RAMP
Regional Aquatics Monitoring Program

2012 TECHNICAL REPORT
EXECUTIVE SUMMARY

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OVERVIEW

The Regional Aquatics Monitoring Program (RAMP) was initiated in 1997 in association with mining development in the Athabasca oil sands region near Fort McMurray, Alberta. RAMP is an industry-funded, multi-stakeholder initiative that monitors aquatic environments in the Regional Municipality of Wood Buffalo. The intent of RAMP is to integrate aquatic monitoring activities so that long-term trends, regional issues, and potential cumulative effects related to oil sands development (surface mining and in situ extraction) can be identified and assessed. In 2012, RAMP was funded by Suncor Energy Inc., Syncrude Canada Ltd., Shell Canada Energy, Canadian Natural Resources Limited, Imperial Oil Resources, Nexen Inc., Husky Energy, Total E&P Canada Ltd., MEG Energy Corp., Dover Operating Corp., ConocoPhillips Canada, Devon Energy Corp., Teck Resources Ltd., Cenovus Energy, Japan Canada Oil Sands Ltd., Statoil Canada Ltd., and Hammerstone Corporation. Non-funding participants included municipal, provincial, and federal government agencies, and one Aboriginal group.

The original Regional Municipality of Wood Buffalo boundary (pre-2012) in northeastern Alberta represents the Regional Study Area (RSA) of RAMP. Within this area, a Focus Study Area (FSA) has been defined and includes those parts of the following watersheds where oil sands and other developments are occurring or planned:

- Lower Athabasca River;
- Major tributary watersheds/basins of the lower Athabasca River including the Clearwater River, Christina River, Hangingstone River, Steepbank River, Muskeg River, MacKay River, Ells River, Tar River, Calumet River, High Hills River, and Firebag River;
- Select minor tributaries of the lower Athabasca River (McLean Creek, Mills Creek, Beaver River, Poplar Creek, Fort Creek, Pierre River, Eymundson Creek, Red Clay Creek, and Big Creek);
- Specific wetlands and shallow lakes in the vicinity of current or planned oil sands and related developments; and
- A selected group of 50 regional acid-sensitive lakes.

The RAMP FSA also includes the Athabasca River Delta as the receiving environment of any oil sands developments occurring in the Athabasca oil sands region.

RAMP incorporates both stressor- and effects-based monitoring approaches. Using impact predictions from the various oil sands environmental impact assessments, specific potential stressors have been identified that are monitored to document *baseline* conditions, as well as potential changes related to development. Examples include specific water quality variables and changes in water quantity. In addition, there is a strong emphasis in RAMP on monitoring sensitive biological indicators that reflect the overall condition of the aquatic environment. By combining both monitoring approaches, RAMP strives to achieve a more holistic understanding of potential effects on the aquatic environment related to oil sands development.

The scope of RAMP focuses on the following key components of boreal aquatic ecosystems:

1. Climate and hydrology are monitored to provide a description of changing climatic conditions in the RAMP FSA, as well as changes in the water level of selected lakes and in the quantity of water flowing through rivers and creeks.

2. Water quality in rivers, lakes and the Athabasca River Delta is monitored to assess the potential exposure of fish and invertebrates to organic and inorganic chemicals.

3. Benthic invertebrate communities and sediment quality in rivers, lakes and the Athabasca River Delta are monitored because they reflect habitat quality, serve as biological indicators, and are important components of fish habitat.

4. Fish populations in rivers and select lakes are monitored as they are biological indicators of ecosystem integrity and are a highly valued resource in the region.

5. Water quality in regional lakes sensitive to acidification is monitored as an early warning indicator of potential effects related to acid deposition.

RAMP is funded by member companies that are constructing and operating oil sands projects in the RAMP FSA. However, there are other companies that are constructing or operating oil sands projects, but who are not members of RAMP. Therefore, the term "focal projects" is used in the RAMP 2012 Technical Report to define those projects owned and operated by the 2012 industry members of RAMP listed above that were under construction or operational in 2012 in the RAMP FSA. For 2012, these projects included a number of oil sands projects and a limestone quarry project.

2012 RAMP industry members do have other projects in the RAMP FSA that were in the application stage as of 2012, or had received approval in 2012 or earlier, but construction had not yet started as of 2012. These projects are noted throughout this technical report, but are not designated as focal projects, as these projects in 2012 would not have contributed to any possible influences on aquatic resources covered by RAMP components.

The term "other oil sands developments" is used in the RAMP 2012 Technical Report to define those oil sands projects operated by non-RAMP members located within the RAMP FSA.

A weight-of-evidence approach is used for the analysis of RAMP data by applying multiple analytical methods to interpret results and determine whether any changes have occurred due to focal projects and other oil sands developments. The analysis:

- is conducted at the watershed/river basin level, with an emphasis on watersheds in which development has already occurred, as well as the lower Athabasca River at the regional level;
- uses a set of measurement endpoints representing the health and integrity of valued environmental resources within the component; and
- uses specific criteria (criteria used in focal project EIAs, AESRD and CCME water quality and sediment quality guidelines, generally-accepted EEM effects criteria) for determining whether or not a change in the measurement endpoints has occurred and is significant with respect to the health and integrity of valued environmental resources.

The RAMP 2012 Technical Report uses the following definitions for monitoring status:

- ***Test*** is the term used in this report to describe aquatic resources and physical locations (i.e., stations, reaches) downstream of a focal project; data collected from these locations are designated as ***test*** for the purposes of analysis, assessment, and reporting. The use of this term does not imply or presume that effects are occurring or have occurred, but simply that data collected from these locations are being tested against *baseline* conditions to assess potential changes; and
- ***Baseline*** is the term used in this report to describe aquatic resources and physical locations (i.e., stations, reaches, data) that are (in 2012) or were (prior to 2012) upstream of all focal projects; data collected from these locations are to be designated as ***baseline*** for the

purposes of data analysis, assessment, and reporting. The terms *test* and *baseline* depend solely on location of the aquatic resource in relation to the location of the focal projects to allow for long-term comparison of trends between *baseline* and *test* stations.

Satellite imagery was used in 2012 in conjunction with more detailed maps of Athabasca oil sands operations provided by a number of RAMP industry members to estimate the type, location, and amount of land changed by focal projects and other development activities. As of 2012, it is estimated that approximately 105,700 ha of the RAMP FSA had undergone land change from focal projects and other oil sands developments. The percentage of the area of watersheds with land change as of 2012 varies from less than 1% for many watersheds (MacKay, Christina, Hangingstone, Horse, and Firebag rivers), to 1% to 5% for the Calumet, Ells, Poplar, and Steepbank watersheds, to 5% to 10% for the Upper Beaver watershed, to more than 10% for the Muskeg River, Fort Creek, Mills Creek, Tar River, Shipyard Lake, and McLean Creek watersheds, as well as for the smaller Athabasca River tributaries from Fort McMurray to the confluence of the Firebag River.

ASSESSMENT OF 2012 MONITORING RESULTS

A tabular summary of the 2012 results by watershed and component is presented at the end of this Executive Summary.

Lower Athabasca River and Athabasca River Delta

Hydrology The mean open-water period (May to October) discharge, open-water minimum daily discharge, annual maximum daily discharge, and mean winter discharge calculated from the observed *test* hydrograph were 0.6%, 1.8%, 0.3% and 1.0% lower, respectively, than from the estimated *baseline* hydrograph. These differences were classified as **Negligible-Low**. The results of the hydrologic assessment were essentially identical to results for the case in which focal projects plus other oil sands developments were considered.

