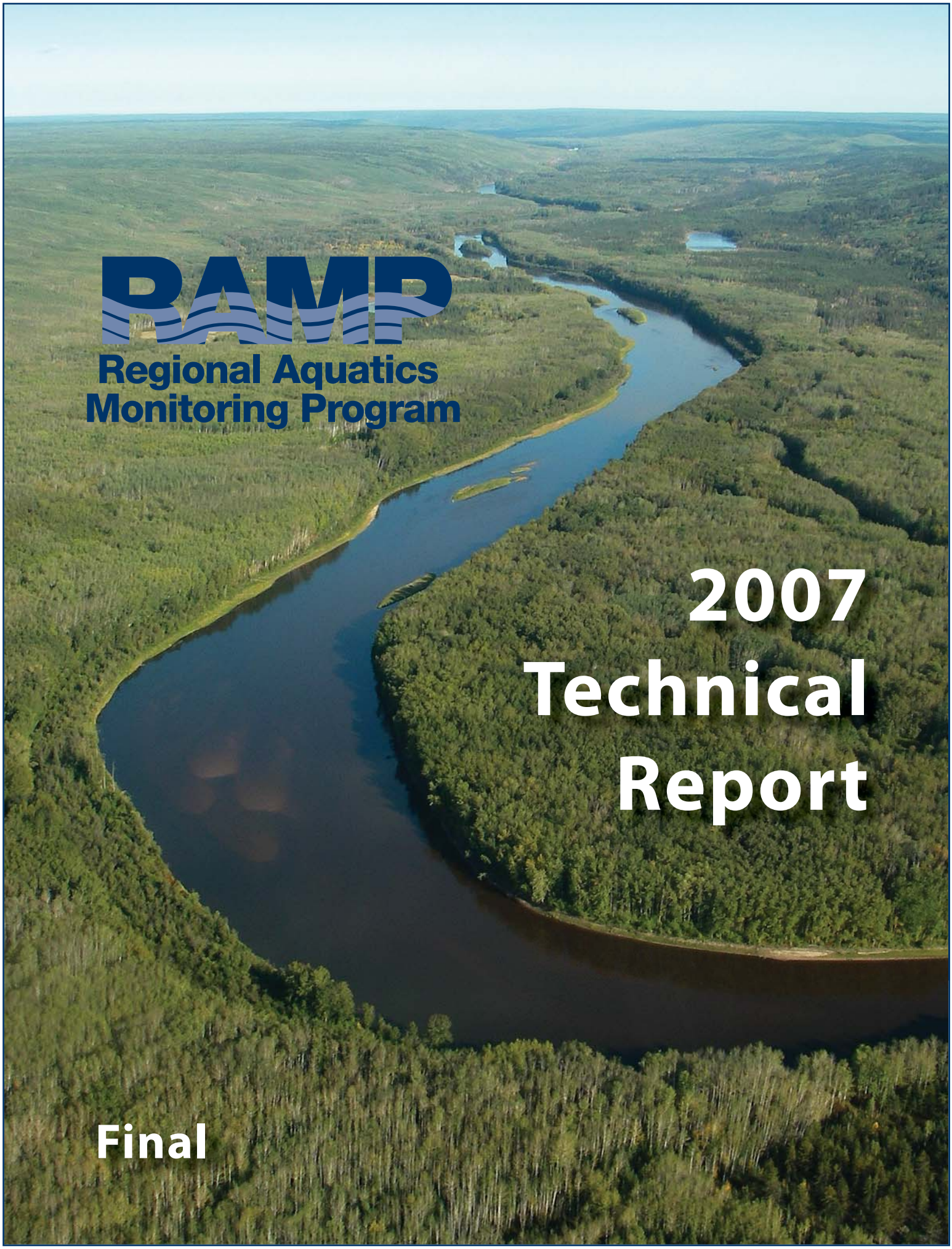
RAMP
Regional Aquatics
Monitoring Program
2007
Technical
Report
Final

REGIONAL AQUATICS MONITORING PROGRAM

2007 Technical Report

FINAL

Prepared for:

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***and* WESTERN RESOURCE SOLUTIONS**

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EXECUTIVE SUMMARY

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 region. 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 can be identified and assessed. In 2007, RAMP was funded by Suncor Energy Inc., Syncrude Canada Ltd., Albian Sands Energy Inc., Shell Canada Limited, Canadian Natural Resources Limited, Imperial Oil Resources, Petro-Canada Oil and Gas, OPTI Canada Inc./Nexen Inc., Husky Energy, Total E&P Joslyn Ltd., Synenco Energy Inc., and Birch Mountain Resources Ltd.

