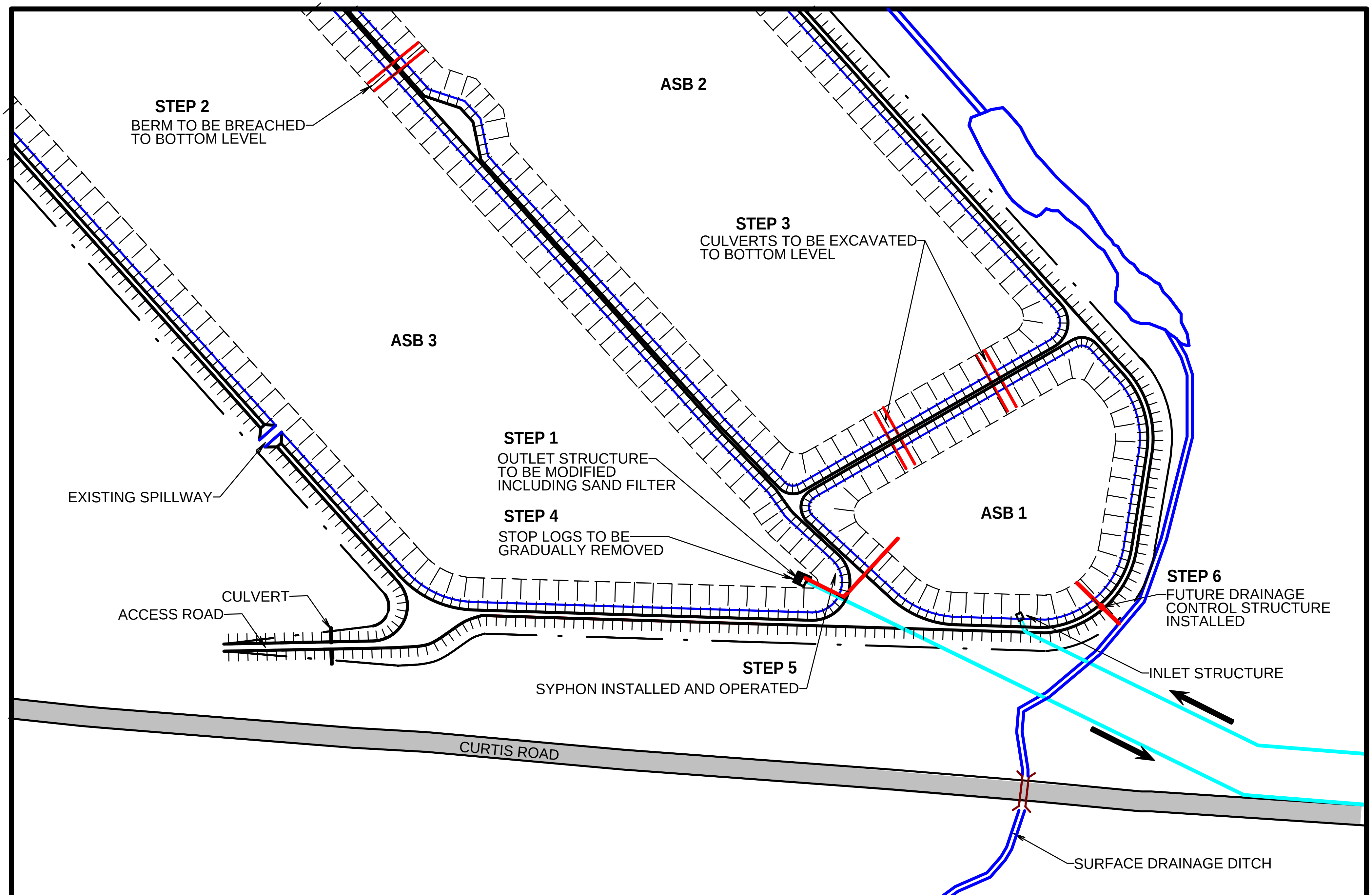

Closure Plan for the Miramichi Pulp and Paper Mill Basins Drainage Approach	NATECH Environmental Services Inc. 2492 Route 640, Hanwell, N.B., E3E 2C2 Ph: (506) 455-1085 Fax: (506) 455-1088	Date: Date: 2014/11/18	Project No.: N° du projet MLC-14-01
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4.2 Ash Basins

The basins will remain unchanged. It is possible that the water levels will decrease over time because the groundwater table (influenced by the ASBs) may decrease.

4.3 Other Clean-up and Safety Measures

The following tasks should be carried out to clean up the site and make sure that is is safe for humans and wildlife:

- ❑ Remove the diffuser at the end of the outfall pipe in the river (divers will be needed, and this should be done at the onset of the project).
- ❑ Remove the aerators, anchoring cables, structures on shore, and cut off the large steel or wooden piles in the ASBs at ground level.
- ❑ Remove the maintenance building and pontoon behind it.
- ❑ Remove the concrete structure of the inlet on the southern berm of ASB 1.
- ❑ Remove power poles, power line, and debris/garbage laying on the ground.
- ❑ Once the lagoons have drained, fill in the deep half of the outlet structures with large size rip-rap. This will allow the water to drain while preventing access (protect the outlet pipe entrance with a grate first).
- ❑ Repair damage to the fence. The fence should remain in place for the first few years. The fence reduces the liability risk, increases public safety, and limits how much terrestrial wildlife accesses the site.
- ❑ Decommission the monitoring wells after groundwater testing is completed.

4.4 Monitoring

Table 4.1 lists the monitoring recommended before, during and after the closure plan is implemented.

Pre closure monitoring involves: check on groundwater quality (for the full range of contaminants tested before in the sediments) using the existing monitoring wells around the basins. Also conduct a baseline water quality test ($CBOD_5$, TSS, TKN, TP, metals) for the three aerated stabilization basins and the Miramichi River upstream of the site.

Construction monitoring involves: measuring flows and water quality in the discharge from the ASBs. In particular, suspended solids concentrations and characteristics need to be recorded and documented. Record the progression of the closure.

In the event of test results exceeding target values, a contingency plan would be implemented. Typically, the plan would consist of stopping all discharges, re-sampling, and developing a plan based on the finding of the analyses. The NBDELG would be involved in the decision-making process.

Post-closure monitoring involves: Monitoring and documenting the success of the restoration. In particular, impacts on wildlife need to be determined, in the short and long term.

If post-closure monitoring revealed excessively high contaminant contaminations in mammals and birds (which is very unlikely), then two courses of action would remain available: either raise the water level again using the new outlet structure (which would be inexpensive), or drain the three ASBs using the same structure, and cap the sediments in the ASBs (which would be expensive).

Table 4.1 - Recommended monitoring effort

Stage	Parameters	Frequency	Location
Pre-construction	- Groundwater (PAHs, hydrocarbons, metals, PCBs, dioxins and furans)	Once	- Four shallow monitoring wells (4 samples)
	- Water in basins ($CBOD_5$, TSS, TKN, TP, metals)	Once	- In ASB 1 to ASB 3 (3 samples)
	- Miramichi River: ($CBOD_5$, TSS, TKN, TP, metals)	Once	- Upstream of outfall (1 sample)
	- Wildlife survey (presence of vegetation, mammals, birds)	Once	Vicinity of basins and basins
Construction	- Water discharge from basins ($CBOD_5$, TSS, TKN, TP, metals)	Monthly for four months	- Where water exits the basins (4 samples)
	- Discharge flow rate while the basins are being drained	Continu-ously	- In outlet structure, or alternatively monitor water level change of each of the three ASBs
	- Miramichi River: ($CBOD_5$, TSS, TKN, TP, metals)	Monthly for four months	- Upstream and downstream of outfall (8 samples)
Post construction	- Water remaining in basins ($CBOD_5$, TSS, TKN, TP, metals)	Once per year for three years	- Three locations (3 samples/year for 3 years)
	- Soil/sediment to verify model (metals, dioxins & furans)	Once after two growing seasons	In ASB 1 to ASB 3 (30 metal samples, 15 dioxin & furan samples)
	- Soil invertebrates to verify model (metals, dioxins & furans)	Once after two growing seasons	(30 samples)

Stage	Parameters	Frequency	Location
Post construction, only if concentrations in soil and soil invertebrates are higher than anticipated	- Wildlife survey (presence of vegetation, mammals, birds, and of habitats for various species)	Once or twice depending on findings	- ASB 1 to ASB 3
	- Body burden analyses of representative wildlife species (metals, dioxins & furans)	Once or twice depending on findings	- ASB 1 to ASB 3

Notes:

- Whenever water samples are taken, the water quality should also be tested in the field for pH, temperature, conductivity, salinity, turbidity, and dissolved oxygen.
- The sediment stability should be checked before walking on the sediment to collect samples.

4.5 Schedule

The proposed schedule is depicted in Figure 4-3. The dewatering schedule will be dependent on the surface water sampling results and on the conclusions of the CCME Environmental Risk Assessment.

Activities →

Milestones ◆

Implementation Schedule of Miramichi Lagoons Closure Plan

Item	2014 Dec	2015 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 Preparation													
Consultation with client and NBDELG	◆	◆			◆								
CCME Environmental Risk Assessment			→										
Engineering				→	→								
Underwater inspections					◆								
Tendering construction work						→							
1 Closure													
Monitoring (before and during construction)						◆	◆	◆	◆	◆			
Implementation of structural changes, draining of ASBs							→	→	→	→			
Demolition of buildings and structures, and clean up							→	→	→	→			
Decommissioning of wells											→		
2 Post-closure													
Monitoring											◆		

Miramichi Lagoons Closure Plan Implementation Schedule	NATECH Environmental Services Inc. 2492 Route 640, Hanwell, NB, E3E 2C2 Phone: (506) 455-1085 Fax: (506) 455-1088	**DATE:** 2014/11/28	**FILE:** MCP-14-01
		VERSION: 1.0	**FIGURE:** 4-3

5. COST ESTIMATE

The cost of the closure is estimated at $300,000 plus HST. This includes the following items in Table 5.1, but no contingency:

Table 5.1. Estimated closure costs

Phase	Description	Cost
1: Preparation	Consultation with NB ENV, CCME Risk Assessment, Engineering, Underwater inspections.	$45,000
2: Closure	Monitoring (pre-and during construction, including analytical fees), Clean-up (removal of power lines, aerators, maintenance building, etc.) Removal of underwater diffuser on outfall, Implementation of closure measures, Structural changes, including new outlet structure, Decommissioning of old outlet structure, Decommissioning of wells.	$190,000
3: Post Closure	Monitoring (Post construction).	$65,000
TOTAL		**$300,000**

Notes: If the post-closure monitoring results show higher than anticipated contaminant concentrations in soil and/or soil invertebrates, additional monitoring of habitat and presence of certain species, as well as body burden analyses may have to be carried once or twice, resulting in an additional $50,000 to $100,000 additional cost (unlikely worst-case scenario). Also, there may be additional monitoring requirements for closure and post-closure monitoring stipulated by the NBDELG. Those requirements could results in costs that are beyond the figures provided in Table 5.1.

6. CONCLUSIONS AND RECOMMENDATIONS

As part of the preparation of this closure plan, the following results were obtained:

- The volume of sediments was surveyed and amounts to approximately 392,000 m^3 in the aerated stabilization basins (ASBs).

- The quality of the sediments in the three ASBs and the four ash basins (ABs) was assessed based on 2009 data from EPS and additional data collected in 2014 by NATECH to address information gaps. It was found that a number of metals, hydrocarbons, and dioxins and furans exceeded screening levels based on quality guidelines for sediment or soil (agricultural land) (Intrinsik, September 2014).

- The Ecological Risk Assessment that was subsequently carried out (Intrinsik, November 2014), including food chain modeling, determined that none of the contaminants in the sediments present significant risk to the fauna and flora that will likely colonize the lagoon site in the future. Therefore no soil cover is necessary at this site.

- The level of the three ASBs already dropped by approximately 0.7 m in the spring of 2014 due to damaged stop logs in the outlet structure. Vegetation colonized the exposed sediment quickly during the summer of 2014. The rapid growth that occurred naturally over the summer indicates that the sediments constitute a good growth media for vegetation.

- Some odours were noticed by neighbours when the level dropped initially. During subsequent site visits in May and July, no noticeable odours were observed.

- Development of dust did not appear to be a problem when large areas of sludge were exposed in 2014.

The following approach is recommended to close the site:

- ❑ Obtain approval from the NBDELG to proceed with closure, based on the results of the Ecological Risk Assessment carried out. It is recommended to continue the permitting process under the follow up to EIA # 4561-3-1156. The information in this report and the methodology proposed are intended to address the questions that were raised by the Technical Review Committee in April of 2010 after reviewing the initial Closure Plan by EPS (February 2010).

- ❑ Conduct a CCME Environmental Risk Assessment of the anticipated discharge into the Miramichi Estuary (while emptying the lagoons) and determine an appropriate drainage flow rate.

- ❑ Design detailed closure measures in early 2015 and present them in a design package. An underwater survey of the outlet structure and of the outfall will be required for the details of the plans to be finalised.

- ❑ Prepare a tender document for the proposed work.

- ❑ Implement the closure. The proposed closure plan consists of leaving the four ash basins as wetlands (they are already vegetated) and partially draining the three former aerated stabilization basins (ASBs). A sand filter will be constructed in front of the outlet structure before starting to drain, to avoid the release of contaminated sediment into the Miramichi River.

- ❑ Monitoring: it is proposed to monitor the water quality of the effluent (pre-construction, during construction and post-construction), the ground water quality in existing monitoring wells around the site (pre-construction). Also additional sediment sampling and wildlife surveys will be carried out (post-construction).

7. REFERENCES

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APPENDIX A - Photographs

Closure Plan for the Miramichi Pulp and Paper Mill Basins Photographs

NATECH Environmental Services Inc.
2492 Route 640, Hanwell, NB, E3E 2C2
ph: (506) 455 1085, fax (506) 455 1088

DATE: 2014/12/01	FILE: MLC 14-01
SCALE: -	FIGURE: Appendix A1

Closure Plan for the Miramichi Pulp and Paper Mill Basins

Photographs

NATECH Environmental Services Inc.
2492 Route 640, Hanwell, NB, E3E 2C2
ph: (506) 455 1085, fax (506) 455 1088

DATE: 2014/12/01	FILE: MLC 14-01
SCALE: -	FIGURE: Appendix A2

Closure Plan for the
Miramichi Pulp and Paper Mill Basins
Photographs

NATECH
Environmental Services Inc.
2492 Route 640, Hanwell, NB, E3E 2C2
ph: (506) 455 1085, fax (506) 455 1088

DATE: 2014/12/01	FILE: MLC 14-01
SCALE: -	FIGURE: Appendix A3

Closure Plan for the
Miramichi Pulp and Paper Mill Basins
Photographs

NATECH
Environmental Services Inc.
2492 Route 640, Hanwell, NB, E3E 2C2
ph: (506) 455 1085, fax (506) 455 1088

DATE: 2014/12/01	FILE: MLC 14-01
SCALE: -	FIGURE: Appendix A4

Maintenance building and power line

Berm between ASB1 and ASB2

Berm between ASB2 and ASB3 2014/05/14

Berm between ASB1 and ASB2 2014/05/14

Closure Plan for the Miramichi Pulp and Paper Mill Basins Photographs	NATECH **Environmental Services Inc.** 2492 Route 640, Hanwell, NB, E3E 2C2 ph: (506) 455 1085, fax (506) 455 1088	DATE: 2014/12/01	FILE: MLC 14-01
		SCALE: -	FIGURE: Appendix A5

Closure Plan for the
Miramichi Pulp and Paper Mill Basins
Photographs

NATECH
Environmental Services Inc.
2492 Route 640, Hanwell, NB, E3E 2C2
ph: (506) 455 1085, fax (506) 455 1088

DATE: 2014/12/01	FILE: MLC 14-01
SCALE: -	FIGURE: Appendix A6

Damaged fence


Aerator and floating Log


Aerator and wooden piles


Damaged control panel on outlet structure

Closure Plan for the Miramichi Pulp and Paper Mill Basins Photographs	**NATECH Environmental Services Inc.** 2492 Route 640, Hanwell, NB, E3E 2C2 ph: (506) 455 1085, fax (506) 455 1088	DATE: 2014/12/01	FILE: MLC 14-01
		SCALE: -	FIGURE: Appendix A7

APPENDIX B - Screening Ecological Risk Assessment Report (Intrinsik)

APPENDIX C - Ecological Risk Assessment Report (Intrinsik)

SCIENCE INTEGRITY KNOWLEDGE

ECOLOGICAL RISK ASSESSMENT OF AERATED STABILIZATION AND ASH BASINS AT A FORMER PULP AND PAPER MILL IN MIRAMICHI, NB

FINAL REPORT

January 21, 2015

Prepared For: **Natech Environmental Services Inc.**
2492 Route 640
Hanwell, NB
E3E 2C2

NB Department of Transportation and Infrastructure
Kings Place
440 King Street
Fredericton, NB
E3B 5H8

Sovereign Place, 5121 Sackville St., Suite 506, Halifax, Nova Scotia, B3J 1K1
Tel: 902-429-0278 ▪ Fax: 902-429-0279▪ ▪ www.intrinsik.com

DISCLAIMER

ECOLOGICAL RISK ASSESSMENT OF AERATED STABILIZATION AND ASH BASINS AT A FORMER PULP AND PAPER MILL IN MIRAMICHI, NB

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1.0 INTRODUCTION

Intrinsik was contacted by Natech Environmental Services Inc. (Natech) to assist with an ecological assessment of chemical characterization data for sediments in a series of aerated stabilization and ash basins at a former kraft pulp mill in Miramichi, NB. Since the area was formerly a series of aerated stabilization and ash basins which functioned to treat effluent and other waste streams from the pulp mill, the basins contain a variety of chemicals in the sediments, including a number of metals, polycyclic aromatic hydrocarbons (PAH), petroleum hydrocarbons (PHC), and chlorinated dioxins and furans (PCDD/PCDF; due to historic use of bleach in the kraft process).

Sediment data were originally collected in 2009, and these data were evaluated by Environmental Planning Specialists Inc. for the owner at the time (Fornebu Development Corporation) in 2010, relative to potential risks for wildlife using the area, based on the proposed ecological closure approach. The NB Department of Environment (NB DOE) reviewed the assessment and screening of data and the approach and had several comments.

Since the time of the 2009 investigation, the NB government acquired ownership of the property, and is interested in evaluating whether an ecological closure of the basins is possible, with respect to potential risks to wildlife that may use the environment in the future. An ecological closure would enable wildlife usage of the area, and would allow natural succession of vegetation to proceed. The NB Department of Transportation and Infrastructure (NBDTI) hired Natech to assist them with moving this project forward. Natech contacted Intrinsik to assist them with ecological risk-related questions associated with possible closure options.

In the summer of 2014, Intrinsik reviewed the 2009 and 2014 data collected on the site and compared to appropriate ecological health-based sediment and soil quality guidelines (See Intrinsik 2014). Based on this screening level ecological risk assessment, it was determined additional study was required for several chemicals in a variety of areas (Table 1-1). For additional details refer to Intrinsik's screening level ERA of this site (Intrinsik, 2014).

Table 1-1 Summary of Results of Screening Level ERA Findings					
Chemical Group	**Ash Basin 1-4 (Soil Quality Guideline Outcomes)**	**Ash Basin 1- 4 (Sediment Quality Guideline Outcomes)**	**Aerated Stabilization Basins (Soil Quality Guideline Outcomes)**		
			1	**2**	**3**
F3 - PHC	NFS	**Further study for aquatic birds and mammals**	**Further study for birds and mammals; vegetation**	**Further study for birds and mammals; vegetation**	**Further study for vegetation**
Metals	**Further study for Cd (UCLM); Ba; V; Zn (birds and mammals)**	**Further study for Cd; Zn (aquatic birds and mammals)**	**Further study for Cd (UCLM); V (birds and mammals)**	**Further study for Cd (UCLM)**	**Further study for Cd (UCLM)**
PCDD/ PCDF	**Further study for birds and mammals**	**Further study for aquatic birds and mammals**	**NS**	**Further study for birds and mammals**	**Further study for birds and mammals**

Notes:
NFS = no further study; UCLM = upper confidence limit of the mean

To determine if these chemicals in these areas posed a risk to relevant receptors, an ecological risk assessment was undertaken with existing data. The details of this study are provided herein.

The preferred ecological closure approach proposed for the site is as follows:

- Gradually drain ASB 1, 2, and 3 over a period of several months, starting in the spring, and allow vegetation to establish.
- Leave AB 1, 2, 3, and 4 as is (vegetated shallow wetlands)
- Install a sediment filter in the outlet structure in ASB 3 to capture any sediment particles that may be discharged due to wave action while the ASB basins are being drained.
- Monitor the reclamation progress and the effluent discharge over several years, in terms of water levels, water quality, vegetation growth, and usage by wildlife.

This document provides a more detailed ecological risk assessment of issues identified requiring further study in the screening level ERA conducted by Intrinsik (2014).

2.0 ECOLOGICAL RISK ASSESSMENT (ERA) FRAMEWORK

This ecological risk assessment of the aerated stabilization and ash basins at the former pulp and paper mill in Miramichi, NB was based on widely accepted ecological risk assessment frameworks, methodologies and guidance published and endorsed by Environment Canada (e.g., FCSAP, 2013a; 2012a, b; 2010 a,b) and the U.S. EPA (i.e., 2007a). The methods used to conduct the ERA are provided in Section 2.1 while outcomes of the assessment are provided in Sections 3.0 to 6.0 with conclusions being provided in Section 7.0.

2.1 ERA Methodology

The basic steps of an ERA are illustrated in Figure 2-1 and include the Problem Formulation, Exposure Assessment, Effects Assessment and Risk Characterization. The ERA Strategy provides the overall plan for how all phases the risk assessment are going to be conducted and is established either within the Problem Formulation stage or after it. The ERA is conducted using an iterative approach with continual feedback between the steps.

A brief outline of each step of the ERA is provided in the following sections.

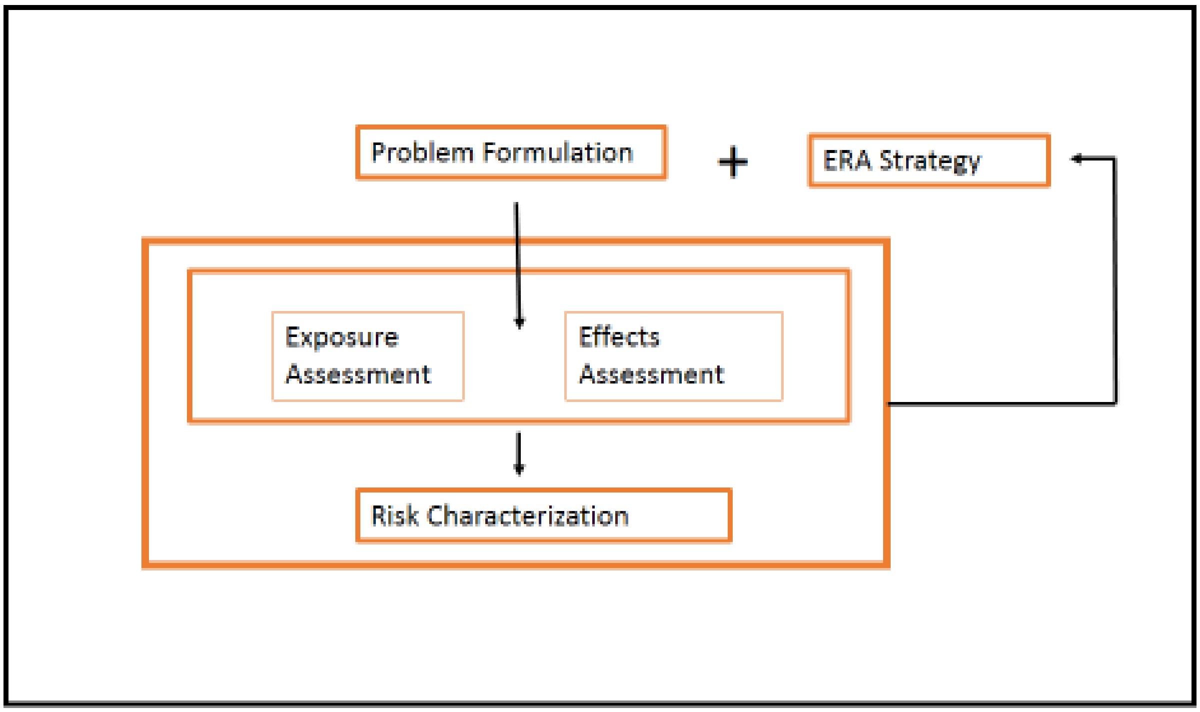


Figure 2-1 Steps of an Ecological Risk Assessment (From FCSAP, 2013b)

2.1.1 Problem Formulation Step

The Problem Formulation acts as an information-gathering and interpretation step, which serves to plan and focus the approach of the ERA on critical areas of concern for the site being evaluated. There are several components to the Problem Formulation stage including:

- Establishing the site management goals (*i.e.,* the central questions to be answered by the ERA);
- Providing regulatory context (*i.e.*, acts and policies that apply to site; land use for which the ERA is being conducted);
- Review existing site information and identify gaps;
- Select contaminants of concern (COC) from greater list of on-site chemicals of potential concern (COPC);
- Select receptors of concern (ROC) and identify relevant exposure pathways;
- Develop a conceptual site model;
- Clarify protection goals (*i.e*., statements describing the level to which ROC should be protected) and acceptable effect levels (which operationalizes the protection goal);
- Identify assessment endpoints (*i.e.,* what is to be protected) and measurement endpoints (*i.e.,* methods used to describe a change in the assessment endpoint);
- Develop Lines of Evidence (LOE) for each assessment endpoint (i.e., one or more LOE is selected for each assessment endpoint and combines information on exposure and effects); and
- Develop the general ERA strategy.

The outcomes of the Problem Formulation stage form the basis of the approach to be taken in the ERA. Details of the Problem Formulation are provided in Section 3.0.

2.1.2 Exposure Assessment

In the Exposure Assessment, the mechanisms by which the ROCs are exposed to COCs are characterized and the magnitude of these exposures are quantified or categorized. The types of exposure data which can be used for each line of evidence include the following:

- External exposure media (*e.g*., contaminant concentration in various site media);
- Internal exposure media (*e.g*., contaminant concentration in receptor tissue);
- Estimation of total doses (*e.g*., total contaminant intake from all exposure pathways);
- Categorical measure of exposure (*e.g*., on-site versus reference; site versus lab; spatial gradient categories such as near-field; far-field).

Details of the Exposure Assessment are provided in Section 4.0.

2.1.3 Effects Assessment

In the Effects Assessment, the type / nature of effect caused by each COC under specific exposure conditions is characterized. Effects information is required along with exposure information for each line of evidence. There are four main types of effects assessment methods, which include:

- Site-specific toxicity studies;
- Indirect toxicity studies;
- Site-specific biology studies; and
- Indirect biology studies.

Details of the Effects Assessment are provided in Section 5.0.

2.1.4 Risk Characterization

Risk Characterization is comprised of several steps including:

- Relevance checks;
- Interpretation and evaluation of each line of evidence;
- Preparation of a compiled data summary;
- Application of weight of evidence procedure;
- Evaluation of uncertainties in ERA;
- Consideration of extrapolation / Interpolation (how representative the ERA is in terms of the site management goal);
- Development of site-specific remediation objectives (if necessary);
- Summarization of risk conclusions; and
- Recommendations for follow-up actions (if necessary).

The Risk Characterization integrates the results of the exposure and effects assessments. In the risk characterization, a Weight of Evidence (WOE) approach is used that considers the results of each LOE evaluation to provide an overall conclusion. Figure 2-2 illustrates how the LOE are used in the overall WOE evaluation.

Details of the Risk Characterization are provided in Section 6.0 while results of the assessment are provided in Section 7.0.

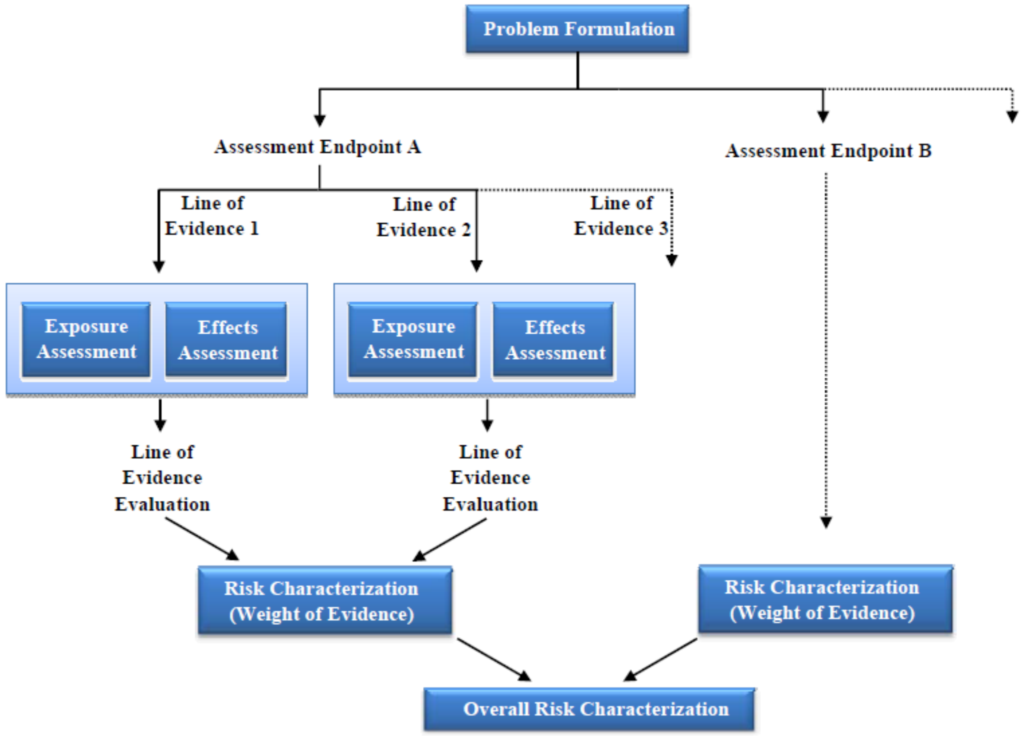


Figure 2-2 Weight of Evidence Approach to ERA (From FCSAP, 2012a)

3.0 PROBLEM FORMULATION

3.1 Site Management Goal and Regulatory Context

The site management goal of the ERA of the aerated stabilization and ash basins at the former pulp and paper mill in Miramichi, NB is to determine whether COCs present in the water, soil and sediment associated with these basins (related to past emissions from the facility) have the potential to adversely affect avian and mammalian ecological receptors inhabiting or foraging the vicinity of this area. No fish are present nor are they expected to be present in the basins. The basins are not natural aquatic life habitat. They are constructed industrial lagoons where some aquatic life tolerant of the lagoons' conditions live. Thus the protection of aquatic invertebrates and aquatic vegetation were not a goal of this assessment.

The site is currently owned by the NB government. As the land is not federally owned, the use of the Environment Canada Federal Contaminated Sites Action Plan (FCSAP) ERA methodology is not required. However, given this is the most recent and comprehensive guidance for ERA in Canada, the FCAPS methodology was used (i.e., the main guidance document; FCSAP, 2012a and relevant aspects of the accompanying modules; FCSAP, 2010 a,b; FCSAP, 2012b; FCSAP, 2013a). Consideration was also given to the guidance provided within the U.S. EPA (2007a) Framework for Inorganic Metals Risk Assessment.

Federal ecological health-based benchmarks were used where available for comparison of site data (*i.e*., CCME, 2014 environmental quality guidelines obtained on-line) in the screening level ERA of this site. Where federal benchmarks were not available, relevant benchmarks from other regulatory agencies were used. For TRVs (toxicity reference values) selection, FCSAP (2010b) guidance was considered.

The land use for which this ERA is being conducted is agricultural. The NB DOE is interested in the land use being "wildlands". Under FCSAP (2013c), natural (or wild) lands are considered under the agricultural land use category. The land use is not expected to change in the future.

3.2 Existing Site Information Based on Past Investigations and Data Gaps

Exiting site sediment data collected in 2009 and 2014 were compiled by Natech and screened against ecological-based soil and sediment quality guidelines in the screening level ERA report (See Intrinsik, 2014, Attachment C).

Water samples were collected as part of the Intrinsik (2014) screening ERA. Water data were analyzed for metals and PCDD/PCDF. Water data are provided in Attachment A.

Data gaps for sediment and water were identified in the Intrinsik (2014) screening level ERA (i.e., collection of chlorophenol, PCDD/PCDF and PCB data). Any data considered essential, were collected prior to conducting the screening level ERA.

3.3 Identification of Chemicals of Concern (COCs)

Chemicals of potential concern (COPC) were screened using the approach described in the following sections to determine what chemicals of concern (COC) would be assessed in this ERA (FCSAP, 2012a).

Ecological receptors could be exposed to a variety of COPCs in the water and sediment / soil associated with the aerated stabilization and ash basins as a result of the operation of the former pulp and paper mill including: metals, PCBs, PCDD/PCDF, chlorophenols, resin and fatty acids.

While resin and fatty acids also could be present on-site as a result of facility operations, no site data were available for these compounds. No soil or sediment guidelines were identified for resin or fatty acids. Fatty acids are used in cosmetics, and in food and pharmaceuticals. These uses of fatty acids were reported not to be toxic (ACT, 1987). As such, these compounds were not considered toxic to wildlife via the ingestion of site media.

Toxicity data for the resin acids are limited. Rosin, which is a complex combination of chemicals derived from wood, comprised primarily of resin acids and modified resin acids was however reported to be of low toxicity following repeated oral exposure (Australia Department of Health, 2013). Given this and given the paucity of toxicity data and lack of site data for resin acids, they were excluded as COCs for this assessment.

3.3.1 COCs in Sediment / Soil

COPCs in sediments were screened against ecologically health-based soil and sediment guidelines (soil guidelines were used as the sediment will become soil if the basins are drained). The resulting COCs in sediment / soil were evaluated as part of the screening level ERA conducted by Intrinsik (20140) on this site (See Appendix C of Intrinsik, 2014). Based on the screening level ERA the following chemicals in sediments / soil required additional assessment:

- Ash basins 1 to 4 (based on soil quality guideline comparison): PCDD/PCDF, barium, cadmium, vanadium, zinc for birds and mammals
- Ash basins 1 to 4 (based on sediment guideline comparison): F3 PHC, PCDD/PCDF, cadmium and zinc for aquatic birds and mammals
- Aerated stabilization basins 1 to 3 (based on soil guideline comparison): F3PHC (for birds mammals and vegetation); PCDD/PCDF, cadmium and vanadium for birds and mammals
- Comparisons of Aerated stabilization basins to sediment quality guidelines was not undertaken, as this was not a desired scenario

F3 PHC were identified as requiring additional assessment in the screening level ERA (Intrinsik, 2014). The CCME (2008) reports that most PHC are metabolized by vertebrates and modified into readily excretable forms and as such do not tend to accumulate in birds and mammals. Similarly, PHC do not readily absorb or accumulate in vegetation (CCME, 2008). As such, the exposure of mammals and birds to PHC via the food chain is expected to be minimal. Therefore, F3 PHC were not carried forward as COCs for birds and mammals. While avian and mammalian species could still be exposed to F3 PHC in soil (via incidental ingestion), this exposure route is expected to be limited (particularly given how quickly exposed soil / sediment associated with the lagoons is growing over with grasses, thus limiting exposure to soils; see Section 7.2).

In addition, average concentrations of F3 within the various basins (which would more appropriately represent the spatial aspects of the soil / sediment exposures to wildlife than a maximum value, as these species are mobile and have relatively large home ranges) were 1717.5 mg/kg (AB 1-4); 12,680 mg/kg (ASB 1); 18,074 mg/kg (ASB 2) and 9,283 mg/kg (ASB3). The PIRI (2012) soil ecological screening level for protection of wildlife (mammals and birds) is 16,000 mg/kg (agricultural land use). The ash basins and ASB1 and ASB 3 are below this limit, whereas ASB 2 only slightly exceeds this limit. This guideline assumes 100% bioavailability, which may not be the case at this site, due to the very high levels of Total Organic Carbon (8.8 – 34% TOC). Given this the likelihood of adverse effects in wildlife as a result of direct exposure to F3 is expected to be low and as such, PHC F3 were not carried forward for assessment in birds or mammals.

The F3 PHC were carried forward as a COC for vegetation.

PCBs were not selected as one of the COCs in the screening level ERA as PCBs were not detected in any sample (at a detection limit of 0.5 mg/kg). Nevertheless, PCBs were carried forward for food chain modelling given the bioaccumulative nature of this COC to provide additional line of evidence for determining whether potential risks were associated with this COC.

In addition to PCBs, PCDD/PCDF and cadmium were carried forward for assessment in the upper trophic level species as these chemicals tend to bioaccumulate in the food chain.

Based on the results of the soil / sediment screening, the following COCs were selected for evaluation in the ERA:

- F3 – PHC (vegetation; ABs)
- PCDD/PCDF (birds and mammals; upper trophic level; ABs and ASBs)
- Barium (birds and mammals; ABs only)
- Cadmium (birds and mammals; upper trophic level; ABs and ASBs)
- Vanadium (birds and mammals; ABs and ASBs)
- Zinc (birds and mammals; ABs only)
- PCBs (birds and mammals; upper trophic level; ABs and ASBs)

3.3.2 COCs in Water

As there are no fish in the basins and aquatic vegetation / invertebrates are not the focus of protection for this assessment, water data were not screened to identify COCs for aquatic life.

Water concentration data for the COCs identified via the soil and sediment screening were however used in the ERA modelling for birds and mammals.

While water data were not screened to identify COCs for aquatic life in the basins, data were screened to identify COCs for aquatic life in the Miramichi River if / when the basins are drained. The water from the basins is planned to be directed into the Miramichi River and as such, it is important to know whether this water could be of concern to aquatic life. Available water data (i.e., metals data) from the basins were screened against surface water quality guidelines for aquatic life to identify any COCs that may be of concern if / when any basins are drained. Although some water data were available for PCDD/PCDF, no water quality guidelines are available for PCDD/PCDF as these compounds are not water soluble. Concentrations identified in water are likely the result of PCDD/PCDF bound to sediments (as water samples were unfiltered).

The comparison of basin water data to freshwater aquatic life guidelines is presented in Attachment B with chemicals in exceedance presented below. These COCs are discussed further with respect to the potential for risks to aquatic life in the Miramichi River if / when the basins are drained into the Miramichi in Section 7.1.

- Aluminium
- Lead
- Vanadium

3.4 Identification of Ecological Receptors of Concern (ROC)

The goal of the receptor identification step is to identify ecological receptors of concern (ROCs) which occur within the study area, and that have the greatest potential for exposure to chemicals of concern (COCs), and/or are the most sensitive to the effects of the COCs. To identify potential ROCs, a variety of sources site data collected by Phil Riebel (P. Riebel, 2014a,b) in addition to anecdotal site information provided by Natech, were used to identify ROCs. Table 3-1 provides rationale for the selection of the receptors of concern.