Water Quality Differences in water quality in fall 2012 at all stations in the Athabasca River were classified as **Negligible-Low** compared to the regional *baseline* conditions, with the exception of the *test* station at the Muskeg River, on the east bank of the Athabasca River, which showed **Moderate** differences from regional *baseline* conditions due to high concentrations of TSS, organic carbon, nutrients, and associated particulate metals. Concentrations of water quality measurement endpoints at the *test* stations were generally similar to those at the upstream *baseline* stations at Donald Creek, on the east and west banks of the Athabasca River, and consistent with regional *baseline* conditions. Concentrations of total aluminum exceeded guidelines at all stations, while total boron showed an increasing trend at the *test* station downstream of all development, on the west bank of the Athabasca River, and both *test* stations at the Muskeg River, on the east and west banks of the Athabasca River.

Benthic Invertebrate Communities and Sediment Quality Benthic invertebrate communities were monitored at four locations in the Athabasca River Delta (ARD) in fall 2012:

1. Differences in measurement endpoints for benthic invertebrate communities in the Athabasca River Delta in Big Point Channel were classified as **Moderate** because there was an increase in equitability over time and abundance and richness were lower in 2012 compared to previous sampling years. In addition, abundance was extremely low in 2012 and lower than the range of historical conditions for all ARD reaches.

2. Differences in measurement endpoints for benthic invertebrate communities in Fletcher Channel were classified as **High** because of significant decreases in abundance and Correspondence Analysis (CA) Axis 2 scores over time and lower abundance, richness, diversity, and equitability in 2012 compared to the mean of previous sampling years. In

addition, abundance, richness, percent EPT (Ephemeroptera, Plecoptera, Trichoptera), equitability, and CA Axis 2 scores were outside the range of historical conditions for all ARD reaches. Abundance was much lower in 2012 compared to all previous years.

3. Differences in measurement endpoints for benthic invertebrate communities in Goose Island Channel were classified as **Moderate** because the CA Axis 2 scores showed a significant difference in 2012, reflecting a potential decrease in relative abundances of bivalves and gastropods. Mean values of all other measurement endpoints were within previously-measured values for this reach and within the range of historical conditions for the ARD.

4. Differences in measurement endpoints for benthic invertebrate communities in the Embarras River were classified as **Moderate** because richness and the percentage of the fauna as EPT taxa significantly decreased over time. In addition, Ephemeroptera were absent, although the benthic fauna was still considered to be in relatively good condition.

Total abundance of benthic invertebrate communities in all four channels of the ARD was negatively correlated with percent substrate as sand. The higher sand content in 2012 in the channels of the ARD was likely related to high discharge events in 2012 prior to the fall sampling period, potentially flushing finer sediments and associated benthos. Although the statistical analyses classified the differences in measurement endpoints as **Moderate** (Big Point Channel, Goose Island Channel, Embarras River) and **High** (Fletcher Channel), the differences in the composition of benthic fauna may be related to natural conditions. Monitoring in subsequent years will be useful to further understand the causes of variation in composition of the benthic invertebrate communities in the channels of the ARD.

In fall 2012, sediment quality in channels of the ARD generally exhibited coarser characteristics with lower organic carbon and hydrocarbon concentrations, than in recent years. All stations were predominantly composed of sand, with the exception of the Embarras River where silt was dominant. Concentrations of sediment quality measurement endpoints at all five stations in the ARD showed concentrations that were generally similar to previously-measured concentrations. PAHs at all stations in fall 2012 were dominated by alkylated species, indicating a petrogenic origin of these compounds. From 1999 to 2010, an increase in concentrations of total PAHs was observed in Big Point Channel, although this trend was not evident in concentrations of carbon-normalized total PAHs. In fall 2012, the concentration of total PAHs in Big Point Channel was lower than the previously-measured minimum concentration. With the exception of the station on the Athabasca River at the confluence with the Embarras River, all stations in the ARD exhibited a decrease in TOC and total PAHs in fall 2012 relative to fall 2011, likely associated with the coarser substrate observed at all stations. The PAH Hazard Index for the Embarras River was above the potential chronic toxicity threshold value of 1.0 but below 1.0 at all other stations. Acute toxicity data for sediments exceeded previously-measured maximum values for *Hyalella* survival in Big Point Channel and *Chironomus* survival at the station on the Athabasca River at the confluence with the Embarras River. Samples collected from Fletcher Channel showed historically low growth of *Chironomus* relative to previously-measured minimum concentrations. SQI values for all stations indicated **Negligible-Low** differences from regional *baseline* conditions.

Fish Populations (fish inventory) As outlined in the RAMP Design and Rationale document, the Athabasca River fish inventory is generally considered to be a community-driven activity, primarily used for assessing general trends in abundance and populations variables for large-bodied species, rather than detailed community structure.

As of 2012, current and historical fish inventory data from the Athabasca River indicated species-specific variability in relative abundance, age-frequency distributions, and condition of fish among years. There has been a significant increase in the catch and CPUE of goldeye in the last two years

(i.e., 2011 and 2012), which could be related to an increase in recruitment during the calm, warm spring seasons in the last two years in the lower Athabasca River. However, it is important to note that the despite the increase in goldeye in the river, the absolute abundances of other KIR species has not concomitantly decreased. More data are necessary to determine any trends and evaluate the cause of the increase in goldeye numbers.

The fish health assessment indicated that abnormalities observed in 2012 in all species were within the historical range and consistent with studies done prior to the major oil sands development in the upper Athabasca River, the ARD, and the Peace and Slave rivers.

Muskeg River Watershed

Hydrology The calculated mean open-water discharge and the annual maximum daily discharge were 5.2% and 6.8% lower in the observed *test* hydrograph than in the estimated *baseline* hydrograph, respectively. These differences were classified as **Moderate.** The calculated mean winter discharge and the open-water period minimum daily discharge were 140.3% and 34.8% higher in the observed *test* hydrograph than in the estimated *baseline* hydrograph, respectively. These differences were classified as **High.**

Water Quality Concentrations of many water quality measurement endpoints at the upper *baseline* station of Jackpine Creek were outside previously-measured concentrations and exceeded the 95th percentile of regional *baseline* conditions. Concentrations of water quality measurement endpoints at other locations of the Muskeg River watershed in fall 2012 were frequently within the range of previously-measured concentrations and generally consistent with regional *baseline* conditions. Differences in water quality in fall 2012 at all stations in the Muskeg River watershed compared to regional *baseline* water quality conditions were **Negligible-Low,** with the exception of the upper *baseline* station of Jackpine Creek and the *test* station of Iyinimin Creek, which had **Moderate** differences from regional *baseline* conditions.

Benthic Invertebrate Communities and Sediment Quality Benthic invertebrate communities were monitored at five *test* reaches in the Muskeg River watershed in fall 2012:

1. Differences in values of measurement endpoints for benthic invertebrate communities at the lower *test* reach of the Muskeg River were classified as **Moderate** because there was a significant increase in total abundance and CA Axis 1 and 2 scores over time and significant differences in abundance, EPT taxa, and CA Axis 1 and 2 scores in 2012 relative to previous sampling years. The benthic invertebrate community; however, appeared to be in good condition, with high relative abundances of chironomids and mayflies and the presence of caddisflies and stoneflies. The percentage of the fauna as worms (tubificids and naidids) was relatively similar to previous years indicating no significant change in the quality of the habitat.

