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REGIONAL AQUATICS MONITORING

in support of the

JOINT OIL SANDS MONITORING PLAN

Final 2014 Program Report – Executive Summary

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Prepared for:

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EXECUTIVE SUMMARY

OVERVIEW

In 2012, the governments of Canada and Alberta developed a "Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring" (Canada and Government of Alberta 2012) specific to the Athabasca oil sands region of northeastern Alberta. The implementation plan was to build and expand on existing environmental monitoring programs for the region, including the Regional Aquatics Monitoring Program (RAMP, www.ramp-alberta.org). RAMP was implemented in 1997 as a multi-stakeholder aquatics monitoring program that assessed the health of rivers and lakes within the oil sands region, and to assess potential cumulative effects of oil sands development. The intent of the new joint implementation plan was to enhance these monitoring activities and work to integrate environmental monitoring across all environmental components (i.e., air, water, land, and biodiversity), which were historically monitored independently through separate organizations or programs.

As a result of the implementation plan, the Joint Oil Sands Monitoring Plan (JOSMP, www.jointoilsandsmonitoring.ca) was initiated over three years (2012 to 2015) to characterize the state of the environment in the Athabasca oil sands region, understand the cumulative effects and changes, and develop recommendations for an integrated environmental monitoring program, with an adaptive management framework for implementation in the oil sands region. From 2012 to 2014, the RAMP Committees worked with the governments of Canada and Alberta to align aquatics monitoring activities historically undertaken by RAMP into the JOSMP, completing this process by April 1, 2014.

Established in 2014, the Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA, www.aemera.org) is an arm's length organization responsible for collecting credible scientific data and other relevant information on the condition of Alberta's environment and providing the public with open and transparent reporting and access to the data and information. AEMERA is responsible for the coordination and implementation of the JOSMP in the oil sands region, as well as the integration of all environmental monitoring in the Province of Alberta. The intent of this agency is to provide timely collection and objective reporting of scientific data and information on air, land, water, and biodiversity, including information necessary to understand cumulative effects, in order to better inform the understanding of the public, policy makers, regulators, planners, researchers, communities, and industries (www.aemera.org).

This report presents the 2014 results for aquatics monitoring in the oil sands regions in support of the JOSMP that was historically conducted under the RAMP. Additional aquatics monitoring under the JOSMP was conducted by Alberta Environment and Sustainable Resource Development (AESRD) and Environment Canada; results from these monitoring activities are not provided in this report.

The study area that was used for this portion of aquatics monitoring under the JOSMP was defined as the major watersheds in the Athabasca oil sands region, where oil sands development has been approved or are active, while the geographic scope of the entire JOSMP encompasses a larger area, particularly to the north (Canada and Government of Alberta 2012). The watersheds where monitoring occurred in 2014 included:

- Lower Athabasca River;
- Major tributary watersheds/basins of the lower Athabasca River including the Clearwater River, Christina River, Hangingstone River, Gregoire 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);
- Select minor tributaries to Christina Lake (Sunday Creek, Birch Creek, Jackfish River, Sawbones Creek, and two unnamed creeks);
- Specific wetlands and shallow lakes in the vicinity of current or planned oil sands and related developments; and
- A selected group of 45 regional acid-sensitive lakes.

The study area also included the Athabasca River Delta as the receiving environment for any oil sands developments occurring in the Athabasca oil sands region.

The program 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 on monitoring sensitive biological indicators that reflect the overall condition of the aquatic environment. By combining both monitoring approaches, the program strives to achieve a more holistic understanding of potential effects on the aquatic environment related to oil sands development.

The scope of the program 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 oil sands region, 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 and lakes 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.

A weight-of-evidence approach is used for the analysis of monitoring data by applying multiple analytical methods to interpret results and determine whether any changes have occurred due to 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 oil sands project EIAs, AESRD, and CCME water quality and sediment quality guidelines, generally-accepted EEM effects criteria) for determining whether or not a change in measurement endpoints has occurred and is significant with respect to the health and integrity of valued environmental resources. The magnitude of change in the values of measurement endpoints has been described as **Negligible-Low**, **Moderate**, or **High** relative to *baseline* conditions (see the tabular summary following the Executive Summary for details regarding these criteria).

The 2014 Program 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 oil sands development; 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 2014) or were (prior to 2014) upstream of all oil sands development; 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 the location of the aquatic resource in relation to the location of the oil sands development to allow for long-term comparison of trends between *baseline* and *test* stations.

Satellite imagery was used in 2014 in conjunction with more detailed maps of Athabasca oil sands operations provided by a number of oil sands operators to estimate the type, location, and amount of land changed by oil sands development activities. As of 2014, it was estimated that approximately 123,990 ha (3.5%) of the Athabasca oil sands region had undergone land change from oil sands developments. The percentage of the area of watersheds with land change as of 2014 varied from less than 1% for many watersheds (MacKay, Horse, Pierre River, and Upper Beaver watersheds), to 1% to 5% for the Steepbank, Calumet, Firebag, Ells, Christina, and Hangingstone watersheds, to more than 10% for the Muskeg River, Fort Creek, Mills Creek, Tar River, Shipyard Lake, Poplar Creek, and McLean Creek watersheds, as well as for the smaller Athabasca River tributaries between Fort McMurray and the confluence of the Firebag River.

ASSESSMENT OF 2014 MONITORING RESULTS

A tabular summary of the 2014 results by watershed and component is presented at the end of this Executive Summary.

Lower Athabasca River and Athabasca River Delta

Hydrology For the 2014 water year (WY), the mean open-water discharge, mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge were 0.7%, 1.6%, 0.6%, and 1.1% lower, respectively, in the observed *test* hydrograph for the Athabasca River than in the estimated *baseline* hydrograph. These differences were classified as **Negligible-Low**.

Water Quality Differences in water quality in fall 2014 at all three stations (east bank, centre of channel, and west bank) of the Athabasca River, downstream of oil sands development, were classified as **Negligible-Low** compared to regional *baseline* conditions (historical *baseline* data for the Athabasca River, upstream of development). Concentrations of water quality measurement endpoints were consistent with regional *baseline* conditions and generally consistent with previously-measured concentrations. Similarities of exceedances of guideline concentrations and regional *baseline* concentrations were generally observed across all three stations. Concentrations of total aluminum exceeded the guideline at all three stations in fall 2014 and total boron continued to show an increasing trend at the station on the west bank of the Athabasca River, downstream of development.

Benthic Invertebrate Communities and Sediment Quality Benthic invertebrate communities were monitored at four locations in the Athabasca River Delta (ARD) in fall 2014:

1. Differences in measurement endpoints for benthic invertebrate communities for Big Point Channel were classified as **Negligible-Low** because although there was a significant change in Correspondence Analysis (CA) Axis 1 scores over time, the change was not indicative of degradation. Additionally, all measurement endpoints of benthic invertebrate communities were within the tolerance limits of the normal range of variation for all previous sampling years at reaches of the ARD.

2. Differences in measurement endpoints for benthic invertebrate communities of Goose Island Channel were classified as **High** because there were significant differences for all measurement endpoints. Abundance and richness were lower and equitability was higher in 2014 than any previous year of sampling, indicating potential negative changes to the benthic invertebrate community. The percentage of sensitive EPT (Ephemeroptera, Plecoptera, Trichoptera) taxa was higher in 2014 and was increasing over time. CA Axis 1 scores were decreasing over time and were lower in 2014 than previous years and CA Axis 2 scores were increasing over time. Abundance and richness were below the tolerance limits of the 5^{th} percentile for the means of previous years of sampling in the ARD. Chironomids were nearly absent in 2014 and tubificids dominated the relative abundance of organisms at this reach, potentially reflecting the high silt content in sediments.

3. Differences in measurement endpoints for benthic invertebrate communities of Fletcher Channel were classified as **Moderate** because of the significant and large decreases in abundance and CA Axis 1 scores, and increase in equitability, over time. However, Fletcher Channel showed numerous indications of a stable community including a higher richness in 2014 and the presence of EPT taxa.

4. Differences in measurement endpoints of benthic invertebrate communities for the Embarras River were classified as **Negligible-Low** because although there were significant decreases in abundance, percentage of fauna as EPT taxa, and CA Axis 1 and 2 scores, the percentage of EPT taxa has actually remained stable over the past three years and abundance was higher in 2014 than 2013. There were no measurement endpoints that exceeded the tolerance limits for the normal range of variation for previous years of sampling in the ARD indicating that there was no concern that conditions were significantly degraded.