Table 3-1 Receptor of Concern (ROC) Selection for the ERA

Receptor Group	Receptor Type	Included in ERA?	Rationale	Surrogate Receptor(s)
Aquatic Primary Producer	Phytoplankton / Periphyton / Macrophyte	No	While some aquatic vegetation is found in the basins, the basins are not natural habitat but rather are constructed industrial ponds where some aquatic life tolerant of the basins' conditions live. Therefore aquatic primary producers not selected for assessment. While aquatic macrophytes were not selected for assessment, tissue concentrations of COCs were estimated and included as dietary inputs for relevant receptors.	Not applicable
Aquatic Invertebrates	Benthic / Pelagic	No	While some aquatic invertebrates inhabit the basins, the basins are not natural habitat but rather are constructed industrial ponds where some aquatic life tolerant of the basins' conditions live. Therefore aquatic invertebrates were not selected for	Not applicable

Table 3-1 Receptor of Concern (ROC) Selection for the ERA				
Receptor Group	**Receptor Type**	**Included in ERA?**	**Rationale**	**Surrogate Receptor(s)**
			assessment. While aquatic invertebrates were not selected for assessment, tissue concentrations of COCs were estimated and included as dietary inputs for relevant receptors.	
Fish	Benthivorus / Planktivorus / Piscivorus	No	No fish in the basins and the lagoons are closed off preventing fish from entering now or in the future. Therefore, fish not selected for assessment.	Not applicable
Aquatic Mammal	***Herbivorous / Insectivorous / Piscivorous***	***Yes (herbivorous)***	As previously indicated, there are no fish in the basins and the lagoons are closed off preventing fish from entering now or in the future. Therefore, fish eating wildlife were not selected for assessment. Similarly, no insectivorous mammals are expected to be found on-site. ***Herbivorous aquatic mammal (i.e., muskrat) have been reported on-site (P. Riebel, 2014b) and may be exposed to COCs via ingestion of aquatic vegetation and were therefore included for assessment. As the muskrat has been seen on-site it was selected as the surrogate for this group.***	***Muskrat***
Aquatic Bird	***Herbivorous / Insectivorous / Piscivorous***	***Yes (herbivorous/ insectivorous)***	As previously indicated, there are no fish in the basins and the lagoons are closed off preventing fish from entering now or in the future. Therefore, neither fish nor fish eating avian species were selected for assessment. ***Waterfowl and other birds feeding on aquatic vegetation / invertebrates are found in the area (Phil Reibel et al., 2014 a,b) and could be exposed to COCs in these media. As such, herbivorous and insectivorous avifauna were selected as ROC. The black duck eats both aquatic vegetation and aquatic invertebrates and was selected to represent both herbivorous and insectivorous aquatic bird.***	***Black duck***
Terrestrial Primary producer	***Moss / Grass / Forb / Shrub / Tree***	***Yes***	***Vegetation has direct contact with COC in soils and could be eaten by other species.***	***Qualitatively assessed as a group***
Terrestrial Invertebrate	Ground Dwelling	No	While COCs in soils could have direct contact to soil invertebrates, this receptor was not identified as requiring further assessment based on the screening level ERA (Intrinsik, 2014) and therefore was not assessed. While terrestrial invertebrates were not selected for assessment, tissue concentrations of COCs were estimated and included as dietary inputs for relevant receptors.	Not applicable
	Aerial	No	While aerial invertebrates could be exposed to COCs, their exposures would be expected to be low relative to exposures to ground dwelling soil invertebrates (as the deposition of the COCs onto soil will accumulate over time).	Not applicable
Terrestrial Mammal	***Herbivorous***	***Yes***	***Herbivorous mammals such as the meadow vole have been seen on site (Phil Riebel, Person Comm). Herbivorous mammals may be exposed to Site COC via soil ingestion and eating vegetation.***	***Meadow vole***
	Insectivorous	***Yes***	***Insectivorous mammals such as the masked shrew are likely found on-site (Phil Riebel, Pers Comm) and could be exposed to Site COCs via soil ingestion and eating invertebrates.***	***Masked shrew***

Table 3-1 Receptor of Concern (ROC) Selection for the ERA

Receptor Group	Receptor Type	Included in ERA?	Rationale	Surrogate Receptor(s)
	Carnivorous	***Yes***	***While carnivorous mammals have been found in the vicinity of the facility (e.g., red fox; P. Reibel, 2014b), they have a large home range which limits the amount of food, water, soil ingestion, obtained from areas potentially most impacted by the former mill. Given this, exposures to carnivorous mammals via the ingestion of wildlife would be expected to be negligible. Nevertheless, given some of the COPCs are considered bioaccumulative (e.g., cadmium, PCDD/PCDF, PCBs), exposures to carnivorous mammals via the ingestion of wildlife was assessed. While the mink was not observed on-site, the habitat on-site could support this species. As such, the mink was selected as a surrogate for mammalian carnivores as mink are very sensitive to PCBs (Aulerich and Ringer, 1977).***	***Mink***
Terrestrial bird	***Herbivorous***	***Yes***	***Herbivorous birds feeding on terrestrial vegetation such as the purple finch are found in the area (P. Rieble, 2014b) and could obtain exposures from Site COCs via the ingestion of impacted terrestrial vegetation and via the incidental ingestion of soil. The purple finch was selected as s surrogate for this group.***	***Purple finch***
	Insectivorous	***Yes***	***Insectivorous birds such as the robin are found in the area (P. Riebel, 2014b) and could obtain exposures from the site via the ingestion of soil invertebrates and via the incidental ingestion of soils.***	***American robin***
	Carnivorous	No	While carnivorous birds have been found area, they have a large home range which limits the amount of food, water, soil ingestion, obtained from areas potentially most impacted by the IOC facility. Since the COCs selected for evaluation are not considered bioaccumulative, exposures to carnivorous avian species via the ingestion of wildlife potentially impacted would be expected to be negligible. As such, carnivorous avian species were not assessed.	Not applicable
Amphibian	***Carnivorous***	***Yes***	***No specific observations on amphibians using the ponds have been noted at this time. There may be species using these areas. Sixteen species of amphibians are found within NB (CARCNET, 2012). Amphibians can have elevated exposure potential to sediment and surface water contaminants, due to their lifecycle and foraging habits. They can also act as food sources for larger species. Toxicity data to assess this group of species are limited***	***Assessed qualitatively (See Section 3.4.2)***
Reptile	***Carnivorous***	***Yes***	***No specific observations on reptiles using the ponds have been noted at this time. There may be species using these areas. Seven species of reptiles are found within NB (CARCNET, 2012). Reptiles can have elevated exposure potential to sediment/soil contaminants, due to their lifecycle and foraging habits. They can also act as food sources for larger species. Toxicity data to assess this group of species are limited.***	***Assessed qualitatively (See Section 3.4.2)***

3.4.1 Consideration of Species at Risk

Of the birds and mammals reported to be found on-site (P. Riebel, 2014a,b), none were reported in the Government of NB (2013) Species at Risk Act with the exception of the barn swallow which is classified as threatened (NB DNR, 2014a). While the barn swallow was reported on-site (P. Riebel, 2014b), it would not be expected to nest in the area since the barn swallow nests in structures that provide a wall with an overhang or flat edges (e.g., caves, buildings, sheds, bridges, culverts; Brown and Bomberger Brown, 1999). While the barn swallow uses mud to make its nests (Brown and Bomberger Brown, 1999), it is unlikely the mud used for nests would come from the site given site sediments would be full of fibrous materials and vegetation quickly grows on exposed sediments limiting the availability of mud (See Section 7.2 for a discussion of vegetation).

The main diet of the barn swallow is flying insects (Brown and Bomberger Brown, 1999). Exposures to COCs in flying insects would be expected to be minimal given the limited time these food sources spent in contact with sediment / soils. The American robin, which was selected for assessment would be expected to have far greater exposures to site COCs.

The eastern kingbird and purple finch were both reported to be sensitive by the NB DNR (2014b) and these species were also reported to be found on-site (P. Riebel, 2014b). Similar to the barn swallow, the eastern kingbird is an insectivorous bird which eats mainly flying insects (Murphy, 1996). Exposures to the American robin would be expected to be much greater than the eastern kingbird. The purple finch eats seeds and buds and was selected to represent herbivorous avian species in the ERA.

3.4.2 Amphibians and Reptiles

There are limited toxicity data for amphibians and reptiles that are applicable for use in ecological risk assessments. While the basins currently would not be expected to provide desirable habitat to reptiles (as they are filled with water and surrounding areas are somewhat marshy), the area could provide habitat in the future if the basins are drained. Species that would be likely to inhabit the area would be tolerant of the conditions on-site.

Similarly the basins are a constructed industrial treatment area and not natural habitat for amphibians. While amphibians could have populated the basins since the cessation of industrial activities on this site, the species that would inhabit these constructed basins would be species that are tolerant of conditions in the basins. The pH of these basins is relatively high (pH in water on-site ranged from 8 to 8.5; See Attachment A). There is a paucity of toxicity data for amphibians in high pH environments, as concern is generally with potential effects as a result of low pH environments (Rowe and Freda, 2000).

No threatened or endangered amphibians or reptiles were reported on-site; however a specific survey of threatened or endangered species on-site was not conducted.

The potential for risk to upper trophic level species ingesting reptiles and amphibians on-site that may have been exposed to COPCs in the basins was not specifically modeled. However, potential risks to carnivorous species (mink) was evaluated, and this species was assumed to eat benthic invertebrates in addition to other prey. Modelling of amphibian uptake of COCs would have used similar generic bioconcentration factors as those used for other prey, and as such, possible consumption of amphibians from this site is likely adequately represented by the current upper trophic level modelling.

3.5 Selection of Exposure Pathways, Routes and Scenarios

If there are no possible exposure pathways to chemicals of potential concern, there can be no potential for adverse effects from those chemicals. Therefore, it is an important step in any ERA to identify the major exposure pathways for each of the selected ROCs.

Across the receptors that are typically considered in terrestrial ERAs, the main exposure pathways can differ markedly. For example, a vascular plant's exposure to chemicals in soil is controlled by the root distribution in the soil profile, rhizosphere processes, and the physicochemical characteristics of the soil (which influence the forms of chemicals and their phytoavailability). For soil invertebrates, exposure is determined by such factors as depth of burrowing, type of materials ingested, activity patterns, and soil characteristics. Mammalian and avian wildlife receptors may be potentially exposed to COCs through soil ingestion, drinking of surface water or water that collects in puddles or on surfaces, as well as the ingestion of plant and animal food sources. Dermal and inhalation exposure can also occur in mammals and birds, but these pathways are generally considered negligible in most ERAs.

The presence of feathers on birds and fur on mammals reduces dermal exposure by limiting the contact of skin with chemicals in environmental media (Sample *et al.*, 1997; Sample and Suter II, 1994). In addition, metals do not readily cross the dermis, and are unlikely to be absorbed through skin (Watters *et al*., 1980).

Inhalation exposure to many chemicals, but particularly metals and metalloids, is generally assumed to be negligible for birds and mammals. Many ecological risk assessment guidance documents consider that air inhalation is a minor exposure pathway for mammalian and avian receptors under most circumstances (*e.g.*, Gaudet *et al.*, 1994; BC MELP, 1998; Sample and Suter II, 1994; Sample *et al.*, 1997; CCME, 1996). This is because most chemicals of interest in terrestrial ERAs tend to be of low volatility, and dust levels, as well as resuspension of soils and dusts (which often contain the highest concentrations of metals, metalloids and some organics because of sorption processes and the large surface area of small particles) tend to be relatively low in areas that are well vegetated. Also, inhalation toxicity data for many chemicals are limited or lacking for both wildlife and experimental animal species. This makes it difficult to assess ecological risks from this exposure route, especially for birds (where inhalation toxicity data is extremely limited), but also for mammals where the toxicity endpoint in the available inhalation studies are often not related to the ecological assessment endpoints of concern (*e.g.*, respiratory tract irritation as opposed to reproduction).

In any terrestrial ERA, the majority of exposure of birds and mammals to chemicals of potential concern occurs via ingestion pathways (*e.g.*, food resources, drinking water, and incidental soil ingestion). For this ERA, food and soil ingestion would be major exposure pathways for the mammalian and avian receptors. Drinking water is typically a minor exposure pathway as many receptors will not ingest water from local freshwater bodies, but rather, will obtain the majority of their daily water requirements from the ingestion of food, as well as water that condenses on vegetation (and other surfaces), and/or accumulates in puddles. While water contained in food as well as water produced metabolically will decrease the daily drinking water requirements of these receptors, these particular sources of water are not typically considered in ERAs.

A summary of the exposure pathways selected for the ROCs is presented in Table 3-2.

Table 3-2 Exposure Pathway Selection for Receptors of Concern

Receptor Group	Exposure Pathway	Included in ERA?	Rationale
Primary Producer (Vegetation)	Direct Contact (soil, soil porewater, groundwater);	Yes (soil only)	Vegetation could be exposed to chemicals via direct contact. Only direct contact with soils was considered relevant as PHC F3 (the only COC for vegetation) do not readily absorb or accumulate in vegetation (CCME, 2008).
Terrestrial / Aquatic Mammal (herbivorous)	Water consumption	Yes	Included for aquatic and terrestrial mammals. Although small terrestrial mammals rarely rely on surface water for drinking; rather they obtain water requirements from food sources, this pathways was included.
	Food consumption	Yes	Herbivorous mammals could be exposed to COC via ingestion of terrestrial / aquatic vegetation grown on impacted soils / sediments.
	Incidental soil / sediment ingestion	Yes	Herbivorous mammals could incidentally ingest soil / sediments and re-suspended dusts when eating vegetation.
	Dermal exposure	No	Dermal exposures of COCs considered negligible[a].
	Inhalation	No	Compounds are not volatile and as such, exposure via inhalation not included.
Terrestrial Mammal (insectivorous)	Water consumption	Yes	Small mammals rarely rely on surface water for drinking; rather they obtain water requirements from food sources. Nevertheless, this pathways was included.
	Food consumption	Yes	Insectivorous mammals could be exposed to COC via ingestion of invertebrates found in impacted soils.
	Incidental soil ingestion	Yes	Insectivorous mammals could incidentally ingest soils and re-suspended dusts when eating invertebrates.
	Dermal exposure	No	Dermal exposures of COCs considered negligible[a].
	Inhalation	No	Compounds are not volatile and as such, exposure via inhalation not included.
Terrestrial Mammal (carnivorous)	Water consumption	Yes	Although small mammals rarely rely on surface water for drinking; rather they obtain water requirements from food sources, this pathways was included.
	Food consumption	Yes	Carnivorous mammals could be exposed to COC via ingestion of prey.
	Incidental soil	No	Carnivorous mammals would have limited potential

Table 3-2 Exposure Pathway Selection for Receptors of Concern			
Receptor Group	**Exposure Pathway**	**Included in ERA?**	**Rationale**
	ingestion		for soil ingestion as such; incidentally soil ingestion was not included.
	Dermal exposure	No	Dermal exposures of COCs considered negligible[a].
	Inhalation	No	Compounds are not volatile and as such, exposure via inhalation not included.
Terrestrial / Aquatic Bird (herbivorous)	Water consumption	Yes	Although birds rarely rely on surface water for drinking; rather they obtain water requirements from food sources, this pathways was included.
	Food consumption	Yes	Herbivorous birds could be exposed to COC via ingestion of terrestrial / aquatic vegetation grown on impacted soils / sediments.
	Incidental soil / sediment ingestion	Yes	Herbivorous birds could incidentally ingest soil / sediments and re-suspended dusts when eating terrestrial / aquatic vegetation and preening.
	Dermal exposure	No	Dermal exposures of COCs considered negligible[a].
	Inhalation	No	Compounds are not volatile and as such, exposure via inhalation not included.
Terrestrial and Aquatic Bird (insectivorous)	Water consumption	Yes	Although birds rarely rely on surface water for drinking; rather they obtain water requirements from food sources, this pathways was included.
	Food consumption	Yes	Insectivorous birds could be exposed to COC via ingestion of terrestrial / aquatic vegetation grown on impacted soils / sediments.
	Incidental soil / sediment ingestion	Yes	Insectivorous birds could incidentally ingest soil / sediments and re-suspended dusts when eating terrestrial / aquatic vegetation and preening.
	Dermal exposure	No	Dermal exposures of COCs considered negligible[a].
	Inhalation	No	Compounds are not volatile and as such, exposure via inhalation not included.

Notes:
a. Suter et al, 2000

3.5.1 Exposure Scenarios

A variety of scenarios were assessed for this ERA which included:

- Scenario 1: ASBs drained and ABs left with water (desired closure/management scenario)
- Scenario 2: ASBs and ABs left with water in place
- Scenario 3: ASB and ABs all drained, and left as terrestrial environment

The receptors quantitatively assessed for each scenario were dependent upon whether the site was covered in water and had sediments / aquatic vegetation, or was drained and exposed soils / terrestrial vegetation were present. COCs evaluated for each scenario were based on results of the screening level ERA (Intrinsik, 2014) and also included bioaccumulative chemicals (See Section 3.3.1). For Scenario 1, both terrestrial and aquatic environments were assumed to be present. As such, potential risks of COCs in the ASBs were evaluated for only receptors with terrestrial-based diets using a combined data set of all ASB data and for only receptors with aquatic-based diets only using a combined data set of all AB data. In Scenario 2, only receptors with aquatic-based diets were evaluated as all areas of the site were assumed to be covered in water. In Scenario 3, only receptors with terrestrial-based diets were evaluated as all areas of the site were assumed to be drained. For Scenarios 2 and 3, a combined data set of all the AB and ASB data were used to evaluate potential risks to applicable receptors. Table 3-3 summarized the COCs and receptors evaluated for each scenario.

Table 3-3 Receptors and COCs Evaluated for Each Exposure Scenario

	Barium	Cadmium	Vanadium	Zinc	PCDD/PCDF	PCBs
Meadow Vole						
Scenario 1	x	√	√	x	√	√
Scenario 2	x	x	x	x	x	x
Scenario 3	√	√	√	√	√	√
Masked Shrew						
Scenario 1	x	√	√	x	√	√
Scenario 2	x	x	x	x	x	x
Scenario 3	√	√	√	√	√	√
American Robin						
Scenario 1	x	√	√	x	√	√
Scenario 2	x	x	x	x	x	x
Scenario 3	√	√	√	√	√	√
Purple Finch						
Scenario 1	x	√	√	x	√	√
Scenario 2	x	x	x	x	x	x
Scenario 3	√	√	√	√	√	√
Black Duck						
Scenario 1	√	√	√	√	√	√
Scenario 2	√	√	√	√	√	√
Scenario 3	x	x	x	x	x	x
Muskrat						
Scenario 1	√	√	√	√	√	√
Scenario 2	√	√	√	√	√	√
Scenario 3	x	x	x	x	x	x
Mink						
Scenario 1	x	√	x	x	√	√
Scenario 2	x	√	x	x	√	√
Scenario 3	x	√	x	x	√	√

Notes:
√ = COC was carried forward for assessment in indicated scenario for indicated receptor
X = COC was not carried forward

3.6 Conceptual Site Model

A conceptual site model (CSM) provides a visual of the key elements of an ERA, including COCs and their sources, fate and transport of these contaminants throughout the Site, ROC and identification of exposure pathways. A CSM for the ERA of the ABs and ASBs of the former kraft pulp mill in Miramichi, NB is provided in Figure 3-1 and is based on agricultural land use classification (which is applicable for use on wildlife range lands).

Remaining water in the ABs and ASBs as a result of historical on-site effluent treatment activities could impact soils or sediments within the basins, and be taken up by on-site terrestrial / aquatic vegetation and terrestrial / aquatic invertebrates which in turn could be ingested by aquatic and terrestrial mammals and birds. Vegetation may also be exposed directly to soil / sediment contamination within the lagoons. Herbivorous and insectivorous mammals and birds may also be exposed to COCs via incidental ingestion of site soils / sediments and via water in the lagoons. Carnivorous species can be exposed to COCs in prey items.

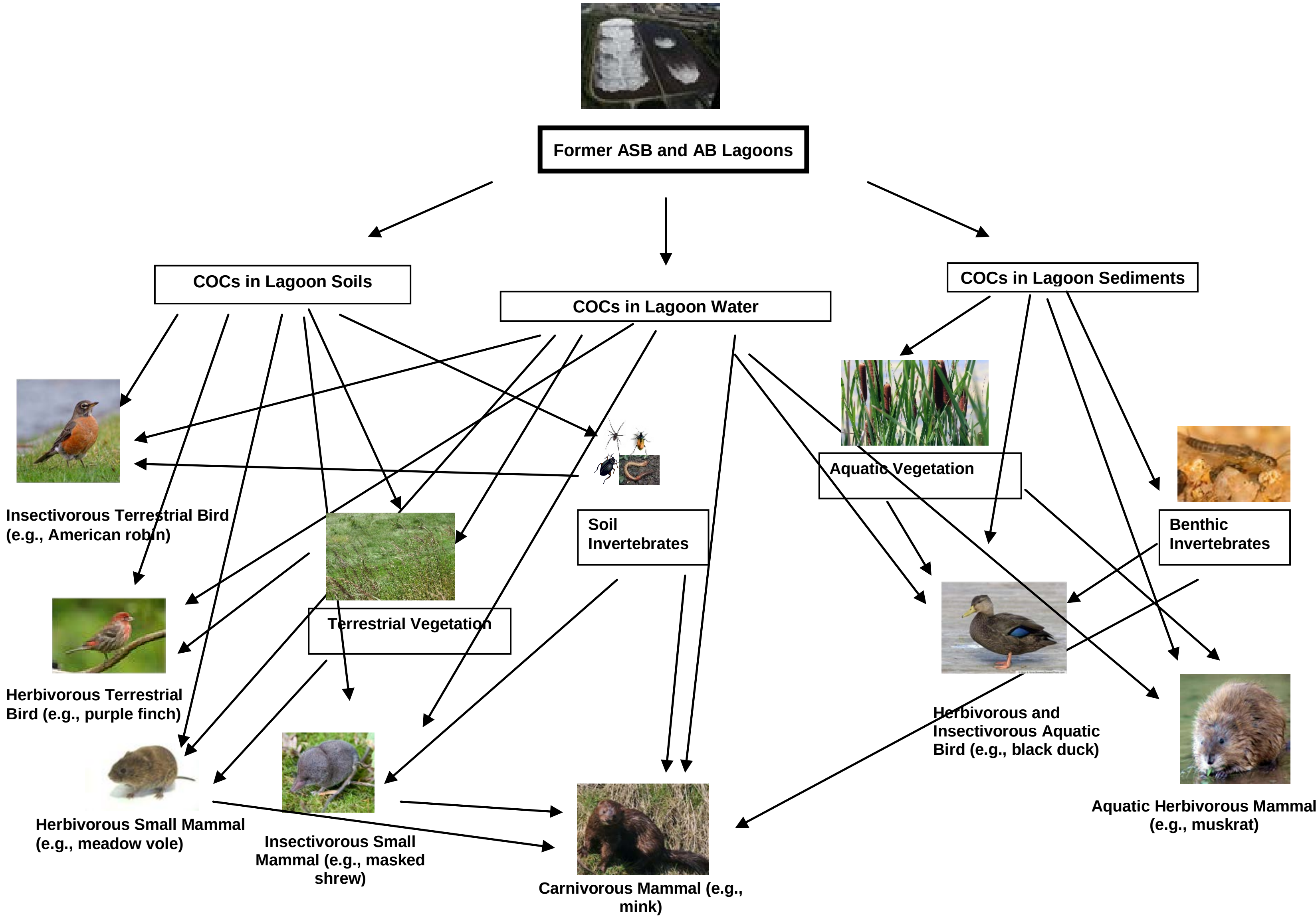


Figure 3-1 Conceptual Site Model for the ERA of the ABs and ASBs of the Former Kraft Pulp Mill in Miramichi, NB

3.7 Protection Goals and Acceptable Effect Levels (AELs)

The Protection Goal for this ERA is to maintain ROC communities / populations similar to background conditions for non-designated and designated species. Although the barn swallow was seen on-site, its diet is mainly from flying insects which would have limited exposure to site COCs. As such, the barn swallow could not be assessed (which remains as an uncertainty in the assessment), but was qualitatively discussed in light of results for other avian species. The selected protection goal for small mammals and avian species therefore focussed on populations rather than individual organisms.

No vegetative species at risk were reported on-site; however it is assumed that a survey to identify sensitive species on-site was not undertaken. The ABs and ASBs are not natural habitat for vegetation, rather they were constructed lagoons for industrial waste. The types of vegetation that would be expected to inhabit the site would be species that are tolerant of wastes in the lagoon soils / sediments. As such, no vegetation species at risk were assumed to be on-site the protection goal for vegetation focussed on communities, rather than individuals.

Acceptable Effect Levels (AELs) therefore focused on community level effects in vegetation, and population level effects in birds and mammals.

For birds and mammals, the TRVs selected are based on lowest adverse effect levels (LOAELs) or some minimal level of risk (e.g., EC10 or EC20), where available. Risk is negligible if the estimated contaminant exposures for small mammals / bird species on-site do not exceed the TRV (i.e., if Hazard Quotient <1 = an acceptable level of risk). A HQ>1 does not necessarily imply there will be an adverse effect. In cases where HQ's are >1, perspective on conservative assumptions and potential for risk will be provided.

Specific TRVs were not selected for vegetation. Rather potential effects of PHC F3 (the only COC for vegetation) was discussed qualitatively by consideration of site data and photos of site conditions.

3.8 Assessment and Measurement Endpoints and Lines of Evidence (LOE)

Assessment endpoints express the environmental value to be protected and include a receptor (what is being protected) and specific property or attribute of that receptor. Measurement endpoints describe (measure) the change in the attribute / property of the assessment endpoint or describes (measures) the exposure or effect for a ROC (FCSAP, 2012a). Lines of evidence used to estimate risks to the ROC are based on the measurement endpoints.

Assessment endpoints, measurement endpoints and lines of evidence used in this ERA are provided in Table 3-3.

Table 3-4 Assessment Endpoints, Measurement Endpoints and Line of Evidence

Terrestrial Receptor Group	Terrestrial Receptor Type	Exposure Pathway	Assessment Endpoint	Measurement endpoint	Line of Evidence
Primary Producer (Vegetation)	Not applicable	Direct soil contact	Health and abundance of terrestrial vegetation communities and ecological function as food and habitat for wildlife species	Soil chemistry data for COCs and photos of site vegetation growth	Exposure potential of vegetation to COCs relative to on-site photographs taken in spring of 2014, and fall of 2014, for various areas of the lagoons
Terrestrial / Aquatic Small Mammal	Herbivorous / Insectivorous / Carnivorous	Incidental soil / sediment ingestion; Food ingestion	Abundance and viability of local small mammal populations	Measured soil / sediment and water chemistry data for COCs; Predicted vegetation, invertebrate and prey tissue concentrations; consideration of accumulation potential / bioaccessibility and size of area affected by COCs Food chain modelling	Consideration toxicity based guidelines, aerial extent of contamination to species home range and other specific species and chemical characteristics which may limit exposure potential Comparison of total small mammal COC exposures to TRVs
Terrestrial / Aquatic Bird	Herbivorous / Insectivorous	Incidental soil / sediment ingestion; Food consumption	Abundance and viability of local avian populations	Measured soil / sediment and water chemistry data for COCs; Predicted vegetation, invertebrate and prey tissue concentrations; consideration of accumulation potential / bioaccessibility and size of area affected by COCs Food chain modelling	Consideration toxicity based guidelines, aerial extent of contamination to species home range and other specific species and chemical characteristics which may limit exposure potential Comparison of total avian COC exposures to TRVs

3.9 ERA Strategy

This ERA was conducted using available data and FCSAP methodology. Vegetation were assessed qualitatively by examining site soil / sediment concentrations and photos of site conditions. Birds and mammals were assessed by modeling exposures and comparing to effect level TRVs.

4.0 EXPOSURE ASSESSMENT

Environment Canada (FCSAP, 2013b) identifies four different types of exposure data including:

- External exposure data (concentrations of COCs in site media, food);
- Internal exposure medial (concentrations of COCs in receptor tissues);
- Estimation of total dose (total intake of COC from all exposure pathways); and
- Categorical measure of exposure (implicit exposure, data collection not required; on-site versus reference; spatial gradient).

For vegetation, external exposure data (i.e., soil concentrations of COCs) were used in the screening level ERA (Intrinsik, 2014). For mammalian and avian wildlife receptors the exposure data used in the assessment included: external exposure data (i.e., site soil / sediment and water concentrations of COCs) and estimation of total dose were used to assess potential exposures to the ROCs. Sections 4.1 and 4.2 respectively provide details of the Exposure Assessment for vegetation and mammalian/avian ROCs.

4.1 Terrestrial Vegetation

Terrestrial vegetation was qualitatively evaluated at the community level. As part of the screening level ERA (Intrinsik, 2014), terrestrial vegetation were assessed by comparing soil concentrations of COCs to soil quality benchmarks that are protective of terrestrial vegetation. Measured soil concentrations were assumed to represent exposure levels to vegetation.

This assumption likely overestimates potential exposure as it ignores an organisms' natural barriers to chemical uptake (*i.e.*, bioavailability considerations), and biochemical transformation processes that may occur within cells, tissues and organs, which may reduce the actual dose that reaches a target site within the organism. In addition, it does not account for possible modifying factors within the soil (such as nutrient levels, organic carbon, etc.), which can reduce uptake of certain contaminants into vegetation.

4.2 Small Mammals and Birds

Exposures for small mammals and birds were quantitatively evaluated in an ERA. The exposure assessment step for these receptors involved the estimation of the amount of a given chemical(s) received by ecological receptors via all the exposure pathways per unit time.

The degree of exposure of ecological receptors to chemicals in the environment depends on the interactions of a number of parameters, including:

- The concentrations of chemicals in various environmental media (as determined by the quantities of chemicals entering the environment from various sources, their persistence, fate and behaviour in these media, and the normal ambient, or background concentrations that exist independent of a specific source).

- The physical-chemical characteristics of the chemicals of concern, which affect their environmental fate, transport, behaviour and persistence, and determine the degree or extent by which chemicals can be absorbed into the body of a receptor.
- The influence of site-specific environmental characteristics, such as geology, soil type, topography, hydrology, hydrogeology, local meteorology and climatology *etc*., on a chemical's fate, transport and behaviour within environmental media.
- The physiological and behavioural characteristics of the receptors (*e.g.*, respiration rate, soils/dusts intake, food ingestion rates, time spent at various activities and in different areas).
- The various exposure pathways for the transfer of the chemicals from the different environmental media to receptors (*e.g.*, ingestion of food items, water, soils/dusts *etc*.).

Receptor characteristics used in the exposure modelling for the mammalian and avian ROCs are provided in Attachment C.

For Scenario 1, potential risks of COCs in the ASBs were evaluated for receptors with terrestrial based diets using a 95th upper confidence level on the mean (UCLM95) of soil data for all ASBs combined for each COC, and for receptors with aquatic-based diets using a UCLM95 of data for all ASBs combined for each COC. In Scenario 2, only receptors with aquatic-based diets were evaluated as all areas of the site were assumed to be covered in water. In Scenario 3, only receptors with terrestrial diets were evaluated, as all areas of the site were assumed to be drained, and terrestrial habitat. For Scenarios 2 and 3, a UCLM95 of the combined data set of all the AB and ASB data were used to evaluate potential risks to applicable receptors.

5.0 EFFECTS ASSESSMENT

Environment Canada (FCSAP, 2013b) identifies four main types of Effects Assessment methods, which include:

- Site-specific toxicity studies;
- Indirect toxicity studies;
- Site-specific biological studies; and
- Indirect biological studies.

For this ERA, indirect toxicity studies were used in the Effects Assessment. The indirect toxicity studies formed the basis of the toxicity reference values used in the assessment

The TRVs selected for ROCs in this ERA are provided in Table 5-1.

Table 5-1 Effects-Based Toxicity Reference Values (TRVs) for Terrestrial Mammalian and Avian Ecological Receptors Carried Forward for Assessment

COPC	Receptor	TRV (mg/kg/day)	Comment	Reference
Barium	Masked shrew Meadow vole Muskrat	121 121 121	No barium reproductive, growth or survival toxicity data for shrew, vole or muskrat were identified in the literature reviewed. Seven bounded LOAELs (2 for reproduction, 2 for growth and 3 for survival) for mammalian species were reported in the U.S. EPA Ecological Screening Level for Barium document (U.S. EPA, 2005a). These studies were conducted with either rats or mice using barium chloride or barium chloride dehydrate in drinking water or via gavage. The lowest LOAEL of 121 mg/kg/day was selected as the basis for the barium TRV. This LOAEL is based on growth and survival effects in rats exposed to barium chloride dehydrate via drinking water (Dietz et al., 1992). Exposures via drinking water would be expected to be greater than exposures via food and soil ingestion. No uncertainty factor was added to this LOAEL for the meadow vole and muskrat TRV since they are of the same order as rats. While the shrew is of a different order than rats and mice, no uncertainty factor was applied to account for species difference in the toxicity data given the form of the compound tested is expected to be highly bioavailable and the route of route of exposure was via drinking water which would tend to overestimate exposures.	U.S. EPA, 2005a
	American robin Purple finch Black duck	NDA	The U.S. EPA (2005) reported that there are insufficient data to develop TRV for avian species. To be discussed qualitatively.	
Cadmium	Masked shrew Meadow vole Muskrat	2.28 1.45 1.45	Limited reproduction, growth or survival cadmium toxicity data were identified in the literature reviewed for the shrew and vole. An unbounded growth LOAEL of 103 mg/kg/day and an unbounded survival NOAEL of 103 mg/kg/day for the common shrew (*Sorex araneus*) was reported by Dodds-Smith et al. (1992) following dietary exposure of cadmium chloride. Unbounded NOAELs for growth in the meadow vole exposed to cadmium sulfate in food were reported by the U.S EPA (2005b) to be 0.179, 0.478 and 0.579 mg/kg/day (Williams et al., 1978). The U.S. EPA (2005b) reported an unbounded LOAEL of 1.45 mg/kg/day for reproductive effects in bank voles (which are of the same family as the meadow vole and common muskrat) fed calcium chloride hydrate (Swiergosz et al., 1998). No effects on growth of bank voles were reported at 4.99, 10.5 and 12.6 mg/kg/day when bank voles were exposed to cadmium chloride hydrate or cadmium chloride in food (Swiergosz et al., 1998; Wlostowski et al., 2000; Wlostowski and Krasowska, 1999). The U.S. EPA (2005b) also reported a bounded LOAEL of 4.99 mg/kg/day for survival of the bank vole (Swiergosz et al., 1998). The U.S. EPA (2005b) reported 36 bounded LOAELs for reproduction, growth and survival	US EPA, 2005b

Table 5-1 Effects-Based Toxicity Reference Values (TRVs) for Terrestrial Mammalian and Avian Ecological Receptors Carried Forward for Assessment

COPC	Receptor	TRV (mg/kg/day)	Comment	Reference
			in mammals. Given there were 11 bounded reproductive LOAELS, the lowest reported bounded LOAEL of 2.28 mg/kg/day from a study in mice fed cadmium chloride (Sawicka-Kapusta et al., 1994) was selected as the basis of the TRV. This value is much lower than the only reported LOAEL for shrew of 103 mg/kg/day for effects on growth and was also lower than the unbounded LOAEL of 4.99 mg/kg/day for survival effects in the bank vole, but higher than the unbounded LOAEL of 1.45 mg/kg/day for reproductive effects in bank voles fed cadmium chloride hydrate. The lowest bounded reproductive LOAEL of 2.28 mg/kg/day was selected as the LOAEL-based TRV for the masked shrew. No uncertainty factor was applied to this value as it was the lowest bounded LOAEL identified and was much lower than the one unbounded LOAEL for the shrew identified in the literature reviewed. Given the lowest bounded LOAEL is greater than the unbounded LOAEL identified for reproductive effects in the bank vole, the unbounded LOAEL of 1.45 mg/kg/day was selected as the TRV for the vole and muskrat.	
	American robin Purple finch Black duck	2.37 2.37 2.37	No passerine bird reproduction, growth or survival cadmium toxicity data were identified in the literature reviewed. Two toxicity studies were identified in the US EPA (2005b) Eco SSL document for cadmium that reported LOAELS for the starling *(Sturnus vulgaris)*. These LOAELs were for biochemical and pathological endpoints, which are generally not considered as relevant as reproduction, growth and survival in an ERA. However, as the robin and finch are passerines and there are no other toxicity data on this order of birds, the starling LOAEL toxicity data were considered. In the starling toxicity studies, LOAELs for biochemical and pathological effects was reported at 7.21 mg/kg/day (Pilastro et al., 1993) and 13.8 mg/kg/day (Congiu et al., 2000). A bounded LOAELs for reproductive effects in the mallard duck fed cadmium chloride at 21.1 mg/kg/day was reported by the U.S. EPA (2005b) in addition to an unbounded NOAEL for reproduction of 4.20 mg/kg/day (White and Finley, 1978; White et al., 1978). Unbounded NOAELs for growth in the mallard or wood duck (which are of the same family as the black duck) reported by the U.S. EPA (2005b) were 0.858, 4.20, and 5.76 mg/kg/day (Cain et al., 1983, Di Giulio and Scanlon, 1984, 1985). They also reported a bounded LOAEL for growth in the mallard duck fed cadmium chloride of 37.6 mg/kg/day (Di Giulio and Scanlon, 1984). An unbounded LOAEL for survival in the duck (species not provided) of 66.9 mg/kg/day was reported by the U.S. EPA (2005)(Van Vleet et al., 1981). They also reported unbounded NOAELs for survival in the duck, wood duck and mallard duck of 5.78,	U.S. EPA, 2005b

Table 5-1 Effects-Based Toxicity Reference Values (TRVs) for Terrestrial Mammalian and Avian Ecological Receptors Carried Forward for Assessment

COPC	Receptor	TRV (mg/kg/day)	Comment	Reference
			13.4, 16.9, 21.1 mg/kg/day (Mayack et al., 1981; Van Vleet et al., 1981; White and Finley, 1978; White et al., 1978). Several bounded avian LOAELS were reported in the US EPA EcoSSL document for cadmium (i.e., 5 reproductive studies; 6 growth and 3 survival). Toxicity data were mainly conducted on chicken, duck and quail. The bounded avian reproductive LOAELs ranged from 2.37 to 21.1 mg/kg/day. The bounded growth LOAELs ranged from 7.08 to 37.6 mg/kg/day and survival from 14.3 to 44.6 mg/kg/day. The lowest LOAEL for biochemical effects in the starling (7.21mg/kg/day) was above the lowest bounded reproductive LOAEL in chickens and ducks (2.37 mg/kg/day), and the bounded LOAEL for reproductive effects in the mallard duck (21.1 mg/kg/day) was also greater than the lowest LOAEL. As such, it is likely that reproductive effects in the robin, finch and duck would occur at concentrations higher than the lowest reproductive LOAEL reported for chickens and ducks. However, given the limited toxicity data available the lowest bounded reproductive LOAEL of 2.37 mg/kg/day was selected for the robin, finch and duck TRVs.	
	Mink	2.28	No mink toxicity data for cadmium were identified in the literature reviewed. A bounded growth LOAEL of 100 mg/kg/day in dogs (which are the same order as mink) exposed to cadmium chloride in food was reported by the U.S. EPA (2005b). The lowest LOAEL of 2.28 mg/kg/day was selected as the LOAEL-based TRV for the mink. No uncertainty factor was applied to this value as it was the lowest bounded LOAEL identified and was much lower than the one unbounded LOAEL for the dog identified in the literature reviewed.	U.S. EPA, 2005b
Vanadium	Masked shrew Meadow vole Muskrat	6.9 6.9 6.9	No vanadium reproduction, growth or survival toxicity data for the shrew, vole or muskrat were identified in the literature reviewed. Seven bounded LOAELs (1 for reproduction, 4 for growth and 2 for survival) for mammalian species were reported in the U.S. EPA Ecological Screening Level for Vanadium document (U.S. EPA, 2005c). These studies were conducted with either rats or mice using either vanadium pentoxide, sodium metavandate or sodium orthovandate in drinking water, food or via gavage. The lowest LOAEL of 5.11 mg/kg/day (based on growth effects in rats exposed to sodium metavandate in food) was from a study conducted in 1938. Given the age of this study, the next lowest bounded LOAEL of 6.85 mg/kg/day (which was also conducted using sodium metavandate in rats but via gavage; Sanchez et al., 1998) was selected as the basis for the vanadium	U.S. EPA, 2005c

Table 5-1 Effects-Based Toxicity Reference Values (TRVs) for Terrestrial Mammalian and Avian Ecological Receptors Carried Forward for Assessment

COPC	Receptor	TRV (mg/kg/day)	Comment	Reference
			mammalian TRV. Exposures via gavage would be expected to be greater than exposures via food and soil ingestion. No uncertainty factor was added to this LOAEL for the meadow vole and muskrat TRV since they are of the same order as rats. This LOAEL was rounded to a TRV of 6.9 mg/kg/day. While the shrew is of a different order than rats and mice, no uncertainty factor was applied to account for species difference in the toxicity data given the form of the compound tested is expected to be highly bioavailable and the route of exposure was gavage. Both of these factors would tend to overestimate potential exposures. As such, a TRV of 6.9 mg/kg/day was selected for the masked shrew.	
	American robin Purple finch Black duck	0.41 0.41 0.41	No vanadium reproduction, growth or survival toxicity data for passerine birds such as the robin or finch were identified in the literature reviewed. The U.S. EPA (2005c) reported a bounded LOAEL for the mallard duck (which is same genus as black duck) of 1.13 mg/kg/day for biochemical effects and an unbounded NOAEL of 12.0 mg/kg/day for survival (Whitle and Dieter, 1978) in addition to another unbounded NOAEL for survival of 13.4 mg/kg/day (Van Vleet et al., 1981). Twenty eight bounded LOAELs for avian species (6 reproductive, 14 growth and 8 survival) were reported in the U.S. EPA Ecological Screening Level for Vanadium document (U.S. EPA, 2005). Bounded LOAELs were from studies where chicken exposed to a variety of vanadium compounds in food. The lowest bounded LOAEL of 0.413 mg/kg/day (for reproductive effects in chickens via exposure to ammonium vanadate in food; Sell et al., 1982) was selected as the basis for the TRV. The study test species is a galliform and the receptors being evaluated are passerines (i.e., robin and finch) and an anseriforme (i.e., black duck). However, given the large number of bounded LOAELs available and that the lowest LOAEL was selected, no uncertainty factor was applied to this LOAEL to derive the TRVs for avian species. The lowest LOAEL of 0.413 mg/kg/day was rounded to a TRV of 0.41 mg/kg/day for the robin, finch and black duck. This value is below the reported NOAELs for biochemical effects and survival in the mallard.	U.S. EPA, 2005c
Zinc	Masked shrew Meadow vole Muskrat	94.2 94.2 94.2	No zinc reproduction, growth or survival toxicity data for the shrew, vole or muskrat were identified in the literature reviewed. Fifteen bounded LOAELs for mammalian species (6 reproductive, 6 growth and 3 survival) were identified in the U.S. EPA Ecological Screening Level for Zinc document (U.S. EPA, 2007). There was a wide range in these LOAELs (75.9 mg/kg/day to 4927 mg/kg/day). The lowest bounded reproductive LOAEL (75.9 mg/kg/day) identified in the U.S. EPA (2007) Eco SSL document was for reproductive effects in cattle (Miller et al., 1989). As	U.S. EPA, 2001

Table 5-1 Effects-Based Toxicity Reference Values (TRVs) for Terrestrial Mammalian and Avian Ecological Receptors Carried Forward for Assessment

COPC	Receptor	TRV (mg/kg/day)	Comment	Reference
			cattle are ruminants, this LOAEL is not applicable for non-ruminants such as the shrew, vole and muskrat. The next lowest LOAEL was 82.3 mg/kg/day for reproductive effects in pigs exposed to zinc oxide in food (Hill et al., 1983). While pigs are non-ruminant, they are in the same order (*i.e.*, *Artiodactyla*) as deer, cattle, sheep and goats, which are ruminants. Given the shrew, vole and muskrat are non-ruminant, pig data were assumed to not be representative of toxicity to these receptors. The next highest bounded reproductive LOAEL was 452 mg/kg/day (where rats were exposed to zinc oxide in their diet; Ketcheson *et al*., 1969). This value is greater than the U.S. EPA (2001) EC20 for zinc of 94.2 mg/kg/day based on reproductive effects in rats. The more conservative EC20 of 94.2 mg/kg/day was selected as the LOAEL-based TRV for the shrew, vole and muskrat. No uncertainty factor was applied to this EC20 for any of the receptors given the wide range of bounded LOAELs and a value on the lower end of this range was selected.	
	American robin Purple finch Black duck	135 135 135	No zinc reproduction, growth or survival toxicity data for the robin or finch were identified in the literature reviewed. The U.S. EPA (2007b) reported a bounded LOAEL for biochemical effects in the mallard duck (which is same genus as black duck) fed zinc carbonate of 153 mg/kg/day, unbounded LOAELs of 126 mg/kg/day for pathology, growth and survival effects, and an unbounded LOAEL of 31.2 mg/kg/day for reproductive effects (Gasaway and Bussm, 1972). This reproductive LOAEL was from a study which used zinc carbonate which would be highly bioavailable. Given the high organic carbon content on-site and the high pH, bioavailability of zinc is expected to be low. As such, this LOAEL was not considered relevant for the black duck. Thirty four bounded LOAELs for avian species (6 reproductive, 21 growth and 7 survival) were reported in the U.S. EPA Ecological Screening Level for Zinc document (U.S. EPA, 2007b). Bounded LOAELs were from studies where chicken, turkey or Japanese quail were exposed to zinc via food. The lowest bounded LOAEL of 66.5 mg/kg/day (for reproductive effects in chickens via exposure to zinc acetate in food; Gibson et al., 1986) was based on a chemical form assumed not to be relevant to this ERA (*i.e*., zinc acetate) and this LOAEL was excluded from further consideration. The next lowest bounded LOAEL identified by the U.S. EPA (2007) is 76.7 mg/kg/day from a study of zinc oxide exposure in the diet of chickens (Stevenson *et al*., 1987). This LOAEL is less than the U.S. EPA (2001) EC20 of 135 mg/kg/day derived from a chicken reproduction study (Stahl *et al*., 1990). Given the assumed low bioavailability of zinc from the site, based on site conditions, the U.S. EPA EC20 of 135 mg/kg/day was selected as the TRV for the robin, finch and duck. While chickens are galliforms and the receptors being evaluated are passerines (i.e., robin and	U.S. EPA, 2001

Table 5-1 Effects-Based Toxicity Reference Values (TRVs) for Terrestrial Mammalian and Avian Ecological Receptors Carried Forward for Assessment

COPC	Receptor	TRV (mg/kg/day)	Comment	Reference
			finch) and an anseriforme (i.e., black duck), no uncertainty factor was applied to this LOAEL to derive the TRV.	
PCDD/ PCDF	Masked shrew Meadow vole Muskrat	0.00001	The Ontario MOE (2011) derived a TRV for TCDD/TCDF of 0.00001 mg/kg/day for the short tailed shrew, meadow vole, red fox and sheep based on a chronic reproductive rat LOAEL (Murray et al., 1979) reported by Sample et al. (1996). This TRV has been selected as the TRV for the masked shrew, meadow vole and muskrat.	OMOE, 2011
	American robin Purple finch Black duck	0.00014	No passerine toxicity data for PCDD/PCDF were identified in the literature reviewed. A chronic reproductive LOAEL for the ring neck pheasant (Nosek et al., 1992) was reported by Sample et al. (1996). The Ontario MOE (2011) selected this LOAEL as a TRV for the red winged black bird, American woodcock and red-tailed hawk. This LOAEL was selected as a TRV for the robin, finch and duck. This study administered TCDD via intraperitoneal injection which would be more bioavailable than via the oral route.	OMOE, 2011
	Mink	0.00001	The Ontario MOE (2011) derived a TRV for TCDD/TCDF of 0.00001 mg/kg/day for the short tailed shrew, meadow vole, red fox and sheep based on a chronic reproductive rat LOAEL (Murray et al., 1979) reported by Sample et al. (1996). This TRV has been selected as the TRV for the mink.	OMOE, 2011
PCBs	Masked shrew Meadow vole Muskrat	0.9 0.9 0.9	The Ontario MOE (2011) derived a PCB TRV 0.9 mg/kg/day for the short tailed shrew, meadow vole, red fox and sheep based on a chronic reproductive rat LOAEL in mice (McCoy et al., 1995). This TRV has been selected as the TRV for the masked shrew, meadow vole and muskrat.	OMOE, 2011
	American robin Purple finch Black duck	0.35 0.35 0.35	The Ontario MOE (2011) selected a chronic reproductive LOAEL in leghorn chickens (Platonow and Reinhart, 1973) as the basis for its TRV. The OMOE (2011) derived TRVs for the red winged black bird, American woodcock and red-tailed hawk of 0.35 mg/kg/day based on this study. This TRV was selected as the TRV for the robin, finch and duck.	OMOE, 2011
	Mink	0.13	A dietary dose LOAELTRV for the mink of 130 µg/kg bw/d (0.13 mg/kg/day) total PCBs was presented in Kannan et al. (2000) based on Heaton et al. (1995). This TRV was selected as the mink TRV for total PCBs.	Heaton et al., 1995 (as referenced in Kannan et al. 2000)

6.0 RISK CHARACTERIZATION

Potential risks to the vegetation ROC was evaluated qualitatively, with risks being characterized using the available lines of evidence (i.e., photographs taken during spring and fall surveys of the basins).