2. Differences in measurement endpoints for benthic invertebrate communities at the middle *test* reach of the Muskeg River were classified as **Negligible-Low** because all benthic measurement endpoints were within the range of variation for depositional *baseline* reaches and there was no evidence of a negative change over time in any measurement endpoints.

3. Differences in measurement endpoints for benthic invertebrate communities at the upper *test* reach of the Muskeg River were classified as **Negligible-Low** because all benthic measurement endpoints were within the range of variation for depositional *baseline* reaches. In addition, there was little evidence of any negative changes and the relative abundance of tubificids were lower than 2011.

4. Differences in measurement endpoints for benthic invertebrate communities at the lower *test* reach of Jackpine Creek were classified as **Negligible-Low** because although there were significant differences from the upper *baseline* reach (i.e., higher CA Axis 1 scores, abundance, and richness at the lower reach), the differences were not indicative of degraded habitat quality at the lower *test* reach. The strong statistical signal in CA Axis 1 scores was due to a lower abundance of tubificids in 2012 at the lower *test* reach, suggesting good habitat quality. The presence of sensitive taxa including mayflies, caddisflies, clams, and snails, also suggested that the lower *test* reach of Jackpine Creek had a benthic fauna indicative of good depositional habitat conditions.

5. Differences in measurement endpoints for benthic invertebrate communities in Kearl Lake were classified as **Moderate** because of the significant decrease in percent EPT (i.e., particularly mayflies and caddisflies) and the increase in CA Axis scores compared to the period when Kearl Lake was designated as *baseline*. However, the benthic invertebrate community contained a diverse fauna and included several taxa that were typically associated with relatively good water and sediment quality in lakes (e.g., the mayfly *Caenis* and caddisflies). The relative abundance of ostracods, which has decreased since 2011, was still high compared to *baseline* lakes in the RAMP FSA and all measurement endpoints were within the range of values reported during the *baseline* period for Kearl Lake, with the exception of diversity. Simpson's Diversity was higher in 2012 than in the *baseline* period, indicating good or better habitat quality.

Sediment quality at all Muskeg River watershed stations sampled in fall 2012 was generally consistent with that of previous years and regional *baseline* conditions. Concentrations of total PAHs at these stations were within previously-measured concentrations, with a few exceptions where PAH concentrations were below previously-measured minimum concentrations. Differences in sediment quality in fall 2012 at all applicable stations in the Muskeg River watershed were assessed as **Negligible-Low** compared to regional *baseline* conditions.

Fish Populations (fish assemblages) Differences in measurement endpoints for fish assemblages between the lower *test* reach of the Muskeg River and regional *baseline* conditions were classified as **Negligible-Low** given that most measurement endpoints were within the regional range of variation of *baseline* reaches. Differences in measurement endpoints for fish assemblages between the middle and upper *test* reaches of the Muskeg River and regional *baseline* conditions were classified as **Moderate** because all measurement endpoints were outside the range of variation for *baseline* depositional reaches. Differences in measurement endpoints for fish assemblages between the lower *test* reach of Jackpine Creek and regional *baseline* conditions were classified as **Moderate** because all measurement endpoints were below the regional range of variation of *baseline* reaches, likely related to the high flows observed in fall 2012.

Fish Populations (sentinel species) Given the small sample size of slimy sculpin captured at the lower *test* site of the Muskeg River, it was not possible to make statistical comparisons or compare the results to the effects criteria to provide a classification of results.

Steepbank River Watershed

Hydrology The calculated mean open-water discharge, mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge were 0.31%, 0.32%, 0.32%, and 0.26% greater, respectively, in the observed *test* hydrograph than in the estimated *baseline* hydrograph. These differences were classified as **Negligible-Low.**

Water Quality Concentrations of many water quality measurement endpoints in the Steepbank River watershed in fall 2012 were higher than previously-measured concentrations, particularly at the *test* station of the North Steepbank River and the upper *baseline* station of the Steepbank River.

When compared with regional *baseline* conditions, concentrations of water quality measurement endpoints were generally consistent and within the regional range. The ionic composition at all water quality monitoring stations in the Steepbank River watershed in fall 2012 was similar to previous years. Differences in water quality in fall 2012 compared to regional *baseline* water quality conditions were classified as **Negligible-Low** for all stations in the Steepbank River watershed.

Benthic Invertebrate Communities Differences in measurement endpoints for the benthic invertebrate community at the lower *test* reach of the Steepbank River were classified as **Moderate** because total abundance, percent EPT, and CA Axis 1 and 2 scores were significantly lower at the lower *test* reach than the upper *baseline* reach. The benthic invertebrate community; however, was diverse and although it was dominated by somewhat tolerant tubificids, many other taxa were noted that require cool, clean water and not suggesting any degradation of habitat conditions at this reach.

Fish Populations (fish assemblages) Differences in measurement endpoints for fish assemblages in fall 2012 between the lower *test* reach of the Steepbank River and regional *baseline* conditions were classified as **Negligible-Low** with all values of measurement endpoints within the range of regional *baseline* variability.

Fish Populations (sentinel species) The number of varying exceedances of effects criteria for slimy sculpin at *test* site SR-E compared to each *baseline* site suggests there was substantial variability in slimy sculpin populations among *baseline* sites, likely related to variability in habitat conditions. Accordingly, to minimize the range of *baseline* variability, the classification of results focused on comparisons between the lower (*test*) and upper (*baseline*) Steepbank River sites given both sites are part of the same river system and; therefore, share similar habitat characteristics. Based on the results of the 2012, which provided inconsistent response patterns in energy use (growth and gonadosomatic index [GSI]) in female and male slimy sculpin at the *test* site of the Steepbank River, the differences from the *baseline* site were classified as **Negligible-Low**. Although the lower GSI could be indicative of a negative change, the higher growth of slimy sculpin at the *test* site was not indicative of a negative change and could suggest an increase in food resources at this site.

Tar River Watershed

Hydrology The calculated mean open-water period discharge, annual maximum daily discharge, and open-water minimum daily discharge were 28.0% lower in the observed *test* hydrograph than in the estimated *baseline* hydrograph. These differences were classified as **High**.

Water Quality Differences in water quality observed in fall 2012 between stations on the Tar River and regional *baseline* fall conditions were classified as **Negligible-Low**. Most water quality measurement endpoints at the lower *test* station and upper *baseline* station of the Tar River were within the range of previously-measured concentrations and were consistent with regional *baseline* concentrations. Higher concentrations of several ions (e.g., Ca, Ng, Na, P, Cl, SO_4) shifted the ionic composition of the lower *test* station to conditions with a greater anion contribution by chloride and sulphate.

Benthic Invertebrate Communities and Sediment Quality Differences in measurement endpoints for benthic invertebrate communities at the lower *test* reach of the Tar River were classified as **Negligible-Low** because although there were significant differences in measurement endpoints over time, the differences were not in a direction consistent with a negative change but rather suggested improvements in habitat quality and species diversity compared to previous years. Mean values of measurement endpoints for benthic invertebrate communities at both reaches of the Tar River were within the range of regional *baseline* conditions. Differences in sediment quality observed in fall 2012 between the lower *test* station of the Tar River and regional *baseline* conditions were classified as **Negligible-Low.** Concentrations of sediment quality measurement endpoints

were within previously-measured concentrations in fall 2012, including total PAHs and predicted PAH toxicity; however, concentrations of benz[a]anthracene and benzo[a]pyrene represented maximum concentrations for the lower *test* station and also exceeded CCME guidelines.