In 2014, all sediment stations of the ARD were dominated by silt. All sediment quality measurement endpoints at *test* stations on Big Point and Fletcher channels were within previously-measured concentrations. Concentrations of F2, F3, and F4 hydrocarbons at Goose Island Channel reached maximum values in fall 2014, while only F4 hydrocarbons exceeded the previously-measured maximum concentration at the Embarras River. Concentrations of retene, total dibenzothiophenes, total polycyclic aromatic hydrocarbons (PAHs), and total alkylated PAHs exceeded previously-measured maximum concentrations, while naphthalene was below the previously-measured minimum concentration at Goose Island Channel. At the Embarras River, concentrations of retene and total dibenzothiophenes also exceeded previously-measured maximum concentrations, while naphthalene and total parent PAHs were below previously-measured minimum results. Concentrations of PAHs at all stations in fall 2014 were dominated by alkylated species, indicating a petrogenic origin of these compounds. At all stations, with the exception of Fletcher Channel, the PAH Hazard Index value exceeded the potential chronic toxicity threshold of 1.0. The concentration of F3 hydrocarbons exceeded the CCME guideline at Goose Island Channel, while concentrations of total arsenic exceeded the CCME guideline at Fletcher Channel, Goose Island Channel, and the Embarras River. All toxicity test measurements were within the range of previously-measured results at all stations for the amphipod *Hyalella*. Because no *baseline* data were available for the ARD, it was not possible to calculate the Sediment Quality Index (SQI) for each station, nor compare concentrations to relative *baseline* conditions.

Fish Populations (fish inventory) The objective of the fish inventory program was to assess general trends in population variables such as abundance and richness as well as to determine age, size, and health of individual fish within these populations. Key findings, with respect to changes observed in 2014 compared to previous years were as follows:

- Total catch in summer and fall 2014 was much lower compared to 2013, although catch in spring was similar to 2013**.** The lower catch in fall was attributed primarily to the timing of sampling with respect to the migration of lake whitefish from Lake Athabasca to spawning grounds in the Athabasca River. Due to restrictions outlined in the Fish Research License issued by AESRD, sampling could not occur during the spawning period, as it has in previous years. Lower water levels were also observed in fall 2014, limiting habitat availability as well as boat access and fishing efficiency. These factors also may have contributed to the reduction in total catch and richness observed in 2014.

- A large change in species composition was observed in fall with a record low percentage of lake whitefish captured. In years where lake whitefish were the most abundant species in fall in the Athabasca River, sampling was generally conducted in the last ten days of September (compared to 2014 when sampling was conducted from September 10 to 15).

- There was a decrease in catch per unit effort (CPUE) of white sucker in 2014 compared to 2013 in spring. However, the highest CPUE of white sucker continued to be observed in the Muskeg area of the Athabasca River, which is a river that white sucker use for spawning.

- The dominant age class of northern pike in 2013 and 2014 was one and two years, respectively; dominance was most pronounced at five years in 2012 and from 1997 to 2011. The increased frequency of younger northern pike in the Athabasca River suggested higher levels of recruitment or increased selection of older individuals from fishing pressure. The limited catch of younger lake

whitefish is typical as lake whitefish are only commonly caught in the Athabasca River in the fall as adults migrate from Lake Athabasca to spawning grounds upstream of Fort McMurray.

- Overall, the 2014 fish health assessment indicated that abnormalities observed among all species were within the historical range (1987 to 2013), despite the higher than average incidence of abnormalities observed in northern pike (14.8%) related primarily to fin erosion. These findings were also consistent with previously cited studies published prior to major oil sands development in the upper Athabasca River, the Athabasca River Delta, and the Peace/Slave rivers.

Fish Populations (fish tissue) Measurement endpoints used in the assessment for the Athabasca River fish tissue program included concentrations of metals and tainting compounds in muscle tissue of both individual and composite samples of lake whitefish and walleye. Potential human health risks from contaminated fish tissue were predicted from both individual and composite samples. In 2014, the mean concentration of mercury in lake whitefish was slightly higher than 2011, but within the range of concentrations observed in previous sampling years. The mean mercury concentration across all size classes of lake whitefish were below the Health Canada guideline for subsistence fishers indicating a **Negligible-Low** risk to human health. The mean concentration of mercury in walleye was higher in 2014 compared to previous years. The mean mercury concentration in size classes of walleye greater than 300 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) Results of the fish assemblage monitoring in the ARD indicated a decrease in abundance across all reaches relative to 2013. All other measurement endpoints were generally consistent across channels, with high values of the Assemblage Tolerance Index (ATI) reflecting the tolerant nature of fish species in the delta. Water temperatures during the 2013 fish assemblage monitoring program in the ARD ranged from 19.5˚C to 20.4˚C with a mean of 19.8˚C, whereas water temperatures during the 2014 monitoring program were higher ranging from 20.4˚C to 23.4˚C, with a mean of 22.1˚C. The higher temperatures in 2014 could have resulted in fish being in deeper, cooler waters, where boat electrofishing was not effective. The most abundant large-bodied species were goldeye and northern pike; goldeye was dominant at reaches of Big Point, Goose Island, and Fletcher channels, while northern pike was dominant at the Embarras River.

Muskeg River Watershed

Hydrology The 2014 WY mean open-water discharge, mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge were -4.9%, -5.5%, -8.3%, and 35.6%, respectively, in the observed *test* hydrograph for the Muskeg River compared to the estimated *baseline* hydrograph. The difference in mean open-water discharge was classified as **Negligible-Low.** The difference in annual maximum daily discharge and mean winter discharge were classified as **Moderate**, and the difference in open-water minimum daily discharge was classified as **High**. The results of the longitudinal assessment of the Muskeg River suggested that the extent of the **High** hydrologic changes was limited to a length of the Muskeg River between Stanley Creek and Muskeg Creek.

In the 2014 WY, the water level of Kearl Lake declined from November until mid-April and then increased from early April to early June and then decreased steadily until early September. The maximum level was 0.05 m higher than the historical mean annual maximum daily lake level. From early September until the

end of the water year, the lake level remained relatively stable. The lake level was within the historical interquartile range for most of the WY, and did not exceed or drop below historical maxima or minima.

Water Quality In fall 2014, concentrations of most water quality measurement endpoints at stations of the Muskeg River watershed were within the range of historical concentrations and generally consistent with regional *baseline* conditions. Differences in water quality in fall 2014 at all stations in the Muskeg River watershed compared to regional *baseline* water quality conditions were classified as **Negligible-Low**.

Concentrations of most water quality measurement endpoints at the lower *test* station of the Muskeg River (sampled monthly) were within the range of regional *baseline* fall concentrations in each month of 2014, with monthly variability generally showing higher concentrations of ions and metals in winter and early spring when water levels were low. Despite some variability across months, the ionic composition of water collected throughout the year at the lower *test* station of the Muskeg River remained consistent.

Benthic Invertebrate Communities and Sediment Quality Benthic invertebrate communities were monitored at five *test* reaches in the Muskeg River watershed in fall 2014:

1. Differences in values of measurement endpoints at the lower *test* reach of the Muskeg River were classified as **Negligible-Low** because the significant changes in CA Axis 1 and 2 scores were a result of higher relative abundances of benthic invertebrates at this reach. Higher relative abundances of chironomids, mayflies, and caddisflies, and the presence of stoneflies were indicative of good water quality and habitat conditions and higher habitat quality relative to 2013. The percentage of the fauna as worms (tubificids and naidids) was low indicating no significant change in the quality of the habitat. The percentage of EPT taxa was slightly higher than the inner tolerance limit for the 95th percentile, indicating a positive change at this reach.

2. Differences in values of measurement endpoints for benthic invertebrate communities at the middle *test* reach of the Muskeg River were classified as **Negligible-Low** because there were no significant changes detected at this reach, with high diversity and a high percentage of EPT taxa in 2014, and habitat quality was higher relative to 2013.

3. Differences in values of measurement endpoints for benthic invertebrate communities at the upper *test* reach of the Muskeg River were classified as **Negligible-Low** because the significant increase over time in the percentage of EPT taxa and the higher percentage of EPT taxa in 2014 compared to the mean of *baseline* years or the mean of all years combined were indicative of a positive change in the benthic invertebrate community. Four measurement endpoints were outside of the tolerance limits for the historical range of variation, but were also indicative of improving water quality and benthic community health. The relative abundance of tubificid worms was high in 2014, but consistent with previous years, and habitat quality was higher relative to 2013.