For ROCs which are evaluated quantitatively, using an exposure modelling approach, risk characterization consists of comparing the total estimated exposure for each chemical of potential concern, to the appropriate TRV (or toxicity-based benchmark if media concentrations are being directly compared). This typically involves the calculation of an Exposure Ratio (ER), which is the predicted total exposure divided by the selected TRV, as indicated in the following equation:

$$\textit{Hazard Quotient (HQ)} = \frac{\textit{Estimated Exposure}}{\textit{TRV}}$$

If estimated exposures are greater than the acceptable TRV (i.e., HQ>1), then there is a potential for risk. However, the risk estimate is highly dependent on the degree of conservatism applied in the assessment, as well as the major sources of uncertainty.

7.0 ERA RESULTS AND CONCLUSIONS

A discussion of the water screening and resulting COCs (if / when basins are drained and water flows into Miramichi River) is provided in Section 7.1. ERA results and discussion for potential effects on vegetation is provided in Section 7.2. In Section 7.3, provides the results for avian and mammalian species are provided.

7.1 Discussion of Water COCs Resulting from Draining of Basins

If the ASBs are drained, and rehabilitated as terrestrial habitat, the water from these basins will be released to the Miramichi River. Attachment B presents the screening of a limited number of samples for both the ASBs, and the ABs. Based on comparisons to water quality guidelines, aluminium, lead and vanadium exceeded water quality guidelines. These are each discussed separately, as follows:

- Aluminum: The CCME water quality guideline for aluminium, when pH is > 6.5 is 100 µg/L. Concentrations within the ASBs ranged from 231 – 643 µg/L. Aluminum toxicity is highly influenced by pH, and the pH of the basins ranged from 8.1 – 8.5, which should further reduce toxicity. Additional water quality monitoring prior to any release of the ASB water should be conducted to confirm concentrations of aluminium and pH of waters, prior to release.
- Lead: A single sample exceeded the lead water quality guideline of 1 µg/L. This sample was taken from ASB1. Prior to release of waters from the basins, further water quality monitoring should be conducted to determine if lead is elevated in waters, as this sample may be an anomalous results.
- Vanadium: Vanadium water quality results within the ASBs ranged from 3 – 8 µg/L, relative to the Ontario water quality objective of 6 µg/L. A secondary chronic value if 20 µg/L is also available from Ontario, and measured concentrations are less than this value, which suggests limited potential for toxicity. As per other metals, additional data are required to better understand the potential for toxicity if ASB waters are released.

Several metals did not have water quality guidelines (bismuth, magnesium, rubidium, sodium, strontium, tellurium, and tin). Additional monitoring, and comparisons to background surface water samples (perhaps from the receiving environment of the Miramichi River), would assist in confirming whether these substances are within expected ranges that occur naturally in the environment.

7.2 Vegetation Results

Based on results of the screening level ERA (Intrinsik, 2014), the only COC for vegetation was F3 PHCs in the ASBs. As previously indicated, the site is a constructed industrial site which was never intended to support vegetation. When drained (or when water levels are lowered), the types of vegetation species that will be present on-site will be those that are tolerant of the chemicals on-site.

P. Riebel (2014c) conducted a site visit in September, 2014. During this site visit he reported extensive growth in vegetation since an earlier site visit conducted in spring (May, 2014; See Figures 7-1 to 7-4). It was thought that this accelerated growth resulted in part to the nitrogen and phosphorus (nutrients) present in the sediment due to the many years of nutrient addition required to operate the ASB during the operation of the pulp and paper mill. In addition, high levels of total organic carbon may be binding F3, limiting uptake into vegetation species. P. Riebel (2014c) also reported that the rapid growth in vegetation indicated that the lagoon sediment presents good conditions for ecological remediation (including phyto-remediation) and that remediation has begun in the areas of exposed sludge. Concentrations of F3 within the ASBs were greater than the PIRI (2012) vegetation-protection guideline for F3 of 1300 mg/kg with 90th percentile concentrations ranging from 14,940 in ASB 3 to 31,560 mg/kg in ASB2 (See Intrinsik, 2014; Attachment C).

Figure 7-1a,b and 7-2a,b are taken in ASB 3, and clearly show robust vegetation growth in the areas which have become exposed soil, as a result of naturally reduced water levels within the basin. Figure 7-3a,b are taken in ASB 2, which had the highest concentrations of F3, and again, vegetation appears to be thriving in exposed soil areas. Overall, it can be concluded that while some individual vegetation species may not be able to survive, grown or reproduce in soils in the aerated stabilization basins, some hardier vegetation species, such as cattails, appear to be thriving. There may be areas within the ASBs which have higher concentrations of F3 than those areas shown in Figures 7-1a,b to 7-3a,b wherein vegetation success may be less robust. Based on the available information, risks to vegetation associated with F3 being present in soils/sediments in the ASBs are considered to be low.

Figure 7-1a Vegetation in the Area of Exposed Sediment at the Top of Cell No.3 of the ASB (Same as Figure 7-1b but taken in May 2014)

Figure 7-1b Vegetation in the Area of Exposed Sediment at the Top of Cell No.3 of the ASB. Note the pilings located in the middle of the ASB cell (September 19, 2014)

Figure 7-2a Vegetation Growing on Area of Exposed Sediment Along the Border of Cell No.3 of the ASB Looking Towards the Outfall Structure (Same area as Figure 7-2b but taken May, 2014)

Figure 7-2b Vegetation Growing on Area of Exposed Sediment Along the Border of Cell No.3 of the ASB Looking Towards the Outfall Structure (September 19, 2014)

Figure 7-3a Vegetation Growing on Area of Exposed Sediment Along the Top of Cell No.2 of the ASB Looking Towards the Electrical Building on Left (Same area as Figure 7-3b but taken May 2014)

Figure 7-3b Vegetation Growing on Area of Exposed Sediment Along the Top of Cell No.2 of the ASB Looking Towards the Electrical Building on Left (September 19, 2014)

7.3 Birds and Mammals

HQ results for the ERA modelling for the receptors of concern for the various exposure scenarios. The Scenarios were as follows:

- Scenario 1:ASBs drained and ABs left with water (desired closure/management scenario)
- Scenario 2: ASBs and ABs left with water in place
- Scenario 3: ASB and ABs all drained, and left as terrestrial environment

7.3.1 Scenario 1

For Scenario 1, the UCLM of the ash basins was used to represent sediment concentrations in the ABs, whereas the UCLM of all 3 aerated stabilization basins was used to represent possible soil concentrations for the ASBs. Where water is assumed to be retained in the basins, aquatic foraging receptors are assumed to be present and could incur exposure. Where water is assumed to be drained from the area, terrestrial foraging receptors are assumed to be present, and could incur exposures. Table 7-1 presents the risk modelling outcomes for this scenario.

Table 7-1 HQ Values for Receptors of Concern for Scenario 1

COC	Scenario 1: ASB drained and AB Containing Water						
	Ash Basins (Wet)		Aerated Stabilization Basins (Dry)				
	Black Duck	Muskrat	American Robin	Masked Shrew	Meadow Vole	Purple Finch	Mink
Barium	NA	0.12					
Cadmium	0.11	0.069	0.77	1.6	0.14	0.66	0.089
PCBs	0.0071	0.003	0.14	0.15	0.0014	0.084	0.047
PCDD/F	0.0035	0.037	0.015	0.61	0.02	0.086	0.14
Vanadium	3.7	0.14	1.7	0.37	0.037	0.43	
Zinc	0.12	0.1					

Notes:
Cells shaded black indicate that chemical was not required to be assessed as it was not identified as a COC for the specific receptor and / or location being evaluated. (See Section 3.5.2 for details).
NA = Not available (limited avian toxicity data; no TRV is available from regulatory or other agencies)
Cells shaded light grey indicates HQ is greater than HQ of 1.0.

Based on the outcomes of Scenario 1, leaving the ash basins with water represent a negligible likelihood of adverse effects in the muskrat and the black duck, with the possible exception of vanadium in the black duck. The modelled concentration in the ash basins was 162 mg/kg, whereas the CCME soil ecological guideline is 130 mg/kg (CCME, 1997). The CCME guideline is based on soil contact, and they considered the data to be too limited to calculate a food ingestion based guideline. Background soil concentrations of vanadium from agricultural areas (N = 68) were reported as 78 mg/kg (98^{th} percentile; Loro, 1996), which can be used as an indication of an upper range of background vanadium concentrations. For comparison purposes, similar concentrations have been reported as background in Ontario (the 98^{th} percentiles of soil samples from undisturbed areas in Ontario were reported as 71 mg/kg for old urban parkland and

77 mg/kg for rural parkland; OMEE 1993, cited in CCME, 1997). The concentrations within the ash basins are therefore 2 times expected background.

Risks for the black duck are being driven by consumption of sediment (59% of exposure), aquatic vegetation (1%) and benthic invertebrates (39%). Bioavailability of vanadium in sediments and foods was assumed to be 100%, which likely biases exposure estimates and risks, high, since bioavailability would likely be limited by organic carbon in sediments, which could not be accounted for in the food chain model. Other conservatisms in the modelling include the amount of food and sediment exposure obtained from the basins (assumed to be 100%) and the form of vanadium used in the toxicity study used to develop the TRV (ammonium vanadate; see Table 5-1), relative to the form that might be present in the environment of these lagoons (likely trivalent, but may not include ammonium). With these factors in mind, exposures, and risks have likely been overestimated for the duck.

The mean home range of female black ducks during pre-laying / laying and incubation were reported to be 130 ha and 109 ha, respectively in Maine with males being >200 ha (Longcore et al., 2000). The size of the site is approximately 22 ha (17.6 ha for the ASBs combined and 0.81 to 1.62 ha for each of the four ABs; P. Riebel, 2014a). Given the relatively small size of the home range compared to the size of the basins and given the close proximity of the Miramichi River to the site (which would also provide food for the ducks), assuming 100% exposure from within the basins has likely overestimated exposures.

Considering the CCME generic guideline of 130 mg/kg, relative to the sediment concentrations present in these basins (UCLM of 162 mg/kg), risks to ducks using the basins are likely within acceptable levels. The number of possible ducks that may use the basins for breeding and nesting would not be high enough to result in population level effects, as the area is too small to host a population.

With respect to draining the ASB areas, and allowing them to become terrestrial habitat, as opposed to aquatic habitat, risk for meadow vole, mink and purple finch are considered to be negligible as all HQs are below the critical value of 1.0 (Table 7-1). Risks were elevated for the American robin (vanadium), and masked shrew (cadmium).

For vanadium, the modelled concentration in soil was 71.3 mg/kg (UCLM of all 3 basins), which is within the background range of 78 mg/kg (Loro, 1996). Further perspective can be provided through the comparison of sediment data within the ASBs to the CCME guideline, wherein all samples (N=28) were less than the CCME guideline of 130 mg/kg except for one sample (at a concentration of 214 mg/kg). The next highest sample concentration in the ASB was 85 mg/kg.

The modelled concentration of cadmium in soil in the ASBs was 4.23 mg/kg (UCLM of all 3 basins), whereas the CCME soil ecological guideline is 3.8 mg/kg (CCME, 1999). The CCME guideline is based on soil and food ingestion (herbivores).

In the ASBs, the average cadmium concentrations are 2.9 mg/kg in ASB1, 3.7 mg/kg in ASB2 and 4.8 in ASB3 while an overall average of the ASBs is 3.8 which is just at the guideline. Background soil concentrations of cadmium from agricultural areas (N = 68) were reported as 0.36 mg/kg (98^{th} percentile; Loro, 1996), so cadmium in the basins is considered elevated, relative to background.

Relative exposure from the diets of these species to these COCs is outlined in Table 7-2.

Table 7-2 Relative Exposure from Various Pathways For Receptors With Elevated Risk Levels When ASBs are Drained of Water

COC	Percent Exposure Via Pathway		
	Soil	**Soil Invertebrates**	**Browse**
Masked Shrew			
Cadmium	1%	98%	1%
American Robin			
Vanadium	67%	30%	3%

Risks for the shrew and robin are been driven by different pathways. As presented in Table 7-2, incidental soil exposure is an important pathway for vanadium in the American robin, whereas for the shrew, soil invertebrate consumption represents an important pathway for cadmium due to the bioaccumulative nature of these compounds in food chains, and high ingestion rate of invertebrates in this receptor.

Based the soil vanadium concentrations modelled, relative to background and existing CCME guidelines, assuming 100% bioavailability in diet and soil, the vanadium HQ in the American robin is considered to be biased high, and exposures are considered unlikely to represent a potential risk to terrestrial species using the ASBs, if water were to be drained.

Cadmium risks to the shrew are only marginal over an HQ of 1 (at HQ 1.6). These risks are being driven by exposures from ingestion of soil invertebrates. For cadmium, the bioavailability was assumed to be 70% in the diet and 33% in soil. Shrews were assumed to be on-site 100% of the time, and receive 100% of their diet from the site. The home range of the masked shrew was reported to be approximately 0.01 acre (0.04 ha) with shrew density ranging from 1 to 12 shrews per acre (Buckner, 1966). The basins are approximately 22 ha (or 54 acres; P. Riebel, 2014a). The size of the ASBs relative to the shrew home range and population density indicates that the area could potentially support shrew populations, if habitat were appropriate. Shrews are not presently on-site (given the basins are filled with water) nor have they been reported in the area, however it is likely the habitat surrounding the basins could support shrews. Similarly, if / when the ASBs are drained, it is expected that at least some areas within the ASBs could provide shrew habitat / food. While the home range of a single shrew could be contained entirely within the area of the ASBs if drained, many shrew would obtain only a portion of their diet on-site. In addition, even if shrew populations are present on-site in the future, the ASBs if drained may not provide appropriate habitat for a large numbers of soil invertebrates (given it is more sludge than soil) that would be consumed by shrews. Based on these considerations, exposures related to site cadmium concentrations in the diet have likely been overestimated. Exposures via incidental soil ingestion may be overestimated given vegetation appears to rapidly grow on-site as water levels decrease (See Section 7.2) and given the site will be covered in snow for several months of the year.

HQs may be overestimated on the hazard side in addition to the exposure side. There was a paucity of toxicity data for cadmium in the shrew. The U.S. EPA (2005b) reported an unbounded growth and survival LOAEL of 103 mg/kg/day for the common shrew (*Sorex araneus*)(Dodds-Smith et al., 1992) following dietary exposure of cadmium chloride. The value selected for the shrew cadmium TRV in this ERA was based on the lowest of 11 bounded reproductive LOAELs for mammals reported by the U.S. EPA (2005b) of 2.28 mg/kg/day. This bounded LOAEL was derived from a study where mice were fed cadmium chloride (Sawicka-Kapusta et al., 1994). This value is much lower than the only reported unbounded LOAEL for shrew of 103 mg/kg/day for effects on growth and survival. As such, the HQs may be overestimated based on a TRV that is conservative.

While conservative assumptions used in the model have likely biased exposures and risk high, population level effects associated with exposures for Scenario 1 are considered unlikely.

7.3.2 Scenario 2

For Scenario 2 (all areas left with water, and considered as aquatic habitat), the UCLM of the Ash basins combined with the Aerated Stabilization basins was used to represent sediment concentrations, since if water is left in both sets of basins, exposures could come from receptors using all areas. Since the predominant environment is an aquatic based habitat, only aquatic-based receptors would incur the largest exposures. Mink is included in this scenario, since part of the minks diet is benthic invertebrates. Terrestrial-based receptors could still incur some exposures to the area, but since it is largely underwater, these exposures would be anticipated to be low. Table 7-3 presents the risk modelling outcomes for this scenario.

Table 7-3 HQ Values for Receptors of Concern in Scenario 2

COC	Scenario 2: ASB and AB Containing Water						
	Ash Basins (Wet) Aerated Stabilization Basins (Wet)						
	Black Duck	Muskrat	American Robin	Masked Shrew	Meadow Vole	Purple Finch	Mink
Barium	NA	0.048					
Cadmium	0.078	0.047					0.097
PCBs	0.0063	0.003					0.047
PCDD/F	0.0025	0.029					0.13
Vanadium	2.3	0.070					
Zinc	0.097	0.071					

Notes:
Cells shaded black indicate that chemical was not required to be assessed as it was not identified as a COC for the specific receptor and / or location being evaluated. (See Section 3.5.2 for details).
NA = Not available (limited avian toxicity data; no TRV is available from regulatory or other agencies
Cells shaded light grey indicates HQ is greater than HQ of 1.0.

Based on the outcomes of Scenario 2, leaving the ash basins and aerated stabilization basins with water represent a negligible likelihood of occurrence of adverse effects in the muskrat and the black duck, with the possible exception of vanadium in the black duck. Mink is also included in this scenario, as its diet was assumed to contain 5% benthic invertebrates. Risks for the mink are also negligible.

With respect to vanadium concentrations across the ash basins and aerated stabilization basins, the modelled UCLM95 was 80.6 mg/kg, whereas the CCME soil ecological guideline is 130 mg/kg (CCME, 1997). While the modelled value is below the CCME guideline, the CCME guideline is based on soil contact. The CCME (1997) considered the data to be too limited to calculate a food ingestion based guideline. As discussed previously, background soil concentrations in agricultural areas of New Brunswick were identified as 78 mg/kg (98th percentile; Loro, 1996), which is similar to 80.6 mg/kg modelled across these basins.

Risks for the Black duck are being driven by consumption of sediment (49% of exposure), aquatic vegetation (1%) and benthic invertebrates (50%).

Based on comparisons to background vanadium concentrations, and consideration of bioavailability assumptions (100%), home ranges for this species discussed under Section 7.3.1, and other conservatisms discussed previously in Scenario 1, the risks identified for the black duck are likely an artefact of the conservatisms in the model, and would not be expected to result in adverse effects to waterfowl breeding and nesting in these lagoons.

Population level effects associated with Scenario 2 are considered unlikely.

7.3.3 Scenario 3

For Scenario 3 (all areas drained, and considered as terrestrial habitat), the UCLM of the ash basins combined with the aerated stabilization basins was used to represent soil concentrations, since if both areas are drained, terrestrial-based exposures could result from both sets of basins. Since the predominant environment is a terrestrial-based habitat, terrestrial-based receptors would incur the largest exposures. In the absence of water, aquatic-based receptors would likely not reside in the area, and hence, exposures would be anticipated to be low. Therefore, risks for aquatic receptors were not calculated. Table 7-4 presents the risk modelling outcomes for this scenario.

Table 7-4 HQ Values for Receptors of Concern in Scenario 3

COC	**Scenario 3: ASB and AB Drained of Water**						
	Ash Basins (Dry) Aerated Stabilization Basins (Dry)						
	Black Duck	**Muskrat**	**American Robin**	**Masked Shrew**	**Meadow Vole**	**Purple Finch**	**Mink**
Barium			NA	0.35	0.043	NA	
Cadmium			0.82	1.7	0.15	0.7	0.097
PCBs			0.14	0.15	0.0014	0.084	0.047
PCDD/F			0.014	0.57	0.018	0.0081	0.13
Vanadium			1.9	0.41	0.042	0.48	
Zinc			0.64	1.0	0.26	0.77	

Notes:
Cells shaded black indicate that chemical was not required to be assessed as it was not identified as a COC for the specific receptor and / or location being evaluated. (See Section 3.5.2 for details).
NA = Not available (limited avian toxicity data; no TRV is available from regulatory or other agencies
Cells shaded light grey indicates HQ is greater than HQ of 1.0.

Based on the outcomes of Scenario 3, draining water from both the ash basins and aerated stabilization basins would pose negligible risks to the meadow vole, purple finch and mink, whereas risks would be slightly elevated for the robin, and masked shrew. The COCs with elevated risk levels include cadmium and vanadium.

The modelled concentration of cadmium in soils across all basins was 4.62 mg/kg, relative to a CCME soil and food ingestion guideline of 3.8 mg/kg and a background soil concentration of 0.36 mg/kg (Loro, 1996). For vanadium, the modelled concentration in soil was 80.6 mg/kg, which is slightly above the background range of 78 mg/kg (Loro, 1996), but less than the CCME ecological guideline of 130 mg/kg (soil contact) (CCME, 1997).

Relative exposure from the diets of these species to these COCs is outlined in Table 7-5.

Table 7-5 Relative Exposure from Various Pathways For Receptors With Elevated Risk Levels When ABs and ASBs are Drained of Water			
COC	Percent Exposure Via Pathway		
	Soil	Soil Invertebrates	Browse
Masked Shrew			
Cadmium	1.1%	98.4%	0.5%
American Robin			
Vanadium	67%	30%	3%

Soil ingestion is an important pathway for vanadium in the robin (67%), whereas in the shrew ingestion of biota (soil invertebrates) are a key pathways for cadmium (98.4%), due to the bioaccumulative nature of this compound.

Based on the discussion presented in Section 7.3.1 for the terrestrial exposures in ASBs, the American robin is not considered to be at risk as a result of vanadium exposures. The soil concentrations in the ASBs are largely within the background concentration range, and are less than the CCME soil quality guideline, and hence, risks are considered to be negligible, and are an artifact of the conservative assumptions used in the model (e.g., 100% bioaccessibility in soils and dietary items).

Cadmium risks to the shrew are only marginal over an HQ of 1 (at HQ 1.7). These risks are being driven by exposures from ingestion of soil invertebrates. Shrews are not presently on-site (given the basins are filled with water) nor have they been reported in the area, however it is likely the habitat surrounding the basins could support shrews and possibly even a shrew population (See Section 7.3.1 for further discussion of shrew HQs and conservative assumptions). Similarly, if / when the ASBs are drained, it is expected that at least some areas within the ASBs could provide shrew habitat. While conservative assumptions used in the model have likely biased exposures and risk high, resulting in an HQ of 1.7 (which is marginally over an HQ of 1.0), population level effects in the shrew are considered unlikely.

7.3.4 Consideration of Species at Risk

The barn swallow was identified as a threatened species that has been reported to be seen in the area (P. Riebel, 2012b). The barn swallow diet is mainly comprised of flying insects which would have lower exposures than benthic invertebrates which was part of the diet for the robin. Based on the HQ results for the robin (all HQs <1.0 with the exception of vanadium which was slightly over 1.0 at a HQ of 1.7), and given the unlikely use of the site for the swallow (See Section 3.4.1), individual level effects in the barn swallow would be considered unlikely.

7.4 Overall Conclusions of ERA and Risk Management Considerations

7.4.1 Conclusions

Conclusions of the risk assessment are as follows:

Draining Water from ASBs: Three metals were in exceedance of freshwater aquatic life guidelines, based on single samples taken in May of 2014. Potential risk to aquatic life in the Miramichi River are uncertain due to the paucity of water quality data available at this time. Monitoring of both the basins, as well as the receiving environment, should be undertaken to confirm whether there will be any risks to the receiving environment related to water release.

Vegetation: Vegetation growth and colonization in the ASBs appears robust and rapid, based on field photographic evidence from 2014. This information suggests that if the ASBs were drained, the basins would likely have rapid succession of vegetation. While the sediments may limit growth or colonization of some species, tolerant species appear to colonize the sediments/soils with relative ease, which is likely due to the nutrients present in the soil.

Avian and Mammalian Risks Related to Scenarios 1 to 3:

- For **Scenario 1** (ABs retain water; ASBs are drained), risks for species using the aquatic environments within the ABs, such as the black duck and muskrat, were considered to be negligible. For the terrestrial habitat in the ASB area, risks for meadow vole, finch, robin and mink were negligible, with masked shrew exhibiting higher risk potential, related to cadmium exposures. Population level effects for shrew and other receptors are considered unlikely.

- For **Scenario 2** (ABs and ASBs retain water), risks for species feeding in these aquatic environments, such as the black duck, the muskrat and mink, are considered unlikely.

- For **Scenario 3** (ABs and ASBs are drained), risks for species feeding in this terrestrial environment, such as the purple finch, American robin, meadow vole and mink, were considered negligible, whereas risks to the shrew were higher. Cadmium was the main COC driving shrew risk estimates, but population level impacts were not considered probable, based on the degree of exceedance and assumptions used in the assessment. Population level effects for other receptors are also considered unlikely.

In all scenarios, fish are assumed to be absent, and should not be allowed to inhabit these ponds, without further assessment being conducted for piscivores.

7.4.2 Risk Management Considerations

For Scenario 1 (ABs retain water; ASBs are drained), the desired closure approach, the following can be considered:

- The modelling results suggest that no risk management is necessary for the ash basins, if water is retained in these basins.

- If water is drained from the aerated stabilization basins, the conclusions of the assessment indicate that risk management is not required to protect wildlife receptors, or vegetation. Since population level effects are considered unlikely based on the outcomes of the ERA, risk management concentrations for soil were not developed for any COPCs or receptors.

- The model used in this ERA is based on standard equations and assumptions, and is a theoretical representation of risk, which has included conservative assumptions related to bioavailability of COPCs within food sources and soils. While management of soils in the ASBs is not recommended based on the outcomes of the ERA, it would be prudent to undertaken some monitoring to validate risk assessment conclusions. It is recommended that an Adaptive Management Approach be implemented, if the desired option of draining the ASBs is put forth as the final selected option. This approach could include the following monitoring initiatives:

  - Water monitoring for ASBs, and the Miramichi River (prior to release of any water), as discussed in Section 7.1, to confirm release of water from the ASBs will not pose a risk to the receiving environment of the Miramichi River.
  - Soil/sediment monitoring in each of the ASBs as water level decreases (or once it is lowered), to confirm that surface soil concentrations of metals and PCDD/F are less than or within the range of concentrations modelled in this assessment. Surface soil sampling could focus on the 0 – 5 cm profile, or at the deepest, 0 – 15 cm, as this would be the active foraging zone for insectivorous avian or mammalian species.
  - Confirmatory sampling and analysis of soil invertebrates upon which insectivorous small mammal species or avian species could forage. The types of species collected should be based on the predominant foraging species present in the area, and samples should be depurated of soil, if at all possible, prior to analysis. The measured concentrations can be compared to the biota concentrations estimated in the model.
  - Outcomes of soil and soil invertebrate monitoring can be compared to modelled estimates, based on a calculated UCLM. Where measured UCLM are less than modelled values, no further study would be considered necessary. Where measured UCLM are higher than modelling values, additional lines of evidence may be recommended to further validate risk levels. These could include a habitat survey to confirm compatibility of habitat for shrew; abundance and diversity studies for insectivorous small mammals, or body burden analysis of organs or whole body, to confirm exposure levels to the COCs of interest.

For Scenario 2 (ABs and ASBs retain water):

- The modelling results suggest that no risk management is necessary for the ash basins and ASBs, if water is retained in these basins. Costs associated with maintaining water levels may be prohibitive but modelling results do not indicate maintaining water levels is necessary from a risk perspective (i.e., water could be left in ABs and ASBs and water levels left to naturally decrease overtime without the need for risk management). Monitoring options are not provided, as this is not the preferred option.

For Scenario 3 (ABs and ASBs are drained):

- If water is drained from the ABs and the ASBs, the only receptors with elevated HQs were the robin (vanadium) and shrew (cadmium), but population level effects are considered unlikely. See discussion for Scenario 1 related to these receptors. Monitoring options for this scenario are not provided, as this is not the preferred option.

- Over time, sediments / soils will undergo natural burial / cover through vegetation matting / succession (e.g., dead bulrushes and other plant material will degrade over time to create compost on top of soils) thereby reducing direct exposures to soils and dusts.

7.5 Uncertainties and Conservative Assumptions

The major limitations, uncertainties and conservative assumptions applicable to this ERA are as follows:

- Treatment of data for the ERA was conducted in a manner that is intentionally conservative. This approach was taken to ensure that exposures and risks associated with the COCs would not be underestimated. For example, a proxy value equivalent to the detection limit was used in the UCLM calculations for COCs in soil / sediments that were below the laboratory RDL. The only exception was PCBs which were not detect in all samples. A proxy value equivalent to ½ the RDL was used for PCBs. This approach is likely to overestimate exposures and risks.

- Upper layer soil / sediment data collected from up to a depth of 1.5 m were used in the assessment. For incidental soil ingestion and ingestion of soil invertebrates, soil data collected at a depth of 0 to 5 cm or 0 to 15 cm is more representative of typical exposures. The use of soils up to 1.5 m adds uncertainty to the assessment.

- The ERA does not address the variability or changes in exposures that could occur over time (*i.e.*, in the future). COPC concentrations in biota (*e.g.*, plants, insects and small mammals) that are consumed by wildlife may fluctuate over time based on seasonal and annual differences in environmental conditions that impact organism physiology and growth, and exposure levels. Complex ecological and physiological factors and variations in exposure, organism growth, accumulation and depuration determine the concentrations in biota within years and over extended periods of time.

- Receptors were assumed to obtain 100% of their diet on-site which likely overestimated potential exposures.

- Predicted concentrations of COCs in biota (terrestrial and aquatic vegetation and soil and benthic invertebrates) were estimated using trophic transfer models (BCFs, regression models) and measured soil / sediment concentrations. Prey concentrations of COCs were estimated using regression models and uptake factors from Sample *et al*. (1998), Blankenship et al. (2005), and Integral (2013). While there is some uncertainty associated with the use of these uptake factors and regression equations, as they are not specific to the Study Area, the underlying models are considered robust, reasonably accurate, conservative, and are commonly used in ERAs where site-specific data on prey concentrations are not available. Collection of on-site invertebrate / vegetation data would aid in reducing uncertainties in the existing dataset.

- All uptake models or factors used in the ERA do not account for extreme situations of excessively high or very low COC uptake (i.e., hyper- or hypoaccumulation), but rather, reflect reasonable upper bounds or upper estimates of central tendency. Such extreme uptake conditions are difficult to account for in any generic or study area-specific uptake models or factors used in ERAs, as these conditions are usually specific to certain species and do not reflect assemblages or communities as a whole.

- Toxicity data directly related to the receptors being evaluated are often unavailable or limited in nature. Therefore, many of the TRVs used in an ERA are derived from similar or related species exposed to the COPCs under controlled laboratory conditions that are designed to maximize the potential for measurable adverse effects. Extrapolation of laboratory toxicity data to other species typically involves the use of uncertainty factors. The TRVs used in the wildlife risk modeling were selected from the toxicology literature to be as appropriate as possible to the receptors of interest, while trying to ensure that potential risks would not be underestimated.

- Receptor body weights were obtained from reliable literature sources (*e.g.*,FCSAP, 2012b). There is some uncertainty associated with these values though, as the body weights are not Study Area-specific. Thus, where possible, preference was given to lower reported body weights in the literature to ensure that a conservative assessment was conducted.

- Data on food intake rates (FIR) are only available for a few species, primarily due to the difficulties in measuring intakes for free-ranging wildlife. Allometric equations developed from measurements of FMR (free metabolic rate) in free-ranging animals were used to estimate food intake rate for each representative wildlife species evaluated in the ERA. Similarly, water intake rates were estimated using standard allometric equations.

- Based on the available literature on dietary items for each receptor of interest, representative diets with fixed proportions of dietary items were selected for all of the receptors evaluated in the ERA. However, there is uncertainty associated with the proportion of dietary items assumed for each receptor as diets will vary between locations, between individuals, and across seasons, and only limited dietary data are available for some species. Dietary assumptions were based on reliable literature sources (e.g., FCSAP, 2012b).

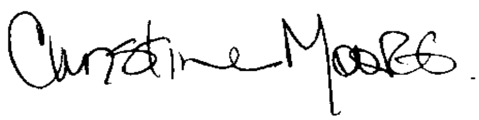
- Bioavailability of the COPCs in food items and soil was conservatively assumed to be 100% with the exception of cadmium and zinc (as literature values were identified for these COCs). This assumption likely overestimates COC exposure as the gastrointestinal absorption of metals from complex matrices such as foods and soil are rarely 100%, depending on such factors as metal speciation, and the physical and chemical properties of the food items and soil. Similarly, given the high organic content of soils on-site, COCs are likely tightly bound and would not be expected to be highly bioavailable.

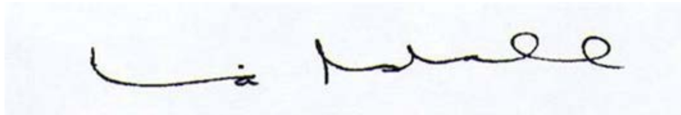
- Soil ingestion for mammalian and avian receptors was assumed to represent a certain percentage of the receptor's overall diet (as direct soil ingestion rates are largely unavailable for ecological receptors). The most closely related receptor was used where possible.

8.0 CLOSURE

Intrinsik Environmental Sciences Inc. (Intrinsik) has completed this report in accordance with accepted practice and usual standards of thoroughness and competence for the profession of toxicology and risk assessment. Any information or facts provided by others, and referred to or utilized in the preparation of this report, is believed to be accurate without any independent verification or confirmation by Intrinsik. The information, opinions and recommendations provided within the aforementioned report have been developed using reasonable and responsible practices, and the report was completed to the best of our knowledge and ability.

Intrinsik Environmental Sciences Inc.





Christine Moore, M.Sc.
Senior Scientist

Lisa Marshall, M.E.S.
Scientist

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ATTACHMENT A

WATER DATA

Report ID: 170800-IAS
Report Date: 29-May-14
Date Received: 16-May-14

CERTIFICATE OF ANALYSIS

for
Natech Environmental Services
2492 Route 640
Hanwell, NB E3E 2C2

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Attention: Vincent Balland
Project #: Not Available
Location: Miramichi Lagoons

Analysis of Water

RPC Sample ID:			170800-1	170800-2	170800-3
Client Sample ID:			Miramichi Lagoon Cell #1	Miramichi Lagoon Cell #2	Miramichi Lagoon Cell #3
Date Sampled:			15-May-14	15-May-14	15-May-14
Analytes	**Units**	**RL**			
Ammonia (as N)	mg/L	0.05	0.11	0.47	5.2
Kjeldahl Nitrogen	mg/L	0.25	1.4	2.8	11.9
pH	units	-	8.5	8.5	8.1
Nitrate + Nitrite (as N)	mg/L	0.05	< 0.05	0.11	< 0.05
Nitrogen - Total	mg/L	0.5	1.4	2.9	11.9
Phosphorus - Total	mg/L	0.002	0.090	0.126	0.50
CBOD	mg/L	6	< 6	12	30
Solids - Total Suspended	mg/L	5	7	8	38

This report relates only to the sample(s) and information provided to the laboratory.