Fish Populations Differences in measurement endpoints for fish assemblages between the lower *test* reach of the Tar River and regional *baseline* conditions were classified as **Negligible-Low** because although the Assemblage Tolerance Index (ATI) value exceeded the regional range of variation for *baseline* reaches, the exceedance was not in a direction consistent with a negative change. The ATI value was lower indicating that sensitive species in greater abundance were present at this reach compared to the range of regional *baseline* conditions.

MacKay River Watershed

Hydrology The 2012 WY mean winter and open-water period discharge, annual maximum daily discharge, and open-water minimum daily discharge calculated from the observed *test* hydrograph were 0.004% lower from the estimated *baseline* hydrograph; these differences were classified as **Negligible-Low**.

Water Quality Differences in water quality in fall 2012 at the lower *test* and upper *baseline* stations of the MacKay River relative to regional *baseline* water quality conditions were classified as **Negligible-Low**, while differences in water quality at the middle *test* station of the MacKay River was classified as **Moderate**, likely due to very high flow conditions at the time of sampling, which resulted in high total suspended solids and total metals that are associated with particulates.

Benthic Invertebrate Communities Differences in measurement endpoints for benthic invertebrate communities at the lower *test* reach of the MacKay River were classified as **Moderate** because there was a decrease in EPT taxa below regional *baseline* conditions and significantly lower abundance of EPT taxa at the lower *test* reach compared to the upper *baseline* reach. In addition, CA Axis 1 scores were significantly lower at the lower *test* reach in 2012 compared to the upper *baseline* reach reflecting a difference in taxa composition, with fewer water mites. Differences in measurement endpoints for benthic invertebrate communities at the middle *test* reach of the MacKay River were classified as **Moderate** because the CA Axis 1 scores were significantly lower compared to the upper *baseline* reach.

Fish Populations Differences in measurement endpoints for fish assemblages between the lower and middle *test* reaches of the MacKay River and regional *baseline* conditions were classified as **Negligible-Low** given there were was only one measurement endpoint for the lower *test* reach that exceeded the regional range of variation of *baseline* reaches. The increase in ATI at the lower *test* reach was due to the dominance of trout-perch captured at this reach, which has a high tolerance value.

Calumet River Watershed

Hydrology For the 2012 WY, the mean open-water season discharge, annual maximum daily discharge, and open-water minimum daily discharge were estimated to be 0.2% lower than from the estimated *baseline* hydrograph; these differences were classified as **Negligible-Low**.

Water Quality In fall 2012, water quality at the lower *test* station and upper *baseline* station of the Calumet River showed **Negligible-Low** differences from regional *baseline* conditions. Concentrations of all water quality measurement endpoints at the lower *test* station and the upper *baseline* station were within the range of regional *baseline* concentrations in fall 2012. The ionic composition of water at the lower *test* station was consistent with previous years, and the ionic composition of the upper *baseline* station appeared to have returned to its historical range following a deviation in fall 2010.

Benthic Invertebrate Communities and Sediment Quality Differences in measurement endpoints for benthic invertebrate communities at the lower *test* reach of the Calumet River were classified as **Negligible-Low** because although there were significant differences in measurement endpoints compared to the upper *baseline* reach (e.g., higher diversity, EPT taxa, and lower equitability at the lower *test* reach), these differences were generally not in a direction consistent with a negative change or degraded habitat quality. In addition, mean values of measurement endpoints were within the range of variation for *baseline* depositional reaches and the benthic invertebrate ommunity at the lower *test* reach of the Calumet River was considered diverse and supported by good water quality. The benthic invertebrate community at the upper *baseline* reach was somewhat unusual relative to previous sampling years. The benthic invertebrate community was heavily dominated by nematodes and copepods, while several groups typically observed were not found in 2012 (e.g., Chaoboridae, Bivalvia, Ceratopogonidae). Concentrations of sediment quality measurement endpoints at both stations of the Calumet River in fall 2012 were generally within the range of previously-measured concentrations, with both stations comprised almost exclusively of sand substrate, with low concentrations of total organic carbon. Direct measurements of sediment toxicity indicated a survival ≥70% at both stations. Differences in sediment quality observed in fall 2012 between the upper *baseline* station and regional *baseline* conditions were classified as **Negligible-Low**. Differences in sediment quality between the lower *test* station of the Calumet River and regional *baseline* conditions were classified as **Moderate**.

Fish Populations Differences in measurement endpoints for fish assemblages between the lower *test* reach of the Calumet River and regional *baseline* conditions were classified as **Negligible-Low** given that all measurement endpoints were within the regional range of variation of *baseline* reaches.

Firebag River Watershed

Hydrology The 2012 WY mean winter and open-water period discharge, annual maximum daily discharge, and open-water minimum daily discharge calculated were 0.1% lower in the observed *test* hydrograph than in the estimated *baseline* hydrograph. These differences were classified as **Negligible-Low**. Water levels recorded for McClelland Lake, were, with the exception of a short period in November 2011 and May 2012, below the historical minimum for the duration of the 2012 WY.

Water Quality In fall 2012, water quality at the lower *test* and upper *baseline* stations of the Firebag River showed **Negligible-Low** differences from regional *baseline* water quality conditions. The ionic composition of water in fall 2012 at both Firebag River stations and McClelland Lake was consistent with previous sampling years. Concentrations of most water quality measurement endpoints at the lower *test* and upper *baseline* stations of the Firebag River were within the range of regional *baseline* concentrations in fall 2012. Concentrations of water quality measurement endpoints for McClelland and Johnson Lake were not compared to regional *baseline* conditions given the ecological differences between lakes and rivers. Many water quality measurement endpoints, primarily ions and select metals, exceeded previously-measured maximum concentrations at all stations in the Firebag River watershed.

Benthic Invertebrate Communities and Sediment Quality Differences in measurement endpoints for benthic invertebrate communities of McClelland Lake in 2012 were classified as **Negligible-Low** because total abundance was higher in the *test* period than the *baseline* period and although the percentage of fauna as EPT taxa was lower in 2012 than the mean of previous sampling years, it was consistent to 2002, 2003, and 2010. CA Axis 1 scores were significantly different from the *baseline* period and CA Axis 2 scores were different in 2012 than all previous sampling years; however, the composition of the community in terms of relative abundances, included fully aquatic forms and generally sensitive taxa including the mayfly *Caenis* and the caddisfly *Mystacides* suggesting that the community of McClelland Lake was still in good condition and generally

similar to *baseline* conditions. The benthic invertebrate community Johnson Lake was indicative of good water and sediment quality conditions due to a the large relative abundance of permanent aquatic forms such as Amphipoda and bivalve clams, the presence of relatively sensitive and large aquatic insect larvae (Ephemeroptera: *Caenis*), and a low relative abundance of worms. Concentrations of sediment quality measurement endpoints for McClelland Lake frequently deviated from historical ranges in fall 2012, generally with lower concentrations of hydrocarbons. The coarser sediment composition and lower total organic carbon content observed in fall 2012 were likely a result of sampling variability and caused concentrations of total metals (normalized to percent fines) and total PAHs (normalized to total organic carbon) to exceed previously-measured maximum concentrations for this lake. Sediment toxicity to invertebrates was within previously-measured ranges for McClelland Lake. Fall 2012 represented the second year of sampling in Johnson Lake; sediment quality in Johnson Lake was generally similar to McClelland Lake, but had higher concentrations of hydrocarbons and total metals.