The Regional Municipality of Wood Buffalo in northeastern Alberta is the RAMP Regional Study Area (RSA). Within this area, a Focus Study Area (FSA) has been defined and includes watersheds where oil sands and other developments are occurring or planned, including:

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

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 key components of boreal aquatic ecosystems, including:

- Climate and hydrology – monitors changes in the water level of selected lakes and in the quantity of water flowing through rivers and creeks in the Athabasca oil sands area;
- Water quality in rivers, lakes and the delta – reflects potential exposure of fish and invertebrates to organic and inorganic chemicals;
- Benthic invertebrate communities and sediment quality in rivers, lakes and the delta – reflect habitat quality, serve as a biological indicators, and are important components of fish habitat;
- Fish populations in rivers and lakes – biological indicators of ecosystem integrity and are a highly valued resource in the region; and

- Water quality in regional lakes sensitive to acidification – early warning indicator of potential effects related to acid deposition.

RAMP is funded by companies that are not exclusively constructing and operating oil sands projects in the RAMP FSA. Therefore, the term "focal projects" is used in the RAMP 2007 Technical Report; focal projects are defined as those projects owned and operated by the 2007 RAMP funders listed above which were under construction or operational in 2007 in the RAMP FSA. For 2007, these projects include a number of oil sands projects and a limestone quarry project.

2007 RAMP funders do have other projects in the RAMP FSA that were in the application stage as of 2007 (e.g., Imperial's Kearl project), or which received approval in 2007 (or earlier), but were not in the construction phase as of 2007. These projects are noted throughout the 2007 Technical Report, but are not designated as focal projects, as these projects in 2007 would not have potentially influenced aquatic resources covered by RAMP components.

The overall analytical approach for the 2007 RAMP Technical Report builds on the methodology used in previous years and the RAMP Technical Design and Rationale document. 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;
- Uses where possible, specific criteria (e.g., criteria used in focal project EIAs, AENV, CCME 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; and
- Uses an analysis of land change to determine which RAMP stations and monitoring years are to be designated as operational or baseline for the purposes of data analysis.

Satellite imagery was used in 2007 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 oil sands and other development activities. It is estimated that there were approximately 64,000 ha of land change attributable to focal projects within the RAMP FSA as of 2007. The percentage of the area of watersheds with land change as of 2007 varies from less than 1% for many watersheds (MacKay, Ells, Christina, and Firebag), to 5% to 10% for the Muskeg and Upper Beaver watersheds, to more than 10% for the Fort Creek, Tar, and McLean watersheds, as well as the smaller Athabasca River tributaries from Fort McMurray to the confluence of the Firebag River.

The following sub-sections summarize results of the monitoring assessment for each watershed evaluated as part of the 2007 RAMP, followed by a summary of regional assessments of the status of aquatic environmental resources within the scope of monitoring under RAMP and the possible influence of focal projects at the regional level.

ASSESSMENT OF 2007 MONITORING RESULTS

Lower Athabasca River and Athabasca River Delta

The large size and flow of the lower Athabasca River means that there is high year-to-year variation in aquatic resources represented by the RAMP components, much of which is due to natural factors; the much lower than average flow year for the lower Athabasca River in 2007 was

no exception in this regard. The differences between hydrologic measurement endpoints for estimated baseline hydrologic conditions and measured operational hydrologic conditions were greater in 2007 than in 2006. It is estimated that focal project activities as of 2007 decreased 2007 mean open-water season discharge by 0.4%, lowered 2007 mean winter discharge by 1.8%, decreased annual maximum daily discharge by 0.18%, and lowered open-water season minimum daily discharge in 2007 by 1.2%. The cumulative effects of focal project activities plus all other active oil sands projects in the RAMP FS are estimated to be only marginally greater. Based on criteria used in previous oil sands project EIAs, these differences would have been assessed as negligible.

Based on comparisons of water quality between upstream and downstream stations over time, no effects of local human activities were apparent on water quality in the Athabasca River in 2007.