RL = Reporting Limit

Ross Kean

A. Ross Kean, M.Sc.
Department Head
Inorganic Analytical Chemistry

Peter Crowhurst, B.Sc., C.Chem
Analytical Chemist
Inorganic Analytical Chemistry

Report ID: 170800-IAS
Report Date: 29-May-14
Date Received: 16-May-14

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for
Natech Environmental Services
2492 Route 640
Hanwell, NB E3E 2C2

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Attention: Vincent Balland
Project #: Not Available
Location: Miramichi Lagoons

Analysis of Water

RPC Sample ID:			170800-4	170800-5	170800-6
Client Sample ID:			Miramichi Lagoon Ash Basin #1	Miramichi Lagoon Ash Basin #2	Miramichi Lagoon Ash Basin #3
Date Sampled:			15-May-14	15-May-14	15-May-14
Analytes	**Units**	**RL**			
Ammonia (as N)	mg/L	0.05	< 0.05	< 0.05	< 0.05
Kjeldahl Nitrogen	mg/L	0.25	< 0.25	< 0.25	< 0.25
pH	units	-	8.0	8.0	8.3
Nitrate + Nitrite (as N)	mg/L	0.05	< 0.05	< 0.05	< 0.05
Nitrogen - Total	mg/L	0.5	< 0.5	< 0.5	< 0.5
Phosphorus - Total	mg/L	0.002	0.036	0.069	0.173
CBOD	mg/L	6	< 6	< 6	< 6
Solids - Total Suspended	mg/L	5	< 5	< 5	< 5

Report ID: 170800-IAS
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for
Natech Environmental Services
2492 Route 640
Hanwell, NB E3E 2C2

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Attention: Vincent Balland
Project #: Not Available
Location: Miramichi Lagoons

Analysis of Water

RPC Sample ID:			170800-7
Client Sample ID:			Miramichi Lagoon Ash Basin #4
Date Sampled:			15-May-14
Analytes	**Units**	**RL**	
Ammonia (as N)	mg/L	0.05	< 0.05
Kjeldahl Nitrogen	mg/L	0.25	0.6
pH	units	-	8.0
Nitrate + Nitrite (as N)	mg/L	0.05	< 0.05
Nitrogen - Total	mg/L	0.5	0.6
Phosphorus - Total	mg/L	0.002	0.090
CBOD	mg/L	6	< 6
Solids - Total Suspended	mg/L	5	< 5

Report ID: 170800-IAS
Report Date: 29-May-14
Date Received: 16-May-14

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for
Natech Environmental Services
2492 Route 640
Hanwell, NB E3E 2C2

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Attention: Vincent Balland
Project #: Not Available
Location: Miramichi Lagoons

Analysis of Metals in Water

RPC Sample ID:			170800-1	170800-2	170800-3
Client Sample ID:			Miramichi Lagoon Cell #1	Miramichi Lagoon Cell #2	Miramichi Lagoon Cell #3
Date Sampled:			15-May-14	15-May-14	15-May-14
Analytes	**Units**	**RL**			
Aluminum	µg/L	1	342	231	643
Antimony	µg/L	0.1	0.6	0.2	0.2
Arsenic	µg/L	1	2	1	< 1
Barium	µg/L	1	53	55	60
Beryllium	µg/L	0.1	< 0.1	< 0.1	< 0.1
Bismuth	µg/L	1	< 1	< 1	< 1
Boron	µg/L	1	48	39	38
Cadmium	µg/L	0.01	0.04	0.03	0.05
Calcium	µg/L	50	13500	23600	29500
Chromium	µg/L	1	< 1	< 1	< 1
Cobalt	µg/L	0.1	0.2	0.1	0.2
Copper	µg/L	1	1	< 1	1
Iron	µg/L	20	160	80	70
Lead	µg/L	0.1	5.9	0.4	0.6
Lithium	µg/L	0.1	0.6	0.3	0.2
Magnesium	µg/L	10	4520	2780	1700
Manganese	µg/L	1	322	528	276
Mercury	µg/L	0.025	< 0.025	< 0.025	< 0.025
Molybdenum	µg/L	0.1	0.4	0.6	0.4
Nickel	µg/L	1	3	< 1	< 1
Potassium	µg/L	20	19100	11700	5420
Rubidium	µg/L	0.1	41.4	24.4	12.9
Selenium	µg/L	1	< 1	< 1	< 1
Silver	µg/L	0.1	< 0.1	< 0.1	< 0.1
Sodium	µg/L	50	157000	106000	50300
Strontium	µg/L	1	28	39	41
Tellurium	µg/L	0.1	< 0.1	< 0.1	< 0.1
Thallium	µg/L	0.1	< 0.1	< 0.1	< 0.1
Tin	µg/L	0.1	< 0.1	< 0.1	< 0.1
Uranium	µg/L	0.1	0.3	0.2	< 0.1
Vanadium	µg/L	1	6	3	8
Zinc	µg/L	1	10	4	9

Report ID: 170800-IAS
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for
Natech Environmental Services
2492 Route 640
Hanwell, NB E3E 2C2

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Attention: Vincent Balland
Project #: Not Available
Location: Miramichi Lagoons

Analysis of Metals in Water

RPC Sample ID:			170800-4	170800-5	170800-6
Client Sample ID:			Miramichi Lagoon Ash Basin #1	Miramichi Lagoon Ash Basin #2	Miramichi Lagoon Ash Basin #3
Date Sampled:			15-May-14	15-May-14	15-May-14
Analytes	**Units**	**RL**			
Aluminum	µg/L	1	119	44	148
Antimony	µg/L	0.1	0.3	0.5	1.1
Arsenic	µg/L	1	< 1	< 1	2
Barium	µg/L	1	70	59	140
Beryllium	µg/L	0.1	< 0.1	< 0.1	< 0.1
Bismuth	µg/L	1	< 1	< 1	< 1
Boron	µg/L	1	39	101	434
Cadmium	µg/L	0.01	0.02	0.02	0.05
Calcium	µg/L	50	17400	19200	20500
Chromium	µg/L	1	< 1	< 1	< 1
Cobalt	µg/L	0.1	< 0.1	< 0.1	< 0.1
Copper	µg/L	1	< 1	< 1	< 1
Iron	µg/L	20	60	30	40
Lead	µg/L	0.1	0.2	0.3	0.7
Lithium	µg/L	0.1	1.4	3.0	9.8
Magnesium	µg/L	10	1360	2310	3810
Manganese	µg/L	1	43	64	50
Mercury	µg/L	0.025	< 0.025	< 0.025	< 0.025
Molybdenum	µg/L	0.1	0.6	1.3	6.8
Nickel	µg/L	1	< 1	< 1	< 1
Potassium	µg/L	20	8740	20500	74100
Rubidium	µg/L	0.1	25.1	52.0	201.
Selenium	µg/L	1	< 1	< 1	< 1
Silver	µg/L	0.1	< 0.1	< 0.1	< 0.1
Sodium	µg/L	50	2320	10600	24400
Strontium	µg/L	1	53	66	129
Tellurium	µg/L	0.1	< 0.1	< 0.1	< 0.1
Thallium	µg/L	0.1	< 0.1	< 0.1	< 0.1
Tin	µg/L	0.1	< 0.1	< 0.1	< 0.1
Uranium	µg/L	0.1	< 0.1	< 0.1	0.2
Vanadium	µg/L	1	9	6	12
Zinc	µg/L	1	5	2	6

Report ID: 170800-IAS
Report Date: 29-May-14
Date Received: 16-May-14

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for
Natech Environmental Services
2492 Route 640
Hanwell, NB E3E 2C2

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Attention: Vincent Balland
Project #: Not Available
Location: Miramichi Lagoons

Analysis of Metals in Water

RPC Sample ID:			170800-7
Client Sample ID: Date Sampled:			Miramichi Lagoon Ash Basin #4 15-May-14
Analytes	**Units**	**RL**	
Aluminum	µg/L	1	46
Antimony	µg/L	0.1	0.2
Arsenic	µg/L	1	< 1
Barium	µg/L	1	23
Beryllium	µg/L	0.1	< 0.1
Bismuth	µg/L	1	< 1
Boron	µg/L	1	13
Cadmium	µg/L	0.01	0.05
Calcium	µg/L	50	25600
Chromium	µg/L	1	< 1
Cobalt	µg/L	0.1	< 0.1
Copper	µg/L	1	1
Iron	µg/L	20	100
Lead	µg/L	0.1	0.8
Lithium	µg/L	0.1	0.1
Magnesium	µg/L	10	900
Manganese	µg/L	1	41
Mercury	µg/L	0.025	< 0.025
Molybdenum	µg/L	0.1	0.5
Nickel	µg/L	1	< 1
Potassium	µg/L	20	2170
Rubidium	µg/L	0.1	3.3
Selenium	µg/L	1	< 1
Silver	µg/L	0.1	< 0.1
Sodium	µg/L	50	1250
Strontium	µg/L	1	27
Tellurium	µg/L	0.1	< 0.1
Thallium	µg/L	0.1	< 0.1
Tin	µg/L	0.1	< 0.1
Uranium	µg/L	0.1	< 0.1
Vanadium	µg/L	1	< 1
Zinc	µg/L	1	8

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for
Natech Environmental Services
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Hanwell, NB E3E 2C2

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Methods

Analyte	RPC SOP #	Method Reference	Method Principle
Ammonia	4.M47	APHA 4500-NH_3 G	"Phenate" Colourimetry
Kjeldahl Nitrogen	4.M16	APHA 4500-NORG	Digestion, phenate colorimetry
pH	4.M03	APHA 4500-H^+ B	pH Electrode - Electrometric
Nitrate + Nitrite (as N)	4.M48	APHA 4500-NO_3 H	Hydrazine Red., Derivitization, Colourimetry
Phosphorus - Total	4.M17	APHA 4500-P E	Digestion, Manual Colourimetry
Solids - Total Suspended	4.M05	APHA 2540 D	Filtration, Gravimetry
Trace Metals	4.M01/4.M29	EPA 200.8/EPA 200.7	ICP-MS/ICP-ES
Mercury	4.M52	EPA 245.1	Cold Vapor AAS

Report ID: 174135-IAS Rev01
Report Date: 12-Aug-14
Date Received: 16-Jul-14

CERTIFICATE OF ANALYSIS
for
Natech Environmental Services
2492 Route 640
Hanwell, NB E3E 2C2

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

*** Revised Report ***

Attention: Vincent Balland
Project #: MIR. LAGOON 2014
Location: Miramichi

Analysis of Soil

Analytes:			Carbon - Organic
Units:			%
RL:			0.1
RPC Sample ID	**Client Sample ID**	**Date Sampled**	
174135-01	Ash Basin 1; Composite Sed.	15-Jul-14	8.9
174135-01 Dup	Lab Duplicate	15-Jul-14	8.8
174135-02	Ash Basin 2; Composite Sed.	15-Jul-14	14.6
174135-03	Ash Basin 3; Composite Sed.	15-Jul-14	12.8
174135-04	Ash Basin 4; Composite Sed.	15-Jul-14	10.9
174135-05	ASB1; Composite Sed.	15-Jul-14	15.4
174135-06	ASB2; Composite Sed.	15-Jul-14	25.5
174135-07	ASB2; T15 Grab Sed.	15-Jul-14	16.6
174135-08	ASB3; Composite Sed.	15-Jul-14	34.2

This report relates only to the sample(s) and information provided to the laboratory.
RL = Reporting Limit

Ross Kean

A. Ross Kean, M.Sc.
Department Head
Inorganic Analytical Chemistry

Peter Crowhurst, B.Sc., C.Chem
Analytical Chemist
Inorganic Analytical Chemistry

Report ID: 174135-IAS Rev01
Report Date: 12-Aug-14
Date Received: 16-Jul-14

CERTIFICATE OF ANALYSIS
for
Natech Environmental Services
2492 Route 640
Hanwell, NB E3E 2C2

921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

*** Revised Report ***

Attention: Vincent Balland
Project #: MIR. LAGOON 2014
Location: Miramichi

Analysis of Water

Analytes:			Solids - Total Suspended	Solids - Volatile Suspended
Units:			mg/L	mg/L
RL:			5	5
RPC Sample ID	**Client Sample ID**	**Date Sampled**		
174135-09	Ash Basin 3 -; Water	15-Jul-14	6	6
174135-10	ASB 3 - Water	15-Jul-14	116	116

CERTIFICATE OF ANALYSIS

for
Natech Environmental Services
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921 College Hill Rd
Fredericton NB
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Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

General Report Comments

A portion of the sample was dried, sieved at 2 mm. Total and Inorganic Carbon were determined using combustion/acid evolution infrared methods. Total Organic Carbon is calculated as the difference.

Revision Comments

Added results for TSS and VSS as requested by the client.

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www.rpc.ca

Methods

Analyte	RPC SOP #	Method Reference	Method Principle
Solids - Total Suspended	4.M05	APHA 2540 D	Filtration, Gravimetry
Suspended Solids- Volatile	-	APHA 2540E	Suspended Solids- Volatile

Report ID: 174135-OAS-C
Report Date: 31-Jul-14
Date Received: 16-Jul-14

Natech Environmental Services
2492 Route 640
Hanwell, NB E3E 2C2

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506-452-1212
Fax: 506-452-0594
www.rpc.ca

Attention: Vincent Balland
Fax #: 506.455.1088
vincent.b@natechenv.com

Project #: MIR. LAGOON 2014
Location: Miramichi
Polychlorinated Dioxins and Furans (PCDD/Fs)

RPC Sample ID	Client Sample ID	Matrix	Date Sampled	Date Analyzed
174135-9	Ash Basin 3 - Water	Water	15-Jul-14	29-Jul-14
174135-10	ASB 3 - Water	Water	15-Jul-14	29-Jul-14
Laboratory Method Blank (W00473)	-	Water	22-Jul-14	29-Jul-14
Matrix Spike (MPT430)	-	Water	22-Jul-14	29-Jul-14

Results are attached.

Method Summary
RPC SOPs DX08 & DX10: Solvent extraction followed by cleanup chromatography and Gas Chromatography/High Resolution Mass Spectrometry (GC/HRMS); based on US EPA Methods 1613B and 8290A.

QC
Acceptance Criteria:
(1) Laboratory blanks per EPA 1613B
(2) Reproducibility (duplicate analysis) TEQ ≤ 25% RPD
(3) Accuracy: surrogates 40-135%; spikes 65-135%

Comments
Sample 174135-10: one surrogate <40%

This report relates only to the sample(s) and information provided to the laboratory.

John Macaulay
Section Manager
Organic Analytical Services

Troy Smith
Lab Supervisor
Organic Analytical Services

DIOXIN AND FURAN (PCDD/F) CONCENTRATIONS & INTERNATIONAL TOXIC EQUIVALENT CONCENTRATIONS (I-TEQ)

CLIENT NAME:	**Natech Environmental Services**	SAMPLE MATRIX:	**Water**
CLIENT SAMPLE ID:	**Ash Basin 3 - Water**	RPC SUBMISSION ID:	**174135-9**
SAMPLING DATE:	**Jul1514**	DATE ANALYZED:	**Jul2914**
% SOLIDS:	**- -**	CORRESPONDING CRM:	**- -**
% LIPID:	**- -**	CORRESPONDING BLANK:	**W00473**

CHLORINATED DIOXINS AND FURANS	CONCENTRATION DETECTED (Note 1)	TOXIC EQUIVALENT CONCENTRATION (Note 2)	LIMIT OF DETECTION (LOD)
Congener	(pg/L)	(pg NATO-PCDD/F-TEQ/L)	(pg/L)
2,3,7,8-TCDD	ND	<1	1.0
1,2,3,7,8-PeCDD	ND	<1.35	2.7
1,2,3,4,7,8-HxCDD	ND	<0.21	2.1
1,2,3,6,7,8-HxCDD	ND	<0.23	2.3
1,2,3,7,8,9-HxCDD	ND	<0.25	2.5
1,2,3,4,6,7,8-HpCDD	7.6	0.076	1.2
OCDD	12.7	0.0127	3.7
2,3,7,8-TCDF	NDR(1.2) E	<0.12	0.7
1,2,3,7,8-PeCDF	ND	<0.045	0.9
2,3,4,7,8-PeCDF	ND	<0.4	0.8
1,2,3,4,7,8-HxCDF	NDR(0.8) E	<0.08	0.3
1,2,3,6,7,8-HxCDF	NDR(0.3)	<0.03	0.3
2,3,4,6,7,8-HxCDF	ND	<0.03	0.3
1,2,3,7,8,9-HxCDF	ND	<0.04	0.4
1,2,3,4,6,7,8-HpCDF	1.3	0.013	1.0
1,2,3,4,7,8,9-HpCDF	ND	<0.014	1.4
OCDF	5.3	0.0053	2.9
TOTAL (Min. Possible: Detected + [0 x LOD x TEF])		0.1	
TOTAL (Detected + [0.5 x LOD x TEF])		2.0	
TOTAL (Max. Possible: Detected + [1 x LOD x TEF])		3.9	

GROUPS	NUMBERS OF PEAKS	CONCENTRATION DETECTED (Note 1)	LIMIT OF DETECTION (LOD)
Homologues		(pg/L)	(pg/L)
TCDD	5	126	1.0
PeCDD	4	61.3	2.7
HxCDD	2	42.4	2.3
HpCDD	1	7.6	1.2
OCDD	1	12.7	3.7
TOTAL DIOXINS		250	
TCDF	4	5.8	0.7
PeCDF	0	ND	0.9
HxCDF	0	NDR(0.8) E	0.3
HpCDF	1	1.3	1.2
OCDF	1	5.3	2.9
TOTAL FURANS		12.4	

Note 1: Results are corrected for surrogate recoveries (not corrected for lab method blank).

Note 2: Concentration Detected (LOD in case of ND) multiplied by corresponding toxic equivalency factor.

E signifies: Possible chlorinated diphenyl ether interference
ND signifies: Not detected
NDR signifies: Not detected due to incorrect isotope ratio
N/R signifies: Not reported

SURROGATE	QUANTITY ADDED (pg)	RECOVERY %
13C12-2,3,7,8-TCDD	2000	103
13C12-1,2,3,7,8-PeCDD	2000	96
13C12-1,2,3,4,7,8-HxCDD	2000	85
13C12-1,2,3,6,7,8-HxCDD	2000	71
13C12-1,2,3,4,6,7,8-HpCDD	2000	81
13C12-OCDD	4000	60

SURROGATE	QUANTITY ADDED (pg)	RECOVERY %
13C12-2,3,7,8-TCDF	2000	90
13C12-1,2,3,7,8-PeCDF	2000	96
13C12-2,3,4,7,8-PeCDF	2000	100
13C12-1,2,3,4,7,8-HxCDF	2000	80
13C12-1,2,3,6,7,8-HxCDF	2000	67
13C12-2,3,4,6,7,8-HxCDF	2000	81
13C12-1,2,3,7,8,9-HxCDF	2000	92
13C12-1,2,3,4,6,7,8-HpCDF	2000	67
13C12-1,2,3,4,7,8,9-HpCDF	2000	85

INTERNATIONAL TOXIC EQUIVALENCY FACTORS
NORTH ATLANTIC TREATY ORGANIZATION (NATO) 1988

Congener	I-TEF
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	0.5
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.001
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.05
2,3,4,7,8-PeCDF	0.5
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
OCDF	0.001

DIOXIN AND FURAN (PCDD/F) CONCENTRATIONS & INTERNATIONAL TOXIC EQUIVALENT CONCENTRATIONS (I-TEQ)

CLIENT NAME:	**Natech Environmental Services**	SAMPLE MATRIX:	**Water**
CLIENT SAMPLE ID:	**ASB 3 - Water**	RPC SUBMISSION ID:	**174135-10**
SAMPLING DATE:	**Jul1514**	DATE ANALYZED:	**Jul2914**
% SOLIDS:	**- -**	CORRESPONDING CRM:	**- -**
% LIPID:	**- -**	CORRESPONDING BLANK:	**W00473**

CHLORINATED DIOXINS AND FURANS	CONCENTRATION DETECTED (Note 1)	TOXIC EQUIVALENT CONCENTRATION (Note 2)	LIMIT OF DETECTION (LOD)
Congener	(pg/L)	(pg NATO-PCDD/F-TEQ/L)	(pg/L)
2,3,7,8-TCDD	ND	<0.6	0.6
1,2,3,7,8-PeCDD	ND	<0.95	1.9
1,2,3,4,7,8-HxCDD	ND	<0.08	0.8
1,2,3,6,7,8-HxCDD	ND	<0.08	0.8
1,2,3,7,8,9-HxCDD	NDR(1.6)	<0.16	0.9
1,2,3,4,6,7,8-HpCDD	16.6	0.166	1.8
OCDD	79.5	0.0795	6.6
2,3,7,8-TCDF	ND	<0.11	1.1
1,2,3,7,8-PeCDF	ND	<0.065	1.3
2,3,4,7,8-PeCDF	ND	<0.6	1.2
1,2,3,4,7,8-HxCDF	ND	<0.12	1.2
1,2,3,6,7,8-HxCDF	ND	<0.11	1.1
2,3,4,6,7,8-HxCDF	ND	<0.13	1.3
1,2,3,7,8,9-HxCDF	ND	<0.14	1.4
1,2,3,4,6,7,8-HpCDF	3.8	0.038	1.3
1,2,3,4,7,8,9-HpCDF	ND	<0.018	1.8
OCDF	8.5	0.0085	4.0
TOTAL (Min. Possible: Detected + [0 x LOD x TEF])		0.3	
TOTAL (Detected + [0.5 x LOD x TEF])		1.9	
TOTAL (Max. Possible: Detected + [1 x LOD x TEF])		3.5	

GROUPS	NUMBERS OF PEAKS	CONCENTRATION DETECTED (Note 1)	LIMIT OF DETECTION (LOD)
Homologues		(pg/L)	(pg/L)
TCDD	1	1.6	0.6
PeCDD	0	ND	1.9
HxCDD	1	2.4	0.8
HpCDD	2	40.2	1.8
OCDD	1	79.5	6.6
TOTAL DIOXINS		124	
TCDF	2	2.9	1.1
PeCDF	0	ND	1.3
HxCDF	0	ND	1.3
HpCDF	1	3.8	1.6
OCDF	1	8.5	4.0
TOTAL FURANS		15.2	

Note 1: Results are corrected for surrogate recoveries (not corrected for lab method blank).

Note 2: Concentration Detected (LOD in case of ND) multiplied by corresponding toxic equivalency factor.

E signifies:	Possible chlorinated diphenyl ether interference
ND signifies:	Not detected
NDR signifies:	Not detected due to incorrect isotope ratio
N/R signifies:	Not reported

SURROGATE	QUANTITY ADDED (pg)	RECOVERY %
13C12-2,3,7,8-TCDD	2000	85
13C12-1,2,3,7,8-PeCDD	2000	72
13C12-1,2,3,4,7,8-HxCDD	2000	50
13C12-1,2,3,6,7,8-HxCDD	2000	45
13C12-1,2,3,4,6,7,8-HpCDD	2000	48
13C12-OCDD	4000	38

SURROGATE	QUANTITY ADDED (pg)	RECOVERY %
13C12-2,3,7,8-TCDF	2000	79
13C12-1,2,3,7,8-PeCDF	2000	67
13C12-2,3,4,7,8-PeCDF	2000	72
13C12-1,2,3,4,7,8-HxCDF	2000	51
13C12-1,2,3,6,7,8-HxCDF	2000	44
13C12-2,3,4,6,7,8-HxCDF	2000	53
13C12-1,2,3,7,8,9-HxCDF	2000	65
13C12-1,2,3,4,6,7,8-HpCDF	2000	41
13C12-1,2,3,4,7,8,9-HpCDF	2000	54

INTERNATIONAL TOXIC EQUIVALENCY FACTORS
NORTH ATLANTIC TREATY ORGANIZATION (NATO) 1988

Congener	I-TEF
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	0.5
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.001
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.05
2,3,4,7,8-PeCDF	0.5
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
OCDF	0.001

DIOXIN AND FURAN (PCDD/F) CONCENTRATIONS &
INTERNATIONAL TOXIC EQUIVALENT CONCENTRATIONS (I-TEQ)

CLIENT NAME:	**rpc**	SAMPLE MATRIX:	**Water**
CLIENT SAMPLE ID:	**Laboratory Purified Water**	RPC SUBMISSION ID:	**W00473**
SAMPLING DATE:	**Jul2214**	DATE ANALYZED:	**Jul2914**
% SOLIDS:	**- -**	CORRESPONDING CRM:	**- -**
% LIPID:	**- -**	CORRESPONDING BLANK:	**- -**

CHLORINATED DIOXINS AND FURANS	CONCENTRATION DETECTED (Note 1)	TOXIC EQUIVALENT CONCENTRATION (Note 2)	LIMIT OF DETECTION (LOD)
Congener	(pg/L)	(pg NATO-PCDD/F-TEQ/L)	(pg/L)
2,3,7,8-TCDD	ND	<0.4	0.4
1,2,3,7,8-PeCDD	ND	<0.45	0.9
1,2,3,4,7,8-HxCDD	ND	<0.15	1.5
1,2,3,6,7,8-HxCDD	ND	<0.16	1.6
1,2,3,7,8,9-HxCDD	ND	<0.17	1.7
1,2,3,4,6,7,8-HpCDD	2.4	0.024	0.8
OCDD	12.5	0.0125	3.4
2,3,7,8-TCDF	ND	<0.14	1.4
1,2,3,7,8-PeCDF	NDR(0.7)	<0.035	0.6
2,3,4,7,8-PeCDF	ND	<0.25	0.5
1,2,3,4,7,8-HxCDF	ND	<0.08	0.8
1,2,3,6,7,8-HxCDF	ND	<0.07	0.7
2,3,4,6,7,8-HxCDF	ND	<0.08	0.8
1,2,3,7,8,9-HxCDF	ND	<0.1	1.0
1,2,3,4,6,7,8-HpCDF	1.3	0.013	0.6
1,2,3,4,7,8,9-HpCDF	ND	<0.009	0.9
OCDF	ND	<0.0037	3.7
TOTAL (Min. Possible: Detected + [0 x LOD x TEF])		<0.1	
TOTAL (Detected + [0.5 x LOD x TEF])		1.1	
TOTAL (Max. Possible: Detected + [1 x LOD x TEF])		2.1	

GROUPS	NUMBERS OF PEAKS	CONCENTRATION DETECTED (Note 1)	LIMIT OF DETECTION (LOD)
Homologues		(pg/L)	(pg/L)
TCDD	0	ND	0.4
PeCDD	0	ND	0.9
HxCDD	0	ND	1.6
HpCDD	1	2.4	0.8
OCDD	1	12.5	3.4
TOTAL DIOXINS		14.9	
TCDF	0	ND	1.4
PeCDF	0	NDR(0.7)	0.6
HxCDF	0	ND	0.8
HpCDF	1	1.3	0.8
OCDF	0	ND	3.7
TOTAL FURANS		1.3	

Note 1: Results are corrected for surrogate recoveries (not corrected for lab method blank).

Note 2: Concentration Detected (LOD in case of ND) multiplied by corresponding toxic equivalency factor.

E signifies:	Possible chlorinated diphenyl ether interference
ND signifies:	Not detected
NDR signifies:	Not detected due to incorrect isotope ratio
N/R signifies:	Not reported

SURROGATE	QUANTITY ADDED (pg)	RECOVERY %
13C12-2,3,7,8-TCDD	2000	96
13C12-1,2,3,7,8-PeCDD	2000	97
13C12-1,2,3,4,7,8-HxCDD	2000	92
13C12-1,2,3,6,7,8-HxCDD	2000	72
13C12-1,2,3,4,6,7,8-HpCDD	2000	85
13C12-OCDD	4000	67

SURROGATE	QUANTITY ADDED (pg)	RECOVERY %
13C12-2,3,7,8-TCDF	2000	87
13C12-1,2,3,7,8-PeCDF	2000	92
13C12-2,3,4,7,8-PeCDF	2000	101
13C12-1,2,3,4,7,8-HxCDF	2000	87
13C12-1,2,3,6,7,8-HxCDF	2000	71
13C12-2,3,4,6,7,8-HxCDF	2000	83
13C12-1,2,3,7,8,9-HxCDF	2000	94
13C12-1,2,3,4,6,7,8-HpCDF	2000	75
13C12-1,2,3,4,7,8,9-HpCDF	2000	90

INTERNATIONAL TOXIC EQUIVALENCY FACTORS
NORTH ATLANTIC TREATY ORGANIZATION (NATO) 1988

Congener	I-TEF
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	0.5
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.001
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.05
2,3,4,7,8-PeCDF	0.5
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
OCDF	0.001

QC: DIOXIN & FURAN (PCDD/F) DUPLICATE & MATRIX SPIKE

CLIENT NAME: **rpc**
CLIENT SAMPLE ID: **Laboratory Purified Water**
SAMPLING DATE: **Jul2214**

SAMPLE MATRIX: **Water**
SPIKED SAMPLE: **W00473**
MATRIX SPIKE ID: **MPT430**
DATE ANALYZED: **Jul2914**

PCDD/F	SAMPLE pg NATO-TEQ/L	[redacted]	DUPLICATE pg NATO-TEQ/L	RPD %	ACCEPTABLE %	PASS/FAIL
Total TEQ (1 x MDL)	-		-	-	± 25	-

PCDD/F Congeners	SAMPLE pg/L	LEVEL OF FORTIFICATION pg/L	MATRIX SPIKE (MS) pg/L	MS RECOVERY %	ACCEPTABLE %	PASS/FAIL
2,3,7,8-TCDD	ND	5.2	4.9	94	65-135	PASS
1,2,3,7,8-PeCDD	ND	26.0	16.9	65	65-135	PASS
1,2,3,4,7,8-HxCDD	ND	26.0	19.9	77	65-135	PASS
1,2,3,6,7,8-HxCDD	ND	26.0	19.7	76	65-135	PASS
1,2,3,7,8,9-HxCDD	ND	26.0	19.5	75	65-135	PASS
1,2,3,4,6,7,8-HpCDD	2.4	26.0	19.2	74	65-135	PASS
OCDD	12.5	51.9	34	65	65-135	PASS
2,3,7,8-TCDF	ND	5.2	4.6	89	65-135	PASS
1,2,3,7,8-PeCDF	NDR(0.7)	26.0	19.4	75	65-135	PASS
2,3,4,7,8-PeCDF	ND	26.0	17.4	67	65-135	PASS
1,2,3,4,7,8-HxCDF	ND	26.0	20.8	80	65-135	PASS
1,2,3,6,7,8-HxCDF	ND	26.0	18.8	72	65-135	PASS
2,3,4,6,7,8-HxCDF	ND	26.0	17.9	69	65-135	PASS
1,2,3,7,8,9-HxCDF	ND	26.0	17	65	65-135	PASS
1,2,3,4,6,7,8-HpCDF	1.3	26.0	18.5	71	65-135	PASS
1,2,3,4,7,8,9-HpCDF	ND	26.0	20	77	65-135	PASS
OCDF	ND	51.9	39	75	65-135	PASS

NOTE: MATRIX SPIKE DATA ARE ADJUSTED BY SUBTRACTION OF SAMPLE DATA.

E signifies: **Possible chlorinated diphenyl ether interference**
NA signifies: **Not applicable**
ND signifies: **Not detected**
NDR signifies: **Not detected due to incorrect isotope ratio**
NR signifies: **Not reported**

ATTACHMENT B

WATER DATA SCREEN

Table B-1 Comparison of Metal Concentrations in Water to Available Freshwater Aquatic Life Guidelines

Client Sample ID:							Miramichi Lagoon Cell #1	Miramichi Lagoon Cell #2	Miramichi Lagoon Cell #3	Miramichi Lagoon Ash Basin #1	Miramichi Lagoon Ash Basin #2	Miramichi Lagoon Ash Basin #3	Miramichi Lagoon Ash Basin #4
Date Sampled:		**FWAL Guideline**	**Reference**				15-May-14	15-May-14	15-May-14	15-May-14	15-May-14	15-May-14	15-May-14
Analytes	**Units**			**RL**	**Maximum**	**Average**							
Aluminum	µg/L	100	CCME, 1987	1	643	225	342	231	643	119	44	148	46
Antimony	µg/L	20	BC, MOE (Nagpal et al., 2006; working guideline)	0.1	1.1	0.44	0.6	0.2	0.2	0.3	0.5	1.1	0.2
Arsenic	µg/L	5	CCME, 1997	1	2	1.29	2	1	1	1	1	2	1
Barium	µg/L	1000 / 5000	BC MOE, 2001 (Nagpal et al., 2006); working water quality guideline - 30 d mean / max	1	140	65.7	53	55	60	70	59	140	23
Beryllium	µg/L	5.3	BC, MOE (Nagpal et al., 2006; working guideline; chronic criterion)	0.1	0.1	0.10	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Bismuth	µg/L	NGA		1	1	1.00	1	1	1	1	1	1	1
Boron	µg/L	1500	CCME, 2009 (long term)	1	434	102	48	39	38	39	101	434	13
Cadmium	µg/L	0.09	CCME, 2014 - adjusted for hardness	0.01	0.05	0.04	0.04	0.03	0.05	0.02	0.02	0.05	0.05
Calcium	µg/L	4000 to >8000	BC, MOE (Nagpal et al., 2006; working guideline; based on sensitivity to acid inputs)	50	29500	21329	13500	23600	29500	17400	19200	20500	25600
Chromium	µg/L	8.9	CCME, 1997	1	1	1.00	1	1	1	1	1	1	1
Cobalt	µg/L	4	BC MOE (Nagpal, 2004)	0.1	0.2	0.13	0.2	0.1	0.2	0.1	0.1	0.1	0.1
Copper	µg/L	2	CCME, 1987 – hardness adjusted	1	1	1.00	1	1	1	1	1	1	1
Iron	µg/L	300	CCME, 1997	20	160	77.1	160	80	70	60	30	40	100
Lead	µg/L	1	CCME, 1987 - adjusted for hardness	0.1	5.9	1.27	5.9	0.4	0.6	0.2	0.3	0.7	0.8
Lithium	µg/L	96	BC, MOE (Nagpal et al., 2006; working guideine; final chronic value)	0.1	9.8	2.20	0.6	0.3	0.2	1.4	3	9.8	0.1
Magnesium	µg/L	NGA		10	4520	2483	4520	2780	1700	1360	2310	3810	900
Manganese	µg/L	800 / 1100	BC MOE, 2001 (Nagpal, 2001); approved water quality guideline - 30 day mean / max values	1	528	189.1	322	528	276	43	64	50	41
Mercury	µg/L	0.026 Hg	CCME, 2003	0.025	0.025	0.03	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Molybdenum	µg/L	73	CCME, 1999	0.1	6.8	1.51	0.4	0.6	0.4	0.6	1.3	6.8	0.5
Nickel	µg/L	25	CCME, 1987 - adjusted for hardness	1	3	1.29	3	1	1	1	1	1	1

Potassium	µg/L	373,000 - 432,000	BC, MOE (Nagpal et al., 2006; working guideine; threshold for Daphnia magna immobilization)	20	74100	20247	19100	11700	5420	8740	20500	74100	2170
Rubidium	µg/L	NGA		0.1	201	51.44	41.4	24.4	12.9	25.1	52	201	3.3
Selenium	µg/L	1	CCME, 1987; BC MOE, 2014 guideline is 2 ug/L	1	1	1.00	1	1	1	1	1	1	1
Silver	µg/L	0.1	CCME, 1987	0.1	0.1	0.10	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sodium	µg/L	NGA		50	157000	50267	157000	106000	50300	2320	10600	24400	1250
Strontium	µg/L	NGA		1	129	54.7	28	39	41	53	66	129	27
Tellurium	µg/L	NGA		0.1	0.1	0.10	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Thallium	µg/L	0.8	CCME, 1999	0.1	0.1	0.10	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Tin	µg/L	NGA		0.1	0.1	0.10	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Uranium	µg/L	15	CCME, 2011; 33 ug/L for short term	0.1	0.3	0.16	0.3	0.2	0.1	0.1	0.1	0.2	0.1
Vanadium	µg/L	6	BC MOE (Nagpal et al., 2006)	1	12	6.43	6	3	8	9	6	12	1
Zinc	µg/L	30	CCME, 1987	1	10	6.29	10	4	9	5	2	6	8

Notes:

Data presented in red were not detected. Values presented are the detection limits.

Note: No hardness data. To convert Ca+ mg/L into CaCO3 mg/L multiplied Ca+ concentration by 2.5.

Ca = 40.08 g/mol

CaCO3 = 100.09 g/mol X mg Ca/L * (100.9 g/mol CaCO3)/(40.08 g/mol Ca) = X mg CaCO3/L = 100.9 / 40.08 = 2.5

Therefore took average calcium concentration of 21329 ug/L and multiplied by 2.5 and divided by 1000 for conversion to mg/L = 53.3 mg/L

Shaded cell = over guideline

ATTACHMENT C

ERA MODELLING RESULTS

Table C-1 Summary of Hazard Quotients (HQs)

Site	Chemical	American_robin	Black_duck	Masked_shrew	Meadow_vole	Mink	Muskrat	Purple_finch
AB	Barium		0.0E+00				1.2E-01	
AB	Cadmium		1.1E-01				6.9E-02	
AB	PCBs		7.1E-03				3.0E-03	
AB	PCDD/F		3.5E-03				3.7E-02	
AB	Vanadium		**3.7E+00**				1.4E-01	
AB	Zinc		1.2E-01				1.0E-01	
AB+ASB	Barium	0.0E+00	0.0E+00	3.5E-01	4.3E-02		4.8E-02	0.0E+00
AB+ASB	Cadmium	8.2E-01	7.8E-02	**1.7E+00**	1.5E-01	9.7E-02	4.7E-02	7.0E-01
AB+ASB	PCBs	1.4E-01	6.3E-03	1.5E-01	1.4E-03	4.7E-02	3.0E-03	8.4E-02
AB+ASB	PCDD/F	1.4E-02	2.5E-03	5.7E-01	1.8E-02	1.3E-01	2.9E-02	8.1E-03
AB+ASB	Vanadium	**1.9E+00**	**2.3E+00**	4.1E-01	4.2E-02		7.0E-02	4.8E-01
AB+ASB	Zinc	6.4E-01	9.7E-02	**1.0E+00**	2.6E-01		7.1E-02	7.7E-01
ASB	Barium							
ASB	Cadmium	7.7E-01		**1.6E+00**	1.4E-01	8.9E-02		6.6E-01
ASB	PCBs	1.4E-01		1.5E-01	1.4E-03	4.7E-02		8.4E-02
ASB	PCDD/F	1.5E-02		6.1E-01	2.0E-02	1.4E-01		8.6E-03
ASB	Vanadium	**1.7E+00**		3.7E-01	3.7E-02			4.3E-01
ASB	Zinc							

Notes:

HQ> or = 1

Cells shaded black indicate that COC / receptor was not carried foreward for assessment in that particular scenario

Scenario 1 = Site ASB HQs for relevant COCs for terrestrial receptors (shrew, vole, mink, robin, finch) and Site AB HQs for relevant COCs for aquatic receptors (duck, muskrat)

Scenario 2 = Site AB + ASB HQs for relevant COCs and aquatic receptors (duck, muskrat) and mink (purely terrestrial receptors not present as ASB and AB contain water)

Scenario 3 = Site AB + ASB HQs for relevant COCs and terrestrail receptors (aquatic receptors would not be present due as ASB and AB drained)