Ells River Watershed

Hydrology The mean winter discharge (November to March) was 0.01% lower in the observed *test* hydrograph than in the estimated *baseline* hydrograph. This difference was classified as **Negligible-Low**. The calculated mean open-water discharge (May to October), the annual maximum daily discharge, and the open-water minimum daily discharge were 0.05% higher in the observed *test* hydrograph than in the estimated *baseline* hydrograph. These differences were classified as **Negligible-Low**.

Water Quality Differences in water quality in fall 2012 between the Ells River and regional *baseline* fall conditions were classified as **Negligible-Low**. Water quality conditions were consistent with previous years at the lower and middle *test* stations, and were within the range of previously-measured concentrations and regional *baseline* conditions. Water quality at the upper *baseline* station in fall 2012 was similar to that at the other two stations and consistent with results since it was first sampled in 2010.

Benthic Invertebrate Communities and Sediment Quality Differences in measurement endpoints for benthic invertebrate communities at the lower *test* reach of the Ells River were classified as **Moderate** because of the significant decrease in Simpson's Diversity and percent EPT taxa in 2012 compared to previous years, and a decrease in percentage of fauna as EPT taxa over time. Additionally, Simpson's Diversity was also lower than the range of *baseline* conditions for depositional reaches. Habitat at the lower *test* reach was of marginal quality for benthic invertebrate communities. The low diversity, high relative abundance of tubificid worms (>60% in 2012), absence of caddisflies and stoneflies, and low relative abundance of mayflies were indicative of an environment that was somewhat limiting to depositional fauna. Differences in measurement endpoints for benthic invertebrate communities at the middle *test* reach of the Ells River were classified as **Moderate** because there was a significant difference in abundance, richness, equitability, percent EPT, and CA Axis 1 and 2 scores between this reach and the upper *baseline* reach. In addition, abundance, and percent EPT were higher and lower, respectively at the middle *test* reach than the regional *baseline* range. Differences in sediment quality observed in fall 2012 between the lower *test* station of the Ells River and regional *baseline* conditions were classified as **Moderate**, and likely related to the exceedance of chrysene from previously-measured concentrations, and the concentration of total PAHs, which exceeded the regional *baseline* range. In addition, guideline exceedances were observed in concentrations of Fraction 2 and Fraction 3 hydrocarbons, pyrene, chrysene, and the potential chronic toxicity threshold.

Fish Populations Differences in fish assemblages observed in fall 2012 between both *test* reaches of the Ells River and regional *baseline* conditions were classified as **Negligible-Low** with all mean values of measurement endpoints within the range of regional *baseline* variability.

Clearwater River Watershed

Hydrology There was no land change in the Clearwater River watershed related to focal projects and other oilsands development in 2012. Accordingly, no assessment of current versus *baseline* hydrologic conditions was warranted.

Water Quality In fall 2012, water quality at the *baseline* station of the High Hills River indicated **Negligible-Low** differences from regional *baseline* conditions. Water quality at the *test* and *baseline* stations on the Clearwater River indicated **Moderate** differences from regional *baseline* water quality conditions, with concentrations of several water quality measurement endpoints exceeding the range of previously-measured concentrations and the range of regional *baseline* conditions in 2012.

Benthic Invertebrate Communities and Sediment Quality The benthic invertebrate community at the *baseline* reach of the High Hill River was diverse, including a high percentage of chironomids and EPT taxa that reflected good water quality. High Hills River was used as a regional *baseline* reach for comparisons to *test* reaches in the RAMP FSA. Sediment quality monitoring was not conducted on the High Hills River given it is an erosional river.

Fish Populations (fish inventory) Total fish captured in the Clearwater River during the fall fish inventory has varied across years, which can be partially attributed to variability in discharge. In lower flow years, the amount of available fish habitat and the accessibility of the river is limited. Species richness across reaches in spring 2012 was higher than previous years, with the exception of 2007 and 2008. Species richness in fall 2012 was also higher than previous sampling years. Species richness at the *test* reach was generally consistent to the *baseline* reaches across years for spring and summer. In fall, species richness was generally higher in the *baseline* reaches than the *test* reach. The relative abundance of fish species in the Clearwater River was variable without any clear trends observed over time. Similarly, there has been no marked shift in species dominance from year to year. Additionally, there have been no significant differences in condition of large-bodied KIR fish species in the *test* reach of the Clearwater River when compared to *baseline* data. It is important to note; however, that condition cannot necessarily be attributed to the environmental conditions in the capture location, as these fish populations are highly migratory throughout the region.

Fish Populations (fish tissue) Measurement endpoints used in the assessment included metals and tainting compounds in both individual and composite samples. In 2012, the mean concentration of mercury in northern pike was lower than in previous sampling years, with the exception of 2009. The mercury concentration in size classes of northern pike greater than 550 mm exceeded the subsistence fishers guideline for consumption, indicating a **High** risk to subsistence fishers and a **Moderate** risk to general consumers.

Fish Populations (fish assemblages) The fish assemblage at the *baseline* reach on the High Hills River was generally consistent with other *baseline* erosional reaches, with a much higher proportion of slimy sculpin. This species is typical of riffle habitat with faster flowing water and as noted above, is a sensitive species, which likely contributed to the lower ATI value observed for this reach.

Christina River Watershed

Hydrology The calculated mean open-water season (May to October) discharge, annual maximum daily discharge, and open-water minimum discharge of the Christina River during the 2012 WY were 0.04% greater in the observed *test* hydrograph than in the estimated *baseline* hydrograph. These differences were classified as **Negligible-Low**. The mean winter discharge was 0.11% lower in the observed *test* hydrograph than in the estimated *baseline* hydrograph. This difference was classified as **Negligible-Low**.

Water Quality In fall 2012, water quality at *test* stations on the lower Christina River, Jackfish River, Sawbones Creek, and Sunday Creek indicated **Negligible-Low** differences from regional *baseline* conditions. Water quality at the upper *test* station of the Christina River indicated **High** differences from regional *baseline* water quality conditions. Concentrations of several water quality measurement endpoints (e.g., total and dissolved metals) were outside the range of previously-measured concentrations and regional *baseline* conditions in fall 2012 at the upper *test* station of the Christina River.