4. Differences in measurement endpoints for benthic invertebrate communities at the *test* reach of Jackpine Creek were classified as **Negligible-Low** because equitability was lower than previous years, indicating improving conditions, and the benthic community was diverse, including clams, snails, mayflies, and stoneflies.

5. Differences in measurement endpoints of benthic invertebrate communities of Kearl Lake were classified as **Negligible-Low** because the statistically large changes observed for richness, equitability, and CA Axis 1 and 2 scores were not indicative of degraded conditions. Additionally, the benthic invertebrate community of Kearl Lake contained a diverse fauna and included several taxa that are typically associated with relatively good water and sediment quality in lakes (e.g., the mayfly *Caenis* and bivalves).

Concentrations of sediment quality measurement endpoints at all Muskeg River watershed stations sampled in fall 2014 were within previously-measured concentrations, with the exception of naphthalene at the *baseline* station of upper Jackpine Creek, and the *test* stations of the upper Muskeg River and Kearl Lake, and total dibenzothiophenes, total PAHs, and total alkylated PAHs at Kearl Lake, which were below previously-measured minimum concentrations. Concentrations of F3 hydrocarbons exceeded the relevant CCME guideline at the *test* stations of lower Jackpine Creek and the middle Muskeg River, and F1, F2, and F3 hydrocarbons exceeded guidelines at Kearl Lake. Concentrations of metals in 2014 were below CCME guidelines at all stations. Differences in sediment quality in fall 2014 at all applicable stations of the Muskeg River watershed were classified as **Negligible-Low** relative to regional *baseline* conditions. Sediment quality monitoring was not conducted at the lower station of the Muskeg River given it is erosional habitat.

Fish Populations (fish assemblages) Differences in measurement endpoints of the fish assemblage at the lower *test* reach of the Muskeg River were classified as **Moderate**. Although values of all measurement endpoints were within the range of regional *baseline* variability, there were significant decreases in abundance and catch per unit effort (CPUE), which were indicative of a potential negative change in the fish assemblage over time. Differences in measurement endpoints for fish assemblages between the middle *test* reach of the Muskeg River and regional *baseline* conditions were classified as **Negligible-Low** given there were no significant differences implying a negative change in the fish assemblage and only abundance and diversity were at the outer tolerance limit of the 5th percentile of variation of *baseline* conditions. Differences in measurement endpoints for the upper *test* reach of the Muskeg River were classified as **High** because although there were no significant differences over time, abundance, diversity, and CPUE have been below the range of *baseline* variability for three consecutive years.

Differences in measurement endpoints of the fish assemblage at the lower *test* reach of Jackpine Creek were classified as **High** because abundance and CPUE were low and near the outer tolerance limit of the 5th percentile of regional *baseline* variability and there were significant decreases in all measurement endpoints that were indicative of a negative change in the fish assemblage over time. It should be noted; however, that although there has been decreases in measurement endpoints since 2009, abundance, CPUE, richness, and diversity were higher in 2014 compared to 2013, which could indicate improving conditions.

Steepbank River Watershed

Hydrology The 2014 WY mean open-water discharge, mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge were 0.33%, 0.34%, 0.34%, and 0.01% higher, respectively, in the observed *test* hydrograph for the Steepbank River than in the estimated *baseline* hydrograph. These differences were classified as **Negligible-Low.**

Water Quality Concentrations of most water quality measurement endpoints in the Steepbank River watershed in fall 2014 were within previously-measured concentrations, with the exception of many ions at the middle *test* station (downstream of the confluence of the North Steepbank River), which showed concentrations higher than previously measured in fall 2014. The ionic composition at all water quality monitoring stations in the Steepbank River watershed in fall 2014 was similar to previous years. Concentrations of water quality measurement endpoints were also generally within the range of regional *baseline* conditions. Differences in water quality in fall 2014 compared to regional *baseline* water quality conditions were classified as **Negligible-Low** for all stations in the Steepbank River watershed, with the exception of the lower *test* station of the Steepbank River (near the mouth), which was classified as **Moderate** due to exceedances of concentrations of total metals, ions, and physical variables from the 95th percentile of regional *baseline* conditions.

Concentrations of most water quality measurement endpoints exhibited fluctuations across months at the middle *test* station of the Steepbank River, which was sampled on a monthly basis in 2014. Typically the maximum concentration of ions were reached in April, while the minimum concentrations were reached in June. Despite the observed changes in ion concentrations from previous years in fall, the ionic composition remained consistent throughout the year.

Benthic Invertebrate Communities Differences in measurement endpoints of the benthic invertebrate community at the lower *test* reach of the Steepbank River were classified as **Moderate** because abundance, richness, CA Axis 1 and 2 scores, and the percentage of EPT taxa were significantly lower than the upstream *baseline* reach. The benthic invertebrate community at the lower *test* reach; however, was diverse and contained many taxa that require cool, clean water indicating a lack of degradation at this reach and generally good water quality conditions. Sediment quality monitoring was not conducted on the Steepbank River given it is an erosional river.

Fish Populations (fish assemblages) Differences in measurement endpoints of the fish assemblage at the lower *test* reach of the Steepbank River were classified as **High** because three of the five measurement endpoints (abundance, richness, and catch per unit effort) significantly decreased over time and catch per unit effort and abundance were lower than the range of regional *baseline* variability, indicating a potential negative change to the fish assemblage.

Tar River Watershed

Hydrology The 2014 WY mean open-water discharge, maximum daily discharge, and minimum daily discharge were all 28.8% lower in the observed *test* hydrograph for the Tar River than in the estimated *baseline* hydrograph. These differences were classified as **High**. While the overall classification of watershed changes was classified as **High**, the results from the longitudinal assessment suggested that the extent of **High** hydrologic changes was limited to the lowest 7 km of the Tar River, which were approved changes as part of the development of the Canadian Natural Horizon project.

Water Quality In fall 2014, water quality at stations of the Tar River indicated **Negligible-Low** differences from regional *baseline* conditions. Most water quality measurement endpoints at the lower *test* and upper *baseline* stations were within the range of previously-measured concentrations and were consistent with regional *baseline* concentrations.

Benthic Invertebrate Communities and Sediment Quality Differences in benthic invertebrate communities at the lower *test* reach of the Tar River were classified as **High** because of the significant decreases in abundance and richness, and increase in equitability (i.e., lower diversity) from the *baseline* period at this reach. A significant time trend was noted for CA Axis 1 scores suggesting a change in taxa composition over time with fewer water mites and mayflies found in more recent years at the lower *test* reach. Abundance and richness were below the normal range of variation for regional *baseline* depositional reaches. Overall diversity and the percentage of EPT taxa has been steadily decreasing since 2009 and mayflies and caddisflies, which were present during the *baseline* period and in previous *test* years, were absent in both 2013 and 2014.

Concentrations of all sediment quality measurement endpoints at the lower *test* station of the Tar River in fall 2014 were within previously-measured concentrations except naphthalene, which was below historical observations. The concentration of F3 hydrocarbons and the predicted PAH toxicity exceeded relevant thresholds, but were within the range of historical observations. Differences in sediment quality observed in fall 2014 between the lower *test* station and regional *baseline* conditions were classified as **Negligible-Low.** Sediment quality monitoring was not conducted at the upper station of the Tar River given it is erosional habitat.

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 all measurement endpoints were within the inner tolerance limits of the *baseline* range of variability and there were no significant changes in measurement endpoints over time.

MacKay River Watershed

Hydrology The 2014 WY mean open-water discharge, mean winter discharge, and open-water minimum daily discharge were 0.004%, 0.069%, 0.045% lower, respectively, and the annual maximum daily discharge was 0.007% higher in the observed *test* hydrograph for the MacKay River than in the estimated *baseline* hydrograph. These differences were classified as **Negligible-Low**.

Water Quality Concentrations of most water quality measurement endpoints for stations of the MacKay River watershed were within the range of previously-measured concentrations and within the range of regional *baseline* concentrations in fall 2014. Differences between water quality at the lower and middle *test* stations, and the upper *baseline* station and regional *baseline* water quality conditions were classified as **Negligible-Low**.

Concentrations of most water quality measurement endpoints exhibited fluctuations across months at the upper *baseline* station, which was sampled on a monthly basis in 2014. Typically, the maximum concentration of ions occurred in March and the minimum concentrations occurred in May, consistent with expected seasonal influences of surface-water runoff (i.e., greatest during freshet and weakest during winter low-flow conditions). The decrease in alkalinity in spring likely resulted from base-cation dilution by snowmelt rather than consumption of alkalinity by acidic compounds in snow, given consistent seasonal trends also were observed in other ions. Despite the observed changes in ion concentrations, the ionic composition remained relatively consistent throughout the year but was slightly less dominated by calcium in winter months.