HQ of 0.0E+00 indicates HQ not calculated as no TRV available

Table C-2 Summary of Media and Diet Concentrations

Site	Chemical	Receptor	Variable	Sediment mg/day	Water mg/day	Dust mg/day	Aquatic_Plant mg/day	Benthic_Invert mg/day	Browse mg/day	Invert mg/day	Prey_herb mg/day	Prey_insect mg/day	Total mg/day	Dose mg/kg/day	HQ (LOAEL) Unitless
AB	Barium	American_robin	AB_Barium_American_robin	1.15E+00	1.48E-03	9.94E-08	0.00E+00	0.00E+00	8.81E-01	1.17E+00	0.00E+00	0.00E+00	3.20E+00	4.16E+01	#VALUE!
AB	Cadmium	American_robin	AB_Cadmium_American_robin	1.27E-03	5.29E-07	3.32E-10	0.00E+00	0.00E+00	4.82E-02	1.69E-01	0.00E+00	0.00E+00	2.18E-01	2.84E+00	1.20E+00
AB	PCBs	American_robin	AB_PCBs_American_robin	1.25E-04	0.00E+00	1.08E-11	0.00E+00	0.00E+00	6.37E-05	3.57E-03	0.00E+00	0.00E+00	3.76E-03	4.89E-02	1.40E-01
AB	PCDD/F	American_robin	AB_PCDD/F_American_robin	2.72E-08	4.13E-11	2.35E-15	0.00E+00	0.00E+00	7.00E-09	1.53E-07	0.00E+00	0.00E+00	1.87E-07	2.43E-06	1.74E-02
AB	Vanadium	American_robin	AB_Vanadium_American_robin	8.12E-02	1.27E-04	7.00E-09	0.00E+00	0.00E+00	4.13E-03	3.64E-02	0.00E+00	0.00E+00	1.22E-01	1.58E+00	3.86E+00
AB	Zinc	American_robin	AB_Zinc_American_robin	5.23E-01	1.06E-04	4.51E-08	0.00E+00	0.00E+00	5.83E+00	2.89E+00	0.00E+00	0.00E+00	9.24E+00	1.20E+02	8.89E-01
AB+ASB	Barium	American_robin	AB+ASB_Barium_American_robin	4.67E-01	1.48E-03	4.03E-08	0.00E+00	0.00E+00	3.57E-01	4.73E-01	0.00E+00	0.00E+00	1.30E+00	1.69E+01	#VALUE!
AB+ASB	Cadmium	American_robin	AB+ASB_Cadmium_American_robin	7.64E-04	5.29E-07	1.99E-10	0.00E+00	0.00E+00	3.65E-02	1.13E-01	0.00E+00	0.00E+00	1.50E-01	1.95E+00	8.22E-01
AB+ASB	PCBs	American_robin	AB+ASB_PCBs_American_robin	1.25E-04	0.00E+00	1.08E-11	0.00E+00	0.00E+00	6.37E-05	3.57E-03	0.00E+00	0.00E+00	3.76E-03	4.89E-02	1.40E-01
AB+ASB	PCDD/F	American_robin	AB+ASB_PCDD/F_American_robin	2.20E-08	4.13E-11	1.90E-15	0.00E+00	0.00E+00	5.66E-09	1.28E-07	0.00E+00	0.00E+00	1.56E-07	2.03E-06	1.45E-02
AB+ASB	Vanadium	American_robin	AB+ASB_Vanadium_American_robin	4.04E-02	1.27E-04	3.48E-09	0.00E+00	0.00E+00	2.06E-03	1.81E-02	0.00E+00	0.00E+00	6.07E-02	7.88E-01	1.92E+00
AB+ASB	Zinc	American_robin	AB+ASB_Zinc_American_robin	2.74E-01	1.06E-04	2.36E-08	0.00E+00	0.00E+00	4.07E+00	2.34E+00	0.00E+00	0.00E+00	6.69E+00	8.68E+01	6.43E-01
ASB	Barium	American_robin	ASB_Barium_American_robin	1.62E-01	6.35E-04	1.40E-08	0.00E+00	0.00E+00	1.24E-01	1.64E-01	0.00E+00	0.00E+00	4.51E-01	5.85E+00	#VALUE!
ASB	Cadmium	American_robin	ASB_Cadmium_American_robin	6.99E-04	5.29E-07	1.83E-10	0.00E+00	0.00E+00	3.48E-02	1.05E-01	0.00E+00	0.00E+00	1.41E-01	1.82E+00	7.70E-01
ASB	PCBs	American_robin	ASB_PCBs_American_robin	1.25E-04	0.00E+00	1.08E-11	0.00E+00	0.00E+00	6.37E-05	3.57E-03	0.00E+00	0.00E+00	3.76E-03	4.89E-02	1.40E-01
ASB	PCDD/F	American_robin	ASB_PCDD/F_American_robin	2.38E-08	3.71E-11	2.05E-15	0.00E+00	0.00E+00	6.12E-09	1.37E-07	0.00E+00	0.00E+00	1.67E-07	2.17E-06	1.55E-02
ASB	Vanadium	American_robin	ASB_Vanadium_American_robin	3.57E-02	8.47E-05	3.08E-09	0.00E+00	0.00E+00	1.82E-03	1.60E-02	0.00E+00	0.00E+00	5.36E-02	6.96E-01	1.70E+00
ASB	Zinc	American_robin	ASB_Zinc_American_robin	2.35E-01	1.06E-04	2.03E-08	0.00E+00	0.00E+00	3.74E+00	2.22E+00	0.00E+00	0.00E+00	6.20E+00	8.05E+01	5.97E-01
AB	Barium	Black_duck	AB_Barium_Black_duck	1.81E+01	1.03E-02	9.27E-07	6.86E+00	2.72E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.77E+01	1.98E+01	#VALUE!
AB	Cadmium	Black_duck	AB_Cadmium_Black_duck	2.00E-02	3.70E-06	3.10E-09	2.27E-02	3.17E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.60E-01	2.57E-01	1.08E-01
AB	PCBs	Black_duck	AB_PCBs_Black_duck	1.97E-03	0.00E+00	1.01E-10	4.96E-04	1.01E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.47E-03	2.48E-03	7.08E-03
AB	PCDD/F	Black_duck	AB_PCDD/F_Black_duck	4.28E-07	2.88E-10	2.19E-14	5.45E-08	2.12E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.95E-07	4.96E-07	3.54E-03
AB	Vanadium	Black_duck	AB_Vanadium_Black_duck	1.27E+00	8.87E-04	6.53E-08	3.22E-02	8.39E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.15E+00	1.53E+00	3.74E+00
AB	Zinc	Black_duck	AB_Zinc_Black_duck	8.21E+00	7.39E-04	4.20E-07	1.26E+01	1.64E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.25E+01	1.60E+01	1.19E-01
AB+ASB	Barium	Black_duck	AB+ASB_Barium_Black_duck	7.34E+00	1.03E-02	3.76E-07	2.78E+00	2.11E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E+01	8.74E+00	#VALUE!
AB+ASB	Cadmium	Black_duck	AB+ASB_Cadmium_Black_duck	1.20E-02	3.70E-06	1.86E-09	2.27E-02	2.23E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.58E-01	1.84E-01	7.77E-02
AB+ASB	PCBs	Black_duck	AB+ASB_PCBs_Black_duck	1.97E-03	0.00E+00	1.01E-10	4.96E-04	6.43E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.11E-03	2.22E-03	6.34E-03
AB+ASB	PCDD/F	Black_duck	AB+ASB_PCDD/F_Black_duck	3.46E-07	2.88E-10	1.77E-14	4.40E-08	1.10E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.00E-07	3.57E-07	2.55E-03
AB+ASB	Vanadium	Black_duck	AB+ASB_Vanadium_Black_duck	6.34E-01	8.87E-04	3.25E-08	1.60E-02	6.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.30E+00	9.29E-01	2.27E+00
AB+ASB	Zinc	Black_duck	AB+ASB_Zinc_Black_duck	4.30E+00	7.39E-04	2.20E-07	1.26E+01	1.43E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.83E+01	1.31E+01	9.70E-02
ASB	Barium	Black_duck	ASB_Barium_Black_duck	2.55E+00	4.44E-03	1.30E-07	9.64E-01	1.57E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.09E+00	3.63E+00	#VALUE!
ASB	Cadmium	Black_duck	ASB_Cadmium_Black_duck	1.10E-02	3.70E-06	1.70E-09	2.27E-02	2.10E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-01	1.74E-01	7.34E-02
ASB	PCBs	Black_duck	ASB_PCBs_Black_duck	1.97E-03	0.00E+00	1.01E-10	4.96E-04	4.45E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.91E-03	2.08E-03	5.93E-03
ASB	PCDD/F	Black_duck	ASB_PCDD/F_Black_duck	3.74E-07	2.59E-10	1.91E-14	4.76E-08	8.19E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.03E-07	3.60E-07	2.57E-03
ASB	Vanadium	Black_duck	ASB_Vanadium_Black_duck	5.61E-01	5.91E-04	2.87E-08	1.41E-02	6.21E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E+00	8.55E-01	2.08E+00
ASB	Zinc	Black_duck	ASB_Zinc_Black_duck	3.69E+00	7.39E-04	1.89E-07	1.26E+01	1.39E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.77E+01	1.26E+01	9.36E-02
AB	Barium	Masked_shrew	AB_Barium_Masked_shrew	2.55E-01	9.63E-05	1.15E-08	0.00E+00	0.00E+00	1.91E-03	1.62E-01	0.00E+00	0.00E+00	4.19E-01	1.05E+02	8.65E-01
AB	Cadmium	Masked_shrew	AB_Cadmium_Masked_shrew	2.81E-04	3.44E-08	3.85E-11	0.00E+00	0.00E+00	1.05E-04	2.34E-02	0.00E+00	0.00E+00	2.38E-02	5.96E+00	2.61E+00
AB	PCBs	Masked_shrew	AB_PCBs_Masked_shrew	2.77E-05	0.00E+00	1.25E-12	0.00E+00	0.00E+00	1.38E-07	4.96E-04	0.00E+00	0.00E+00	5.24E-04	1.31E-01	1.46E-01
AB	PCDD/F	Masked_shrew	AB_PCDD/F_Masked_shrew	6.02E-09	2.68E-12	2.72E-16	0.00E+00	0.00E+00	1.52E-11	2.12E-08	0.00E+00	0.00E+00	2.72E-08	6.81E-06	6.81E-01
AB	Vanadium	Masked_shrew	AB_Vanadium_Masked_shrew	1.79E-02	8.25E-06	8.11E-10	0.00E+00	0.00E+00	8.97E-06	5.05E-03	0.00E+00	0.00E+00	2.30E-02	5.75E+00	8.34E-01
AB	Zinc	Masked_shrew	AB_Zinc_Masked_shrew	1.16E-01	6.88E-06	5.23E-09	0.00E+00	0.00E+00	1.27E-02	4.01E-01	0.00E+00	0.00E+00	5.29E-01	1.32E+02	1.40E+00
AB+ASB	Barium	Masked_shrew	AB+ASB_Barium_Masked_shrew	1.03E-01	9.63E-05	4.67E-09	0.00E+00	0.00E+00	7.74E-04	6.56E-02	0.00E+00	0.00E+00	1.70E-01	4.24E+01	3.51E-01
AB+ASB	Cadmium	Masked_shrew	AB+ASB_Cadmium_Masked_shrew	1.69E-04	3.44E-08	2.31E-11	0.00E+00	0.00E+00	7.93E-05	1.56E-02	0.00E+00	0.00E+00	1.59E-02	3.97E+00	1.74E+00
AB+ASB	PCBs	Masked_shrew	AB+ASB_PCBs_Masked_shrew	2.77E-05	0.00E+00	1.25E-12	0.00E+00	0.00E+00	1.38E-07	4.96E-04	0.00E+00	0.00E+00	5.24E-04	1.31E-01	1.46E-01
AB+ASB	PCDD/F	Masked_shrew	AB+ASB_PCDD/F_Masked_shrew	4.86E-09	2.68E-12	2.20E-16	0.00E+00	0.00E+00	1.23E-11	1.78E-08	0.00E+00	0.00E+00	2.27E-08	5.68E-06	5.68E-01
AB+ASB	Vanadium	Masked_shrew	AB+ASB_Vanadium_Masked_shrew	8.92E-03	8.25E-06	4.04E-10	0.00E+00	0.00E+00	4.46E-06	2.51E-03	0.00E+00	0.00E+00	1.14E-02	2.86E+00	4.15E-01
AB+ASB	Zinc	Masked_shrew	AB+ASB_Zinc_Masked_shrew	6.05E-02	6.88E-06	2.74E-09	0.00E+00	0.00E+00	8.84E-03	3.24E-01	0.00E+00	0.00E+00	3.94E-01	9.84E+01	1.04E+00
ASB	Barium	Masked_shrew	ASB_Barium_Masked_shrew	3.58E-02	4.13E-05	1.62E-09	0.00E+00	0.00E+00	2.69E-04	2.28E-02	0.00E+00	0.00E+00	5.89E-02	1.47E+01	1.22E-01
ASB	Cadmium	Masked_shrew	ASB_Cadmium_Masked_shrew	1.54E-04	3.44E-08	2.12E-11	0.00E+00	0.00E+00	7.56E-05	1.46E-02	0.00E+00	0.00E+00	1.48E-02	3.70E+00	1.62E+00
ASB	PCBs	Masked_shrew	ASB_PCBs_Masked_shrew	2.77E-05	0.00E+00	1.25E-12	0.00E+00	0.00E+00	1.38E-07	4.96E-04	0.00E+00	0.00E+00	5.24E-04	1.31E-01	1.46E-01
ASB	PCDD/F	Masked_shrew	ASB_PCDD/F_Masked_shrew	5.26E-09	2.41E-12	2.38E-16	0.00E+00	0.00E+00	1.33E-11	1.90E-08	0.00E+00	0.00E+00	2.43E-08	6.07E-06	6.07E-01
ASB	Vanadium	Masked_shrew	ASB_Vanadium_Masked_shrew	7.89E-03	5.50E-06	3.57E-10	0.00E+00	0.00E+00	3.94E-06	2.22E-03	0.00E+00	0.00E+00	1.01E-02	2.53E+00	3.67E-01
ASB	Zinc	Masked_shrew	ASB_Zinc_Masked_shrew	5.20E-02	6.88E-06	2.35E-09	0.00E+00	0.00E+00	8.13E-03	3.08E-01	0.00E+00	0.00E+00	3.69E-01	9.22E+01	9.78E-01
AB	Barium	Meadow_vole	AB_Barium_Meadow_vole	3.02E-01	7.30E-04	6.98E-08	0.00E+00	0.00E+00	1.89E-01	0.00E+00	0.00E+00	0.00E+00	4.92E-01	1.29E+01	1.07E-01
AB	Cadmium	Meadow_vole	AB_Cadmium_Meadow_vole	3.33E-04	2.61E-07	2.33E-10	0.00E+00	0.00E+00	1.03E-02	0.00E+00	0.00E+00	0.00E+00	1.07E-02	2.81E-01	1.94E-01
AB	PCBs	Meadow_vole	AB_PCBs_Meadow_vole	3.28E-05	0.00E+00	7.58E-12	0.00E+00	0.00E+00	1.37E-05	0.00E+00	0.00E+00	0.00E+00	4.65E-05	1.22E-03	1.36E-03
AB	PCDD/F	Meadow_vole	AB_PCDD/F_Meadow_vole	7.14E-09	2.03E-11	1.65E-15	0.00E+00	0.00E+00	1.50E-09	0.00E+00	0.00E+00	0.00E+00	8.66E-09	2.28E-07	2.28E-02
AB	Vanadium	Meadow_vole	AB_Vanadium_Meadow_vole	2.13E-02	6.26E-05	4.91E-09	0.00E+00	0.00E+00	8.87E-04	0.00E+00	0.00E+00	0.00E+00	2.22E-02	5.85E-01	8.48E-02
AB	Zinc	Meadow_vole	AB_Zinc_Meadow_vole	1.37E-01	5.22E-05	3.17E-08	0.00E+00	0.00E+00	1.25E+00	0.00E+00	0.00E+00	0.00E+00	1.39E+00	3.65E+01	3.88E-01
AB+ASB	Barium	Meadow_vole	AB+ASB_Barium_Meadow_vole	1.22E-01	7.30E-04	2.83E-08	0.00E+00	0.00E+00	7.65E-02	0.00E+00	0.00E+00	0.00E+00	2.00E-01	5.25E+00	4.34E-02
AB+ASB	Cadmium	Meadow_vole	AB+ASB_Cadmium_Meadow_vole	2.00E-04	2.61E-07	1.40E-10	0.00E+00	0.00E+00	7.84E-03	0.00E+00	0.00E+00	0.00E+00	8.04E-03	2.11E-01	1.46E-01
AB+ASB	PCBs	Meadow_vole	AB+ASB_PCBs_Meadow_vole	3.28E-05	0.00E+00	7.58E-12	0.00E+00	0.00E+00	1.37E-05	0.00E+00	0.00E+00	0.00E+00	4.65E-05	1.22E-03	1.36E-03
AB+ASB	PCDD/F	Meadow_vole	AB+ASB_PCDD/F_Meadow_vole	5.77E-09	2.03E-11	1.33E-15	0.00E+00	0.00E+00	1.21E-09	0.00E+00	0.00E+00	0.00E+00	7.00E-09	1.84E-07	1.84E-02
AB+ASB	Vanadium	Meadow_vole	AB+ASB_Vanadium_Meadow_vole	1.06E-02	6.26E-05	2.44E-09	0.00E+00	0.00E+00	4.41E-04	0.00E+00	0.00E+00	0.00E+00	1.11E-02	2.92E-01	4.23E-02
AB+ASB	Zinc	Meadow_vole	AB+ASB_Zinc_Meadow_vole	7.18E-02	5.22E-05	1.66E-08	0.00E+00	0.00E+00	8.74E-01	0.00E+00	0.00E+00	0.00E+00	9.46E-01	2.49E+01	2.64E-01
ASB	Barium	Meadow_vole	ASB_Barium_Meadow_vole	4.25E-02	3.13E-04	9.82E-09	0.00E+00	0.00E+00	2.66E-02	0.00E+00	0.00E+00	0.00E+00	6.94E-02	1.83E+00	1.51E-02
ASB	Cadmium	Meadow_vole	ASB_Cadmium_Meadow_vole	1.83E-04	2.61E-07	1.28E-10	0.00E+00	0.00E+00	7.47E-03	0.00E+00	0.00E+00	0.00E+00	7.65E-03	2.01E-01	1.39E-01
ASB	PCBs	Meadow_vole	ASB_PCBs_Meadow_vole	3.28E-05	0.00E+00	7.58E-12	0.00E+00	0.00E+00	1.37E-05	0.00E+00	0.00E+00	0.00E+00	4.65E-05	1.22E-03	1.36E-03
ASB	PCDD/F	Meadow_vole	ASB_PCDD/F_Meadow_vole	6.24E-09	1.83E-11	1.44E-15	0.00E+00	0.00E+00	1.31E-09	0.00E+00	0.00E+00	0.00E+00	7.57E-09	1.99E-07	1.99E-02

Table C-2 Summary of Media and Diet Concentrations

Site	Chemical	Receptor	Variable	Sediment	Water	Dust	Aquatic_Plant	Benthic_Invert	Browse	Invert	Prey_herb	Prey_insect	Total	Dose	HQ (LOAEL)
				mg/day	mg/day	mg/day	mg/day	mg/day	mg/day	mg/day	mg/day	mg/day	mg/day	mg/kg/day	Unitless
AB	Barium	American_robin	AB_Barium_American_robin	1.15E+00	1.48E-03	9.94E-08	0.00E+00	0.00E+00	8.81E-01	1.17E+00	0.00E+00	0.00E+00	3.20E+00	4.16E+01	#VALUE!
ASB	Vanadium	Meadow_vole	ASB_Vanadium_Meadow_vole	9.36E-03	4.17E-05	2.16E-09	0.00E+00	0.00E+00	3.90E-04	0.00E+00	0.00E+00	0.00E+00	9.79E-03	2.58E-01	3.73E-02
ASB	Zinc	Meadow_vole	ASB_Zinc_Meadow_vole	6.17E-02	5.22E-05	1.42E-08	0.00E+00	0.00E+00	8.03E-01	0.00E+00	0.00E+00	0.00E+00	8.65E-01	2.28E+01	2.42E-01
AB	Barium	Mink	AB_Barium_Mink	0.00E+00	1.39E-02	9.55E-07	0.00E+00	6.59E-02	0.00E+00	3.48E-01	2.26E+00	2.26E+00	4.94E+00	4.94E+00	#VALUE!
AB	Cadmium	Mink	AB_Cadmium_Mink	0.00E+00	4.95E-06	3.19E-09	0.00E+00	7.70E-03	0.00E+00	5.04E-02	1.29E-02	2.79E-01	3.50E-01	3.50E-01	1.54E-01
AB	PCBs	Mink	AB_PCBs_Mink	0.00E+00	0.00E+00	1.04E-10	0.00E+00	2.44E-05	0.00E+00	1.07E-03	2.43E-04	4.73E-03	6.07E-03	6.07E-03	4.67E-02
AB	PCDD/F	Mink	AB_PCDD/F_Mink	0.00E+00	3.86E-10	2.25E-14	0.00E+00	5.15E-09	0.00E+00	4.56E-08	7.98E-07	7.98E-07	1.65E-06	1.65E-06	1.65E-01
AB	Vanadium	Mink	AB_Vanadium_Mink	0.00E+00	1.19E-03	6.72E-08	0.00E+00	2.04E-02	0.00E+00	1.09E-02	3.62E-02	2.91E-02	9.77E-02	9.77E-02	#VALUE!
AB	Zinc	Mink	AB_Zinc_Mink	0.00E+00	9.90E-04	4.33E-07	0.00E+00	3.97E-02	0.00E+00	8.62E-01	2.53E+00	2.53E+00	5.96E+00	5.96E+00	#VALUE!
AB+ASB	Barium	Mink	AB+ASB_Barium_Mink	0.00E+00	1.39E-02	3.87E-07	0.00E+00	5.13E-02	0.00E+00	1.41E-01	9.13E-01	9.13E-01	2.03E+00	2.03E+00	#VALUE!
AB+ASB	Cadmium	Mink	AB+ASB_Cadmium_Mink	0.00E+00	4.95E-06	1.92E-09	0.00E+00	5.41E-03	0.00E+00	3.36E-02	1.01E-02	1.71E-01	2.20E-01	2.20E-01	9.65E-02
AB+ASB	PCBs	Mink	AB+ASB_PCBs_Mink	0.00E+00	0.00E+00	1.04E-10	0.00E+00	1.56E-05	0.00E+00	1.07E-03	2.43E-04	4.73E-03	6.06E-03	6.06E-03	4.66E-02
AB+ASB	PCDD/F	Mink	AB+ASB_PCDD/F_Mink	0.00E+00	3.86E-10	1.82E-14	0.00E+00	2.66E-09	0.00E+00	3.83E-08	6.32E-07	6.32E-07	1.31E-06	1.31E-06	1.31E-01
AB+ASB	Vanadium	Mink	AB+ASB_Vanadium_Mink	0.00E+00	1.19E-03	3.34E-08	0.00E+00	1.58E-02	0.00E+00	5.40E-03	1.80E-02	1.45E-02	5.48E-02	5.48E-02	#VALUE!
AB+ASB	Zinc	Mink	AB+ASB_Zinc_Mink	0.00E+00	9.90E-04	2.27E-07	0.00E+00	3.47E-02	0.00E+00	6.98E-01	2.41E+00	2.41E+00	5.55E+00	5.55E+00	#VALUE!
ASB	Barium	Mink	ASB_Barium_Mink	0.00E+00	5.94E-03	1.34E-07	0.00E+00	3.82E-02	0.00E+00	4.90E-02	3.17E-01	3.17E-01	7.27E-01	7.27E-01	#VALUE!
ASB	Cadmium	Mink	ASB_Cadmium_Mink	0.00E+00	4.95E-06	1.75E-09	0.00E+00	5.09E-03	0.00E+00	3.13E-02	9.73E-03	1.57E-01	2.03E-01	2.03E-01	8.91E-02
ASB	PCBs	Mink	ASB_PCBs_Mink	0.00E+00	0.00E+00	1.04E-10	0.00E+00	1.08E-05	0.00E+00	1.07E-03	2.43E-04	4.73E-03	6.05E-03	6.05E-03	4.66E-02
ASB	PCDD/F	Mink	ASB_PCDD/F_Mink	0.00E+00	3.47E-10	1.97E-14	0.00E+00	1.99E-09	0.00E+00	4.09E-08	6.88E-07	6.88E-07	1.42E-06	1.42E-06	1.42E-01
ASB	Vanadium	Mink	ASB_Vanadium_Mink	0.00E+00	7.92E-04	2.96E-08	0.00E+00	1.51E-02	0.00E+00	4.78E-03	1.59E-02	1.28E-02	4.93E-02	4.93E-02	#VALUE!
ASB	Zinc	Mink	ASB_Zinc_Mink	0.00E+00	9.90E-04	1.95E-07	0.00E+00	3.36E-02	0.00E+00	6.64E-01	2.38E+00	2.38E+00	5.46E+00	5.46E+00	#VALUE!
AB	Barium	Muskrat	AB_Barium_Muskrat	1.21E+01	1.39E-02	9.55E-07	1.58E+00	2.19E-01	0.00E+00	3.86E-01	0.00E+00	0.00E+00	1.43E+01	1.43E+01	1.18E-01
AB	Cadmium	Muskrat	AB_Cadmium_Muskrat	1.33E-02	4.95E-06	3.19E-09	5.21E-03	2.56E-02	0.00E+00	5.59E-02	0.00E+00	0.00E+00	1.00E-01	1.00E-01	6.90E-02
AB	PCBs	Muskrat	AB_PCBs_Muskrat	1.31E-03	0.00E+00	1.04E-10	1.14E-04	8.13E-05	0.00E+00	1.18E-03	0.00E+00	0.00E+00	2.69E-03	2.69E-03	2.99E-03
AB	PCDD/F	Muskrat	AB_PCDD/F_Muskrat	2.85E-07	3.86E-10	2.25E-14	1.25E-08	1.71E-08	0.00E+00	5.06E-08	0.00E+00	0.00E+00	3.65E-07	3.65E-07	3.65E-02
AB	Vanadium	Muskrat	AB_Vanadium_Muskrat	8.49E-01	1.19E-03	6.72E-08	7.40E-03	6.77E-02	0.00E+00	1.21E-02	0.00E+00	0.00E+00	9.37E-01	9.37E-01	1.36E-01
AB	Zinc	Muskrat	AB_Zinc_Muskrat	5.47E+00	9.90E-04	4.33E-07	2.90E+00	1.32E-01	0.00E+00	9.57E-01	0.00E+00	0.00E+00	9.46E+00	9.46E+00	1.00E-01
AB+ASB	Barium	Muskrat	AB+ASB_Barium_Muskrat	4.88E+00	1.39E-02	3.87E-07	6.39E-01	1.71E-01	0.00E+00	1.56E-01	0.00E+00	0.00E+00	5.86E+00	5.86E+00	4.85E-02
AB+ASB	Cadmium	Muskrat	AB+ASB_Cadmium_Muskrat	7.98E-03	4.95E-06	1.92E-09	5.21E-03	1.80E-02	0.00E+00	3.73E-02	0.00E+00	0.00E+00	6.85E-02	6.85E-02	4.73E-02
AB+ASB	PCBs	Muskrat	AB+ASB_PCBs_Muskrat	1.31E-03	0.00E+00	1.04E-10	1.14E-04	5.19E-05	0.00E+00	1.18E-03	0.00E+00	0.00E+00	2.66E-03	2.66E-03	2.95E-03
AB+ASB	PCDD/F	Muskrat	AB+ASB_PCDD/F_Muskrat	2.30E-07	3.86E-10	1.82E-14	1.01E-08	8.85E-09	0.00E+00	4.25E-08	0.00E+00	0.00E+00	2.92E-07	2.92E-07	2.92E-02
AB+ASB	Vanadium	Muskrat	AB+ASB_Vanadium_Muskrat	4.22E-01	1.19E-03	3.34E-08	3.68E-03	5.25E-02	0.00E+00	5.99E-03	0.00E+00	0.00E+00	4.86E-01	4.86E-01	7.04E-02
AB+ASB	Zinc	Muskrat	AB+ASB_Zinc_Muskrat	2.86E+00	9.90E-04	2.27E-07	2.90E+00	1.16E-01	0.00E+00	7.74E-01	0.00E+00	0.00E+00	6.65E+00	6.65E+00	7.06E-02
ASB	Barium	Muskrat	ASB_Barium_Muskrat	1.70E+00	5.94E-03	1.34E-07	2.22E-01	1.27E-01	0.00E+00	5.43E-02	0.00E+00	0.00E+00	2.10E+00	2.10E+00	1.74E-02
ASB	Cadmium	Muskrat	ASB_Cadmium_Muskrat	7.31E-03	4.95E-06	1.75E-09	5.21E-03	1.69E-02	0.00E+00	3.48E-02	0.00E+00	0.00E+00	6.42E-02	6.42E-02	4.43E-02
ASB	PCBs	Muskrat	ASB_PCBs_Muskrat	1.31E-03	0.00E+00	1.04E-10	1.14E-04	3.59E-05	0.00E+00	1.18E-03	0.00E+00	0.00E+00	2.64E-03	2.64E-03	2.94E-03
ASB	PCDD/F	Muskrat	ASB_PCDD/F_Muskrat	2.49E-07	3.47E-10	1.97E-14	1.10E-08	6.62E-09	0.00E+00	4.53E-08	0.00E+00	0.00E+00	3.12E-07	3.12E-07	3.12E-02
ASB	Vanadium	Muskrat	ASB_Vanadium_Muskrat	3.73E-01	7.92E-04	2.96E-08	3.25E-03	5.02E-02	0.00E+00	5.30E-03	0.00E+00	0.00E+00	4.33E-01	4.33E-01	6.27E-02
ASB	Zinc	Muskrat	ASB_Zinc_Muskrat	2.46E+00	9.90E-04	1.95E-07	2.90E+00	1.12E-01	0.00E+00	7.36E-01	0.00E+00	0.00E+00	6.21E+00	6.21E+00	6.59E-02
AB	Barium	Purple_finch	AB_Barium_Purple_finch	8.30E-03	6.98E-04	4.18E-08	0.00E+00	0.00E+00	4.65E-01	2.27E-01	0.00E+00	0.00E+00	7.01E-01	2.80E+01	#VALUE!
AB	Cadmium	Purple_finch	AB_Cadmium_Purple_finch	9.15E-06	2.49E-07	1.40E-10	0.00E+00	0.00E+00	2.55E-02	3.29E-02	0.00E+00	0.00E+00	5.84E-02	2.34E+00	9.86E-01
AB	PCBs	Purple_finch	AB_PCBs_Purple_finch	9.01E-07	0.00E+00	4.54E-12	0.00E+00	0.00E+00	3.36E-05	6.97E-04	0.00E+00	0.00E+00	7.31E-04	2.93E-02	8.36E-02
AB	PCDD/F	Purple_finch	AB_PCDD/F_Purple_finch	1.96E-10	1.94E-11	9.87E-16	0.00E+00	0.00E+00	3.69E-09	2.98E-08	0.00E+00	0.00E+00	3.37E-08	1.35E-06	9.63E-03
AB	Vanadium	Purple_finch	AB_Vanadium_Purple_finch	5.84E-04	5.98E-05	2.94E-09	0.00E+00	0.00E+00	2.18E-03	7.10E-03	0.00E+00	0.00E+00	9.92E-03	3.97E-01	9.68E-01
AB	Zinc	Purple_finch	AB_Zinc_Purple_finch	3.76E-03	4.98E-05	1.89E-08	0.00E+00	0.00E+00	3.08E+00	5.63E-01	0.00E+00	0.00E+00	3.64E+00	1.46E+02	1.08E+00
AB+ASB	Barium	Purple_finch	AB+ASB_Barium_Purple_finch	3.36E-03	6.98E-04	1.69E-08	0.00E+00	0.00E+00	1.88E-01	9.21E-02	0.00E+00	0.00E+00	2.84E-01	1.14E+01	#VALUE!
AB+ASB	Cadmium	Purple_finch	AB+ASB_Cadmium_Purple_finch	5.50E-06	2.49E-07	8.38E-11	0.00E+00	0.00E+00	1.93E-02	2.20E-02	0.00E+00	0.00E+00	4.12E-02	1.65E+00	6.96E-01
AB+ASB	PCBs	Purple_finch	AB+ASB_PCBs_Purple_finch	9.01E-07	0.00E+00	4.54E-12	0.00E+00	0.00E+00	3.36E-05	6.97E-04	0.00E+00	0.00E+00	7.31E-04	2.93E-02	8.36E-02
AB+ASB	PCDD/F	Purple_finch	AB+ASB_PCDD/F_Purple_finch	1.58E-10	1.94E-11	7.98E-16	0.00E+00	0.00E+00	2.99E-09	2.50E-08	0.00E+00	0.00E+00	2.82E-08	1.13E-06	8.06E-03
AB+ASB	Vanadium	Purple_finch	AB+ASB_Vanadium_Purple_finch	2.91E-04	5.98E-05	1.46E-09	0.00E+00	0.00E+00	1.08E-03	3.53E-03	0.00E+00	0.00E+00	4.96E-03	1.99E-01	4.84E-01
AB+ASB	Zinc	Purple_finch	AB+ASB_Zinc_Purple_finch	1.97E-03	4.98E-05	9.93E-09	0.00E+00	0.00E+00	2.15E+00	4.56E-01	0.00E+00	0.00E+00	2.61E+00	1.04E+02	7.72E-01
ASB	Barium	Purple_finch	ASB_Barium_Purple_finch	1.17E-03	2.99E-04	5.88E-09	0.00E+00	0.00E+00	6.53E-02	3.20E-02	0.00E+00	0.00E+00	9.88E-02	3.95E+00	#VALUE!
ASB	Cadmium	Purple_finch	ASB_Cadmium_Purple_finch	5.03E-06	2.49E-07	7.68E-11	0.00E+00	0.00E+00	1.84E-02	2.05E-02	0.00E+00	0.00E+00	3.88E-02	1.55E+00	6.56E-01
ASB	PCBs	Purple_finch	ASB_PCBs_Purple_finch	9.01E-07	0.00E+00	4.54E-12	0.00E+00	0.00E+00	3.36E-05	6.97E-04	0.00E+00	0.00E+00	7.31E-04	2.93E-02	8.36E-02
ASB	PCDD/F	Purple_finch	ASB_PCDD/F_Purple_finch	1.71E-10	1.74E-11	8.62E-16	0.00E+00	0.00E+00	3.23E-09	2.67E-08	0.00E+00	0.00E+00	3.01E-08	1.20E-06	8.60E-03
ASB	Vanadium	Purple_finch	ASB_Vanadium_Purple_finch	2.57E-04	3.99E-05	1.29E-09	0.00E+00	0.00E+00	9.59E-04	3.12E-03	0.00E+00	0.00E+00	4.38E-03	1.75E-01	4.27E-01
ASB	Zinc	Purple_finch	ASB_Zinc_Purple_finch	1.69E-03	4.98E-05	8.52E-09	0.00E+00	0.00E+00	1.98E+00	4.33E-01	0.00E+00	0.00E+00	2.41E+00	9.64E+01	7.14E-01

Table C-3 Summary of Media and Diet Concentrations

						Environmental Concentrations					
						Aquatic_Plant	Benthic_Invert	Browse	Invert	Prey_Herb	Prey_Insect
			Sediment	Water	Dust	Aquatic	Aquatic	Soil	Soil	Soil	Soil
Site	Chemical	Variable	mg/kg	mg/L	mg/m3	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw
AB	Barium	AB_Barium	2.30E+03	1.40E-01	1.75E-06	3.45E+01	2.56E+01	3.45E+01	2.03E+02	1.30E+02	1.30E+02
AB	Cadmium	AB_Cadmium	7.69E+00	5.00E-05	5.84E-09	1.14E-01	4.27E+00	1.89E+00	4.19E+01	7.46E-01	1.61E+01
AB	PCBs	AB_PCBs	2.50E-01	0.00E+00	1.90E-10	2.50E-03	9.48E-03	2.50E-03	6.21E-01	1.41E-02	2.73E-01
AB	PCDD/F	AB_PCDD/F	5.44E-05	3.90E-09	4.13E-14	2.75E-07	2.00E-06	2.75E-07	2.65E-05	4.61E-05	4.61E-05
AB	Vanadium	AB_Vanadium	1.62E+02	1.20E-02	1.23E-07	1.62E-01	7.90E+00	1.62E-01	6.32E+00	2.09E+00	1.68E+00
AB	Zinc	AB_Zinc	1.04E+03	1.00E-02	7.93E-07	6.35E+01	2.57E+01	2.29E+02	8.36E+02	1.46E+02	1.46E+02
AB+ASB	Barium	AB+ASB_Barium	9.33E+02	1.40E-01	7.09E-07	1.40E+01	1.99E+01	1.40E+01	8.21E+01	5.28E+01	5.28E+01
AB+ASB	Cadmium	AB+ASB_Cadmium	4.62E+00	5.00E-05	3.51E-09	1.14E-01	3.00E+00	1.43E+00	2.80E+01	5.86E-01	9.87E+00
AB+ASB	PCBs	AB+ASB_PCBs	2.50E-01	0.00E+00	1.90E-10	2.50E-03	6.05E-03	2.50E-03	6.21E-01	1.41E-02	2.73E-01
AB+ASB	PCDD/F	AB+ASB_PCDD/F	4.40E-05	3.90E-09	3.34E-14	2.22E-07	1.03E-06	2.22E-07	2.23E-05	3.65E-05	3.65E-05
AB+ASB	Vanadium	AB+ASB_Vanadium	8.06E+01	1.20E-02	6.13E-08	8.06E-02	6.12E+00	8.06E-02	3.14E+00	1.04E+00	8.36E-01
AB+ASB	Zinc	AB+ASB_Zinc	5.47E+02	1.00E-02	4.16E-07	6.35E+01	2.25E+01	1.60E+02	6.76E+02	1.39E+02	1.39E+02
ASB	Barium	ASB_Barium	3.24E+02	6.00E-02	2.46E-07	4.86E+00	1.48E+01	4.86E+00	2.85E+01	1.83E+01	1.83E+01
ASB	Cadmium	ASB_Cadmium	4.23E+00	5.00E-05	3.21E-09	1.14E-01	2.82E+00	1.37E+00	2.61E+01	5.62E-01	9.07E+00
ASB	PCBs	ASB_PCBs	2.50E-01	0.00E+00	1.90E-10	2.50E-03	4.19E-03	2.50E-03	6.21E-01	1.41E-02	2.73E-01
ASB	PCDD/F	ASB_PCDD/F	4.75E-05	3.50E-09	3.61E-14	2.40E-07	7.72E-07	2.40E-07	2.38E-05	3.98E-05	3.98E-05
ASB	Vanadium	ASB_Vanadium	7.13E+01	8.00E-03	5.42E-08	7.13E-02	5.85E+00	7.13E-02	2.78E+00	9.19E-01	7.39E-01
ASB	Zinc	ASB_Zinc	4.70E+02	1.00E-02	3.57E-07	6.35E+01	2.18E+01	1.47E+02	6.43E+02	1.38E+02	1.38E+02

Table C-4. Literature and Site-specific Derived Regression Models and Bio-Concentration Factors [Dry Weight Basis]

			Regression Variables		BCF			
			Constant	Coeff#1				
Diet	Chemical	Abbreviation	Average	Average	Value	Model	Basis	Reference
Aquatic_Plant	Barium	Aquatic_Plant_Barium			1.50E-02	BCF	Sediment	Baes et al 1984
Aquatic_Plant	Cadmium	Aquatic_Plant_Cadmium			2.28E+03	BCF	Water	US EPA OSW 1999 App C, Table C-4 Water-to-Algae BCF
Aquatic_Plant	PCBs	Aquatic_Plant_PCBs			1.00E-02	BCF	Sediment	based on Acrolor 1254; US EPA OSW 2005 App C, Table C-2 Sediment-to-Plant BCF
Aquatic_Plant	TCDD	Aquatic_Plant_TCDD			5.60E-03	BCF	Sediment	US EPA OSW 1999 App C, Table C-4 Water-to-Algae BCF
Aquatic_Plant	TCDF	Aquatic_Plant_TCDF			4.50E-03	BCF	Sediment	US EPA OSW 1999 App C, Table C-4 Water-to-Algae BCF
Aquatic_Plant	PCDD/F	Aquatic_Plant_PCDD/F			5.05E-03	BCF	Sediment	Based on average of TCDD & TCDF
Aquatic_Plant	Vanadium	Aquatic_Plant_Vanadium			1.00E-03	BCF	Sediment	CCME 1997
Aquatic_Plant	Zinc	Aquatic_Plant_Zinc			6.35E+03	BCF	Water	US EPA OSW 1999 App C, Table C-4 Water-to-Algae BCF
Benthic_Invert	Barium	Benthic_Invert_Barium	1.09E+00	2.78E-01		Ln_Normal	Sediment	BJC 1998; Assumed based on copper
Benthic_Invert	Cadmium	Benthic_Invert_Cadmium	3.95E-02	6.92E-01		Ln_Normal	Sediment	BJC 1998
Benthic_Invert	PCBs	Benthic_Invert_PCBs			5.86E-01	BCF	Sediment	Di Toro and McGrath, 2000
Benthic_Invert	TCDD	Benthic_Invert_TCDD			5.51E-01	BCF	Sediment	Di Toro and McGrath, 2000
Benthic_Invert	TCDF	Benthic_Invert_TCDF			5.86E-01	BCF	Sediment	Di Toro and McGrath, 2000
Benthic_Invert	PCDD/F	Benthic_Invert_PCDD/F			5.68E-01	BCF	Sediment	Di Toro and McGrath, 2000
Benthic_Invert	Vanadium	Benthic_Invert_Vanadium	2.09E-01	3.65E-01		Ln_Normal	Sediment	BJC 1998; Assumed same as chromium
Benthic_Invert	Zinc	Benthic_Invert_Zinc	1.80E+00	2.08E-01		Ln_Normal	Sediment	BJC 1998
Browse	Barium	Browse_Barium			1.50E-02	BCF	Sediment	Baes et al 1984
Browse	Cadmium	Browse_Cadmium	-4.76E-01	5.46E-01		Ln_Normal	Sediment	BJC 1998
Browse	PCBs	Browse_PCBs			1.00E-02	BCF	Sediment	based on Acrolor 1254; US EPA OSW 2005 App C, Table C-2 Sediment-to-Plant BCF
Browse	TCDD	Browse_TCDD			5.60E-03	BCF	Sediment	US EPA OSW 2005 App C, Table C-2 Sediment-to-Plant BCF
Browse	TCDF	Browse_TCDF			4.50E-03	BCF	Sediment	US EPA OSW 2005 App C, Table C-2 Sediment-to-Plant BCF
Browse	PCDD/F	Browse_PCDD/F			5.05E-03	BCF	Sediment	Based on average of TCDD & TCDF
Browse	Vanadium	Browse_Vanadium			1.00E-03	BCF	Sediment	CCME 1997
Browse	Zinc	Browse_Zinc	1.58E+00	5.55E-01		Ln_Normal	Sediment	BJC 1998
Invert	Barium	Invert_Barium			8.80E-02	BCF	Sediment	mean value; BJC 1998
Invert	Cadmium	Invert_Cadmium	2.11E+00	7.95E-01		Ln_Normal	Sediment	Sample et al. 1998b
Invert	PCBs	Invert_PCBs	1.41E+00	1.36E+00		Ln_Normal	Sediment	Sample et al. 1998b
Invert	TCDD	Invert_TCDD	3.53E+00	1.18E+00		Ln_Normal	Sediment	Sample et al. 1998b
Invert	TCDF	Invert_TCDF			7.61E+00	BCF	Sediment	US EPA OSW 2005
Invert	PCDD/F	Invert_PCDD/F	-2.49E+00	8.19E-01		Ln_Normal	Sediment	Integral, 2013
Invert	Vanadium	Invert_Vanadium			3.90E-02	BCF	Sediment	Sample et al. 1998b
Invert	Zinc	Invert_Zinc	4.45E+00	3.28E-01		Ln_Normal	Sediment	Sample et al. 1998b
Prey_herb	Barium	Prey_herb_Barium			5.66E-02	BCF	Sediment	Sample et al. 1998a
Prey_herb	Cadmium	Prey_herb_Cadmium	-1.26E+00	4.72E-01		Ln_Normal	Sediment	Sample et al. 1998a
Prey_herb	PCBs	Prey_herb_PCBs			5.63E-02	BCF	Sediment	Blankenship et al. 2005; Table 3
Prey_herb	TCDD	Prey_herb_TCDD	8.11E-01	1.10E+00		Ln_Normal	Sediment	Sample et al. 1998a
Prey_herb	TCDF	Prey_herb_TCDF			1.25E-01	BCF	Sediment	Sample et al. 1998a
Prey_herb	PCDD/F	Prey_herb_PCDD/F	8.11E-01	1.10E+00		Ln_Normal	Sediment	Based on TCDD regression model
Prey_herb	Vanadium	Prey_herb_Vanadium			1.29E-02	BCF	Sediment	Sample et al. 1998a
Prey_herb	Zinc	Prey_herb_Zinc	4.47E+00	7.38E-02		Ln_Normal	Sediment	Sample et al. 1998a
Prey_insect	Barium	Prey_insect_Barium			5.66E-02	BCF	Sediment	Sample et al. 1998a
Prey_insect	Cadmium	Prey_insect_Cadmium	8.15E-01	9.64E-01		Ln_Normal	Sediment	Sample et al. 1998a
Prey_insect	PCBs	Prey_insect_PCBs			1.09E+00	BCF	Sediment	Blankenship et al. 2005; Table 3
Prey_insect	TCDD	Prey_insect_TCDD	8.11E-01	1.10E+00		Ln_Normal	Sediment	Sample et al. 1998a
Prey_insect	TCDF	Prey_insect_TCDF			1.25E-01	BCF	Sediment	Sample et al. 1998a
Prey_insect	PCDD/F	Prey_insect_PCDD/F	8.11E-01	1.10E+00		Ln_Normal	Sediment	Based on TCDD regression model
Prey_insect	Vanadium	Prey_insect_Vanadium			1.04E-02	BCF	Sediment	Sample et al. 1998a; based on omnivore
Prey_insect	Zinc	Prey_insect_Zinc	4.47E+00	7.38E-02		Ln_Normal	Sediment	Sample et al. 1998a

Table C-5 Kow

Chemical	Value	Log(Kow)	Reference
Barium			Not applicable
Cadmium			Not applicable
PCBs	1.24E+06	6.10E+00	US EPA OSW 2005; Assumed average of Aroclor 1016 & 1254
TCDD	6.31E+06	6.80E+00	US EPA OSW 2005
TCDF	1.26E+06	6.10E+00	US EPA OSW 2005
PCDD/F	2.82E+06	6.45E+00	Average of TCDD & TCDF
Vanadium			Not applicable
Zinc			Not applicable