Benthic Invertebrate Communities and Sediment Quality Differences in measurement endpoints for benthic invertebrate communities at the lower *test* reach of the Christina River were classified as **Moderate** because abundance, richness, and the percentage of EPT taxa were lower in 2012 compared to previous years and diversity and abundance were below the range of variation for *baseline* depositional reaches. The benthic invertebrate community at the lower *test* reach has consistently been dominated by tubificid worms over time suggesting that the observed differences in 2012 may be due to natural variation. The reach also contained stoneflies (Plecoptera) suggesting reasonably good habitat quality. Differences in measurement endpoints for benthic invertebrate communities at the upper *test* reach of the Christina River were classified as **Negligible-Low** because the significantly higher percentage of EPT taxa in the *test* period compared to the *baseline* period was not consistent with a negative change. Differences in measurement endpoints for benthic invertebrate communities at the *test* reaches of Sawbones Creek, Sunday Creek, and Jackfish River were classified as **Negligible-Low** because almost all measurement endpoints including the CA Axis scores were either within or above regional *baseline* conditions. Differences in measurement endpoints for the benthic invertebrate community of Christina Lake in fall 2012 were classified as **Negligible-Low** given that the lake contained a diverse benthic fauna including several permanently aquatic forms (e.g., clams, snails, amphipods), as well as several large aquatic insects (mayflies and caddisflies). In fall 2012, concentrations of sediment quality measurement endpoints at both stations of the Christina River were generally lower than previously-measured concentrations and a decreasing trend in concentrations of total PAHs was observed over time at the lower *test* station. Concentrations of sediment quality measurement endpoints at stations on tributaries to Christina Lake (i.e., Sawbones and Sunday creeks) were within regional *baseline* conditions. Sediment quality in fall 2012 showed **Negligible-Low** differences at all stations in the Christina River watershed, excluding Christina Lake, from regional *baseline* conditions.

Fish Populations (fish assemblages) Differences in measurement endpoints for fish assemblages between the lower and upper *test* reaches of the Christina River and regional *baseline* conditions were classified as **Negligible-Low** because only abundance at the lower *test* reach was below the range of variation for regional *baseline* reaches. The lower catch was likely due to difficulties in effectively sampling the river in high water conditions in fall 2012. Regional information for this part of the RAMP FSA was limited; therefore, comparisons to regional *baseline* conditions were made with areas further to the north (i.e., reaches sampled by RAMP to the north of Fort McMurray). Differences in measurement endpoints for fish assemblages between the *test* reach of Sunday Creek and regional *baseline* conditions were classified as **Negligible-Low** because although the ATI was lower than regional *baseline* conditions, this difference was indicative of more sensitive species captured and not consistent with a negative change. Differences in measurement endpoints for fish assemblages between the *test* reach of Jackfish River and regional *baseline* conditions were classified as **Negligible-Low** because all measurement endpoints were within regional *baseline* range of variation. Differences in measurement endpoints for fish assemblages between the *test* reach of Sawbones Creek and regional *baseline* conditions were classified as **Moderate** because three of the four measurement endpoints were below the 5th percentile of regional *baseline* conditions. Given that historical data were limited for Sawbones Creek, a more complete assessment of fish assemblages in this creek will be conducted in fall 2013, once two years of data are acquired. A total of 784 fish from nine species were captured using the three methods during the fish assemblage survey in Christina Lake in summer 2012. Two species captured during the

RAMP 2012 survey had not been previously documented in either Christina Lake or its tributaries, including the Iowa darter (*Etheostoma exile*) and northern redbelly dace (*Phoxinus eos*).

Fish Populations (fish tissue) Mercury concentrations in northern pike and walleye from Gregoire Lake in 2012 were below any Health Canada consumption guidelines indicating a **Negligible-Low** risk to human health. Mercury concentrations in fish from Gregoire Lake were near the lower end of the historical range of mercury concentrations in fish sampled from other regional lakes.

Hangingstone River Watershed

Hydrology The calculated mean open-water period discharge, annual maximum daily discharge, and open-water minimum daily discharge were 0.05% lower in the observed *test* hydrograph than in the estimated *baseline* hydrograph. These differences were classified as **Negligible-Low**.

Pierre River Area

Water Quality Differences in water quality in fall 2012 between the *baseline* stations of Big Creek, Pierre River, Red Clay Creek, and Eymundson Creek and regional *baseline* fall conditions were classified as **Negligible-Low**. The *baseline* station on Eymundson Creek differed from the other stations in its ionic composition, with a higher concentration of sulphate and less bicarbonate, which may suggest greater groundwater influence at this station.

Miscellaneous Aquatic Systems

Isadore's Lake and Mills Creek The calculated mean open-water discharge, minimum daily discharge, annual maximum daily discharge, and mean winter discharge were 37.2% lower in the observed *test* hydrograph than in the estimated *baseline* hydrograph for Mills Creek. These differences were classified as **High**.

In the 2012 WY, lake levels of Isadore's Lake generally decreased from November 2011 to early March 2012, with levels in November and December near historical median values and levels from January to late March varying between the historical minimum and lower-quartile values. Lake levels increased during freshet in late March and April followed by decreasing levels until mid-May. Lake levels increased from late May through July in response to rainfall events, and generally remained between the historical maximum and upper quartile values until the end of the 2012 WY.

Differences in water quality in fall 2012 between Mills Creek and regional *baseline* conditions were classified as **Moderate**, likely due to relatively high concentrations of many ions and other dissolved species that exceeded the 95th percentile of regional *baseline* concentrations. The ionic compositions of test stations on Isadore's Lake and Mills Creek showed many similarities, supporting the idea that historical changes in water quality at Isadore's Lake may have occurred as a result of receiving water from Mills Creek.

Differences in measurement endpoints for the benthic invertebrate community of Isadore's Lake were classified as **Negligible-Low** because the significant (though subtle) increase in percent EPT over time and the higher percent EPT in 2012 than the mean of previous years does not suggest degrading conditions. The percentage of fauna as EPT has always been <1% (normally EPT are absent), but in 2012 EPT taxa accounted for about half a percent of the fauna. Further, all measurement endpoints were within the range of historical values for the lake. Historically, Isadore's Lake has had a unique benthic invertebrate community compared to other lakes in the area, having low diversity and high abundance of nematodes. While there has been very little negative change over time, the benthic invertebrate community in Isadore's Lake has been representative of a degraded system since sampling was initiated in 2006. Concentrations of most sediment quality measurement endpoints in fall 2012 in Isadore's Lake were within previously-measured concentrations with only a few exceptions (i.e., carbon-normalized PAHs and

naphthalene). The SQI was not calculated for lakes in 2012 due to potential ecological differences in regional sediment quality characteristics between lakes and rivers.

Shipyard Lake Concentrations of most water quality measurement endpoints in fall 2012 at the *test* station of Shipyard Lake were within previously-measured concentrations with only a few exceptions (i.e., magnesium and total aluminum). The ionic composition of water of Shipyard Lake continued to exhibit an increase in sodium and chloride concentrations relative to historical concentrations, perhaps due to reduced surface-water inflow and increased groundwater influence in the lake associated with focal projects in the upper portion of the Shipyard Lake watershed (the upper 93% of the Shipyard Lake watershed has been disturbed). A WQI was not calculated for lakes in 2012 due to potential ecological differences in regional water quality characteristics between lakes and rivers and the limited *baseline* lake data.

Differences in measurement endpoints for the benthic invertebrate community of Shipyard Lake in 2012 were classified as **Negligible-Low**. The increasing trend over time of abundance and taxa richness were significant and were not indicative of degraded water or habitat quality. The lake contained a number of fully aquatic forms including amphipods, clams, and snails, indicating generally good water and sediment quality. Concentrations of most sediment quality measurement endpoints in fall 2012 at the *test* station of Shipyard Lake were within previously-measured concentrations with only a few exceptions (i.e., TOC and benzo[a]pyrene). The SQI was not calculated for lakes in 2012 due to potential ecological differences in regional sediment quality characteristics between lakes and rivers.