Benthic Invertebrate Communities Differences in measurement endpoints for benthic invertebrate communities at the lower *test* reach of the MacKay River were classified as **Negligible-Low** because, although richness was significantly lower than the upper *baseline* reach, richness was higher in 2014 than the mean of all *baseline* years for the lower and upper reaches. Differences in CA Axis 2 scores were due to slight differences in taxa composition between the lower *test* and upper *baseline* reaches. Additionally, the taxa composition at the lower *test* reach has remained stable and diverse over the past two years with the presence of EPT taxa and a low overall abundance of worms. Differences in measurement endpoints for the benthic invertebrate community at the middle *test* reach of the MacKay River were classified as **Negligible-Low** because the only significant change was an increasing trend over time in the percentage of the fauna as EPT taxa and differences in CA Axis 2 scores, which did not imply a negative change in the benthic invertebrate community. The benthic fauna at the middle *test* reach was representative of good overall water quality with a high percentage of EPT taxa and a low relative abundance of worms. Sediment quality monitoring was not conducted on the MacKay River given it is an erosional river.

Fish Populations Differences in measurement endpoints of the fish assemblage at the lower *test* reach of the MacKay River were classified as **Moderate** because of significant decreases in abundance and catch per unit effort over time and differences compared to the upper *baseline* reach. In addition, abundance and catch per unit effort were also lower than regional *baseline* conditions. Differences in measurement endpoints for the fish assemblage at the middle *test* reach of the MacKay River were classified as **Negligible-Low** given there was only a significant decrease in abundance over time and all measurement endpoints were within regional *baseline* variability.

Calumet River Watershed

Hydrology The 2014 WY mean open-water discharge, maximum daily discharge, and minimum daily discharge were 0.26% lower in the observed *test* hydrograph for the Calumet River than in the estimated *baseline* hydrograph. These differences were classified as **Negligible-Low**.

Water Quality In fall 2014, water quality at the lower *test* station and upper *baseline* station of the Calumet River indicated **Negligible-Low** differences from regional *baseline* conditions. Concentrations of most water quality measurement endpoints were within previously-measured concentrations for both stations, with the exception of concentrations of many hydrocarbons (CCME fractions and PAHs) in 2014 at the lower *test* station, which had concentrations substantially greater than historically observed at this station and compared to the upper *baseline* station in 2014. Significantly higher flows in 2014 in the Calumet River in May and June 2014 contributed to bank erosion near the lower water quality station, which may have caused the increase in total suspended solids and PAHs and hydrocarbons from bank sediments. The ionic composition of water at the lower *test* station was consistent with previous years, while the ionic composition of water at the upper *baseline* station was less dominated by bicarbonate ions in 2014 than most previous sampling years.

Firebag River Watershed

Hydrology The 2014 WY mean open-water discharge, mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge were 0.23% lower in the observed *test* hydrograph for the Firebag River than in the estimated *baseline* hydrograph. These differences were classified as **Negligible-Low.** The water level of McClelland Lake, in winter of the 2014 WY was generally near the

upper quartile and reached a peak in early June due to rainfall events. The lake level from June to October was above the historical median values.

Water Quality In fall 2014, water quality at the lower *test* station and upper *baseline* station of the Firebag River showed **Negligible-Low** differences from regional *baseline* water quality conditions. Concentrations of most water quality measurement endpoints at both stations were within the range of regional *baseline* concentrations and within the range of previously-measured concentrations in fall 2014. The ionic composition of water in fall 2014 at both Firebag River stations and Johnson Lake were consistent with previous sampling years and dominated by calcium and bicarbonate ions. The ionic composition of McClelland Lake was dominated by magnesium and bicarbonate and consistent with previous sampling years. Concentrations of water quality measurement endpoints for McClelland Lake and Johnson Lake were not compared to regional *baseline* conditions given the ecological differences between lakes and rivers and the lack of *baseline*-lake data for the region.

Benthic Invertebrate Communities and Sediment Quality Differences in benthic invertebrate communities of McClelland Lake were classified as **Negligible-Low** because although there was a significant increase in the percentage of fauna as EPT taxa and lower equitability in 2014 compared to previous years, these changes were indicative of good lake conditions. The general composition of the community in terms of relative abundances, presence of fully aquatic forms, and presence of generally sensitive taxa such as the mayfly *Caenis* and six types of caddisflies suggested that the benthic invertebrate community of McClelland Lake was in good condition and generally consistent to *baseline* conditions.

The benthic invertebrate community of Johnson Lake showed some improvement in 2014 compared to 2013, with the presence of sensitive EPT taxa, which were not observed in 2013. The abundance of worms (Tubificidae and Naididae) were lower in 2014 compared to 2013 and there were amphipods and gastropods present, indicating that Johnson Lake was generally in good condition.

Sediment of McClelland Lake and Johnson Lake was predominantly composed of silt. The percentage of silt and the total organic carbon content exceeded previously-measured maximum values at McClelland Lake, while the percentage of sand was below the previously-measured minimum value. All physical sediment variables for Johnson Lake were within the range of previously-measured values. Concentrations of naphthalene, retene, total dibenzothiophenes, total PAHs, and total alkylated PAHs at Johnson Lake were below previously-measured minimum concentrations. All sediment quality measurement endpoints were below the relevant sediment quality guidelines, with the exception F3 hydrocarbons, which exceeded the CCME guideline at both lakes. SQI values were not calculated for McClelland and Johnson lakes given the absence of regional *baseline* concentrations for lakes.

Ells River Watershed

Hydrology The 2014 WY mean open-water discharge (May to October), mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge were 0.15% higher in the observed *test* hydrograph for the Ells River than in the estimated *baseline* hydrograph. These differences were classified as **Negligible-Low**.

Water Quality Differences in water quality in fall 2014 between the Ells River and regional *baseline* conditions were classified as **Negligible-Low**. Water quality conditions were consistent with previous years at the lower *test* station of the Ells River and were typically within the range of previously-measured

concentrations and regional *baseline* conditions. The upper *baseline* station, initiated in 2013, showed similar water quality to the lower *test* station, and was within regional *baseline* conditions in fall 2014 for all measurement endpoints with the exception of lower concentrations of total mercury (ultra-trace). Concentrations of water quality measurement endpoints for Gardiner and Namur lakes were not compared to regional *baseline* conditions given the ecological differences between lakes and rivers. The ionic composition of water in Namur and Gardiner lakes was similar to stations of the Ells River but showed a slightly lower and greater dominance of calcium and bicarbonate, respectively, compared to the stations on the Ells River. There were no water quality guideline exceedances at Namur Lake and very few at Gardiner Lake in 2014.

Benthic Invertebrate Communities and Sediment Quality Differences in measurement endpoints for the benthic invertebrate community at the lower *test* reach of the Ells River were classified as **Moderate** because significant decreases in abundance, EPT taxa, richness, and CA Axis 2 scores over time were indicative of potentially degrading conditions. Abundance in fall 2014 (111 organisms per sample) was higher than fall 2013 (48 organisms per sample), but still lower than previous years. Most of the major groups of larger organisms (e.g., clams, snails, mayflies, caddisflies) were sparse in 2014 and EPT taxa were absent. All of the smaller and previously-abundant organisms remained abundant in 2014 and a decrease in tubificid worms has been occurring over time. Chironomids were dominated by forms that are not known to be particularly tolerant of degraded water quality. Similar to 2013, water velocity at the lower Ells River in 2014 (0.6 m/s) was higher than previously reported (normally in the 0.05 to 0.2 m/s range), and could be an explanation for the absence of larger forms of benthic invertebrates at the lower *test* reach in recent years.

The benthic invertebrate communities of Gardiner and Namur lakes were sampled for the first time in 2014. The benthic invertebrate communities of both lakes were evident of good water quality conditions, with the presence of EPT taxa and permanent aquatic forms (e.g., bivalves, gastropods). The relative abundance of worms were high in both lakes in 2014.

Sediment quality in fall 2014 at the lower *test* station of the Ells River indicated **Negligible-Low** differences from regional *baseline* conditions, and most sediment quality measurement endpoints were within the range of the regional *baseline* concentrations, with the exception of total PAHs. Concentrations of F2 and F3 hydrocarbons, and chrysene exceeded CCME guidelines and the predicted PAH toxicity exceeded the potential chronic effect level at the lower *test* station. Sediment quality monitoring was not conducted at the upper station of the Ells River given it is erosional habitat. SQI values were not calculated for Namur and Gardiner lakes because lakes were not included in the regional *baseline* calculations. Sampling at Namur and Gardiner lakes was initiated in 2014; therefore, no historical data were available for comparison. No sediment guidelines or threshold values were exceeded at either lake in 2014.