Table C-6 Exposure Point Concentrations Used in the ERA Model

Site	Chemical	Media	Statistic	Abbreviation	Value	Units	Reference/Comments
AB	Barium	Sediment	95UCL	AB_Barium_Sediment	2.30E+03	mg/kg	Student's-t UCL
AB	Cadmium	Sediment	95UCL	AB_Cadmium_Sediment	7.69E+00	mg/kg	Student's-t UCL
AB	PCBs	Sediment	ND	AB_PCBs_Sediment	2.50E-01	mg/kg	Non-detect; used 1/2 detection limit
AB	PCDD/F	Sediment	95UCL	AB_PCDD/F_Sediment	5.44E-05	mg/kg	Student's-t UCL
AB	Vanadium	Sediment	95UCL	AB_Vanadium_Sediment	1.62E+02	mg/kg	Student's-t UCL
AB	Zinc	Sediment	95UCL	AB_Zinc_Sediment	1.04E+03	mg/kg	Student's-t UCL
AB	Barium	Water	Max	AB_Barium_Water	1.40E-01	mg/L	Based on maximum
AB	Cadmium	Water	Max	AB_Cadmium_Water	5.00E-05	mg/L	Based on maximum
AB	PCBs	Water	Max	AB_PCBs_Water	0.00E+00		No data.
AB	PCDD/F	Water	Max	AB_PCDD/F_Water	3.90E-09	mg/L	Based on maximum
AB	Vanadium	Water	Max	AB_Vanadium_Water	1.20E-02	mg/L	Based on maximum
AB	Zinc	Water	Max	AB_Zinc_Water	1.00E-02	mg/L	Based on maximum
AB+ASB	Barium	Sediment	95UCL	AB+ASB_Barium_Sediment	9.33E+02	mg/kg	Chebyshev (Mean, Sd) UCL
AB+ASB	Cadmium	Sediment	95UCL	AB+ASB_Cadmium_Sediment	4.62E+00	mg/kg	Student's-t UCL
AB+ASB	PCBs	Sediment	ND	AB+ASB_PCBs_Sediment	2.50E-01	mg/kg	Non-detect; used 1/2 detection limit
AB+ASB	PCDD/F	Sediment	95UCL	AB+ASB_PCDD/F_Sediment	4.40E-05	mg/kg	Student's-t UCL
AB+ASB	Vanadium	Sediment	95UCL	AB+ASB_Vanadium_Sediment	8.06E+01	mg/kg	Modified-t UCL
AB+ASB	Zinc	Sediment	95UCL	AB+ASB_Zinc_Sediment	5.47E+02	mg/kg	Student's-t UCL
AB+ASB	Barium	Water	Max	AB+ASB_Barium_Water	1.40E-01	mg/L	Based on maximum
AB+ASB	Cadmium	Water	Max	AB+ASB_Cadmium_Water	5.00E-05	mg/L	Based on maximum
AB+ASB	PCBs	Water	Max	AB+ASB_PCBs_Water	0.00E+00		No data.
AB+ASB	PCDD/F	Water	Max	AB+ASB_PCDD/F_Water	3.90E-09	mg/L	Based on maximum
AB+ASB	Vanadium	Water	Max	AB+ASB_Vanadium_Water	1.20E-02	mg/L	Based on maximum
AB+ASB	Zinc	Water	Max	AB+ASB_Zinc_Water	1.00E-02	mg/L	Based on maximum
ASB	Barium	Sediment	95UCL	ASB_Barium_Sediment	3.24E+02	mg/kg	Student's-t UCL
ASB	Cadmium	Sediment	95UCL	ASB_Cadmium_Sediment	4.23E+00	mg/kg	Student's-t UCL
ASB	PCBs	Sediment	ND	ASB_PCBs_Sediment	2.50E-01	mg/kg	Non-detect; used 1/2 detection limit
ASB	PCDD/F	Sediment	95UCL	ASB_PCDD/F_Sediment	4.75E-05	mg/kg	Student's-t UCL
ASB	Vanadium	Sediment	95UCL	ASB_Vanadium_Sediment	7.13E+01	mg/kg	Modified-t UCL
ASB	Zinc	Sediment	95UCL	ASB_Zinc_Sediment	4.70E+02	mg/kg	Student's-t UCL
ASB	Barium	Water	Max	ASB_Barium_Water	6.00E-02	mg/L	Based on maximum
ASB	Cadmium	Water	Max	ASB_Cadmium_Water	5.00E-05	mg/L	Based on maximum
ASB	PCBs	Water	Max	ASB_PCBs_Water	0.00E+00		No data.
ASB	PCDD/F	Water	Max	ASB_PCDD/F_Water	3.50E-09	mg/L	Based on maximum
ASB	Vanadium	Water	Max	ASB_Vanadium_Water	8.00E-03	mg/L	Based on maximum
ASB	Zinc	Water	Max	ASB_Zinc_Water	1.00E-02	mg/L	Based on maximum

Table C-7 Site Specific Physical Parameters					
Site	**Parameter**	**Statistic**	**Variable**	**Value**	**Refence/Comment**
AB	TOC	95UCL	AB_TOC	0.1469	
AB+ASB	TOC	95UCL	AB+ASB_TOC	0.23	
ASB	TOC	95UCL	ASB_TOC	0.3324	

Table C-8 Diet Lipid Fraction and Total Organic Fraction Adjustment Factor

Site	Diet	Chemical	Variable	F_{lipid}	F_{TOC}	Value	Reference/Comment
AB	Aquatic_Plant	Barium	AB_Aquatic_Plant_Barium	NR	1.47E-01	1	Assumed most conservative default value
AB	Aquatic_Plant	Cadmium	AB_Aquatic_Plant_Cadmium	NR	1.47E-01	1	Assumed most conservative default value
AB	Aquatic_Plant	PCBs	AB_Aquatic_Plant_PCBs	NR	1.47E-01	1	Assumed most conservative default value
AB	Aquatic_Plant	PCDD/F	AB_Aquatic_Plant_PCDD/F	NR	1.47E-01	1	Assumed most conservative default value
AB	Aquatic_Plant	Vanadium	AB_Aquatic_Plant_Vanadium	NR	1.47E-01	1	Assumed most conservative default value
AB	Aquatic_Plant	Zinc	AB_Aquatic_Plant_Zinc	NR	1.47E-01	1	Assumed most conservative default value
AB	Benthic_Invert	Barium	AB_Benthic_Invert_Barium	9.50E-03	1.47E-01	1	Assumed most conservative default value
AB	Benthic_Invert	Cadmium	AB_Benthic_Invert_Cadmium	9.50E-03	1.47E-01	1	Assumed most conservative default value
AB	Benthic_Invert	PCBs	AB_Benthic_Invert_PCBs	9.50E-03	1.47E-01	0.06467	Di Toro and McGrath, 2000
AB	Benthic_Invert	PCDD/F	AB_Benthic_Invert_PCDD/F	9.50E-03	1.47E-01	0.06467	Di Toro and McGrath, 2000
AB	Benthic_Invert	Vanadium	AB_Benthic_Invert_Vanadium	9.50E-03	1.47E-01	1	Assumed most conservative default value
AB	Benthic_Invert	Zinc	AB_Benthic_Invert_Zinc	9.50E-03	1.47E-01	1	Assumed most conservative default value
AB	Browse	Barium	AB_Browse_Barium	NR	1.47E-01	1	Assumed most conservative default value
AB	Browse	Cadmium	AB_Browse_Cadmium	NR	1.47E-01	1	Assumed most conservative default value
AB	Browse	PCBs	AB_Browse_PCBs	NR	1.47E-01	1	Assumed most conservative default value
AB	Browse	PCDD/F	AB_Browse_PCDD/F	NR	1.47E-01	1	Assumed most conservative default value
AB	Browse	Vanadium	AB_Browse_Vanadium	NR	1.47E-01	1	Assumed most conservative default value
AB	Browse	Zinc	AB_Browse_Zinc	NR	1.47E-01	1	Assumed most conservative default value
AB	Invert	Barium	AB_Invert_Barium	NR	1.47E-01	1	Assumed most conservative default value
AB	Invert	Cadmium	AB_Invert_Cadmium	NR	1.47E-01	1	Assumed most conservative default value
AB	Invert	PCBs	AB_Invert_PCBs	NR	1.47E-01	1	Assumed most conservative default value
AB	Invert	PCDD/F	AB_Invert_PCDD/F	NR	1.47E-01	1	Assumed most conservative default value
AB	Invert	Vanadium	AB_Invert_Vanadium	NR	1.47E-01	1	Assumed most conservative default value
AB	Invert	Zinc	AB_Invert_Zinc	NR	1.47E-01	1	Assumed most conservative default value
AB	Prey_Herb	Barium	AB_Prey_Herb_Barium	NR	1.47E-01	1	Assumed most conservative default value
AB	Prey_Herb	Cadmium	AB_Prey_Herb_Cadmium	NR	1.47E-01	1	Assumed most conservative default value
AB	Prey_Herb	PCBs	AB_Prey_Herb_PCBs	NR	1.47E-01	1	Assumed most conservative default value
AB	Prey_Herb	PCDD/F	AB_Prey_Herb_PCDD/F	NR	1.47E-01	1	Assumed most conservative default value
AB	Prey_Herb	Vanadium	AB_Prey_Herb_Vanadium	NR	1.47E-01	1	Assumed most conservative default value
AB	Prey_Herb	Zinc	AB_Prey_Herb_Zinc	NR	1.47E-01	1	Assumed most conservative default value
AB	Prey_Insect	Barium	AB_Prey_Insect_Barium	NR	1.47E-01	1	Assumed most conservative default value
AB	Prey_Insect	Cadmium	AB_Prey_Insect_Cadmium	NR	1.47E-01	1	Assumed most conservative default value
AB	Prey_Insect	PCBs	AB_Prey_Insect_PCBs	NR	1.47E-01	1	Assumed most conservative default value
AB	Prey_Insect	PCDD/F	AB_Prey_Insect_PCDD/F	NR	1.47E-01	1	Assumed most conservative default value
AB	Prey_Insect	Vanadium	AB_Prey_Insect_Vanadium	NR	1.47E-01	1	Assumed most conservative default value
AB	Prey_Insect	Zinc	AB_Prey_Insect_Zinc	NR	1.47E-01	1	Assumed most conservative default value
AB+ASB	Aquatic_Plant	Barium	AB+ASB_Aquatic_Plant_Barium	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Aquatic_Plant	Cadmium	AB+ASB_Aquatic_Plant_Cadmium	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Aquatic_Plant	PCBs	AB+ASB_Aquatic_Plant_PCBs	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Aquatic_Plant	PCDD/F	AB+ASB_Aquatic_Plant_PCDD/F	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Aquatic_Plant	Vanadium	AB+ASB_Aquatic_Plant_Vanadium	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Aquatic_Plant	Zinc	AB+ASB_Aquatic_Plant_Zinc	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Benthic_Invert	Barium	AB+ASB_Benthic_Invert_Barium	9.50E-03	2.30E-01	1	Assumed most conservative default value
AB+ASB	Benthic_Invert	Cadmium	AB+ASB_Benthic_Invert_Cadmium	9.50E-03	2.30E-01	1	Assumed most conservative default value
AB+ASB	Benthic_Invert	PCBs	AB+ASB_Benthic_Invert_PCBs	9.50E-03	2.30E-01	0.041304	Di Toro and McGrath, 2000
AB+ASB	Benthic_Invert	PCDD/F	AB+ASB_Benthic_Invert_PCDD/F	9.50E-03	2.30E-01	0.041304	Di Toro and McGrath, 2000
AB+ASB	Benthic_Invert	Vanadium	AB+ASB_Benthic_Invert_Vanadium	9.50E-03	2.30E-01	1	Assumed most conservative default value
AB+ASB	Benthic_Invert	Zinc	AB+ASB_Benthic_Invert_Zinc	9.50E-03	2.30E-01	1	Assumed most conservative default value
AB+ASB	Browse	Barium	AB+ASB_Browse_Barium	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Browse	Cadmium	AB+ASB_Browse_Cadmium	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Browse	PCBs	AB+ASB_Browse_PCBs	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Browse	PCDD/F	AB+ASB_Browse_PCDD/F	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Browse	Vanadium	AB+ASB_Browse_Vanadium	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Browse	Zinc	AB+ASB_Browse_Zinc	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Invert	Barium	AB+ASB_Invert_Barium	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Invert	Cadmium	AB+ASB_Invert_Cadmium	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Invert	PCBs	AB+ASB_Invert_PCBs	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Invert	PCDD/F	AB+ASB_Invert_PCDD/F	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Invert	Vanadium	AB+ASB_Invert_Vanadium	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Invert	Zinc	AB+ASB_Invert_Zinc	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Prey_Herb	Barium	AB+ASB_Prey_Herb_Barium	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Prey_Herb	Cadmium	AB+ASB_Prey_Herb_Cadmium	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Prey_Herb	PCBs	AB+ASB_Prey_Herb_PCBs	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Prey_Herb	PCDD/F	AB+ASB_Prey_Herb_PCDD/F	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Prey_Herb	Vanadium	AB+ASB_Prey_Herb_Vanadium	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Prey_Herb	Zinc	AB+ASB_Prey_Herb_Zinc	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Prey_Insect	Barium	AB+ASB_Prey_Insect_Barium	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Prey_Insect	Cadmium	AB+ASB_Prey_Insect_Cadmium	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Prey_Insect	PCBs	AB+ASB_Prey_Insect_PCBs	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Prey_Insect	PCDD/F	AB+ASB_Prey_Insect_PCDD/F	NR	2.30E-01	1	Assumed most conservative default value

Table C-8 Diet Lipid Fraction and Total Organic Fraction Adjustment Factor

Site	Diet	Chemical	Variable	F_{lipid}	F_{TOC}	Value	Reference/Comment
AB+ASB	Prey_Insect	Vanadium	AB+ASB_Prey_Insect_Vanadium	NR	2.30E-01	1	Assumed most conservative default value
AB+ASB	Prey_Insect	Zinc	AB+ASB_Prey_Insect_Zinc	NR	2.30E-01	1	Assumed most conservative default value
ASB	Aquatic_Plant	Barium	ASB_Aquatic_Plant_Barium	NR	3.32E-01	1	Assumed most conservative default value
ASB	Aquatic_Plant	Cadmium	ASB_Aquatic_Plant_Cadmium	NR	3.32E-01	1	Assumed most conservative default value
ASB	Aquatic_Plant	PCBs	ASB_Aquatic_Plant_PCBs	NR	3.32E-01	1	Assumed most conservative default value
ASB	Aquatic_Plant	PCDD/F	ASB_Aquatic_Plant_PCDD/F	NR	3.32E-01	1	Assumed most conservative default value
ASB	Aquatic_Plant	Vanadium	ASB_Aquatic_Plant_Vanadium	NR	3.32E-01	1	Assumed most conservative default value
ASB	Aquatic_Plant	Zinc	ASB_Aquatic_Plant_Zinc	NR	3.32E-01	1	Assumed most conservative default value
ASB	Benthic_Invert	Barium	ASB_Benthic_Invert_Barium	9.50E-03	3.32E-01	1	Assumed most conservative default value
ASB	Benthic_Invert	Cadmium	ASB_Benthic_Invert_Cadmium	9.50E-03	3.32E-01	1	Assumed most conservative default value
ASB	Benthic_Invert	PCBs	ASB_Benthic_Invert_PCBs	9.50E-03	3.32E-01	0.02858	Di Toro and McGrath, 2000
ASB	Benthic_Invert	PCDD/F	ASB_Benthic_Invert_PCDD/F	9.50E-03	3.32E-01	0.02858	Di Toro and McGrath, 2000
ASB	Benthic_Invert	Vanadium	ASB_Benthic_Invert_Vanadium	9.50E-03	3.32E-01	1	Assumed most conservative default value
ASB	Benthic_Invert	Zinc	ASB_Benthic_Invert_Zinc	9.50E-03	3.32E-01	1	Assumed most conservative default value
ASB	Browse	Barium	ASB_Browse_Barium	NR	3.32E-01	1	Assumed most conservative default value
ASB	Browse	Cadmium	ASB_Browse_Cadmium	NR	3.32E-01	1	Assumed most conservative default value
ASB	Browse	PCBs	ASB_Browse_PCBs	NR	3.32E-01	1	Assumed most conservative default value
ASB	Browse	PCDD/F	ASB_Browse_PCDD/F	NR	3.32E-01	1	Assumed most conservative default value
ASB	Browse	Vanadium	ASB_Browse_Vanadium	NR	3.32E-01	1	Assumed most conservative default value
ASB	Browse	Zinc	ASB_Browse_Zinc	NR	3.32E-01	1	Assumed most conservative default value
ASB	Invert	Barium	ASB_Invert_Barium	NR	3.32E-01	1	Assumed most conservative default value
ASB	Invert	Cadmium	ASB_Invert_Cadmium	NR	3.32E-01	1	Assumed most conservative default value
ASB	Invert	PCBs	ASB_Invert_PCBs	NR	3.32E-01	1	Assumed most conservative default value
ASB	Invert	PCDD/F	ASB_Invert_PCDD/F	NR	3.32E-01	1	Assumed most conservative default value
ASB	Invert	Vanadium	ASB_Invert_Vanadium	NR	3.32E-01	1	Assumed most conservative default value
ASB	Invert	Zinc	ASB_Invert_Zinc	NR	3.32E-01	1	Assumed most conservative default value
ASB	Prey_Herb	Barium	ASB_Prey_Herb_Barium	NR	3.32E-01	1	Assumed most conservative default value
ASB	Prey_Herb	Cadmium	ASB_Prey_Herb_Cadmium	NR	3.32E-01	1	Assumed most conservative default value
ASB	Prey_Herb	PCBs	ASB_Prey_Herb_PCBs	NR	3.32E-01	1	Assumed most conservative default value
ASB	Prey_Herb	PCDD/F	ASB_Prey_Herb_PCDD/F	NR	3.32E-01	1	Assumed most conservative default value
ASB	Prey_Herb	Vanadium	ASB_Prey_Herb_Vanadium	NR	3.32E-01	1	Assumed most conservative default value
ASB	Prey_Herb	Zinc	ASB_Prey_Herb_Zinc	NR	3.32E-01	1	Assumed most conservative default value
ASB	Prey_Insect	Barium	ASB_Prey_Insect_Barium	NR	3.32E-01	1	Assumed most conservative default value
ASB	Prey_Insect	Cadmium	ASB_Prey_Insect_Cadmium	NR	3.32E-01	1	Assumed most conservative default value
ASB	Prey_Insect	PCBs	ASB_Prey_Insect_PCBs	NR	3.32E-01	1	Assumed most conservative default value
ASB	Prey_Insect	PCDD/F	ASB_Prey_Insect_PCDD/F	NR	3.32E-01	1	Assumed most conservative default value
ASB	Prey_Insect	Vanadium	ASB_Prey_Insect_Vanadium	NR	3.32E-01	1	Assumed most conservative default value
ASB	Prey_Insect	Zinc	ASB_Prey_Insect_Zinc	NR	3.32E-01	1	Assumed most conservative default value

Table C-9 Metabolism Factors

Chemical	Diet	Variable	MF	Reference/Comment
Barium	Aquatic_Plant	Barium_Aquatic_Plant	1	Assumed most conservative default value
Barium	Benthic_invert	Barium_Benthic_invert	1	Assumed most conservative default value
Barium	Browse	Barium_Browse	1	Assumed most conservative default value
Barium	Invert	Barium_Invert	1	Assumed most conservative default value
Barium	Prey_herb	Barium_Prey_herb	1	Assumed most conservative default value
Barium	Prey_insect	Barium_Prey_insect	1	Assumed most conservative default value
Cadmium	Aquatic_Plant	Cadmium_Aquatic_Plant	1	Assumed most conservative default value
Cadmium	Benthic_invert	Cadmium_Benthic_invert	1	Assumed most conservative default value
Cadmium	Browse	Cadmium_Browse	1	Assumed most conservative default value
Cadmium	Invert	Cadmium_Invert	1	Assumed most conservative default value
Cadmium	Prey_herb	Cadmium_Prey_herb	1	Assumed most conservative default value
Cadmium	Prey_insect	Cadmium_Prey_insect	1	Assumed most conservative default value
PCBs	Aquatic_Plant	PCBs_Aquatic_Plant	1	Assumed most conservative default value
PCBs	Benthic_invert	PCBs_Benthic_invert	1	Assumed most conservative default value
PCBs	Browse	PCBs_Browse	1	Assumed most conservative default value
PCBs	Invert	PCBs_Invert	1	Assumed most conservative default value
PCBs	Prey_herb	PCBs_Prey_herb	1	Assumed most conservative default value
PCBs	Prey_insect	PCBs_Prey_insect	1	Assumed most conservative default value
PCDD/F	Aquatic_Plant	PCDD/F_Aquatic_Plant	1	Assumed most conservative default value
PCDD/F	Benthic_invert	PCDD/F_Benthic_invert	1	Assumed most conservative default value
PCDD/F	Browse	PCDD/F_Browse	1	Assumed most conservative default value
PCDD/F	Invert	PCDD/F_Invert	1	Assumed most conservative default value
PCDD/F	Prey_herb	PCDD/F_Prey_herb	1	Assumed most conservative default value
PCDD/F	Prey_insect	PCDD/F_Prey_insect	1	Assumed most conservative default value
Vanadium	Aquatic_Plant	Vanadium_Aquatic_Plant	1	Assumed most conservative default value
Vanadium	Benthic_invert	Vanadium_Benthic_invert	1	Assumed most conservative default value
Vanadium	Browse	Vanadium_Browse	1	Assumed most conservative default value
Vanadium	Invert	Vanadium_Invert	1	Assumed most conservative default value
Vanadium	Prey_herb	Vanadium_Prey_herb	1	Assumed most conservative default value
Vanadium	Prey_insect	Vanadium_Prey_insect	1	Assumed most conservative default value
Zinc	Aquatic_Plant	Zinc_Aquatic_Plant	1	Assumed most conservative default value
Zinc	Benthic_invert	Zinc_Benthic_invert	1	Assumed most conservative default value
Zinc	Browse	Zinc_Browse	1	Assumed most conservative default value
Zinc	Invert	Zinc_Invert	1	Assumed most conservative default value
Zinc	Prey_herb	Zinc_Prey_herb	1	Assumed most conservative default value
Zinc	Prey_insect	Zinc_Prey_insect	1	Assumed most conservative default value

Table C-10 Bioaccessibility Factors for Dietary Components

Diet	Chemical	Variable	Value	Reference/Comment
Aquatic_Plant	Barium	Aquatic_Plant_Barium	100%	Assumed most conservative default value
Aquatic_Plant	Cadmium	Aquatic_Plant_Cadmium	100%	Assumed most conservative default value
Aquatic_Plant	PCBs	Aquatic_Plant_PCBs	100%	Assumed most conservative default value
Aquatic_Plant	PCDD/F	Aquatic_Plant_PCDD/F	100%	Assumed most conservative default value
Aquatic_Plant	Vanadium	Aquatic_Plant_Vanadium	100%	Assumed most conservative default value
Aquatic_Plant	Zinc	Aquatic_Plant_Zinc	100%	Assumed most conservative default value
Benthic_invert	Barium	Benthic_invert_Barium	100%	Assumed most conservative default value
Benthic_invert	Cadmium	Benthic_invert_Cadmium	70%	Cain et al. (2004)
Benthic_invert	PCBs	Benthic_invert_PCBs	100%	Assumed most conservative default value
Benthic_invert	PCDD/F	Benthic_invert_PCDD/F	100%	Assumed most conservative default value
Benthic_invert	Vanadium	Benthic_invert_Vanadium	100%	Assumed most conservative default value
Benthic_invert	Zinc	Benthic_invert_Zinc	60%	Cain et al. (2004)
Browse	Barium	Browse_Barium	100%	Assumed most conservative default value
Browse	Cadmium	Browse_Cadmium	100%	Assumed most conservative default value
Browse	PCBs	Browse_PCBs	100%	Assumed most conservative default value
Browse	PCDD/F	Browse_PCDD/F	100%	Assumed most conservative default value
Browse	Vanadium	Browse_Vanadium	100%	Assumed most conservative default value
Browse	Zinc	Browse_Zinc	100%	Assumed most conservative default value
Invert	Barium	Invert_Barium	100%	Assumed most conservative default value
Invert	Cadmium	Invert_Cadmium	70%	Cain et al. (2004)
Invert	PCBs	Invert_PCBs	100%	Assumed most conservative default value
Invert	PCDD/F	Invert_PCDD/F	100%	Assumed most conservative default value
Invert	Vanadium	Invert_Vanadium	100%	Assumed most conservative default value
Invert	Zinc	Invert_Zinc	60%	Cain et al. (2004)
Prey_herb	Barium	Prey_herb_Barium	100%	Assumed most conservative default value
Prey_herb	Cadmium	Prey_herb_Cadmium	100%	Assumed most conservative default value
Prey_herb	PCBs	Prey_herb_PCBs	100%	Assumed most conservative default value
Prey_herb	PCDD/F	Prey_herb_PCDD/F	100%	Assumed most conservative default value
Prey_herb	Vanadium	Prey_herb_Vanadium	100%	Assumed most conservative default value
Prey_herb	Zinc	Prey_herb_Zinc	100%	Assumed most conservative default value
Prey_insect	Barium	Prey_insect_Barium	100%	Assumed most conservative default value
Prey_insect	Cadmium	Prey_insect_Cadmium	100%	Assumed most conservative default value
Prey_insect	PCBs	Prey_insect_PCBs	100%	Assumed most conservative default value
Prey_insect	PCDD/F	Prey_insect_PCDD/F	100%	Assumed most conservative default value
Prey_insect	Vanadium	Prey_insect_Vanadium	100%	Assumed most conservative default value
Prey_insect	Zinc	Prey_insect_Zinc	100%	Assumed most conservative default value

Table C-11 Sediment Bioaccessibility Assumed for Direct Ingestion [%]

Chemical	Value	Reference / Comment
Barium	100%	Assumed most conservative value
Cadmium	33%	US DOD 2003
PCBs	100%	Assumed most conservative value
PCDD/F	100%	Assumed most conservative value
Vanadium	100%	Assumed most conservative value
Zinc	100%	Assumed most conservative value

Table C-12 Area Use Factor [%]

Site	Receptor	Variable	Value	Reference / Comment
AB	Black_duck	AB_Black_duck	100%	Assumed most conservative value
AB	Muskrat	AB_Muskrat	100%	Assumed most conservative value
AB	American_robin	AB_American_robin	100%	Assumed most conservative value
AB	Purple_finch	AB_Purple_finch	100%	Assumed most conservative value
AB	Masked_shrew	AB_Masked_shrew	100%	Assumed most conservative value
AB	Meadow_vole	AB_Meadow_vole	100%	Assumed most conservative value
AB	Mink	AB_Mink	100%	Assumed most conservative value
AB+ASB	Black_duck	AB+ASB_Black_duck	100%	Assumed most conservative value
AB+ASB	Muskrat	AB+ASB_Muskrat	100%	Assumed most conservative value
AB+ASB	American_robin	AB+ASB_American_robin	100%	Assumed most conservative value
AB+ASB	Purple_finch	AB+ASB_Purple_finch	100%	Assumed most conservative value
AB+ASB	Masked_shrew	AB+ASB_Masked_shrew	100%	Assumed most conservative value
AB+ASB	Meadow_vole	AB+ASB_Meadow_vole	100%	Assumed most conservative value
AB+ASB	Mink	AB+ASB_Mink	100%	Assumed most conservative value
ASB	Black_duck	ASB_Black_duck	100%	Assumed most conservative value
ASB	Muskrat	ASB_Muskrat	100%	Assumed most conservative value
ASB	American_robin	ASB_American_robin	100%	Assumed most conservative value
ASB	Purple_finch	ASB_Purple_finch	100%	Assumed most conservative value
ASB	Masked_shrew	ASB_Masked_shrew	100%	Assumed most conservative value
ASB	Meadow_vole	ASB_Meadow_vole	100%	Assumed most conservative value
ASB	Mink	ASB_Mink	100%	Assumed most conservative value

Table C-13 Soil Ingestion Rate [kg/day]

Receptor	Value
Black_duck	7.86E-03
Muskrat	5.24E-03
American_robin	5.01E-04
Purple_finch	3.60E-06
Masked_shrew	1.11E-04
Meadow_vole	1.31E-04
Mink	0.00E+00

Receptor	**Percent Soil in Diet**
Black_duck	3.3%

NFMR

3.50E+02	kcal/kg/day
4.91E+02	kcal/day

BW

1.40E+00	kg

Estimation of Average Metabolizable Energy

Diet	Portion	GE [kcal/kg-DW]	AE [%]	MEavg kcal/kg-DW
Browse	0%	4200	47%	0.00E+00
Invert	0%	5400	72%	0.00E+00
Benthic_Invert	60%	3600	77%	1.66E+03
Aquatic_Plant	40%	4300	23%	3.96E+02
Prey_herb	0%	5000	78%	0.00E+00
Prey_insect	0%	5000	78%	0.00E+00
	100%		**Sum**	**2.06E+03**

Estimation of Total Ingestion Rate [kg-food / day]	2.38E-01
Soil Ingestion Rate [kg-soil / day]	7.86E-03
Estimation of Total Ingestion Rate [kg-food / kg-BW day]	1.70E-01

Receptor	**Percent Soil in Diet**
Muskrat	9.4%

NFMR

1.79E+02	kcal/kg/day
1.79E+02	kcal/day

BW

1.00E+00	kg

Estimation of Average Metabolizable Energy

Diet	Portion	GE [kcal/kg-DW]	AE [%]	MEavg kcal/kg-DW
Browse	0%	4200	76%	0.00E+00
Invert	5%	5400	87%	2.35E+02
Benthic_Invert	15%	3600	87%	4.70E+02

Table C-13 Soil Ingestion Rate [kg/day]

Aquatic_Plant	80%	4300	73%	2.51E+03
Prey_herb	0%	5000	84%	0.00E+00
Prey_insect	0%	5000	84%	0.00E+00
	100%		**Sum**	**3.22E+03**

Estimation of Total Ingestion Rate [kg-food / day]	5.57E-02
Soil Ingestion Rate [kg-soil / day]	5.24E-03
Estimation of Total Ingestion Rate [kg-food / kg-BW day]	5.57E-02

Receptor	**Percent Soil in Diet**
American_robin	2.1%

NFMR

6.19E+02	kcal/kg/day
4.77E+01	kcal/day

BW

7.70E-02	kg

Estimation of Average Metabolizable Energy

Diet	Portion	GE [kcal/kg-DW]	AE [%]	MEavg kcal/kg-DW
Browse	60%	2200	51%	6.73E+02
Invert	40%	4600	72%	1.32E+03
Benthic_Invert	0%	3600	72%	0.00E+00
Aquatic_Plant	0%	4300	47%	0.00E+00
Prey_herb	0%	5000	78%	0.00E+00
Prey_insect	0%	5000	78%	0.00E+00
	100%		**Sum**	**2.00E+03**

Estimation of Total Ingestion Rate [kg-food / day]	2.39E-02
Soil Ingestion Rate [kg-soil / day]	5.01E-04
Estimation of Total Ingestion Rate [kg-food / kg-BW day]	3.10E-01

Receptor	**Percent Soil in Diet**
Purple_finch	0.03%

NFMR

8.73E+02	kcal/kg/day
2.18E+01	kcal/day

BW

2.50E-02	kg

Estimation of Average Metabolizable Energy

Diet	Portion	GE [kcal/kg-DW]	AE [%]	MEavg kcal/kg-DW
Browse	80%	2200	59%	1.04E+03
Invert	20%	5400	72%	7.78E+02
Benthic_Invert	0%	3600	72%	0.00E+00

Table C-13 Soil Ingestion Rate [kg/day]

Aquatic_Plant	0%	4300	47%	0.00E+00
Prey_herb	0%	5000	78%	0.00E+00
Prey_insect	0%	5000	78%	0.00E+00
	100%		**Sum**	**1.82E+03**

Estimation of Total Ingestion Rate [kg-food / day]	1.20E-02
Soil Ingestion Rate [kg-soil / day]	3.60E-06
Estimation of Total Ingestion Rate [kg-food / kg-BW day]	4.81E-01

Receptor	**Percent Soil in Diet**
Masked_shrew	13.0%

NFMR

9.88E+02	kcal/kg/day
3.95E+00	kcal/day

BW

4.00E-03	kg

Estimation of Average Metabolizable Energy

Diet	Portion	GE [kcal/kg-DW]	AE [%]	MEavg kcal/kg-DW
Browse	5%	4200	85%	1.79E+02
Invert	95%	5400	87%	4.46E+03
Benthic_Invert	0%	3600	87%	0.00E+00
Aquatic_Plant	0%	4300	73%	0.00E+00
Prey_herb	0%	5000	84%	0.00E+00
Prey_insect	0%	5000	84%	0.00E+00
	100%		**Sum**	**4.64E+03**

Estimation of Total Ingestion Rate [kg-food / day]	8.51E-04
Soil Ingestion Rate [kg-soil / day]	1.11E-04
Estimation of Total Ingestion Rate [kg-food / kg-BW day]	2.13E-01

Receptor	**Percent Soil in Diet**
Meadow_vole	2.4%

NFMR

4.59E+02	kcal/kg/day
1.75E+01	kcal/day

BW

3.80E-02	kg

Estimation of Average Metabolizable Energy

Diet	Portion	GE [kcal/kg-DW]	AE [%]	MEavg kcal/kg-DW
Browse	100%	4200	76%	3.19E+03
Invert	0%	5400	87%	0.00E+00
Benthic_Invert	0%	3600	87%	0.00E+00

Table C-13 Soil Ingestion Rate [kg/day]				
Aquatic_Plant	0%	4300	73%	0.00E+00
Prey_herb	0%	5000	84%	0.00E+00
Prey_insect	0%	5000	84%	0.00E+00
	100%		**Sum**	**3.19E+03**

Estimation of Total Ingestion Rate [kg-food / day]	5.47E-03
Soil Ingestion Rate [kg-soil / day]	1.31E-04
Estimation of Total Ingestion Rate [kg-food / kg-BW day]	1.44E-01

Receptor	**Percent Soil in Diet**
Mink	0.0%

NFMR

1.61E+02	kcal/kg/day
1.61E+02	kcal/day

BW

1.00E+00	kg

Estimation of Average Metabolizable Energy

Diet	Portion	GE [kcal/kg-DW]	AE [%]	MEavg kcal/kg-DW
Browse	0%	4200	76%	0.00E+00
Invert	5%	5400	87%	2.35E+02
Benthic_Invert	5%	3600	87%	1.57E+02
Aquatic_Plant	0%	4300	73%	0.00E+00
Prey_herb	45%	5000	84%	1.89E+03
Prey_insect	45%	5000	84%	1.89E+03
	100%		**Sum**	**4.17E+03**

Estimation of Total Ingestion Rate [kg-food / day]	3.87E-02
Soil Ingestion Rate [kg-soil / day]	0.00E+00
Estimation of Total Ingestion Rate [kg-food / kg-BW day]	3.87E-02

Table C-14 Wildlife Receptor Exposure Variables

Receptor	Variable	Abbreviation	Value	Units	Comment / Reference
American_robin	AIR	AIR_American_robin	5.7E-02	m^3/day	Allometric equation for birds 3-19; US EPA 1993
American_robin	BW	BW_American_robin	7.70E-02	kg	NatureServe, 2009
American_robin	Per_SIR	Per_SIR_American_robin	2.10%	% of diet	Sample and Suter 1994
American_robin	SIR	SIR_American_robin	5.01E-04	kg-soil/day	Calculated; See estimation of Soil Ingestion Rate
American_robin	WIR	WIR_American_robin	1.06E-02	L/day	Allometric equation 3-15; US EPA 1993
Black_duck	AIR	AIR_Black_duck	5.3E-01	m^3/day	Allometric equation for birds 3-19; US EPA 1993
Black_duck	BW	BW_Black_duck	1.40E+00	kg	NatureServe, 2009
Black_duck	Per_SIR	Per_SIR_Black_duck	3.3%	% of diet	Mallard; Suter et al. 2000
Black_duck	SIR	SIR_Black_duck	7.86E-03	kg-soil/day	Calculated; See estimation of Soil Ingestion Rate
Black_duck	WIR	WIR_Black_duck	7.39E-02	L/day	Allometric equation 3-15; US EPA 1993
Masked_shrew	AIR	AIR_Masked_shrew	6.6E-03	m^3/day	Allometric equation for mammals 3-20; US EPA 1993
Masked_shrew	BW	BW_Masked_shrew	4.00E-03	kg	NatureServe, 2009
Masked_shrew	Per_SIR	Per_SIR_Masked_shrew	13%	% of diet	Short-tailed shrew; Suter et al. 2000
Masked_shrew	SIR	SIR_Masked_shrew	1.11E-04	kg-soil/day	Calculated; See estimation of Soil Ingestion Rate
Masked_shrew	WIR	WIR_Masked_shrew	6.88E-04	L/day	Allometric equation 3-17; US EPA 1993
Meadow_vole	AIR	AIR_Meadow_vole	4.0E-02	m^3/day	Allometric equation for mammals 3-20; US EPA 1993
Meadow_vole	BW	BW_Meadow_vole	3.80E-02	kg	BC MOE 2001
Meadow_vole	Per_SIR	Per_SIR_Meadow_vole	2.40%	% of diet	Meadow vole; Suter et al. 2000
Meadow_vole	SIR	SIR_Meadow_vole	1.31E-04	kg-soil/day	Calculated; See estimation of Soil Ingestion Rate
Meadow_vole	WIR	WIR_Meadow_vole	5.22E-03	L/day	Allometric equation 3-17; US EPA 1993
Mink	AIR	AIR_Mink	5.5E-01	m^3/day	Allometric equation for mammals 3-20; US EPA 1993
Mink	BW	BW_Mink	1.00E+00	kg	BC MOE 2001
Mink	Per_SIR	Per_SIR_Mink	0.00%	% of diet	Sample and Suter 1994
Mink	SIR	SIR_Mink	0.00E+00	kg-soil/day	Calculated; See estimation of Soil Ingestion Rate
Mink	WIR	WIR_Mink	9.90E-02	L/day	Allometric equation 3-17; US EPA 1993
Muskrat	AIR	AIR_Muskrat	5.5E-01	m^3/day	Allometric equation for mammals 3-20; US EPA 1993
Muskrat	BW	BW_Muskrat	1.00E+00	kg	BC MOE 2001
Muskrat	Per_SIR	Per_SIR_Muskrat	9.4%	% of diet	Raccoon; Beyer 1994
Muskrat	SIR	SIR_Muskrat	5.24E-03	kg-soil/day	Calculated; See estimation of Soil Ingestion Rate
Muskrat	WIR	WIR_Muskrat	9.90E-02	L/day	Allometric equation 3-17; US EPA 1993
Purple_finch	AIR	AIR_Purple_finch	2.4E-02	m^3/day	Allometric equation for birds 3-19; US EPA 1993
Purple_finch	BW	BW_Purple_finch	2.50E-02	kg	NatureServe, 2009
Purple_finch	Per_SIR	Per_SIR_Purple_finch	0.03%	% of diet	Feeds in trees (range of hieghts from 0.5 m - 30 m), and feeds mainly on buds, seeds, blossoms, and fruits, as well as insects (Wooton et al, 1996). Low ingestion rate of soil assumed, based on foraging locations and habits.
Purple_finch	SIR	SIR_Purple_finch	3.60E-06	kg-soil/day	Calculated; See estimation of Soil Ingestion Rate
Purple_finch	WIR	WIR_Purple_finch	4.98E-03	L/day	Allometric equation 3-15; US EPA 1993

NOTES:
AIR = Air inhalation rate
BW = Body Weight
SIR = Soil ingestion rate
WIR = Water ingestion rate

Table C-15 Normalized to Body Weight Free-living (Field) Metabolic Rate (NFMR)

Receptor	NFMR [kcal/kg bw/day] [A]	FMR [kcal/day] [B]	Body Weight [grams]	a	b	Reference/Comments
American_robin	6.19E+02	4.77E+01	7.70E+01	1.04E+01	6.80E-01	Passerines; Nagy et al 1999
Black_duck	3.50E+02	4.91E+02	1.40E+03	4.54E+00	8.44E-01	Pelecaniformes; Nagy et al 1999
Masked_shrew	9.88E+02	3.95E+00	4.00E+00	6.98E+00	6.22E-01	Insectivores; Nagy et al 1999
Meadow_vole	4.59E+02	1.75E+01	3.80E+01	5.48E+00	7.12E-01	Rodentia; Nagy et al 1999
Mink	1.61E+02	1.61E+02	1.00E+03	1.67E+00	8.69E-01	Carnivora; Nagy et al 1999
Muskrat	1.79E+02	1.79E+02	1.00E+03	5.48E+00	7.12E-01	Rodentia; Nagy et al 1999
Purple_finch	8.73E+02	2.18E+01	2.50E+01	1.59E+01	5.43E-01	Temperate forest birds; Nagy et al 1999

NOTES:

A) NFMR = Normalized Free Metabolic Rate = FMR / BW; Where BW is in kg.

B) FMR = Free Metabolic Rate [kcal/day] = (a x BW^b) / 4.184 Kj/calorie; Where BW is in grams; moose equation already in kcal units.

Table C-16 Metabolizable Energy (ME) of Dietary Items [kcal/kg] A

Receptor	Dietary Item	Abbreviation	Value
American_robin	Aquatic_Plant	American_robin_Aquatic_Plant	2021
American_robin	Benthic_Invert	American_robin_Benthic_Invert	2592
American_robin	Browse	American_robin_Browse	1122
American_robin	Invert	American_robin_Invert	3312
American_robin	Prey_herb	American_robin_Prey_herb	3900
American_robin	Prey_insect	American_robin_Prey_insect	3900
Black_duck	Aquatic_Plant	Black_duck_Aquatic_Plant	989
Black_duck	Benthic_Invert	Black_duck_Benthic_Invert	2772
Black_duck	Browse	Black_duck_Browse	1974
Black_duck	Invert	Black_duck_Invert	3888
Black_duck	Prey_herb	Black_duck_Prey_herb	3900
Black_duck	Prey_insect	Black_duck_Prey_insect	3900
Masked_shrew	Aquatic_Plant	Masked_shrew_Aquatic_Plant	3139
Masked_shrew	Benthic_Invert	Masked_shrew_Benthic_Invert	3132
Masked_shrew	Browse	Masked_shrew_Browse	3570
Masked_shrew	Invert	Masked_shrew_Invert	4698
Masked_shrew	Prey_herb	Masked_shrew_Prey_herb	4200
Masked_shrew	Prey_insect	Masked_shrew_Prey_insect	4200
Meadow_vole	Aquatic_Plant	Meadow_vole_Aquatic_Plant	3139
Meadow_vole	Benthic_Invert	Meadow_vole_Benthic_Invert	3132
Meadow_vole	Browse	Meadow_vole_Browse	3192
Meadow_vole	Invert	Meadow_vole_Invert	4698
Meadow_vole	Prey_herb	Meadow_vole_Prey_herb	4200
Meadow_vole	Prey_insect	Meadow_vole_Prey_insect	4200
Mink	Aquatic_Plant	Mink_Aquatic_Plant	3139
Mink	Benthic_Invert	Mink_Benthic_Invert	3132
Mink	Browse	Mink_Browse	3192
Mink	Invert	Mink_Invert	4698
Mink	Prey_herb	Mink_Prey_herb	4200
Mink	Prey_insect	Mink_Prey_insect	4200
Muskrat	Aquatic_Plant	Muskrat_Aquatic_Plant	3139
Muskrat	Benthic_Invert	Muskrat_Benthic_Invert	3132
Muskrat	Browse	Muskrat_Browse	3192
Muskrat	Invert	Muskrat_Invert	4698
Muskrat	Prey_herb	Muskrat_Prey_herb	4200
Muskrat	Prey_insect	Muskrat_Prey_insect	4200
Purple_finch	Aquatic_Plant	Purple_finch_Aquatic_Plant	2021
Purple_finch	Benthic_Invert	Purple_finch_Benthic_Invert	2592
Purple_finch	Browse	Purple_finch_Browse	1298
Purple_finch	Invert	Purple_finch_Invert	3888
Purple_finch	Prey_herb	Purple_finch_Prey_herb	3900
Purple_finch	Prey_insect	Purple_finch_Prey_insect	3900

NOTES:
A) US EPA 1993; Equation 4-17.