Poplar Creek and Beaver River The calculated mean open-water discharge (May to October) was 1.6% greater in the observed *test* hydrograph than in the estimated *baseline* hydrograph. This difference was classified as **Negligible-Low**. The annual maximum daily discharge and open-water minimum daily discharge were 1.8% lower in the observed *test* hydrograph than in the estimated *baseline* hydrograph. These differences were classified as **Negligible-Low**.

Concentrations of several water quality measurement endpoints, primarily ions and other dissolved species, exceeded regional *baseline* concentrations at the lower *test* station of the Beaver River, resulting in a **Moderate** difference from regional *baseline* conditions. Although concentrations of several measurement endpoints were high at the lower *test* station of Poplar Creek and the upper *baseline* station of the Beaver River, differences in water quality in fall 2012 and regional *baseline* conditions were classified as **Negligible-Low**.

Differences in measurement endpoints for benthic invertebrate communities at the lower *test* reach of Poplar Creek were classified as **Moderate** because of the significant and large differences in abundance, percentage of fauna as EPT taxa, and CA Axis scores compared to *baseline* reach BER-D2. The benthic invertebrate community at the lower *test* reach of Poplar Creek was in generally good condition, reflected by low relative abundances of worms and higher relative abundances of fingernail clams. The low relative abundance of mayflies and caddisflies, and lack of stoneflies potentially indicated some level of disturbance, but over time the percentage of EPT taxa has been increasing. Differences in sediment quality observed in fall 2012 at the lower *test* station of Poplar Creek and the upper *baseline* station of the Beaver River were classified as **Negligible-Low** compared to regional *baseline* conditions. Concentrations of most sediment quality measurement endpoints were within the range of previously-measured concentrations and within the range of regional *baseline* conditions.

Differences in measurement endpoints for fish assemblages between the lower *test* reach of Poplar Creek and regional *baseline* conditions were classified as **Negligible-Low** because although the assemblage tolerance index (ATI) was lower than regional *baseline* conditions, this difference was indicative of more sensitive species captured, and not reflective of degrading conditions in Poplar Creek.

McLean Creek Concentrations of water quality measurement endpoints at the lower *test* station of McLean Creek were often higher than regional *baseline* concentrations in fall 2012. Concentrations of TSS, TDS, and many ions and dissolved species of water quality measurement endpoints were high relative to regional *baseline* conditions and exhibited guideline exceedances, indicating a **Moderate** difference from regional *baseline* concentrations.

Fort Creek The calculated mean open-water period (May to October) discharge volume was 11.7% greater in the observed *test* hydrograph than in the estimated *baseline* hydrograph. This difference was classified as **Moderate**. In addition to changes in flow volume, variability in daily flow has also increased due to focal project activity in the watershed. This variability in daily flow was sufficiently large to adjust the expected flow characteristics previously evident at this station. The 2012 WY showed multiple precipitation-driven annual maximum daily discharges within the annual hydrograph, and did not display a defined open-water minimum daily flow following a sustained dry period as is typical in other systems.

Differences in water quality in fall 2012 between the lower *test* station of Fort Creek and regional *baseline* conditions were classified as **Negligible-Low**. However, relatively high concentrations of several water quality measurement endpoints were observed, but were within the range of previously-measured concentrations. A large increase in the concentration of sulphate has been observed at the lower *test* station of Fort Creek since 2008 (not a statistically significant trend), which appeared to have occurred in the absence of other apparent changes in ionic composition.

Differences in measurement endpoints for benthic invertebrate communities at the lower *test* reach of Fort Creek were classified as **High** because of the significantly lower abundance and richness during the *test* period compared to the *baseline* period. Additionally, four of the five measurement endpoints were outside of the range of variation for regional *baseline* depositional rivers. Although the percentage of fauna as EPT taxa has increased over time, this could be an artifact of the low overall abundance in the reach during many years of sampling (including 2012). Differences in sediment quality observed in fall 2012 between the lower *test* station of Fort Creek and regional *baseline* conditions were **Negligible-Low** with nearly all sediment quality measurement endpoints within the range of previously-measured concentrations and regional *baseline* concentrations.

Differences in measurement endpoints for fish assemblages between the lower *test* reach of Fort Creek and regional *baseline* conditions were classified as **Negligible-Low** given that the mean value all measurement endpoints were within the range of variation for regional *baseline* reaches.

Susan Lake Outlet Flows decreased after monitoring began in the outlet of Susan Lake, with the exception of two rainfall induced peaks on June 4 and June 24. Daily flows recorded in July showed multiple peak flows due to rainfall events from late June to mid-July. Flows generally decreased from late July through August to below the historical minimum values in mid-August. Rainfall events in late August and early September resulted in flows exceeding the historical maximum values. Following this peak, flows decreased through September before steadily increasing until monitoring ended on October 16, 2012.

Acid-Sensitive Lakes

Results of the analysis of the RAMP lakes in 2012 compared to historical data suggest that there was no significant change in the overall chemistry of the lakes across years that were attributable to acidification. Significant increases in pH, Gran alkalinity, sodium, TDS, conductivity, and sum of base cations were observed; however, these changes appeared to be the result of factors other than acidifying emissions (e.g., hydrology).

A summary of the state of the RAMP lakes in 2012 with respect to the potential for acidification was prepared for each physiographic subregion by examining deviations from the mean chemical

concentrations of measurement endpoints (in a direction indicative of acidification) for each lake within a subregion. A two standard deviation criterion was used in each case. In general, data in 2012 were less variable than in 2011 resulting in fewer exceedances of the two standard deviation criterion. The highest number of exceedances (3) occurred in lakes in the Canadian Shield subregion, which are remote from emissions sources and considered *baseline* lakes. Exceedances were observed in base cation concentrations in two lakes, which are increasing due to factors other than acidification. Taking into account these factors, the subregions were all classified as having a **Negligible-Low** indication of incipient acidification.

Summary and Recommendations

The following table provides a summary of the 2012 RAMP monitoring program results, by watershed and component.

The report concluded with a number of recommendations directed towards refining the monitoring program and increasing the value of RAMP monitoring activities. These recommendations are for consideration during the design of monitoring in future years of RAMP:

- Continue to monitor existing climate and hydrometric stations to enhance record length and data availability.
- Expand the climate and hydrology monitoring network to support the provision of *baseline* and *test* hydrometric information and regional climate data.
- Evaluate additional hydrometric measurement endpoints and indicators (such as the timing and frequency of flow conditions) that would further support the RAMP assessment and understanding of aquatic conditions.
- Conduct water balance assessments as a consistent approach applicable to tributary watersheds, independent of the length of the data record, and, as possible, continue to refine inputs such as the time-step of industrial data and delay of releases reaching the measurement station.
- Delineate watershed areas for all RAMP hydrometric stations using updated topographic elevation data and assess if watershed areas need to be updated.
- Continue to add *baseline* stations for ongoing RAMP water quality sampling, particularly stations that are expected to remain *baseline* well into the future.
- Continue to expand seasonal or monthly sampling within the RAMP water quality program, particularly for larger tributaries, to better capture the range of conditions in these locations and allow better discrimination of natural versus anthropogenic changes in water quality in future.
- Consider the addition of deep-water benthic sampling in lakes in which a thermocline has had an opportunity to develop. Such sampling would ensure that any changes in deep-water habitats are detected, if they occur.
- Consider the use of sediment traps in some channels of the delta (especially Fletcher Channel), to estimate sediment deposition rates and also to specifically assess concentrations of hydrocarbons and metal in sediments deposited in the ARD in a given year.
- Continue to collaborate with Environment Canada and AESRD on lethal fish sampling in rivers and lakes in the region to minimize potential impacts on fish populations related to monitoring activities.