Fish Populations Differences in measurement endpoints for the fish assemblage at the lower *test* reach of the Ells River were classified as **Moderate** given that abundance and catch per unit effort (CPUE) have decreased over time and all measurement endpoints were lower compared to the upper *baseline* reach. It is noted; however, that there was a decrease in the assemblage tolerance index (ATI) value, indicating a greater proportion of sensitive species in the assemblage, and all measurement endpoints were within regional *baseline* conditions.

Clearwater River Watershed

Hydrology Flows of the Clearwater River, downstream of the Christina River confluence, decreased from November 2013 to January 2014 and then remained relatively constant until early April. Flows then increased in mid-April in response to spring thaw, and reached the annual peak flow on June 12 shortly after rainfall accumulations starting in late May. Flows then receded until the minimum open-water daily flow on September 25. Flows from early July until the end of October were within the historical interquartile range. There was no effect in the Clearwater River watershed related to oil sands development in 2014, with the exception of development in the Christina River watershed. Accordingly, no assessment of current versus *baseline* hydrologic conditions was warranted.

Water Quality In fall 2014, water quality at all stations of the Clearwater River watershed indicated **Negligible-Low** differences from regional *baseline* conditions. Concentrations of most water quality measurement endpoints were within the range of previously-measured concentrations and were within the range of regional *baseline* conditions. Concentrations that exceeded previously-measured concentrations most frequently occurred at the *baseline* station on the High Hills River (tributary to the Clearwater River), due to the limited historical data available for comparison. All stations showed similar ionic composition to previous years of sampling, with the ionic composition at the *baseline* station of the High Hills River continuing to be more dominated by calcium and bicarbonate ions than the stations of the Clearwater River mainstem. No trends in measurement endpoints were observed over time, with the exception of a decreasing trend in potassium at the lower *test* station of the Clearwater River. Concentrations of many water quality variables fluctuated across months in 2014 at the upper *baseline* station of the Clearwater River, which was sampled on a monthly basis in 2014. Despite these fluctuations, the ionic composition of the Clearwater River remained fairly consistent across the year, with only slight differences in May and June. Concentrations of many water quality variables (e.g., metals) in May, June, and July exceeded guidelines and frequently exceeded fall regional *baseline* conditions.

Benthic Invertebrate Communities and Sediment Quality Differences in measurement endpoints of benthic invertebrate communities at the lower *test* reach of the Clearwater River were classified as **Negligible-Low** because the observed differences in equitability and CA axis scores were not related to oil sands development given similar trends were observed at both the *test* and *baseline* reaches. Equitability was higher at the *test* reach generally across all years of sampling but the reach had a relatively diverse community, and contained a number of taxa considered sensitive to degrading habitat such as the chironomid *Lopesocladius* and the mayfly *Ametropus neavei* (Ephemeroptera).

Sediments at the *test* and *baseline* stations of the Clearwater River were composed of sand, with concentrations of hydrocarbon fractions and PAHs below detection limits or in very low concentrations. Chronic toxicity tests yielded high survival and growth rates for the midge *Chironomus* and the amphipod *Hyalella* at both stations, indicating low toxicity of sediments. The SQI value for both the *test* and *baseline* stations of the Clearwater River in fall 2014 was 100, indicating **Negligible-Low** differences from regional *baseline* conditions.

The benthic invertebrate community at the *baseline* reach of the High Hills River contained a high diversity of typical riffle fauna including mayflies, stoneflies, and caddisflies, and chironomids that reflected good water quality conditions. The relative abundance of naidid worms (50%) was much higher

in 2013, but similar to 2011 and 2012. The *baseline* reach of the High Hills River was used as a regional *baseline* reach for comparisons to *test* reaches. Sediment quality monitoring was not conducted on the High Hills River given it is an erosional river.

Fish Populations (fish inventory) The objective of the fish inventory program on the Clearwater River was to assess general trends in population variables such as abundance and richness as well as to determine age, size, and health of individual fish within these populations. Key findings, with respect to changes observed in 2014 compared to previous years included:

- The total catch in spring and summer of 2014 decreased by 440 and 420 fish from 2013, respectively. Comparisons were unable to be carried out in fall because the *baseline* reaches were not sampled due to low water levels.
- The abundance of goldeye in spring 2014 was the highest recorded since 2009. This increase may be related to an increase in survival rates among the population given that the dominant age class was five years in 2011 but now has shifted to an older age class of seven years in 2013 and 2014.
- The dominant age classes for northern pike have been two and three year-olds since 2012, which has been a shift towards a younger age class.
- The percentage of external abnormalities increased in 2014 from 2013, with the majority of abnormalities observed in white sucker and a higher percentage of overall abnormalities observed in summer. The increase in abnormalities was primarily driven by the increase in parasites on fish, which could be related to higher water temperatures in the river.

Fish Populations (fish assemblages) The fish assemblage at the *baseline* reach of the High Hills River was consistent with other *baseline* reaches of similar habitat conditions. Fish species captured at this reach were consistent with fish assemblages commonly observed in fast-flowing riffle habitat (e.g., slimy sculpin, longnose sucker, longnose dace).

Christina River Watershed

Hydrology For the 2014 WY, the differences in mean open-water discharge, mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge between the observed *test* and estimated *baseline* hydrographs for the Christina River were 0.1%, 0.0%, 0.1% and 0.1%, respectively. These differences were classified as **Negligible-Low**.

In the 2014 WY, the water level of Christina Lake decreased slightly from November 2013 to early April 2014, and remained below historical median levels throughout this period. By early April, the lake level was close to the historical minima, but then increased in late April due to the spring thaw. The annual peak occurred on June 5, shortly after rainfall accumulations. The lake level decreased after this peak, dropping below historical median levels after mid-July and was close to historical minima from early August until late September. The annual minimum lake level occurred on September 24, and the lake level then remained relatively constant until the end of the 2014 WY.

In the 2014 WY, Jackfish River flows declined gradually from November until mid-April, and then increased due to the spring thaw in late April. Flows increased again in late May, shortly after rainfall

accumulations. All flows from May 30 to June 12 exceeded historical maxima recorded on these dates. Flows then decreased rapidly until late July, and stabilized thereafter, remaining within the historical interquartile range until the end of the year.

Water Quality In fall 2014, water quality at *test* stations of the lower, middle, and upper Christina River, Jackfish River, Sawbones Creek, Sunday Creek, and two unnamed creeks (east and south of Christina Lake), and *baseline* stations of Birch Creek, upper Christina River, and upper Sunday Creek indicated **Negligible-Low** differences from regional *baseline* conditions. The *test* station of the lower Gregoire River indicated **Moderate** differences from regional *baseline* water quality conditions, given that concentrations of several water quality measurement endpoints (e.g., total metals) exceeded relevant guidelines and regional *baseline* conditions in 2014. Gregoire River had many guideline exceedances in spring and summer 2014, whereas there were no guideline exceedances at Gregoire Lake, where the river flows from. Due to limited historical data at most sampling stations, it was only possible to compare the lower and middle *test* stations of the Christina River to historical results. Generally these stations were similar to previous years, but many ions in fall 2014 had higher concentrations than previously-measured maximums. Despite higher ion concentrations, the ionic composition at the two *test* stations remained similar across sampling years. Where comparisons were possible to recent years, the ionic composition at all other stations has also remained similar across sampling years.

Concentrations of most water quality measurement endpoints exhibited fluctuations across months at the lower and middle *test* stations of the Christina River, where monthly sampling occurred in 2014. Typically, a higher dominance of calcium and lower dominance of chloride occurred in summer months at the lower *test* station, while the middle *test* station did not show any fluctuation in ionic composition throughout the year. The highest number of water quality guideline and regional fall *baseline* concentration exceedances occurred in May, June, July, and August, which were also the months where maximum yearly concentrations of metals were most frequently reached at both stations.

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 **Negligible-Low**. The decreasing trend in CA Axis 1 scores over time and the significant difference in 2014 CA Axis 1 scores relative to the mean of previous years were not indicative of a negative change at the lower *test* reach. All measurement endpoints were within the inner tolerance limits of the normal range of variation for means from previous years of sampling. Although overall abundance was low, the relative abundance of worms was high, and the reach contained mayflies and stoneflies, suggesting reasonably good habitat quality.