Table C-17 Gross Energy (GE) of Dietary Items [kcal/kg dw] A

Receptor	Dietary Item	Abbreviation	Value	Reference/Comments
American_robin	Aquatic_Plant	American_robin_Aquatic_Plant	4300	aquatic emergent vegetation; US EPA 1993
American_robin	Benthic_Invert	American_robin_Benthic_Invert	3600	isopods, amphipods; US EPA 1993
American_robin	Browse	American_robin_Browse	2200	pulp, skin, seeds; US EPA 1993
American_robin	Invert	American_robin_Invert	4600	earthworms; US EPA 1993
American_robin	Prey_herb	American_robin_Prey_herb	5000	mice, voles, rabbits; US EPA 1993
American_robin	Prey_insect	American_robin_Prey_insect	5000	mice, voles, rabbits; US EPA 1993
Black_duck	Aquatic_Plant	Black_duck_Aquatic_Plant	4300	aquatic emergent vegetation; US EPA 1993
Black_duck	Benthic_Invert	Black_duck_Benthic_Invert	3600	isopods, amphipods; US EPA 1993
Black_duck	Browse	Black_duck_Browse	4200	monocot young grasses; US EPA 1993
Black_duck	Invert	Black_duck_Invert	5400	grasshopper, crickets; US EPA 1993
Black_duck	Prey_herb	Black_duck_Prey_herb	5000	mice, voles, rabbits; US EPA 1993
Black_duck	Prey_insect	Black_duck_Prey_insect	5000	mice, voles, rabbits; US EPA 1993
Masked_shrew	Aquatic_Plant	Masked_shrew_Aquatic_Plant	4300	aquatic emergent vegetation; US EPA 1993
Masked_shrew	Benthic_Invert	Masked_shrew_Benthic_Invert	3600	isopods, amphipods; US EPA 1993
Masked_shrew	Browse	Masked_shrew_Browse	4200	monocot young grasses; US EPA 1993
Masked_shrew	Invert	Masked_shrew_Invert	5400	grasshopper, crickets; US EPA 1993
Masked_shrew	Prey_herb	Masked_shrew_Prey_herb	5000	mice, voles, rabbits; US EPA 1993
Masked_shrew	Prey_insect	Masked_shrew_Prey_insect	5000	mice, voles, rabbits; US EPA 1993
Meadow_vole	Aquatic_Plant	Meadow_vole_Aquatic_Plant	4300	aquatic emergent vegetation; US EPA 1993
Meadow_vole	Benthic_Invert	Meadow_vole_Benthic_Invert	3600	isopods, amphipods; US EPA 1993
Meadow_vole	Browse	Meadow_vole_Browse	4200	monocot young grasses; US EPA 1993
Meadow_vole	Invert	Meadow_vole_Invert	5400	grasshopper, crickets; US EPA 1993
Meadow_vole	Prey_herb	Meadow_vole_Prey_herb	5000	mice, voles, rabbits; US EPA 1993
Meadow_vole	Prey_insect	Meadow_vole_Prey_insect	5000	mice, voles, rabbits; US EPA 1993
Mink	Aquatic_Plant	Mink_Aquatic_Plant	4300	aquatic emergent vegetation; US EPA 1993
Mink	Benthic_Invert	Mink_Benthic_Invert	3600	isopods, amphipods; US EPA 1993
Mink	Browse	Mink_Browse	4200	monocot young grasses; US EPA 1993
Mink	Invert	Mink_Invert	5400	grasshopper, crickets; US EPA 1993
Mink	Prey_herb	Mink_Prey_herb	5000	mice, voles, rabbits; US EPA 1993
Mink	Prey_insect	Mink_Prey_insect	5000	mice, voles, rabbits; US EPA 1993
Muskrat	Aquatic_Plant	Muskrat_Aquatic_Plant	4300	aquatic emergent vegetation; US EPA 1993
Muskrat	Benthic_Invert	Muskrat_Benthic_Invert	3600	isopods, amphipods; US EPA 1993
Muskrat	Browse	Muskrat_Browse	4200	monocot young grasses; US EPA 1993
Muskrat	Invert	Muskrat_Invert	5400	grasshopper, crickets; US EPA 1993
Muskrat	Prey_herb	Muskrat_Prey_herb	5000	mice, voles, rabbits; US EPA 1993
Muskrat	Prey_insect	Muskrat_Prey_insect	5000	mice, voles, rabbits; US EPA 1993
Purple_finch	Aquatic_Plant	Purple_finch_Aquatic_Plant	4300	aquatic emergent vegetation; US EPA 1993
Purple_finch	Benthic_Invert	Purple_finch_Benthic_Invert	3600	isopods, amphipods; US EPA 1993
Purple_finch	Browse	Purple_finch_Browse	2200	pulp, skin, seeds; US EPA 1993
Purple_finch	Invert	Purple_finch_Invert	5400	grasshopper, crickets; US EPA 1993
Purple_finch	Prey_herb	Purple_finch_Prey_herb	5000	mice, voles, rabbits; US EPA 1993
Purple_finch	Prey_insect	Purple_finch_Prey_insect	5000	mice, voles, rabbits; US EPA 1993

NOTES:
A) US EPA 1993; Tables 4-1 & 4-2.

Table C-18 Assimilation Efficiency (AE) of Dietary Items [Percent Efficiency] A

Receptor	Dietary Item	Abbreviation	Value	Reference/Comments
American_robin	Aquatic_Plant	American_robin_Aquatic_Plant	47%	grasses, leaves; US EPA 1993
American_robin	Benthic_Invert	American_robin_Benthic_Invert	72%	terrestrial insects; US EPA 1993
American_robin	Browse	American_robin_Browse	51%	fruit pulp, skin, seeds; US EPA 1993
American_robin	Invert	American_robin_Invert	72%	terrestrial insects; US EPA 1993
American_robin	Prey_herb	American_robin_Prey_herb	78%	birds, small mammals; US EPA 1993
American_robin	Prey_insect	American_robin_Prey_insect	78%	birds, small mammals; US EPA 1993
Black_duck	Aquatic_Plant	Black_duck_Aquatic_Plant	23%	aquatic vegetation; US EPA 1993
Black_duck	Benthic_Invert	Black_duck_Benthic_Invert	77%	aquatic invertebrates; US EPA 1993
Black_duck	Browse	Black_duck_Browse	47%	grasses, leaves; US EPA 1993
Black_duck	Invert	Black_duck_Invert	72%	terrestrial insects; US EPA 1993
Black_duck	Prey_herb	Black_duck_Prey_herb	78%	birds, small mammals; US EPA 1993
Black_duck	Prey_insect	Black_duck_Prey_insect	78%	birds, small mammals; US EPA 1993
Masked_shrew	Aquatic_Plant	Masked_shrew_Aquatic_Plant	73%	green forbs; US EPA 1993
Masked_shrew	Benthic_Invert	Masked_shrew_Benthic_Invert	87%	insects; US EPA 1993
Masked_shrew	Browse	Masked_shrew_Browse	85%	seeds, nuts; US EPA 1993
Masked_shrew	Invert	Masked_shrew_Invert	87%	insects; US EPA 1993
Masked_shrew	Prey_herb	Masked_shrew_Prey_herb	84%	small birds, mammals; US EPA 1993
Masked_shrew	Prey_insect	Masked_shrew_Prey_insect	84%	small birds, mammals; US EPA 1993
Meadow_vole	Aquatic_Plant	Meadow_vole_Aquatic_Plant	73%	green forbs; US EPA 1993
Meadow_vole	Benthic_Invert	Meadow_vole_Benthic_Invert	87%	insects; US EPA 1993
Meadow_vole	Browse	Meadow_vole_Browse	76%	"herbivory"; US EPA 1993
Meadow_vole	Invert	Meadow_vole_Invert	87%	insects; US EPA 1993
Meadow_vole	Prey_herb	Meadow_vole_Prey_herb	84%	small birds, mammals; US EPA 1993
Meadow_vole	Prey_insect	Meadow_vole_Prey_insect	84%	small birds, mammals; US EPA 1993
Mink	Aquatic_Plant	Mink_Aquatic_Plant	73%	green forbs; US EPA 1993
Mink	Benthic_Invert	Mink_Benthic_Invert	87%	insects; US EPA 1993
Mink	Browse	Mink_Browse	76%	"herbivory"; US EPA 1993
Mink	Invert	Mink_Invert	87%	insects; US EPA 1993
Mink	Prey_herb	Mink_Prey_herb	84%	small birds, mammals; US EPA 1993
Mink	Prey_insect	Mink_Prey_insect	84%	small birds, mammals; US EPA 1993
Muskrat	Aquatic_Plant	Muskrat_Aquatic_Plant	73%	green forbs; US EPA 1993
Muskrat	Benthic_Invert	Muskrat_Benthic_Invert	87%	insects; US EPA 1993
Muskrat	Browse	Muskrat_Browse	76%	"herbivory"; US EPA 1993
Muskrat	Invert	Muskrat_Invert	87%	insects; US EPA 1993
Muskrat	Prey_herb	Muskrat_Prey_herb	84%	small birds, mammals; US EPA 1993
Muskrat	Prey_insect	Muskrat_Prey_insect	84%	small birds, mammals; US EPA 1993
Purple_finch	Aquatic_Plant	Purple_finch_Aquatic_Plant	47%	grasses, leaves; US EPA 1993
Purple_finch	Benthic_Invert	Purple_finch_Benthic_Invert	72%	terrestrial insects; US EPA 1993
Purple_finch	Browse	Purple_finch_Browse	59%	wild seeds; US EPA 1993
Purple_finch	Invert	Purple_finch_Invert	72%	terrestrial insects; US EPA 1993
Purple_finch	Prey_herb	Purple_finch_Prey_herb	78%	birds, small mammals; US EPA 1993
Purple_finch	Prey_insect	Purple_finch_Prey_insect	78%	birds, small mammals; US EPA 1993

NOTES:
A) US EPA 1993; Table 4-3.

Table C-19 Receptor Dietary Composition [media % of diet]

Receptor	Dietary Item	Abbreviation	Value
American_robin	Aquatic_Plant	American_robin_Aquatic_Plant	0.0%
American_robin	Benthic_Invert	American_robin_Benthic_Invert	0.0%
American_robin	Browse	American_robin_Browse	60.0%
American_robin	Invert	American_robin_Invert	40.0%
American_robin	Prey_herb	American_robin_Prey_herb	0.0%
American_robin	Prey_insect	American_robin_Prey_insect	0.0%
Black_duck	Aquatic_Plant	Black_duck_Aquatic_Plant	40.0%
Black_duck	Benthic_Invert	Black_duck_Benthic_Invert	60.0%
Black_duck	Browse	Black_duck_Browse	0.0%
Black_duck	Invert	Black_duck_Invert	0.0%
Black_duck	Prey_herb	Black_duck_Prey_herb	0.0%
Black_duck	Prey_insect	Black_duck_Prey_insect	0.0%
Masked_shrew	Aquatic_Plant	Masked_shrew_Aquatic_Plant	0.0%
Masked_shrew	Benthic_Invert	Masked_shrew_Benthic_Invert	0.0%
Masked_shrew	Browse	Masked_shrew_Browse	5.0%
Masked_shrew	Invert	Masked_shrew_Invert	95.0%
Masked_shrew	Prey_herb	Masked_shrew_Prey_herb	0.0%
Masked_shrew	Prey_insect	Masked_shrew_Prey_insect	0.0%
Meadow_vole	Aquatic_Plant	Meadow_vole_Aquatic_Plant	0.0%
Meadow_vole	Benthic_Invert	Meadow_vole_Benthic_Invert	0.0%
Meadow_vole	Browse	Meadow_vole_Browse	100.0%
Meadow_vole	Invert	Meadow_vole_Invert	0.0%
Meadow_vole	Prey_herb	Meadow_vole_Prey_herb	0.0%
Meadow_vole	Prey_insect	Meadow_vole_Prey_insect	0.0%
Mink	Aquatic_Plant	Mink_Aquatic_Plant	0.0%
Mink	Benthic_Invert	Mink_Benthic_Invert	5.0%
Mink	Browse	Mink_Browse	0.0%
Mink	Invert	Mink_Invert	5.0%
Mink	Prey_herb	Mink_Prey_herb	45.0%
Mink	Prey_insect	Mink_Prey_insect	45.0%
Muskrat	Aquatic_Plant	Muskrat_Aquatic_Plant	80.0%
Muskrat	Benthic_Invert	Muskrat_Benthic_Invert	15.0%
Muskrat	Browse	Muskrat_Browse	0.0%
Muskrat	Invert	Muskrat_Invert	5.0%
Muskrat	Prey_herb	Muskrat_Prey_herb	0.0%
Muskrat	Prey_insect	Muskrat_Prey_insect	0.0%
Purple_finch	Aquatic_Plant	Purple_finch_Aquatic_Plant	0.0%
Purple_finch	Benthic_Invert	Purple_finch_Benthic_Invert	0.0%
Purple_finch	Browse	Purple_finch_Browse	80.0%
Purple_finch	Invert	Purple_finch_Invert	20.0%
Purple_finch	Prey_herb	Purple_finch_Prey_herb	0.0%
Purple_finch	Prey_insect	Purple_finch_Prey_insect	0.0%

Table C-20 Wildlife Oral Toxicity Reference Values (TRVs) [mg/kg/day]

Wildlife Receptor	Chemical	Abbreviation	TRV	Comment
American_robin	Barium	American_robin_Barium	NDA	
Black_duck	Barium	Black_duck_Barium	NDA	
Masked_shrew	Barium	Masked_shrew_Barium	121	US EPA 2005
Meadow_vole	Barium	Meadow_vole_Barium	121	US EPA 2005
Mink	Barium	Mink_Barium	Not assessed	
Muskrat	Barium	Muskrat_Barium	121	US EPA 2005
Purple_finch	Barium	Purple_finch_Barium	NDA	
American_robin	Cadmium	American_robin_Cadmium	2.37	US EPA 2005
Black_duck	Cadmium	Black_duck_Cadmium	2.37	US EPA 2005
Masked_shrew	Cadmium	Masked_shrew_Cadmium	2.28	US EPA 2005
Meadow_vole	Cadmium	Meadow_vole_Cadmium	1.45	US EPA 2005
Mink	Cadmium	Mink_Cadmium	2.28	US EPA 2005
Muskrat	Cadmium	Muskrat_Cadmium	1.45	US EPA 2005
Purple_finch	Cadmium	Purple_finch_Cadmium	2.37	US EPA 2005
American_robin	PCBs	American_robin_PCBs	0.35	OMOE 2011
Black_duck	PCBs	Black_duck_PCBs	0.35	OMOE 2011
Masked_shrew	PCBs	Masked_shrew_PCBs	0.9	OMOE 2011
Meadow_vole	PCBs	Meadow_vole_PCBs	0.9	OMOE 2011
Mink	PCBs	Mink_PCBs	0.13	Heaton et al. 1995
Muskrat	PCBs	Muskrat_PCBs	0.9	OMOE 2011
Purple_finch	PCBs	Purple_finch_PCBs	0.35	OMOE 2011
American_robin	PCDD/F	American_robin_PCDD/F	1.40E-04	OMOE 2011
Black_duck	PCDD/F	Black_duck_PCDD/F	1.40E-04	OMOE 2011
Masked_shrew	PCDD/F	Masked_shrew_PCDD/F	1.00E-05	OMOE 2011
Meadow_vole	PCDD/F	Meadow_vole_PCDD/F	1.00E-05	OMOE 2011
Mink	PCDD/F	Mink_PCDD/F	1.00E-05	OMOE 2011
Muskrat	PCDD/F	Muskrat_PCDD/F	1.00E-05	OMOE 2011
Purple_finch	PCDD/F	Purple_finch_PCDD/F	1.40E-04	OMOE 2011
American_robin	Vanadium	American_robin_Vanadium	0.41	Sell et al., 1982
Black_duck	Vanadium	Black_duck_Vanadium	0.41	Sell et al., 1982
Masked_shrew	Vanadium	Masked_shrew_Vanadium	6.9	US EPA 2005
Meadow_vole	Vanadium	Meadow_vole_Vanadium	6.9	US EPA 2005
Mink	Vanadium	Mink_Vanadium	Not assessed	
Muskrat	Vanadium	Muskrat_Vanadium	6.9	US EPA 2005
Purple_finch	Vanadium	Purple_finch_Vanadium	0.41	Sell et al., 1982
American_robin	Zinc	American_robin_Zinc	135	US EPA, 2001
Black_duck	Zinc	Black_duck_Zinc	135	US EPA, 2001
Masked_shrew	Zinc	Masked_shrew_Zinc	94.2	US EPA, 2001
Meadow_vole	Zinc	Meadow_vole_Zinc	94.2	US EPA, 2001
Mink	Zinc	Mink_Zinc	Not assessed	
Muskrat	Zinc	Muskrat_Zinc	94.2	US EPA, 2001
Purple_finch	Zinc	Purple_finch_Zinc	135	US EPA, 2001

NDA: No Data Available

Table C-21 Other Parameters

Moisture Content (%)

Variable	Value	Comment
Mammals	68%	mice, voles, rabbits

Lipid Content of Oganisms (%)

Dietary Component	Value	Comment
Aquatic_Plant	NR	Not required
Benthic_Invert	0.0095	
Browse	NR	Not required
Invert	NR	Not required
Prey_Herb	NR	Not required
Prey_Insect	NR	Not required

Chemicals Assesed with DiToro and McGrath (2000) Model

Chemical	Value	Comment
Barium	No	
Cadmium	No	
PCBs	Yes	
TCDD	Yes	
TCDF	Yes	
PCDD/F	Yes	
Vanadium	No	
Zinc	No	

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Environmental Risk Assessment
for the Purpose of Draining the Miramichi Lagoons
(Former UPM Pulp & Paper Mill Site)

Submitted to: **N.B. Department of Transportation and Infrastructure**
6670 King Street
Fredericton, N.B.
E3B 5H1

Prepared by: **NATECH Environmental Services Inc.**
2492 Route 640
Hanwell, N.B.
E3E 2C2

Date: **October 30, 2015**

NATECH

TABLE OF CONTENTS

1. INTRODUCTION

The Province of New Brunswick owns the site of the former UPM pulp and paper mill in Miramichi (see Figure 1-1). The property includes three large wastewater treatment lagoons, more than half-filled with organic sludge. The sludge is currently covered with water. As part of the planned ecological closure of the site (NATECH, 2015), the lagoons are to be drained and the berms breached, allowing the sludge to dry and become vegetated.

A number of contaminants are known to be present in the sludge, a few of which are water soluble. An outlet structure equipped with stop logs is located at the southern edge of the third lagoon cell. The effluent is discharged underwater into the river via an outfall equipped with a diffuser.

The purpose of this study is to determine what discharge flow rate is appropriate to drain the lagoons within a few weeks or months, without impacting aquatic life in the Northwest Miramichi River.

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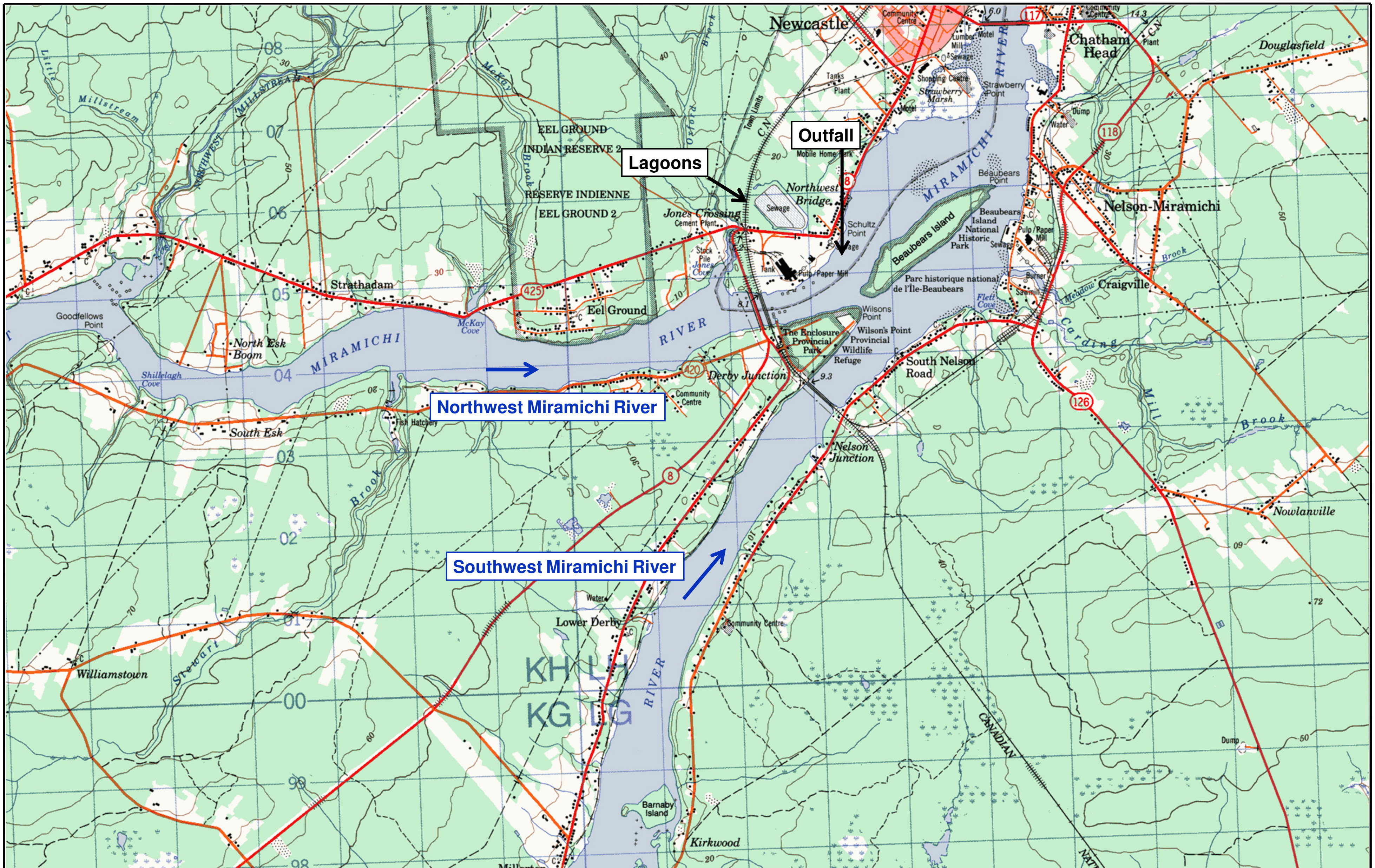


Environmental Risk Assessment

Miramichi Lagoons

Location Map

NATECH

Environmental Services Inc.

2492 Route 640, Hanwell, NB, E3E 2C2

ph: (506) 455 1085, fax (506) 455 1088

DATE: 2015/10/20	FILE: MLC-15-01
SCALE: 1 KM GRID	FIGURE: 1-1

2. METHODOLOGY

This Environmental Risk Assessment is based on the methodology provided in the *Canada-wide Strategy for the Management of Municipal Wastewater Effluent* (CCME, 2009). The CCME methodology relies on the concept of allocating a mixing zone, at the edge of which the Canadian Guidelines for the Protection of Aquatic Life (CCME, 2015) should be met for all substances of potential concern.

The substances of potential concern were determined based on the default list provided in the CCME Strategy, and based on the results of the Ecological Risk Assessment carried out during the preparation of the Closure Plan for the site (Intrinsik, 2015). It should be noted that the federal *Fisheries Act* also requires that the effluent from the lagoons should not be acutely toxic to fish.

For each relevant substance of potential concern, a calculation was carried out to determine what level of dilution would be needed to avoid negatively impacting the river water quality downstream (once the diluted effluent reaches the edge of the mixing zone).

A mixing model was run for various discharge scenarios. Several effluent flow rates were simulated, during both average and low river flow conditions. An appropriate effluent flow rate to drain the lagoons was selected, based on the dilution requirements and the model predictions.

3. RECEIVING WATER BODY CHARACTERIZATION

3.1 Physical Characteristics

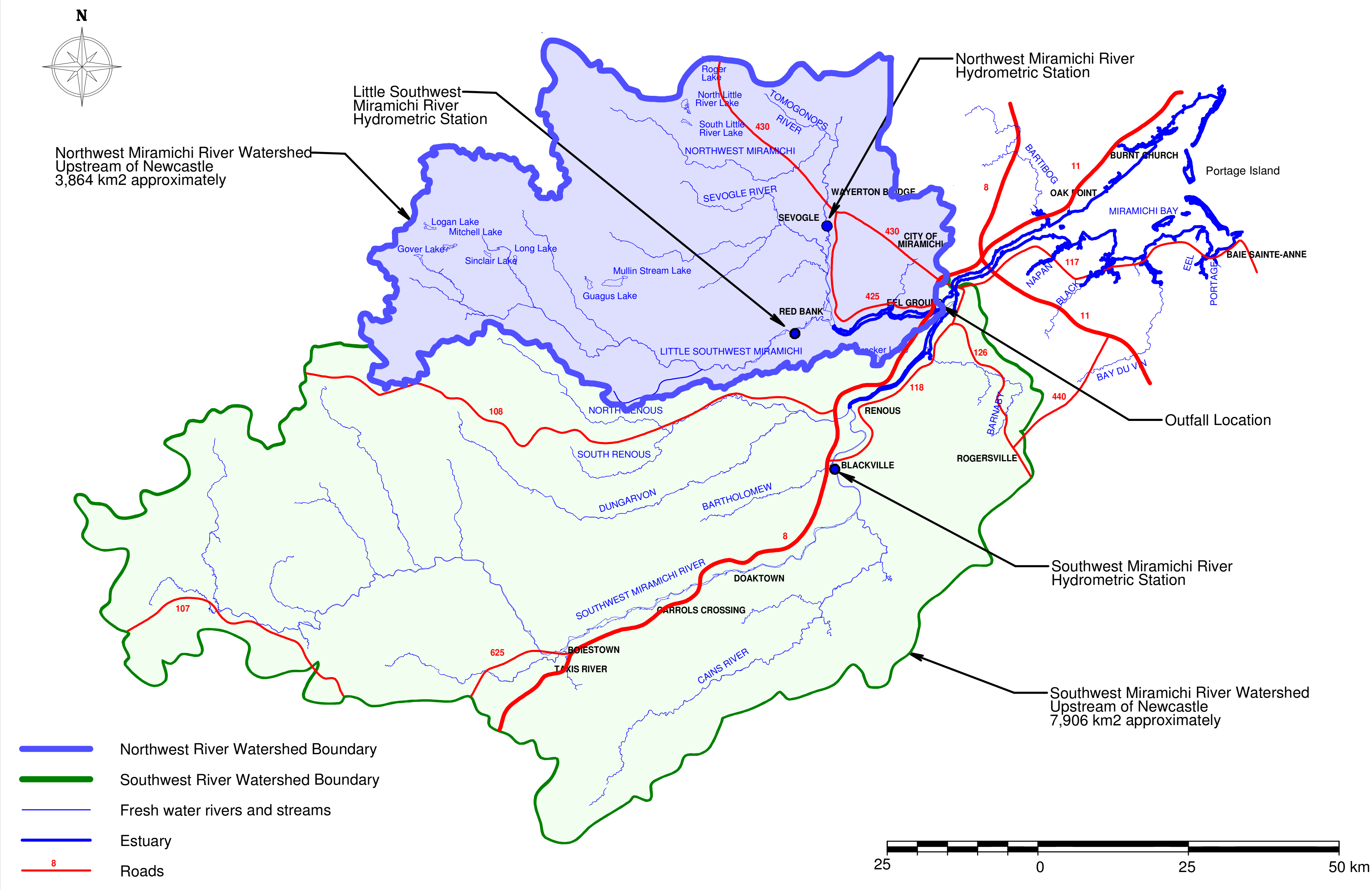
The Northwest Miramichi and the Southwest Miramichi merge close to the outfall location, forming the Miramichi River Estuary. For the purpose of this assessment, it was assumed that only the flow from the Northwest Miramichi contributes to effluent dilution in the vicinity of the outfall, due to the presence of a large island separating the two river channels (see Figure 1-1). This assumption is assumed to provide conservative results.

Figure 3-1 shows the drainage area of the Northwest Miramichi River upstream of the WWTP outfall. This area covers approximately 3,864 km^2. Table 3.1 lists the typical flow statistics at several gauging stations from Environment Canada located in the Miramichi River watershed. The river flows at the outfall location were calculated by proration based on records from these gauging stations. Figure 3-2 illustrates the prorated monthly river flows. The average flow of the Northwest Miramichi River is 92 m^3/s, and the 7 day-10 year low flow (7DQ10) is approximately 9.1 m^3/s.

The water level in the Miramichi River at the outfall location is influenced by the tides. Table 3.2 lists the characteristics of the tides for the Newcastle area. The average tidal amplitude is 1.3 m.

3.2 Resource Usage Downstream

The river flows through the City of Miramichi downstream of the outfall, and widens into a large estuary after 25 km. There are aquaculture sites in the estuary. Most of the inner bay of the estuary is closed to shellfish harvesting due to contamination with micro-organisms. The Miramichi River is used for recreation and the potential for bodily contact can not be precluded. There are no residential properties along the river within 250 m of the outfall.



Environmental Risk Assessment Miramichi Lagoons Watershed areas	NATECH Environmental Services Inc. 2492 Route 640, Hanwell, N.B., E3E 2C2 Ph: (506) 455-1085 Fax: (506) 455-1088	Date: 2015/09/15	File: MLC-15-01
		Scale: AS SHOWN	Figure: 3-1

Table 3.1. Characteristics of the Miramichi River Tributaries

Parameter	**Southwest Miramichi River at Blackville (Station 01BO001)**	**Little Southwest Miramichi River at Lyttleton (Station 01BP001)**	**Northwest Miramichi River at Trout Brook (Station 01BQ001)**	**Northwest Miramichi River at WWTP outfall location (1)**
Drainage area (km^2)	5,050	1,340	948	3864
Flow regime	Natural	Natural	Natural	Natural
Average annual flow (m^3/s)	**117**	**33**	**22**	**92**
Average annual flow ($L/s/km^2$)	23.2	24.7	22.9	23.9
1:10 year - 7 day (7DQ10) low flow (m^3/s)	**13.5**	**3.5**	**1.9**	**9.1**
7DQ10 low flow ($L/s/km^2$)	2.7	2.6	2.0	2.3

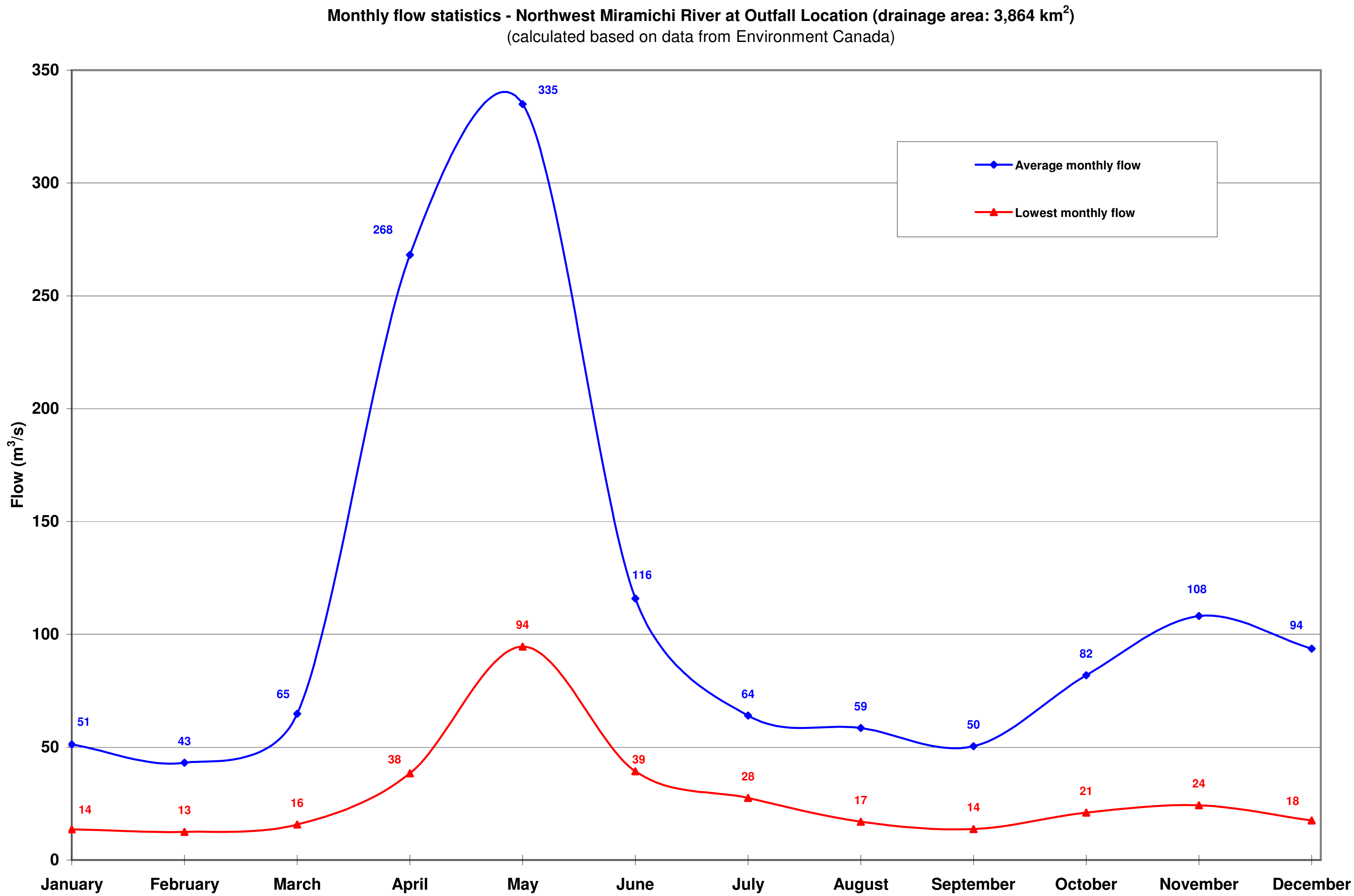
Note: Statistics obtained from Caissie et al. (2011)

(1) Prorated based on flows for Stations 01BP001 and 01BQ001, both located upstream of the outfall.

Table 3.2. Tidal water level characteristics in Newcastle (from Nautical Chart No. 4912).

Parameter	**Mean tides**		**Large tides**	
	(m above CD)	(m geodetic)	(m above CD)	(m geodetic)
Low water level	0.1	-0.5	0.0	-0.6
High water level	1.4	0.8	1.9	1.3
Range	1.3		1.9	

Note: the chart datum (CD, 0.0 m elevation on nautical chart) is at -0.6 m geodetic in Escuminac (at the southern end of Miramichi Bay). The mean water level is at 0.6 m above CD (0.0 m geodetic) in Newcastle.



Environmental Risk Assessment **Miramichi Lagoons** **River Flow Statistics**	NATECH **Environmental Services Inc.** 2492 Route 640, Hanwell, NB, E3E 2C2 Phone: (506) 455-1085 Fax: (506) 455-1088	**DATE:** 2015/10/20	**FILE:** MLC-15-01
		SCALE: As shown	**FIGURE:** 3-2

3.3 Background Water Quality

Table 3.3 summarizes background river water quality data obtained from the New Brunswick Department of Environment and Local Government (NBDELG).

Table 3.3. Historical water quality for the Northwest Miramichi River near Exmoor

Parameter	Unit	Min	Max	Average	Number of data
DO	mg/L	6.5	11.9	**9.4**	14
TSS	mg/L	<10	<10	**<10**	9
NH_3-N Total	mg/L	<0.01	0.08	**0.02**	24
Nitrite	mg/L	<0.05	<0.05	**<0.05**	24
Nitrate	mg/L	<0.05	0.09	**<0.05**	24
TN	mg/L	<0.3	0.4	**<0.3**	24
TP	mg/L	0.004	0.019	**0.010**	24
pH	units	6.8	7.8	**7.3**	13
Hardness	mg/L	13	24	**19**	24
Aluminum	µg/L	20	380	**126**	24
Arsenic	µg/L	<1.0	1.1	**<1.0**	24
Cadmium	µg/L	<0.1	0.2	**< 0.1**	24
Chromium	µg/L	<0.5	0.8	**< 0.5**	24
Copper	µg/L	<0.5	2.6	**1.0**	24
Iron	µg/L	87	699	**303**	24
Lead	µg/L	<1	6.0	**1.2**	24
Nickel	µg/L	<5	<5	**<5**	24
Zinc	µg/L	<5	10	**6**	24

Note: summary based on data from 2008 to 2013, typically measured between May and December

3.4 Field Reconnaissance

The following conditions were observed during field work carried out on September 2, 2015:

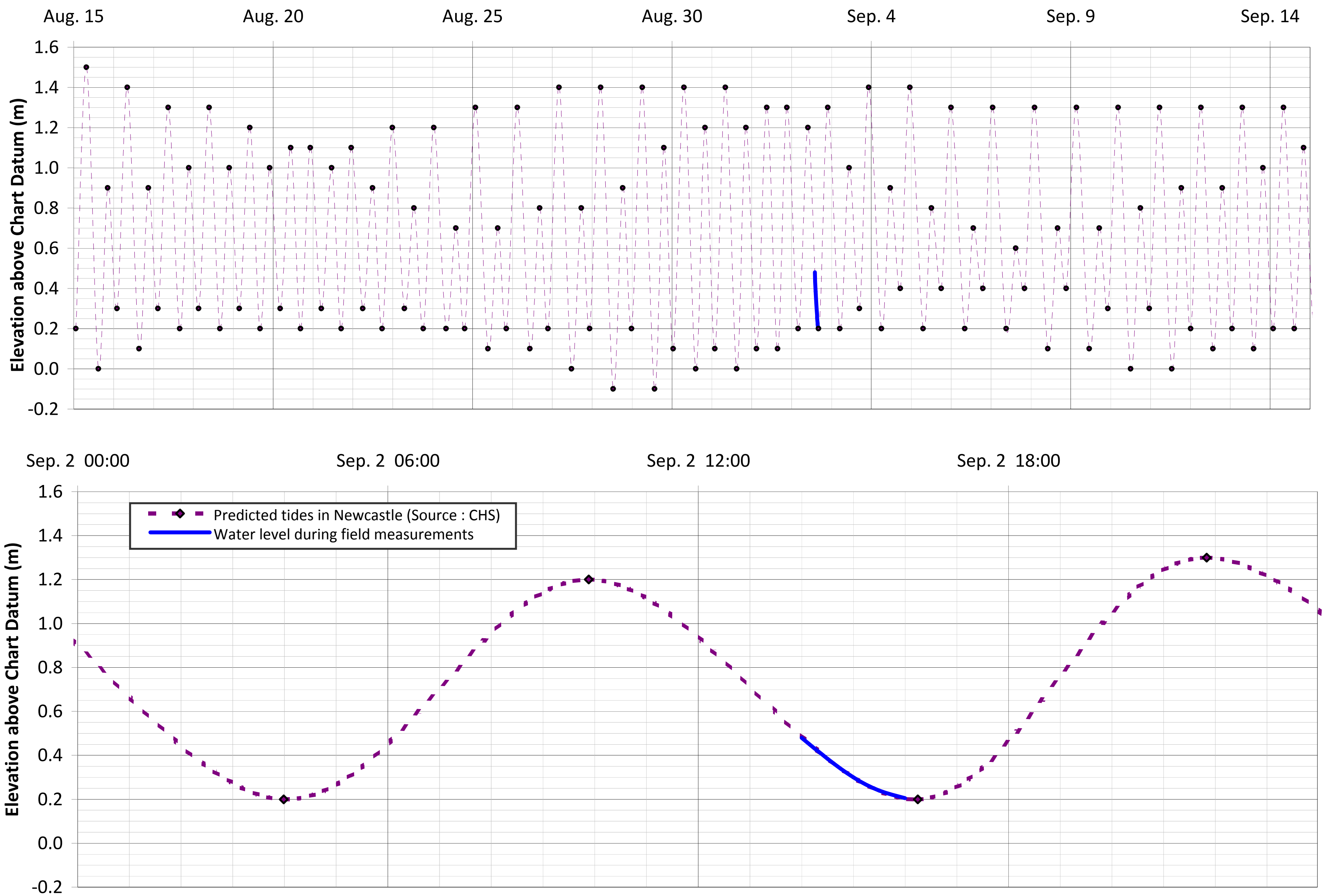
- The tidal amplitude was 1.0 m, as illustrated Figure 3-3.

- Based on the two gauging stations from Environment Canada located upstream on the same river (Northwest Miramichi) and on the Little Southwest Miramichi, the river flow was approximately 18.4 m^3/s at the outfall location, which is roughly twice more than the seven-day ten year low flow of 9.1 m^3/s calculated at the same location (see Table 3.1).

- Current velocities in the Miramichi River ranged from 0.26 to 0.65 m/s, during the second half of the falling tide. Figure 3-4 illustrates where the velocities were recorded, using drogues equipped with GPS devices.

- The bathymetry measured in the outfall area is displayed on Figure 3-5. The end of the outfall pipe is located approximately 30 m from the shore at low tide, and 40 m from the shore on average. Figures 3-6 and 3-7 show cross-sectional views of the river and of the outfall.

- Water quality measurements were taken upstream of the outfall, at the location shown on Figure 3-4. A sample was collected at the same location and sent to an independent laboratory for additional testing. The water quality results are listed in Table 3.4.