Benthic invertebrate communities in the ARD were in generally good condition in 2007 with relatively high diversity for a shifting-sand environment and no evidence of undue deleterious effects on ARD benthic invertebrate communities. In addition, results of fall 2007 and historical sediment surveys in the Athabasca River mainstem and ARD do not suggest changes in sediment quality over time, with the exception of a trend toward finer sediments at Fletcher Channel, which may suggest reducing current velocities in this delta reach over the sampling period. In particular, analysis of absolute and carbon-normalized concentrations of total PAHs and total hydrocarbons in sediments indicates that the highest concentrations of PAHs and hydrocarbons in sediments have consistently been measured at the Athabasca river station upstream of Donald Creek, designated as reference, with lower concentrations generally observed at other mainstem stations. Concentrations of PAHs and total hydrocarbons in sediments at all locations sampled in the ARD have been generally stable, and one to several orders of magnitude below those observed at the Athabasca river station upstream of Donald Creek. In contrast, concentrations of total arsenic in sediments of the Athabasca River mainstem and the ARD have generally been similar among all stations and across years, with concentrations at all stations typically exhibiting concentrations near the CCME interim sediment-quality guideline (5.9 mg/kg; No longitudinal trends or trends over time are apparent in these data.

As of 2007, current and historical fish inventory data from the Athabasca River indicate species-specific variability in relative abundance, length-frequency distribution, and condition factor. Statistically significant differences were observed between years for condition and length-frequency distributions of the KIR fish species, but there was no clear pattern that would suggest a consistent negative or positive change in the populations.

Results from the 2007 Athabasca River sentinel species program with trout-perch showed no clear differences in growth, condition or survival between downstream sites and the reference site, between seasons, or between years. The results of this program do not indicated that characteristics of trout-perch populations between sites, between summer and fall, and between 2007 and previous Athabasca River sentinel monitoring programs have changed due to activities from focal projects or other oil sands developments.

Muskeg River Watershed

The cumulative effects of focal projects at the watershed level for the Muskeg River watershed for 2007 are assessed as follows:

- There were differences in hydrologic measurement endpoints between observed, potentially influenced, conditions and estimated reference conditions; these differences are assessed as low to high, depending on the measurement endpoint being considered. It must be noted that these differences have been estimated under the assumption that

all CWD discharge waters would not have reported to the Muskeg River under reference conditions (i.e., worst case scenario);

- Water quality remains largely unaffected by focal project activities, with few exceedances of water quality guidelines throughout the watershed and concentrations of most water quality measurement endpoints throughout the watershed that remained within historical regional baseline ranges. The only exception to these overall results for water quality is an indication of greater variability of water quality in fall 2007 in potentially influenced areas of the Muskeg River watershed than in reference areas, which is a continuation of conditions measured in 2006; and
- There is little evidence of focal project effects on benthic invertebrate communities. Values of all benthic invertebrate community measurement endpoints in 2007 at all reaches sampled in the Muskeg river watershed were within the normal range of values observed from regional reference reaches, and there continues to be consistency across years in values of all benthic invertebrate community measurement endpoints with respect to regional reference reaches.

Steepbank River Watershed

There is little evidence in 2007 of watershed-level effects of focal project activities on RAMP aquatic resources in the Steepbank River watershed. Cumulative, watershed-level changes in hydrologic conditions in the Steepbank River caused by focal project activities in the watershed as of 2007 have been negligible. In 2007 there were few exceedances of water quality guidelines throughout the watershed, concentrations of all water quality measurement endpoints throughout the watershed were within historical regional baseline ranges, and ion balance in fall 2007 was consistent throughout the watershed with ion balance in previous years. Benthic invertebrate communities of the lower Steepbank River are presently in good condition relative to reference erosional reaches, but may be changing over time. Continued monitoring of the lower Steepbank River will determine whether the observed trends are a function of changing habitat quality in a part of the river potentially influenced by focal projects or due to natural variability.

Tar River Watershed

Monitoring activities in the Tar River watershed in 2007 consisted of hydrology and water quality. The Tar River watershed in 2007 exhibited changes in aquatic resources measured by RAMP. The effects of focal project activities on hydrologic conditions in 2007 was assessed as low to high based on effects criteria used in oil sands EIAs for mean open-water season discharge, annual maximum daily discharge, and open-season minimum daily discharge.

There was evidence of effects of focal project activities on water quality in the lower Tar River in fall 2007. Concentrations of total nitrogen in the lower Tar River have shown an approximate seven-fold and three-fold increase since 2003 and 2005, respectively. This may be related to discharges from the sewage treatment plant at CNRL's Horizon project. The source and cause of high total mercury concentration measured in the lower Tar River in fall 2007 is unknown, and future monitoring data from the lower Tar River in 2008 and onwards will help to clarify if this individual observation was an isolated event or the beginning of a longer-term change in water quality.