Differences in measurement endpoints for benthic invertebrate communities at the middle *test* reach of the Christina River were classified as **Negligible-Low**. The decreasing trend in CA Axis 1 scores over time reflected a shift in taxa composition at this *test* reach in 2014, with the absence of several relatively abundant taxa found in previous years, including Tubificidae, Bivalvia, Ephemeroptera, and Trichoptera. Other missing taxa in 2014 included Enchytraeidae, Hydracarina, Coleoptera, and Odonata. In 2014, chironomids were one of the only taxa found at this reach. All measurement endpoints were within the inner tolerance limits of the normal range of variation for previous years of sampling at this reach.

Differences in measurement endpoints for benthic invertebrate communities at the upper *test* reach of the Christina River were classified as **Negligible-Low** because all measurement endpoints were within

the inner tolerance limits of the normal range of variation for regional *baseline* depositional reaches. This reach was sampled in erosional habitat with a Hess sampler in 2013 and in depositional habitat using an Ekman grab in 2014, confounding any assessment of changes in composition (or condition). The benthic fauna at this reach in 2014, were representative of good habitat quality, with the presence of mayflies, stoneflies, and caddisflies, and only a small relative abundance of worms.

Differences in measurement endpoints at the lower *test* reach of Sunday Creek were classified as **Moderate.** The reach contained a benthic invertebrate community with lower abundance, richness, and percentage of EPT taxa, and higher CA Axis 2 scores than the upper *baseline* reach, indicating that the lower *test* reach was of lower quality than the upper *baseline* reach. However, taxa richness and the percentage of EPT taxa have increased over the past three years of sampling at the lower *test* reach, indicating improving conditions. Additionally, all measurement endpoints for the lower *test* reach have consistently remained within the inner tolerance limits of the normal range of variation for regional *baseline* depositional reaches, indicating generally acceptable conditions at this reach.

Differences in measurement endpoints of benthic invertebrate communities at the *test* reach of Sawbones Creek were classified as **Negligible-Low.** Although there were large variations in abundance, total numbers were well within the inner tolerance limits of regional *baseline* conditions for depositional reaches. None of the other measurement endpoints varied significantly, and all were within the range of regional *baseline* conditions for depositional reaches. The benthic invertebrate community of this *test* reach was diverse and supported a community with permanent aquatic forms (snails, fingernail clams) and flying insects.

Differences in measurement endpoints of benthic invertebrate communities at the *test* reaches of two unnamed creeks (east and south of Christina Lake) were classified as **Negligible-Low** because all measurement endpoints, with the exception of richness and equitability, were within the range of regional *baseline* depositional reaches. Richness was higher than the *baseline* range of variability in 2014 at the *test* reach of Unnamed Creek, south of Christina Lake and equitability for the *test* reach of Unnamed Creek east of Christina Lake was just below the lower outer limit of the *baseline* range, neither of which indicated a negative change. The benthic invertebrate communities of both reaches had low total abundance of worms, high diversity of chironomids, and the presence of permanent aquatic forms and flying insects.

Differences in measurement endpoints of benthic invertebrate communities at the *test* reach of Jackfish River were classified as **Negligible-Low** because the community was highly diverse, and the statistically significant increases in richness and percentage of EPT taxa in 2014 were considered to be positive changes. All measurement endpoints, with the exception of abundance, were within regional *baseline* ranges. Abundance was higher than the inner tolerance limit for the 95th percentile of regional *baseline* reaches.

Gregoire River was sampled for the first time in 2014. Differences in measurement endpoints of benthic invertebrate communities at the *test* reach of Gregoire River were classified as **Negligible-Low.** Although naidid worms accounted for a large proportion of the benthic fauna (>40%), flying insects were present in relatively high numbers.

Differences in measurement endpoints of the benthic invertebrate community at Christina Lake in fall 2014 were classified as **Moderate** because several measurement endpoints (richness, abundance, EPT taxa) were lower than the previous two years, indicating a potential negative change. However, the lake still contained a diverse benthic fauna that included several permanent aquatic forms (e.g., clams, snails, amphipods), as well as several large aquatic insects (mayflies, dragonflies and caddisflies). Differences in measurement endpoints of the benthic invertebrate community at Gregoire Lake in fall 2014 were classified as **Negligible-Low** given that amphipods, chironomids, and bivalves were abundant, the abundance of worms was relatively low, and there were no concerns regarding water quality in the lake in 2014.

In fall 2014, concentrations of sediment quality measurement endpoints were generally similar to previous years (where applicable) and were typically within regional *baseline* concentrations at all stations of the Christina River watershed, except total PAHs (absolute) and PAH hazard index values at the lower *test* station and upper *baseline* station of the Christina River, and the *test* stations of Sunday Creek and one unnamed creeks (south of Christina Lake), which were below regional *baseline* ranges. Sediment quality at all stations in fall 2014 indicated **Negligible-Low** differences compared to regional *baseline* conditions. Sediment quality measurement endpoints were not compared to regional *baseline* concentrations for Christina and Gregoire lakes because lakes were not included in the calculation of *baseline* concentrations; however, sediment quality at Christina Lake was similar to conditions observed in 2012 and 2013. Sediment quality monitoring was not conducted on the Gregoire River and Jackfish River given these rivers are erosional.

Fish Populations (fish assemblages) Information on fish assemblages for the southern oil sands region is just beginning to be collected; therefore, a comparison with *baseline* conditions in the northern region was conducted. Differences in measurement endpoints for the lower and upper *test* reaches of the Christina River were classified as **Negligible-Low** because all measurement endpoints were within the range of *baseline* variability. Differences in measurement endpoints for the middle *test* reach of the Christina River were also classified as **Negligible-Low** because only two measurement endpoints (abundance and catch per unit effort) were below the range of *baseline* variability. Differences in measurement endpoints for the *test* reach of Gregoire River were classified as **Negligible-Low** because all measurement endpoints were within the *baseline* range of variability. Differences in measurement endpoints for the *test* reach of Jackfish River were classified as **Negligible-Low** because although diversity and richness exceeded the *baseline* range of variability, this was indicative of a positive change in the fish assemblage. Only abundance was below the *baseline* range of variability, indicating a potential negative change in the fish assemblage. Differences in measurement endpoints for fish assemblages for the *test* reach of Sunday Creek were classified as **Negligible-Low** because all measurement endpoints were within the range of *baseline* variability. Differences in measurement endpoints for fish assemblages at the *test* reaches of Sawbones Creek, and two unnamed creeks (east and south of Christina Lake) were classified as **High** because all endpoints were near or below the *baseline* range of variability due to low or no catch of fish at these reaches. It should be noted that an effort was made to survey other areas of these creeks to find more suitable fish habitat; however, the creeks were primarily deep-water, depositional, and often flooded muskeg habitat along most of the length of the watercourse. This type of habitat is generally not suitable for many fish species in the region that prefer faster water, with harder substrate.

Hangingstone River Watershed

Hydrology For the 2014 WY, the differences in mean open-water discharge, mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge between the observed *test* and estimated *baseline* hydrograph for the Hangingstone River were 0.2%, -0.1%, 0.2%, and 0.2%, respectively. These differences were classified as **Negligible-Low**.

Water Quality Differences in water quality in fall 2014 between the lower *test* station (downstream of the town of Fort McMurray) and the middle *test* station (upstream of the town of Fort McMurray) and regional *baseline* fall conditions were classified as **Moderate**. Differences were attributed to higher concentrations of ions and dissolved metals in the Hangingstone River, relative to regional *baseline* concentrations. In addition, concentrations of a few metals and ions exceeded their historical range (2004 to 2008 and 2013) for the middle *test* station. Despite having higher concentrations of dissolved ions in 2014, the ionic composition at the middle *test* station was similar to previous years and similar to the *test* station downstream of Fort McMurray.

Pierre River Area

Water Quality Differences in water quality in fall 2014 between *baseline* stations on Big Creek, Eymundson Creek, Pierre River and Red Clay Creek and regional *baseline* fall conditions were classified as **Negligible-Low**. The *baseline* station at Eymundson Creek differed from the other stations in this area in its ionic composition, with a higher concentration of sulphate and lower concentration of bicarbonate, which may suggest greater groundwater influence at this station. Eymundson Creek also had a higher concentration of total suspended solids than the other stations.