- Continue to work with AESRD and Environment Canada on fish monitoring activities to further harmonize fishing methods and data collection, which will eventually result in more efficient sampling in the region and increased data and information sharing to meet the objectives of all stakeholder needs.
- Continue to collect data on fish abnormalities to develop a better understanding of the prevalence of abnormalities in fish in Northern Alberta.
- Consider the use of an electrofishing boat for fish assemblage monitoring in the Athabasca River Delta, which will allow better spatial coverage and increased capture success such that data collected will more accurately represent the fish assemblage present in the delta.
- Evaluate the two basins of Christina Lake separately, if a fish survey is conducted again, to ensure adequate spatial coverage in both basins.

Summary assessment of RAMP 2012 monitoring results.

Watershed/Region	Differences Between *Test* and *Baseline* Conditions						Fish Populations: Human Health Risk from Mercury in Fish Tissue[8]			Acid-Sensitive Lakes: Variation from Long-Term Average Potential for Acidification[9]
	Hydrology[1]	Water Quality[2]	Benthic Invertebrate Communities[3]	Sediment Quality[4]	Fish Assemblages[5]	Sentinel Fish Species[6]	Species	Subs. Fishers	General Cons.	
Athabasca River	○	○ / ●	-	-	-	-	-			-
Athabasca River Delta	-	-	● / ●	○	n/a	-	-			-
Muskeg River	●	○	● / ○	○	○ / ●	-[7]	-			-
Jackpine Creek	nm	○	○	○	○	-	-			-
Kearl Lake	nm	○	●	n/a	-	-	-			-
Steepbank River	○	○	●	-	○	●	-			-
Tar River	●	○	○	○	-	-	-			-
MacKay River	○	○ / ●	●	-	○	-	-			-
Calumet River	○	○	○	●	○	-	-			-
Firebag River	○	○	nm	nm	nm	-	-			-
McClelland Lake	nm	n/a	●	n/a	-	-	-			-
Johnson Lake	-	n/a	n/a	n/a	-	-	-			-
Ells River	○	○	●	●	○	-	-			-
Christina River	○	○ / ●	● / ○	○	-	-	-			-
Christina Lake	nm	n/a	n/a	n/a	n/a	-	-			-
Christina Lake Tributaries[10]	nm	○	○	○	● / ○	-	-			-
Gregoire Lake	-	-	-	-	-	-	WALL NRPK	○	○	-
Clearwater River	nm	●	nm	nm	-	-	NRPK (>500mm)	●	●	-
High Hills River	-	○	n/a	-	n/a	n/a	-			-
Hangingstone River	○	-	-	-	-	-	-			-
Fort Creek	●	○	●	○	○	-	-			-
Beaver River	-	●	-	-	-	-	-			-
McLean Creek	-	●	-	-	-	-	-			-
Mills Creek	●	●	-	-	-	-	-			-
Isadore's Lake	nm	n/a	○	n/a	-	-	-			-
Poplar Creek	○	○	●	○	○	-	-			-
Shipyard Lake	-	n/a	○	n/a	-	-	-			-
Big Creek	-	○	-	-	-	-	-			-
Pierre River	-	○	-	-	-	-	-			-
Red Clay Creek	-	○	-	-	-	-	-			-
Eymundson Creek	-	○	-	-	-	-	-			-
Stony Mountains	-	-	-	-	-	-	-			○
West of Fort McMurray	-	-	-	-	-	-	-			○
Northeast of Fort McMurray	-	-	-	-	-	-	-			○
Birch Mountains	-	-	-	-	-	-	-			○
Canadian Shield	-	-	-	-	-	-	-			○
Caribou Mountains	-	-	-	-	-	-	-			○

Legend and Notes

○ Negligible-Low change

● Moderate change

● High change

"-" program was not completed in 2012.

nm - not measured in 2012.

n/a - classification could not be completed because there were no *baseline* conditions to compare against.

[1] **Hydrology:** Calculated on differences between observed *test* and estimated *baseline* hydrographs: ± 5% - Negligible-Low; ± 15% - Moderate; > 15% - High.

Note: As not all hydrology measurement endpoints are calculated for each watershed because of differing lengths of the hydrographic record for 2012, hydrology results above are for those measurement endpoints that were calculated.

Note: Mean Open-Water Season Discharge and Annual Maximum Daily Discharge in the Muskeg River watershed were assessed as Moderate; Mean Winter Discharge and Minimum Open-Water Season Discharge were assessed as High.

[2] **Water Quality:** Classification based on adaptation of CCME water quality index.

Note: Water quality at all stations in the Athabasca River was assessed as Negligible-Low with the exception of station ATR-MR-E, which was assessed as Moderate.

Note: Water quality at the lower station of the MacKay River was assessed as Negligible-Low and water quality at the middle station was assessed as Moderate.

Note: Water quality at the lower station of the Christina River was assessed as Negligible-Low and water quality at the upper station was assessed as High.

[3] **Benthic Invertebrate Communities:** Classification based on statistical differences in measurement endpoints between *baseline* and *test* reaches or between *baseline* and *test* periods or trends over time for a reach as well as comparison to regional *baseline* conditions.

Note: Benthic invertebrate communities in the Athabasca River Delta were assessed as Moderate at Big Point Channel and Embarras River, and Goose Island Channel and High at Fletcher Channel.

Note: Benthic invertebrate communities at the lower reach of the Muskeg River were assessed as Moderate and benthic invertebrate communities at the middle and upper reaches were assessed as Negligible-Low.

Note: Benthic invertebrate communities at the lower reach of the Christina River were assessed as Moderate and benthic invertebrate communities at the upper reach were assessed as Negligible-Low.

[4] **Sediment Quality:** Classification based on adaptation of CCME sediment quality index.

[5] **Fish Populations (fish assemblages):** Classification based on exceedances of measurement from the regional variation in *baseline* reaches; see Section 3.2.4.3 for a detailed description of the classification methodology.

Note: Fish assemblages in the Muskeg River were assessed as Negligible-Low at the lower reach and Moderate at the middle and upper reaches.

Note: Fish assemblages Sawbones Creek were assessed as Moderate and fish assemblages at Sunday Creek and Jackfish River were assessed as Negligible-Low.

[6] **Fish Populations (sentinel species):** Classification based on effects criteria established for Environment Canada's Environmental Effects Monitoring Program for pulpmills (Environment Canada 2010); see Section 3.2.4.4 for a description of the classification methodology.

[7] A classification of results could not be completed for the lower Muskeg River site given the low sample size of slimy sculpin captured for the sentinel species program.

[8] **Fish Populations (human health):** Uses Health Canada criteria for risks to human health. NRPK – northern pike; WALL – walleye; Sub. refers to subsistence fishers; Gen. refers to general consumers as defined by Health Canada.

[9] **Acid-Sensitive Lakes:** Classification based the frequency in each region with which values of seven measurement endpoints in 2012 were more than twice the standard deviation from their long-term mean in each lake.

[10] Christina Lake tributaries include Sawbones Creek, Sunday Creek, and Jackfish River.