MacKay River Watershed

Data collected in the MacKay River in 2007 indicate negligible changes in hydrological conditions as a result of focal project activities and no measurable effects of focal projects on water quality in the MacKay River to date. There are some statistically significant differences in some benthic invertebrate community measurement endpoints between sampled reaches designated as

potentially-influenced and *reference* over time. However, benthic invertebrate community measurement endpoints in the lower MacKay River designated as *potentially-influenced* continue to be within the normal range of regional baseline conditions for erosional habitats, and there is a continued presence of a number of sensitive and very sensitive taxa in 2007 in the lower MacKay River reach. This suggests that factors other than focal project activities may be influencing measured differences in temporal trends between the lower MacKay and upper MacKay River reaches.

Calumet River Watershed

RAMP aquatic resources were measured in the Calumet River watershed in 2007 as being similar to previous years. Values of few measurement endpoints in 2007 exceeded existing environmental guidelines, and few selected measurement endpoints were outside the range of expected reference conditions for similar river systems and habitats in the RAMP FSA. Effects of focal project activities in the watershed were negligible in 2007 in the case of hydrologic conditions, and no effects of focal project activities on water quality were detected.

Firebag River Watershed

Conditions in the Firebag River in 2007 were similar to previous years. Cumulative, watershed-level changes in hydrologic conditions caused by focal project activities in the Firebag River watershed as of 2007 have been negligible. Water quality conditions were similar in 2007 to water quality conditions in previous years, with the exception of a number of major ions at the upper station, concentrations of many of which increased in fall 2007 relative to previous years, in both relative and absolute terms. Benthic invertebrate community measurement endpoints in fall 2007 were at levels similar to those previously measured, with higher diversity in fall 2007 than in previous years. Concentrations of many sediment quality measurement endpoints were higher than previously-recorded.

Ells River Watershed

Conditions in the Ells River in 2007 were similar to previous years. Cumulative, watershed-level changes in hydrologic conditions caused by focal project activities in the Ells River watershed as of 2007 have been negligible. Water quality conditions were similar in 2007 to water quality conditions in previous years. Values of benthic invertebrate community measurement endpoints were consistent with values measured in previous years at the same locations in the watershed, and values of most sediment quality measurement endpoints were within the range of previously-measured values for the watershed. Results from the 2007 Ells River sentinel species program with longnose dace showed no consistent differences in population survival or growth between sites, seasons, or between 2005 (the most recent year in which sentinel species monitoring was conducted on the Ells River) and 2007. Given the variability observed under reference conditions and challenges experienced in conducting particular analyses, use of longnose dace sentinel monitoring in the Ells River requires further refinement prior to being used when parts of the Ells River watershed become designated as *potentially influenced*.

Clearwater-Christina River System

Monitoring activities in the Clearwater River and Christina River watersheds in 2007 focused on expanding baseline datasets for hydrology, water quality, benthic invertebrate communities and fish populations.

While hydrologic measurement endpoints for the Christina River watershed could not be estimated because there is no hydrometric station at the mouth of the Christina River, estimated effects of focal project activities in 2007 were to remove 0.0058 mm of runoff depth from the watershed. Estimated effects of focal project activities plus oil sands projects in the Christina River watershed that were under construction or operation in 2007 but which were not owned by 2007

RAMP funders were to remove 0.029 mm of runoff depth from the watershed. Water quality measurement endpoints were generally within historical ranges and within the range for regional reference stations. Benthic invertebrate community and sediment quality measurement endpoints in the Christina River watershed in fall 2007 continued to be within the normal range of regional baseline conditions for similar habitats in the Christina River watershed, and there have been no unusual trends in these measurement endpoints since sampling began in 2002.

A fifth year of fish inventory work on the Clearwater River was conducted to expand the baseline dataset for this river. Fish community composition, length-frequency relationships external fish health indices, and condition factors were similar to what was found in previous years. Mercury tissue concentrations in northern pike from the Clearwater River measured in 2007 are consistent with the range of concentrations observed in this region of northern Alberta and, as in previous years, mercury and arsenic levels in sampled northern pike fish tissue exceeded relevant screening criteria (i.e., guidelines). No fish tissue effects thresholds for fish and fish health were exceeded with the exception of selenium, and all potential tainting compounds in sampled Clearwater River fish tissue were present at concentrations well below the 1 mg/kg threshold for palatability.

Hangingstone River Watershed

2007 results confirm that the Hangingstone River is a typical Athabasca River basin watershed, with aquatic resources in 2007 within the range of regional baseline conditions for similar watersheds and habitat types and at levels similar to previous years.