Benthic Invertebrate Communities and Sediment Quality The benthic invertebrate communities at *baseline* reaches of Big Creek, Eymundson Creek, and the Pierre River were typical of sand-bottomed rivers and had a high abundance of chironomids and worms, which are indicative of poor water quality conditions; but also an increasing proportion of EPT taxa and more sensitive fauna. With the decrease in the abundance of worms and an increase in EPT taxa, the *baseline* reach of the Pierre River, in particular, showed improving conditions from 2013. The benthic invertebrate communities at the *baseline* reach of Red Clay Creek had a greater proportion of tolerant worms in 2014 than 2013 but continued to maintain a good proportion of EPT taxa, indicating good habitat quality. The benthic invertebrate community reaches in the Pierre River area were used as regional *baseline* reaches for comparison to *test* reaches of the Athabasca oil sands region.

All sediment stations of the Pierre River area had sediment quality index values indicating **Negligible-Low** differences from regional *baseline* conditions. Concentrations of sediment quality measurement endpoints did not exceed any sediment or soil quality guidelines at the *baseline* station of Big Creek, while total arsenic exceeded the guideline at *baseline* stations of Eymundson Creek and the Pierre River, and F3 hydrocarbons and predicted PAH toxicity also exceeded guidelines at the *baseline* station of the Pierre River. Survival of the midge *Chironomus* was fairly low at *baseline* stations of Big Creek and the Pierre River in 2014 (52% and to 58%, respectively). In general, all sediment quality measurement endpoints at all locations in fall 2014 were similar to results from fall 2013. Sediment quality monitoring was not conducted at Red Clay Creek given it is an erosional river.

Fish Populations (fish assemblages) The fish assemblages at *baseline* reaches of Big Creek, Eymundson Creek, Pierre River, and Red Clay Creek were similar to other *baseline* reaches in the region, and with each other. Species composition was generally the same across each reach and there was a decrease in the catch of burbot in 2014 compared to 2013 at all reaches.

Miscellaneous Aquatic Systems

Isadore's Lake and Mills Creek The 2014 WY mean open-water discharge, mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge were all 68.4% lower in the observed *test* hydrograph for Mills Creek than in the estimated *baseline* hydrograph. These differences were classified as **High**. These **High** magnitude of changes were due to land disturbance located immediately upstream of the hydrology station. Given the limited size of the Mills Creek watershed downstream of JOSMP Station S6, the magnitude of impact would remain high along the entire length of Mills Creek; therefore, a longitudinal classification of Mills Creek was not conducted.

In the 2014 WY, the water level of Isadore's Lake slowly decreased by about 0.1 m from November to early April, and was within the historical interquartile range for this period. During spring thaw, the lake level initially rose by approximately 0.15 m, and then decreased sharply in mid-May. A second rise occurred in late May following rainfall accumulations, and lasted until the first week in June. The lake level then gradually increased until early September, until the peak annual lake level occurred before gradually decreasing until the end of October.

Differences in water quality in fall 2014 between Mills Creek and regional *baseline* fall conditions were classified as **Moderate**, due to relatively high concentrations of many ions that exceeded the 95th percentile of regional *baseline* concentrations. The ionic composition of water of 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 of the benthic invertebrate community at Isadore's Lake were classified as **Negligible-Low** because although there were significant time trends in the percentage of EPT taxa and CA Axis 1, both were indicative of improving habitat quality. The percentage of EPT taxa has been higher than usual since 2013. Several of the measurement endpoints exceeded the tolerance limits of the normal range of variation; however, none of the exceedances were considered an indication of degrading conditions. Isadore's Lake, historically, has had low diversity and high abundances of nematodes making it unique in comparison to the other lakes in the program. In 2014, the relative abundance of nematodes was lower but the abundance of naidid worms was higher than previously observed in Isadore's Lake. The percentage of EPT taxa and taxa richness have increased in recent years, suggesting that water and sediment quality of Isadore's Lake was potentially improving over time.

Sediment quality measurement endpoints for Isadore's Lake were generally within the range of previously-measured concentrations, with the exception of F2 hydrocarbons, retene, and total arsenic that exceeded previously-measured maximum concentrations and naphthalene, which was below the previously-measured minimum concentration. Concentrations of total arsenic, and F1, F2, and F3 hydrocarbons exceeded sediment quality guidelines in fall 2014, with the concentration of F3 hydrocarbons significantly higher than the guideline value. A SQI was not calculated for Isadore's Lake because lakes were not included in regional *baseline* conditions given ecological differences between lakes and rivers and because there are limited *baseline* lake data for the oil sands region.

Shipyard Lake Concentrations of most water quality measurement endpoints in fall 2014 at Shipyard Lake were within previously-measured concentrations. The ionic composition of water at Shipyard Lake continued to exhibit an increase in concentrations of sodium and chloride relative to historical concentrations, perhaps due to reduced surface-water inflow and increased groundwater influence in the lake associated with oil sands development in the upper portion of the watershed (91% of the Shipyard Lake watershed has been disturbed). The Water Quality Index (WQI) was not calculated for lakes in 2014 due to potential ecological differences in regional water quality characteristics between lakes and rivers and the lack of *baseline* data for lakes in the region.

Differences in measurement endpoints of benthic invertebrate communities for Shipyard Lake in 2014 were classified as **Negligible-Low**. The increasing trend in taxa richness and lower equitability in 2014 were indicative of improving habitat quality. The lake contained a number of fully aquatic forms including amphipods, clams, and snails, indicating generally good water and sediment quality. In fall 2014, some sediment quality measurement endpoints exceeded previously-measured maximum concentrations at Shipyard Lake, including percent sand, total organic carbon, and all hydrocarbons (BTEX and F1 to F4 fractions), while percent clay and silt were below predicted-measured minimum values. Concentrations of total arsenic, F1, F2, and F3 hydrocarbons, and several PAHs (benz[a]anthracene, benz[a]pyrene, chrysene, dibenz(a,h)anthracene, and phenanthrene) exceeded sediment or soil quality guidelines in 2014. Shipyard Lake was not compared to regional *baseline* conditions due to ecological differences between lakes and rivers.

Poplar Creek and Beaver River The 2014 WY mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge were -1.8%, +3.7% and -1.8%, respectively, in the observed *test* hydrograph for Poplar Creek than in the estimated *baseline* hydrograph. These differences were classified as **Negligible-Low**. The 2014 WY mean open-water discharge was 22.7% higher in the observed *test* hydrograph than in the estimated *baseline* hydrograph and this difference was classified as **High**. Assessed changes to the hydrology of Poplar Creek, were classified as **High** from the mouth of the creek until the confluence with the Poplar Creek spillway (approximately 2 km upstream of JOSMP Station S11), and **Negligible-Low** upstream of the confluence. The results from the longitudinal assessment suggested that the extent of **High** hydrologic change was only limited to the lowest 4 km of Poplar Creek.

Concentrations of several water quality measurement endpoints, primarily ions, exceeded regional *baseline* concentrations at *test* stations of Poplar Creek and the lower Beaver River, resulting in **Moderate** differences from regional *baseline* conditions. Although concentrations of several measurement endpoints were high at the upper *baseline* station of the Beaver River, differences in water quality in fall 2014 between the *baseline* station of the Beaver River and regional *baseline* conditions were classified as **Negligible-Low**. Concentrations of most water quality measurement endpoints exhibited some variability throughout the year at Poplar Creek (sampled monthly in 2014), which was apparent in the ionic composition of water, which showed seasonal variability. Generally the highest concentrations of ions and metals occurred in September. Guideline exceedances occurred most frequently in January, June, August, and November; however, most monthly concentrations of water quality measurement endpoints were within the range of regional *baseline* fall conditions.

Differences in measurement endpoints of benthic invertebrate communities at Poplar Creek were classified as **Negligible-Low** because although there were significant and large differences in equitability and the percentage of EPT taxa at this *test* reach compared to the *baseline* reach of the upper Beaver River (connected hydrologically to lower Poplar Creek), these changes were not indicative of degradation. In addition, the percentage of EPT taxa was higher in 2014 than 2013 and diversity has been steadily increasing over the last three years at the *test* reach of Poplar Creek. The benthic invertebrate community of lower Poplar Creek was in generally good health and was comprised of what would be expected for a sand-bottomed river dominated by worms and chironomids. The relative abundance of fingernail clams was higher in 2014 compared to 2013. Differences in sediment quality observed in fall 2014 at the *test* station of Poplar Creek and the *baseline* station of the Beaver River compared to the regional *baseline* conditions were classified as **Negligible-Low.** Concentrations of total hydrocarbons and PAHs at Poplar Creek and the Beaver River were within historical ranges, with the exception of F2 hydrocarbons at the *test* station of Poplar Creek, which exceeded the previously-measured maximum concentration, and total parent PAHs and the predicted PAH toxicity at the *baseline* station of the Beaver River, which were below previously-measured minimum concentrations. No sediment quality measurement endpoints exceeded CCME guidelines, with the exception of F2 and F3 hydrocarbons at the *test* station of Poplar Creek.