Environmental Risk Assessment
Miramichi Lagoons
Water Level Variations in the Miramichi River
in August and September of 2015

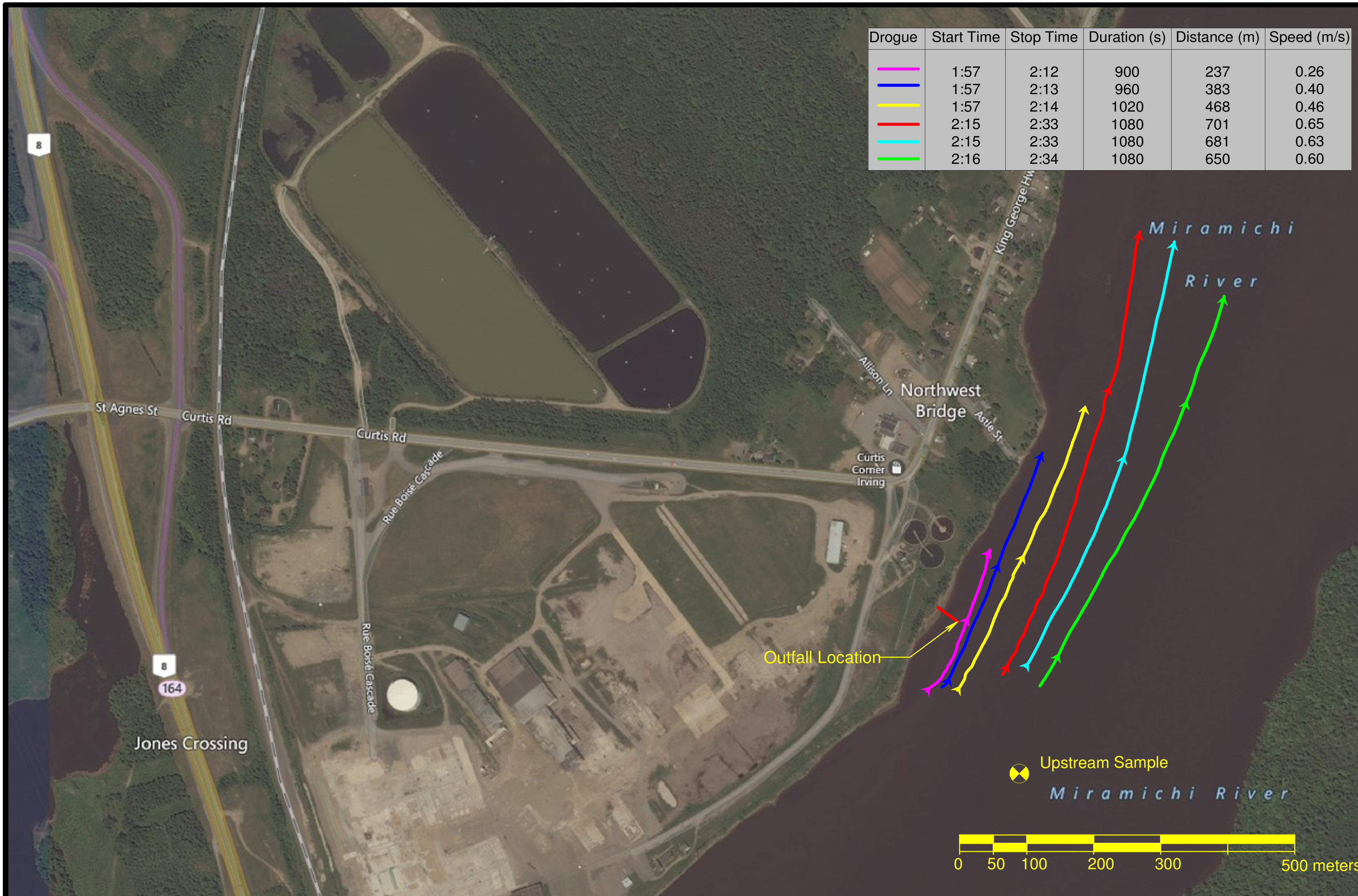
NATECH
Environmental Services Inc.
2492 Route 640, Hanwell, NB, E3E 2C2
Phone: (506) 455-1085 Fax: (506) 455-1088

DATE: 2015/10/20

FILE: MLC-15-01

SCALE: As shown

FIGURE: 3-3



Drogue	Start Time	Stop Time	Duration (s)	Distance (m)	Speed (m/s)
magenta	1:57	2:12	900	237	0.26
blue	1:57	2:13	960	383	0.40
yellow	1:57	2:14	1020	468	0.46
red	2:15	2:33	1080	701	0.65
cyan	2:15	2:33	1080	681	0.63
green	2:16	2:34	1080	650	0.60

Environmental Risk Assessment
Miramichi Lagoons
Current Velocity Measurements and
Sampling Locations on September 2 , 2015

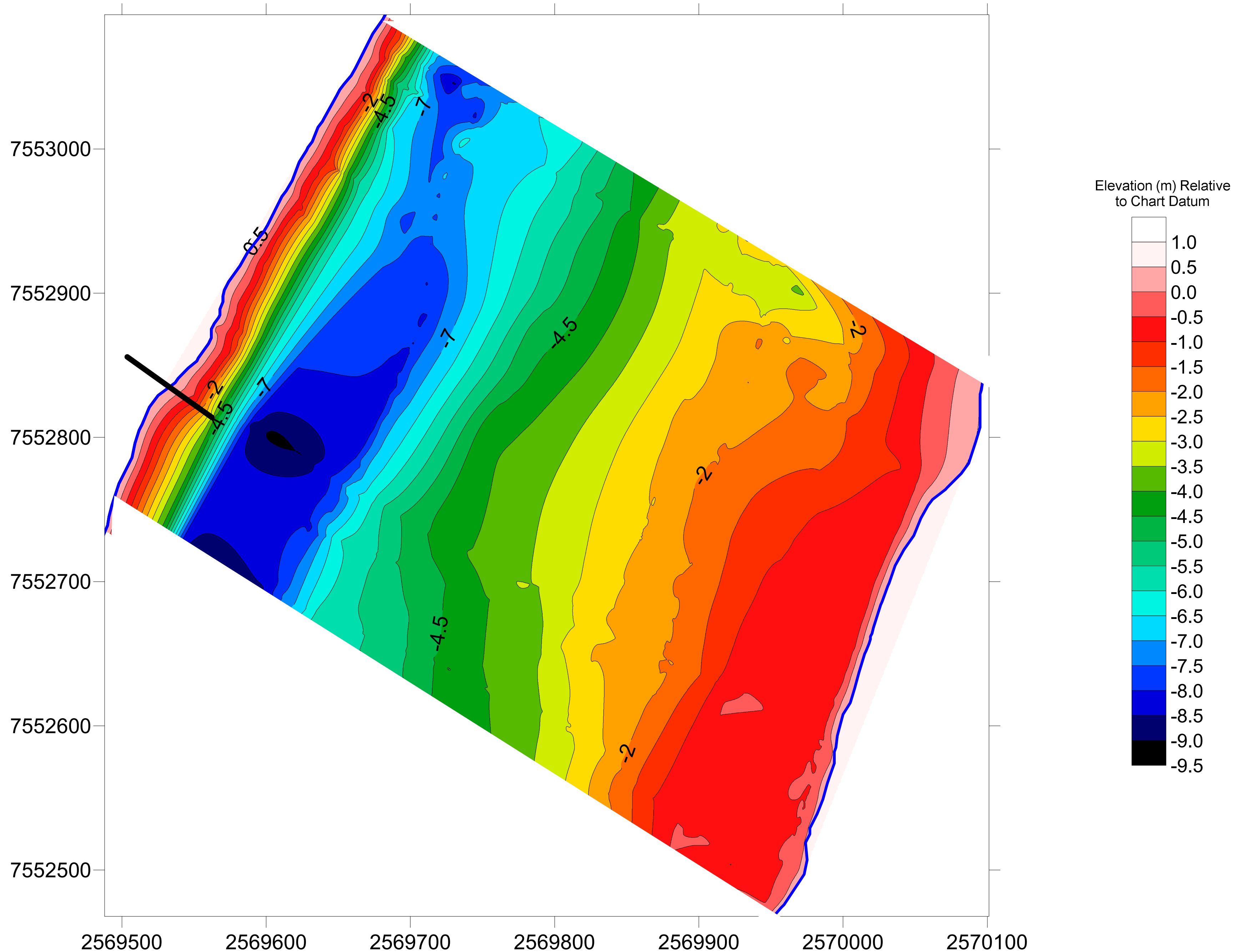
NATECH
Environmental Services Inc.
2492 Route 640, Hanwell, NB E3E 2C2
Ph: (506) 455-1085 Fax: (506) 455-1088

Date: Date: 2015/09/21

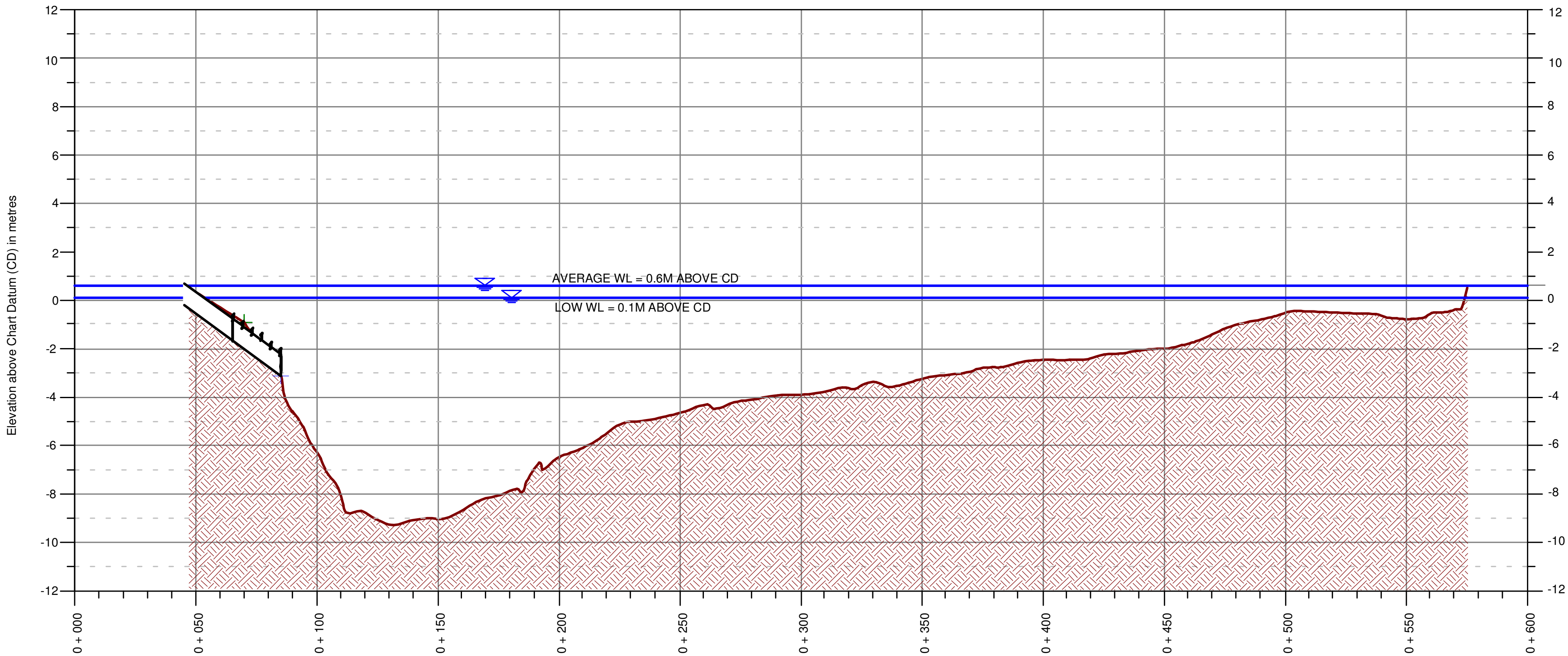
Project No.: N du projet MLC-15-01

Scale: Echelle: AS SHOWN

Sheet No.: Nº de la feuille: FIGURE 3-4



Environmental Risk Assessment Miramichi Lagoons Bathymetric Survey on September 2, 2015	NATECH Environmental Services Inc. 2492 Route 640, Hanwell, N.B. E3E 2C2 Ph.: (506) 455-1085 Fax: (506) 455-1088	DATE: 2015/09/02	FILE: MLC-15-01
		SCALE: NB Stereographic Coordinates (m)	FIGURE: 3-5

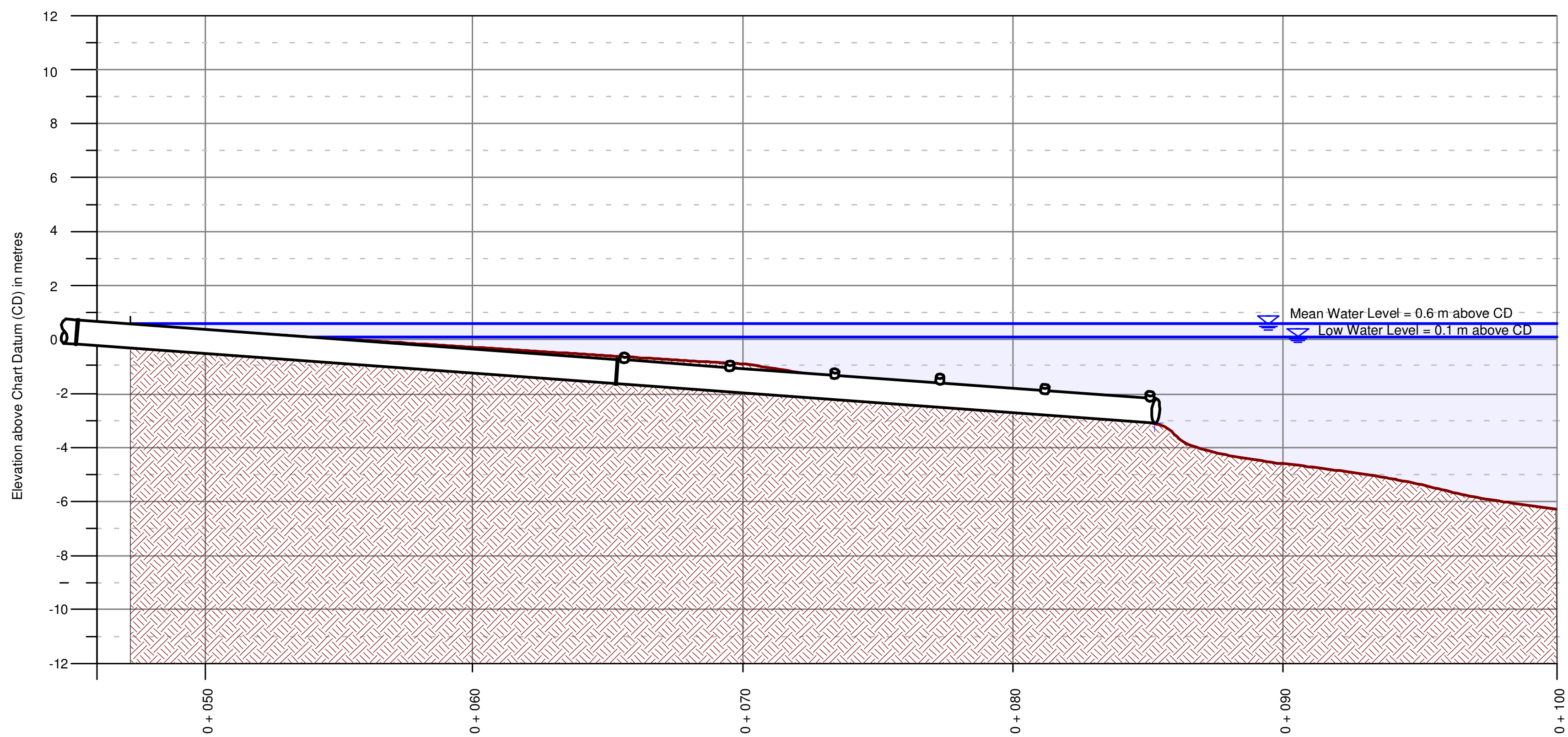


Northwest Miramichi River Profile at Outfall Location

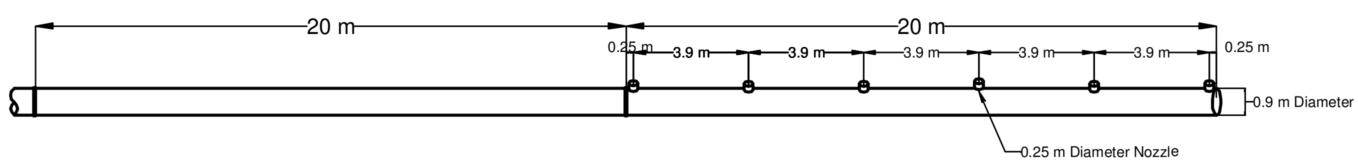
Environmental Risk Assessment
Miramichi Lagoons
Profile of the Northwest Miramichi River

NATECH Environmental Services Inc.
2492 Route 640, Hanwell, NB E3E 2C2
Ph: (506) 455-1085 Fax: (506) 455-1088

Date: Date: 2015/09/21	Project No.: Nº du projet MLC-15-01
Scale: Echelle: Distances in metres	Sheet No.: Nº de la feuille: FIGURE 3-6



Northwest Miramichi River Profile at Outfall Location



Diffuser Detail

Environmental Risk Assessment
Miramichi Lagoons
Profile & Outfall Pipe Detail

NATECH Environmental Services Inc.
2492 Route 640, Hanwell, NB E3E 2C2
Ph: (506) 455-1085 Fax: (506) 455-1088

Date: / Date: 2015/09/21	Project No.: / Nº du projet MLC-15-01
Scale: / Echelle: Distances in metres	Sheet No.: / Nº de la feuille: FIGURE 3-7

Table 3.4. Water quality of the Miramichi River upstream of the outfall on Sept. 2, 2015

Parameter	**Unit**	**Value**
Field measurements		
DO	mg/L	7.7
pH	units	7.8
Temperature	°C	22.3
Conductivity	mS/cm	9.8
Salinity	ppt	5.5
Laboratory analyses		
$CBOD_5$	mg/L	<6
TSS	mg/L	5
NH_3-N Total	mg/L	<0.05
TKN	mg/L	<0.25
TP	mg/L	0.023
Aluminum	µg/L	70
Arsenic	µg/L	<10
Boron	µg/L	780
Cadmium	µg/L	<0.1
Chromium	µg/L	<10
Copper	µg/L	<10
Iron	µg/L	300
Lead	µg/L	<1
Mercury	µg/L	<0.025
Molybdenum	µg/L	3
Nickel	µg/L	<10
Selenium	µg/L	<10
Silver	µg/L	<1
Thallium	µg/L	<1
Uranium	µg/L	<1
Vanadium	µg/L	20
Zinc	µg/L	<10

4. EFFLUENT QUALITY

Effluent quality data are not available. However in 2014 the water quality of the three formerly Aerated Stabilization Basins (ASB) was tested. The results are listed in Table 4.1.

Table 4.1. Water quality results from samples taken on May 15, 2014

Parameter	Unit	ASB 1	ASB 2	ASB 3
Field measurements				
DO	mg/L	11.7	15.8	22.0
pH	units	8.5	8.5	8.1
Temperature	°C	12.7	14.1	19.1
Conductivity	mS/cm	0.836	0.623	0.397
Salinity	ppt	0.4	0.3	0.2
Laboratory analyses				
$CBOD_5$	mg/L	<6	12	30
TSS	mg/L	7	8	38
NH_3-N Total	mg/L	0.11	0.47	5.20
TKN	mg/L	1.4	2.8	11.9
TP	mg/L	0.090	0.126	0.500
Aluminum	µg/L	342	231	643
Arsenic	µg/L	2	1	<1
Boron	µg/L	48	39	38
Cadmium	µg/L	0.04	0.03	0.05
Chromium	µg/L	<1	<1	<1
Copper	µg/L	1	<1	1
Iron	µg/L	160	80	70
Lead	µg/L	5.9	0.4	0.6
Mercury	µg/L	<0.025	<0.025	<0.025
Molybdenum	µg/L	0.4	0.6	0.4
Nickel	µg/L	3	<1	<1
Selenium	µg/L	<1	<1	<1
Silver	µg/L	<0.1	<0.1	<0.1
Thallium	µg/L	<0.1	<0.1	<0.1
Uranium	µg/L	0.3	0.2	<0.1
Vanadium	µg/L	6	3	8
Zinc	µg/L	10	4	9

5. DETERMINATION OF EFFLUENT DISCHARGE FLOW RATE

5.1 Applicable River Quality Guidelines

The guideline values applicable to the Miramichi River mainly consist of the Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2015). There are two different sets of values, for freshwater environments, and for marine/estuarine environments. Here both were taken into consideration because the river in the outfall area is subject to the tides and is brackish at times. The stricter of the two values was applied. Table 5.1 lists the guideline values chosen. When no value was provided in the CCME guidelines for a particular parameter, other guideline sources were used, as explained in the footnotes.

Table 5.1. Water Quality Guidelines for the Miramichi River

Parameter	Unit	Freshwater guidelines	Estuarine guidelines	Guideline Chosen
DO	mg/L	DO > 6.5 (1)	DO >8.0 (1)	**DO > 8.0**
TSS	mg/L	**<5 to <25 above background (2)**		
NH_3-N Total	mg/L	<0.29 - 2.7 (3)	<0.69 - 4.6 (3)	**<0.29**
TKN	mg/L	<0.50 (4)	<0.55 (4)	**<0.50**
TP	mg/L	<0.035 (5)	<0.055 (5)	**<0.035**
pH	units	6.5 - 9.0	7.0 - 8.7	**7.0 - 8.7**
Aluminum	µg/L	<100 (6)	NA	**<100**
Arsenic	µg/L	<5	<12.5	**<5**
Boron	µg/L	<1500	NRG	**<1500**
Cadmium	µg/L	<0.09	<0.12	**<0.09**
Chromium	µg/L	<1	<1.5	**<1**
Copper	µg/L	<2 (7)	NA	**<2**
Iron	µg/L	<300	NA	**<300**
Lead	µg/L	<1 (7)	NA	**<1**
Mercury	µg/L	<0.026	<0.016	**<0.016**
Molybdenum	µg/L	<73	NA	**<73**
Nickel	µg/L	<25 (7)	NA	**<25**
Selenium	µg/L	<1	NA	**<1**
Silver	µg/L	<0.1	<7.5	**<0.1**
Thallium	µg/L	<0.8	NA	**<0.8**
Uranium	µg/L	<15	NRG	**<15**
Vanadium	µg/L	<6 (8)	NA	**<6 (8)**
Zinc	µg/L	<30	NA	**<30**
Acute toxicity	TU	**<1 (non-lethal) at end of pipe (9)**		

NA = Not available, NRG=no recommended guideline TU = toxicity unit

(1) **Dissolved oxygen:**

6.5 mg/L was chosen as a minimum for cold water fish species in freshwater

Freshwater guideline:

"The concentration of dissolved oxygen for early life stages of cold water species shall be equal to or greater than 9.5 ppm and for other life stages shall be equal to or greater than 6.5 ppm; the concentration of dissolved oxygen for early life stages of warm water species shall be equal to or greater than 6.0 ppm and for other life stages shall be equal to or greater than 5.0 ppm." (New Brunswick Water Classification Regulation, 2002). The Canadian Water Quality Guidelines for the Protection of Aquatic Life are similar except for warm water species- other life stages where the lowest acceptable dissolved oxygen concentration "shall be equal to or greater than 5.5 ppm.

Marine/estuarine waters: "The recommended minimum concentration of DO in marine and estuarine waters is 8.0 mg/L. Depression of DO below the recommended value should only occur as a result of natural processes. When ambient DO concentrations are >8.0 mg/L, human activities should not cause DO levels to decrease by more than 10% of the natural concentration expected in the receiving environment at that time." From Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2015)

(2) **Suspended sediments:**

Clear flow : Maximum increase of 25 mg/L from background levels for any short-term exposure (e.g., 24-h period). Maximum average increase of 5 mg/L from background levels for longer term exposures (e.g., inputs lasting between 24 h and 30 d).

High flow: Maximum increase of 25 mg/L from background levels at any time when background levels are between 25 and 250 mg/L. Should not increase more than 10% of background levels when background is >250 mg/L. From Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2015)

(3) **Ammonia:**

Freshwater: The guideline for NH_3-N (unionized) is a maximum of 0.019 mg/L . The corresponding NH_3-N (total) concentration is given by the following equation

$$\mathbf{NH_3\text{-N (unionized)} = (NH_3\text{-N Total}/0.8224)/(1+10^{0.0901821+2729.92\ (T+273.15)-pH})}$$

with T the ambient water temperature in deg. C.

Here in the worst-case of a pH of 8.0 and a water temperature of 25°C in the river, NH_3-N total should be less than 0.29 mg/L (in the summer, from June to September). For an average case of a pH of 7.5 and a temperature of 10°C in the river, NH_3-N total should be less than 2.7 mg/L.

Marine/estuarine waters: There is no recommended guideline for marine aquatic life from CCME. The following values for total NH_3-N were determined based on values used in BC (Nordin, 2001), assuming a temperature

of 25 deg. C, and a pH of 8.0 in the estuary:
<0.69 mg/L average 5 to 30-day concentration, and <4.6 mg/L maximum concentration

(4) **Total Kjeldahl Nitrogen:**
Freshwater: 0.5 mg/L was chosen based on the "moderately impaired" criteria for the St. John River proposed by the Canadian Rivers Institute (2011). No criteria for TKN is available in the Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2015).
Marine/estuarine waters: A maximum concentration of 0.55 mg/L for nitrogen was chosen based on the mean guidelines proposed by Bricker et al (1999) for a medium degree of over-enrichment in estuarine waters (in CCME, 2007).

(5) **Total Phosphorus:**
Freshwater: 0.035 mg/L was chosen to remain in the meso-eutrophic trigger range.
The trigger ranges are: Ultra-oligotrophic: <0.004 mg/L
Oligotrophic: 0.004 to 0.010 mg/L
Mesotrophic: 0.010 to 0.020 mg/L,
Meso-eutrophic: 0.020 to 0.035 mg/L,
Eutrophic range: 0.035 to 0.100 mg/l
(From Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2015)
Marine/estuarine waters: A maximum concentration of 0.055 mg/L for phosphorus was chosen based on the mean guidelines proposed by Bricker et al (1999) for a medium degree of over-enrichment in estuarine waters (in CCME, 2007).

(6) **Aluminum:** Freshwater: guideline values calculated assuming a pH greater than 6.5 in the river.

(7) **Copper, lead, nickel:** Freshwater: guideline values calculated assuming a hardness of 20 mg/L in the river (based on Table 3.3).

(8) **Vanadium**: No CCME guideline is available, instead the water quality objective of less than 6 µg/L from the Ontario Ministry of Environment (1994) was used.

(9) **Acute toxicity:** limits stated in the Canada-wide Strategy for the Management of Municipal Wastewater Effluent (CCME, 2009). "TU" means Toxicity Unit. The toxicity value in TU is the dilution level at which the effluent stops being toxic (0 TU means no toxicity, and a value greater than 1 means that some toxicity is present). The federal *Fisheries Act* also required that the effluent should not be acutely toxic to fish.

5.2 Effluent Dilution Needed

For each water quality parameter of concern, a calculation was carried out to determine how diluted the effluent from the lagoons would have to be to ensure that the concentration of the mix of effluent water and river water would meet the corresponding river water quality guideline. The following equations were used:

Conservation of matter:

$$Q_{upstream} \times C_{upstream} + Q_{effluent} \times C_{effluent} = Q_{downstream} \times C_{downstream}$$

with Q the flows and C the concentrations, and:

$$Q_{downstream} = Q_{upstream} + Q_{effluent}$$

The effluent dilution is defined as:

$$D = 1 / (Q_{effluent} / Q_{downstream})$$

By combining the above equations the dilution needed can be calculated using only concentrations:

$$D = 1 + (C_{effluent} - C_{downstream}) / (C_{downstream} - C_{upstream})$$

The calculated dilutions are listed in Table 5.2 . For the purpose of this calculation and to be conservative, the effluent concentration used ($C_{effluent}$) was the highest value measured in 2014. The downstream concentration used ($C_{downstream}$) was either the river guideline value, or when the river background was already higher than the guideline, a criteria of a maximum increase of 10% over the measured background was used for the calculation. ($C_{downstream} = C_{upstream} * (100+10)/100$). This is the case for aluminum and lead.

It appears that a dilution in the order of 1 in 40 would be sufficient for the diluted effluent to either meet the river quality guidelines or be within 10% of the background concentrations.

Table 5.2 Calculated effluent dilution needed for each water quality parameter

Parameter	**Unit**	**River guideline** (1)	**Average River WQ** (2)	**Water quality in basins (range)** (3)	**Dilution needed**
DO	mg/L	**DO > 8**	9.4	$CBOD_5$ from 12 to 22	**16**
TSS	mg/L	**<5 to <25 above background**	5 assumed	7 - **38**	**7 to 1**
NH_3-N Total	mg/L	**<0.29**	0.02	0.10 - **5.2**	**19**
TKN	mg/L	**<0.50**	<0.30, 0.10 assumed	1.4 - 11.9	**30**
TP	mg/L	**<0.035**	0.010	0.090 - 0.500	**20**
pH	units	**7.0 - 8.7**	6.8 - 7.8	8.1 - 8.5	None
Aluminum	µg/L	**<100**	**126**	**231 - 643**	**41**
Arsenic	µg/L	**<5**	<1	<1 - 2	None
Boron	µg/L	**<1500**	780	38 - 48	None
Cadmium	µg/L	**<0.09**	<0.1	0.03 - 0.05	None
Chromium	µg/L	**<1**	<0.5	<1	None
Copper	µg/L	**<2**	1	<1 - 1	None
Iron	µg/L	**<300**	303	70 - 160	None
Lead	µg/L	**<1**	**1.2**	0.4 - **5.9**	**39**
Mercury	µg/L	**<0.016**	<0.025	<0.025	None
Molybdenum	µg/L	**<73**	3	0.4 - 0.6	None
Nickel	µg/L	**<25**	<5	<1 to 3	None

Parameter	**Unit**	**River guideline (1)**	**Average River WQ (2)**	**Water quality in basins (range) (3)**	**Dilution needed**
Selenium	µg/L	**<1**	<10	<1	None
Silver	µg/L	**<0.1**	<1	<0.1	None
Thallium	µg/L	**<0.8**	<1	<0.1	None
Uranium	µg/L	**<15**	<1	<0.1 - 0.3	None
Vanadium	µg/L	**<6**	**20**	3 - 8	None (effluent concentration lower than background)
Zinc	µg/L	**<30**	6	4 - 10	None
Acute toxicity	TU	**<1 at end of pipe**	NA	NA	No dilution allowed

NA = Not available

TU = toxicity unit

(1) From Table 5.1

(2) From Tables 3.3 and 3.4

(3) From Table 4.1

5.3 Allocated Mixing Zone

In the case of the Miramichi River, three conditions limit the size of the mixing zone that can be allocated (CCME, 2009) and:

- ❑ A maximum dilution factor of 1 in 100 is allowed at the edge of the mixing zone (NBDELG, 2011).
- ❑ The mixing zone cannot extend past 250 m of the outfall in any direction (NBDELG, 2012).
- ❑ A mixing zone should not occupy more than 25% of the cross-sectional area or volume of flow of a receiving watercourse, during 7 day - 10 year low flow conditions (Schedule B of Regulation 2002-13 under the NB Clean Water Act).

It was recommended in the previous section that a 1 in 40 dilution of the effluent should be achieved within the mixing zone allocated, which does not conflict with the first condition.

The second condition requires that this 1 in 40 level of dilution should occur within 250 m from the outfall.

The third condition implies that during extreme low flow conditions in the river (7 day duration - 10 year return period low flow), the 1 in 40 dilution should be achieved by the time the effluent mixes into 25% of the river flow (calculated to be 9.1 m^3/s in Table 3.1). Therefore under such conditions the effluent discharge rate would be limited to 0.057 m^3/s (9.1 times 25% and divided by 40). To discharge at higher flow rates there should be more flow in the river, and it would be preferable to empty the lagoons in the spring rather than in the summer. The lowest monthly flows on record are 94 m^3/s in May and 39 m^3/s in June, compared to 17 m^3/s in August and 14 m^3/s in September (see Figure 3-2).

5.4 Mixing Calculations

The CORMIX model was run to simulate the effluent mixing under average and worst-case scenarios, to determine the range of dilutions that can be achieved within 250 m of the outfall. The average scenario consists of an average flow (92 m^3/s) and average water level in the river (0.6 m above chart datum). The worst-case scenario consists of the 7DQ10 low river flow (9.1 m^3/s) combined with a low tide water level (0.1 m above chart datum).

Based on the 2014 bathymetric survey of the three basins, they contain approximately 390,000 m^3 of sludge, and 320,000 m^3 of water. Several effluent flow rates were tested (0.240, 0.120, and 0.060 m^3/s) corresponding to various time requirements to drain the water volume (2 weeks, 1 month, 2 months respectively).

The diffuser was replicated in the CORMIX model as a accurately as possible, based on the results of the recent underwater survey carried out in September of 2015. During that survey five nozzles of 0.25 m diameter were located, placed from 15 m to 30 m from the shore. Also the end cap was found to be still in place.

Table 5.3 lists the main assumptions used in the model, as well as the results of the simulations. The dilution predicted 250 m downstream of the outfall is usually greater than 40, except for the highest effluent flow under the worst-case scenario (1 in 30 predicted).

Therefore the drainage period recommended is one month, with a corresponding discharge flow of 0.120 m^3/s (120 L/s, or 1,900 USgpm).

Table 5.3. Cormix assumptions and results for various discharge scenarios

Parameter	Unit	Average case simulations			Worst case simulations		
CORMIX assumptions							
Receiving water:							
River width	m	530			520		
River flow	m3/s	92			9.1		
Depth at outfall	m	1.5 to 3.5			1.0 to 3.0		
Current speed	m/s	1.0			0.1		
Outfall:							
Effluent flow	L/s	0.240	0.120	0.060	0.240	0.120	0.060
CORMIX results							
Distance to 1:50	m	1	0.5	0.3	600	220	15
Distance to 1:100	m	3	1.0	0.5	1000	560	210
Distance to 1:200	m	250	3	1	1500	910	490
Characteristics 250 m downstream							
Dilution	**1 in**	**200**	**405**	**810**	**30**	**50**	**110**
Plume width	m	20	20	20	105	85	75
Plume thickness	m	2.5	2.5	2.5	1.4	1.3	1.1

6. CONCLUSIONS AND RECOMMENDATIONS

This Environmental Risk Assessment was carried out to determine at what rate and when the former UPM wastewater treatment lagoons could be drained, without negatively impacting the receiving environment downstream (the Miramichi River). As part of the ecological closure plan for the lagoon site, the water in the three formerly aerated cells is to be drained, and the sludge in the cells will remain in place, be allowed to dry out, and be vegetated. The berms will be breached and future surface runoff will be directed into an adjacent ditch. Currently, the overflow from the lagoons (due to precipitation) is discharged into the Miramichi River via the existing diffuser, and the same diffuser will be used to disperse the effluent when the lagoons are drained.

The diffuser was surveyed with the help of divers in September of 2015. Five nozzles were found, and the end of the pipe is capped and partially buried. At low tide and during low river flow conditions, the diffuser is in two metres of water depth, and extends from 15 m to 30 m from the shore. The average tidal water level is 0.5 m higher than the low tide level.

There are approximately 320,000 m^3 of water in the lagoons, and 390,000 m^3 of sludge. The water quality in the lagoon cells was tested in 2014 and showed elevated concentrations for certain parameters, compared to the Canadian Guidelines for the Protection of Aquatic Life (CCME, 2015) that apply to the river. These parameters include suspended solids, ammonia, total nitrogen, total phosphorus, and a few metals (aluminum, lead, and vanadium). Background water quality data for the river were collected and reviewed, and it was found that the same three metals are also exceeding the river guidelines upstream of the site, possibly due to the geochemistry of the soils in the watershed.

Calculations were carried out to determine how much effluent dilution is required to have a minimal impact on the river quality during the discharge. A dilution factor of 1 in 40 is recommended to ensure that the diluted effluent will either meet the river guidelines, or not exceed 10% of the background concentration upstream when this background is already above the guideline value.

The Environmental Risk Assessment framework from CCME (2009) and related NB regulations allow for the establishment of a mixing zone around an effluent discharge. At the edge of this mixing zone, the river quality guidelines should be met. The extent of a mixing zone in NB is limited in size by several conditions (maximum 250 m downstream, maximum 25% of the river during seven-day ten-year (7DQ10) low flow, and maximum 100 times dilution).

The CORMIX model was used to test different discharge scenarios , i.e. average case and worst case river conditions combined with several effluent flow rates. The average flow in the Northwest Miramichi River is calculated to be 92 m^3/s, and the 7DQ10 low flow 9.1 m^3/s. In this case the model predictions show that if the lagoons were drained over a one month period (which corresponds to an effluent flow rate of 0.120 m^3/s or 10,400 m^3/day) the dilution 250 m downstream of the outfall would greater than 1 in 40 in all scenarios. In comparison, when the pulp mill was operating it was discharging 65,000 m^3/day of effluent.

It is recommended to drain the lagoons in the spring (May or June) when the river flow is relatively high. If the flow was as low as the seven-day ten year low flow, the discharge rate would have to decrease by a factor of two to 0.060 m^3/s to meet the"25% of the river flow " limit, and it would take twice longer to drain the lagoons.

The Fisheries Act requires that the pure effluent (not diluted) must not be acutely toxic to fish, and the effluent will have to be tested for acute toxicity prior to starting to discharge.

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8. GLOSSARY

A

Acutely Lethal *(Létal aigu)*

At 100 percent concentration of effluent, more than 50 percent of the test species subjected to it over the test period are killed when tested in accordance with the acute lethality test set out in the appropriate method. For rainbow trout this is Reference Method EPS 1/RM/13.

Allocated Mixing Zone *(Zone de mélange allouée)***:** see mixing zone

Ammonia *(Ammoniac)*

Total ammonia expressed as nitrogen. Total ammonia means the sum of the unionized ammonia (NH_3) and ionized ammonia (NH_4+) species which exist in equilibrium in water. Analytical methods measure and typically report on ammonia nitrogen as opposed to total ammonia. The unionized ammonia (NH_3) is toxic to fish in low concentrations. The amount of NH_3 is calculated as a fraction of the total nitrogen, based on temperature and pH.

C

Canadian Environmental Quality Guidelines *(Recommandations canadiennes pour la qualité de l'environnement)*

Nationally endorsed, science-based goals for the quality of atmospheric, aquatic, and terrestrial ecosystems. Environmental quality guidelines are defined as numerical concentrations or narrative statements that are recommended as levels that should result in negligible risk to biota, their functions, or any interactions that are integral to sustaining the health of ecosystems and the designated resource uses they support. Developed by CCME.

Carbonaceous Biochemical Oxygen Demand (CBOD5, 5-day) *(Demande biochimique en oxygène des matières carbonées [DBO5C, 5 jours])*
A measure of the quantity of oxygen used in the biochemical oxidation of organic matter in 5 days, at a specific temperature, and under specified conditions. The method of analysis is defined by Method 5210 in Standard Methods. The CBOD is a fraction of the total BOD. This fraction is specific to each effluent.

Chronic Toxicity *(Toxicité chronique)*
The ability of a substance or mixture of substances to cause harmful effects over an extended period, usually upon repeated or continuous exposure sometimes lasting for the entire life of the exposed organism. Chronic toxicity results in reduced reproductive capacity or reduced growth of young, in fish or invertebrate populations.

Combined Sewer *(Égout unitaire)*
A sewer intended to receive both sanitary waste and storm water.

Combined Sewer Overflow (CSO) *(Débordement d'égout unitaire [DEU])*
A discharge to the environment from a combined sewer system that occurs when the hydraulic capacity of the combined sewer system has been exceeded, usually as a result of rainfall and/or snow melt events.

D

Designated Area *(Zone désignée)*
Sensitive areas as identified by the regulator and that may be affected by municipal wastewater discharges, such as fish spawning sites, beaches, drinking water intakes, etc.

E

Effluent Discharge Objective (EDO) *(Objectif environnemental de rejet [OER])*
Concentration, load or toxicity units that should be met at the municipal wastewater effluent discharge to adequately protect all water uses in the receiving environment. Effluent discharge objectives are obtained through an environmental risk assessment methodology using the principles of assimilative capacity and mixing zone, in conjunction with environmental quality.

Environmental Quality Objective (EQO) *(Objectif de qualité de l'environnement [OQE])*
Concentration of a substance considered safe for aquatic life and for the human uses that exist or should exist outside of a determined mixing zone. The *Canadian Environmental Quality Guidelines* (CEQG) are generic EQOs often used in Canada. The numerical concentrations or narrative statements that establish the conditions necessary to support and protect the most sensitive designated use of water at a specified site (CCME, 1987)

Environmental Risk Assessment (ERA) *(Évaluation des risques environnementaux [ERE])*
A procedure that will enable the establishment of effluent discharge objectives for substances of concern. This process will take into account the characteristics of the effluent and of the site-specific receiving environment. The environmental risk assessment includes a one-year period where a facility will characterize its effluent (initial characterization).

Eutrophication: Excessive growth of aquatic vegetation in response to elevated concentrations of nutrients (often associated with wastewater discharges).

M

Mixing Zone *(Zone de mélange)*

Also called the initial dilution zone. The area contiguous with a point source (effluent discharge site) or a delimited non-point source where the discharge mixes with ambient water and where concentrations of some substances may not comply with water quality guidelines or objectives. For the purpose of the Strategy, “mixing zone” means the “allocated mixing zone” at the edge of which environmental quality objectives should be met.

N

Near-Field Mixing Zone The volume of water between the end of the discharge pipe or the diffuser nozzle, and the point where the energy (mainly momentum and buoyancy) of the effluent has dissipated. Beyond this point - in the far-field - river or coastal current transport takes over.

Nutrient *(Élément nutritif)*

Any substance that is assimilated by organisms and promotes growth; generally applied to nitrogen and phosphorus in wastewater, but also to other essential and trace elements.

R

Receiving Environment *(Milieu récepteur)*

The water body into which effluent is discharged.

S

Streeter Phelps algorithm: A method of predicting oxygen depletion in a receiving water body as a function of organic loadings and existing background condition.