Differences in measurement endpoints of the fish assemblage at the *test* reach of Poplar Creek were classified as **Negligible-Low** because the significant increases in richness, diversity, and catch per unit effort (CPUE) and the significant decrease in the assemblage tolerance index (ATI) were not indicative of a negative change in the fish assemblage. In addition, all measurement endpoints for this *test* reach were within the inner tolerance limits of the *baseline* range of variability.

McLean Creek Concentrations of water quality measurement endpoints at the *test* station of lower McLean Creek were generally within the range of previously-measured concentrations in fall 2014. The WQI value indicated **Moderate** differences between this *test* station and regional *baseline* concentrations, mostly attributed to high levels of dissolved ions and total metals. Despite having no significant temporal trends, total dissolved solids and several ions have shown consistent annual increases since 2009.

Fort Creek The 2014 WY mean open-water discharge, maximum daily discharge, and minimum daily discharge were all 20.24% lower in the observed *test* hydrograph for Fort Creek than in the estimated *baseline* hydrograph. These differences were classified as **High**. This **High** magnitude of change was due to land disturbances throughout most of the watershed, upstream of JOSMP Station S12 (i.e., 84% of the watershed has been developed). Given the small size of the Fort Creek watershed, downstream of JOSMP Station S12, the magnitude of impacts would remain **High** along the entire length of Fort Creek; therefore, a longitudinal classification was not conducted for this watershed.

Concentrations of most water quality measurement endpoints for Fort Creek were within the range of previously-measured concentrations and regional *baseline* concentrations in fall 2014. Differences in water quality between the *test* station of Fort Creek and regional *baseline* conditions were classified as **Negligible-Low**. Many significant temporal trends in water quality measurement endpoints continued to be observed, including decreasing concentrations of dissolved phosphorus, total arsenic, and total nitrogen, and increasing concentrations of calcium, magnesium, potassium, total boron, total dissolved solids, total strontium, and sulphate. The ionic composition of water has showed a continued shift in anions over time, having a greater influence of sulphate in fall 2014 compared to earlier sampling years.

Differences in measurement endpoints for benthic invertebrate communities at the *test* reach of Fort Creek were classified as **Moderate.** There were statistically significant and large variations in abundance, richness, and equitability, indicating potential degradation of habitat conditions. In addition, the percentage of EPT taxa was below the inner tolerance limits of the normal range of variability for this reach, but was still higher than values from *baseline* years (2001 to 2003). Lower richness and higher equitability during the *test* years were potentially suggestive of moderate degradation, but the presence of clams, snails, and particularly stoneflies suggested that habitat quality was not significantly degraded. The benthic invertebrate community of Fort Creek has typically had low diversity including during the *baseline* period, and the community in 2014 was consistent with previous years.

Sediment quality at the *test* station of Fort Creek in fall 2014 showed **Negligible-Low** differences from regional *baseline* conditions. All sediment quality measurement endpoints were within the range of previously-measured concentrations, with concentrations of F3 hydrocarbons, dibenz(a,h)anthracene, and chrysene exceeding sediment quality guidelines in 2014.

Differences in measurement endpoints for the fish assemblage at the *test* reach of Fort Creek were classified as **Moderate** because there were significant decreases in abundance, richness, and catch per unit effort, implying a negative change to the fish assemblage.

Susan Lake Outlet Peak flow from Susan Lake in the 2014 open-water period occurred on May 30. Flows decreased after this peak, and fluctuated until the end of the open-water period. Flows remained above historical median values on most dates, and often above historical maxima, especially during the month of June, but the historical record was limited.

Acid-Sensitive Lakes

Results of the analysis of the ASL lakes in 2014 compared to the historical data suggested that there have been no significant changes in the water chemistry of the 45 lakes across years that could be attributed to acidification. These results were consistent with the revised estimates of potential acid input (PAI) suggesting that only 14 of the 45 lakes were actually exposed to acidifying deposition.

A summary of the state of the ASL lakes in 2014, with respect to the potential for acidification, was prepared for each physiographic subregion by examining deviations from the mean concentrations of the 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 2014 there were no exceedances of the criterion for any of the measurement endpoints in any of the subregions. Therefore, all subregions were classified as having a **Negligible-Low** indication of incipient acidification.

Summary assessment of the 2014 monitoring results.

Watershed/Region	Differences Between *Test* and *Baseline* Conditions					Fish Populations: Human Health Risk from Mercury in Fish Tissue[6]			Acid-Sensitive Lakes: Variation from Long-Term Average Potential for Acidification[7]
	Hydrology[1]	Water Quality[2]	Benthic Invertebrate Communities[3]	Sediment Quality[4]	Fish Assemblages[5]	Species	Subsistence Fishers	General Consumers	
Athabasca River	○	○	-	-	-	LKWH WALL	○ ●	○ ●	-
Athabasca River Delta	-	-	○/●/●	○	n/a		-		-
Muskeg River	●	○	○	○	○/●/●		-		-
Jackpine Creek	nm	○	○	○	●		-		-
Kearl Lake	nm	●/○	○	n/a	-		-		-
Steepbank River	○	●	●	-	●		-		-
Tar River	●	○	●	○	○		-		-
MacKay River	○	○	●/○	-	●/○		-		-
Calumet River	○	○	nm	nm	nm		-		-
Firebag River	○	○	-	-	-		-		-
McClelland Lake	nm	n/a	○	n/a	-		-		-
Johnson Lake	-	n/a	n/a	n/a	-		-		-
Ells River	○	○	●	○	●		-		-
Gardiner Lake	-	-	n/a	n/a	-				
Namur Lake	-	-	-	-	-		-		-
Clearwater River	nm	○	○	○	-		-		-
High Hills River	-	○	n/a	-	n/a		-		-
Christina River	○	○/●	○	○	-		-		-
Christina Lake	nm	n/a	●	n/a	-		-		-
Gregoire Lake	nm	n/a	○	n/a	-				
Gregoire River	nm	●	○	n/a	○				
Jackfish River	nm	○	○	○	○		-		-
Sawbones Creek	nm	○	○	○	●		-		-
Sunday Creek	nm	○	●	○	○		-		-
Birch Creek	nm	○	n/a	○	n/a		-		-
Unnamed Creeks (east and south of Christina Lake)	nm	○	○	○	●/●		-		-
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	-	○	n/a	○	n/a		-		-
Pierre River	-	○	n/a	○	n/a		-		-
Red Clay Creek	-	○	n/a	○	n/a		-		-
Eymundson Creek	-	○	n/a	○	n/a		-		-
Stony Mountains	-	-	-	-	-		-		○
West of Fort McMurray	-	-	-	-	-		-		○
Northeast of Fort McMurray	-	-	-	-	-		-		○
Birch Mountains	-	-	-	-	-		-		○
Canadian Shield	-	-	-	-	-		-		○

Legend and Notes

○ Negligible-Low change

● Moderate change

● High change

"-" program was not completed in 2014; nm – not measured in 2014.

n/a – classification could not be completed because there were no *baseline* conditions to compare against or reach was sampled to add to the regional *baseline* dataset.

[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 were calculated for each watershed because of differing lengths of the hydrographic record for 2014, hydrology results were for those measurement endpoints that were calculated.

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

Note: Mean Open-Water Season Discharge, Mean Winter Discharge, and Annual Maximum Daily Discharge in Poplar Creek were assessed as Negligible-Low; Mean Open-Water Discharge was assessed as High.

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

Note: Water Quality in the Steepbank River was assessed as Moderate at the lower station, and Negligible-Low at all other stations.

[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 comparisons to regional *baseline* conditions.

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

[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 3.2.4.4 for a detailed description of the classification methodology.

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

Note: Fish assemblages in the MacKay River were assessed as High at the lower reach and Negligible-Low at the middle reach.

[6] **Fish Populations (human health):** Uses Health Canada criteria for risks to human health. LKWH – lake whitefish; WALL – walleye; Subsistence fishers and General consumers as defined by Health Canada (see Section 3.2.4.2).

[7] **Acid-Sensitive Lakes:** Classification based the frequency in each subregion with which values of seven measurement endpoints in 2014 were more than twice the standard deviation from their long-term mean in each lake.