Miscellaneous Aquatic Systems

Miscellaneous aquatic systems designated as *potentially influenced* in 2007 included Mills Creek, Fort Creek, Poplar Creek, McLean Creek, Isadore's Lake, and Shipyard Lake, while miscellaneous aquatic systems designated as *reference* in 2007 included Kearl Lake and McClelland Lake. The effect of focal project activities on the hydrology of Poplar Creek is assessed as High, due to the hydrologic effects of the Poplar Creek spillway, while the effect of focal project activities on the hydrology of Fort Creek is assessed as Moderate. There was little to distinguish 2007 water quality conditions in these aquatic systems from previous years, and there was little evidence of effects on focal project activities on water quality conditions in these aquatic systems in 2007. Benthic invertebrate communities in miscellaneous aquatic systems that were sampled in 2007 had values of benthic invertebrate measurement endpoints that were in the range of regional baseline conditions. The exception was Isadore's Lake, in which lower diversity and the absence of sensitive faunal species in 2007 is indicative of a stressed benthic community.

Mercury tissue concentrations in walleye, northern pike, and lake whitefish from Gregoire Lake measured in the 2007 Regional Lakes program are consistent with the range of concentrations observed in this region of northern Alberta. No fish tissue effects thresholds for mercury and fish and fish health were exceeded in either Gregoire or Namur lakes.

REGIONAL SYNTHESIS

Hydrology

The hydrologic effects of focal projects and other oil sands developments on the Athabasca River are assessed as being negligible in magnitude and negative in direction over the past four years (2004 to 2007), with a trend toward increasing negative effects on both open-water season and winter minimum discharges since 2005.

Most of the hydrologic assessments at the watershed level are rated as negligible with the exception of effects on particular hydrologic measurement endpoints in the Muskeg, Tar, Poplar, and Fort Creek watersheds. Specific water withdrawals and releases, and water diversions, were

the focal project activities with the greatest influence in 2007 on hydrologic conditions in these watersheds, including:

- Effects of water withdrawals from the Athabasca River on winter flows;
- Discharges via the Aurora Clean Water Diversion into Stanley Creek and on into the Muskeg River; and
- Increased flows into Poplar Creek via the Beaver Creek diversion and Poplar Creek spillway.

Activities that caused land change resulting in closed-circuited areas were the focal project activities that had the second greatest influence on hydrologic conditions in 2007 in RAMP FSA watersheds; these land change activities were as important an effect on hydrologic conditions in the Muskeg River in 2007 as the Aurora Clean Water Diversion.

Activities that caused land change resulting in areas that were not closed-circuited were focal project activities that had minor effects on hydrologic conditions in RAMP FSA watersheds in 2007, with the exception of the Tar and Fort Creek watersheds. The cumulative hydrologic effects of focal project activities plus all other active oil sands projects in the RAMP FS are estimated to be only marginally greater than the hydrologic effects of the focal projects alone.

A review of the average estimated percent change from 2004 to 2007 for each of the four hydrologic measurement endpoints indicates that, in all cases, most of the assessed area has experienced negligible hydrologic impacts. In cases where the estimated effects are classified as low, medium, or high, they often consist of decreases in maximum discharge or increases in minimum discharge. Therefore, while there have been changes in key hydrologic measurement endpoints in particular watersheds that have been moderate to high, hydrologic effects of focal projects and other oil sands developments at a regional level have been largely negligible to 2007.

Water Quality

At a regional scale, water quality data collected by RAMP in fall 2007 was generally similar for all key measurement endpoints between stations designated as *potentially influenced* and those designated as *reference*. Both baseline and operational data from 2007 generally fell within the range of historical observations from previous years, although 2007 data in aggregate did exhibit relative increases or decreases in some variables relative to historical data, such as ultra-trace mercury, which was detected more frequently in 2007 than in previous years, at both reference and potentially influenced stations.

This regional analysis also highlighted excursions from historical and regionally typical water quality at specific stations, including:

- **Lower Tar River:** Increases in total nitrogen, and speciation of nitrogen, that suggest effects of the treated-sewage discharge from CNRL's Horizon project on water quality;
- **Lower Beaver River:** Regionally high concentrations of major anions (sulphate and chloride) that may be related to seepage from Syncrude's Mildred Lake site into this drainage, which had most of its flow diverted away to Poplar Creek in 1974; and
- **Shipyard Lake:** Increasing concentrations of several major ions, including sulphate, which in 2007 exhibited a concentration outside the regional range of natural variability. The change in concentrations of these anions from regional reference ranges supports the hypothesis that project-specific effects on water quality may be occurring in this waterbody.

Benthic Invertebrate Communities and Sediment Quality

At the regional level, variations within and among reaches (and lakes) designated as *potentially influenced* have almost always been within the normal (background) range of variability as observed in the reference reaches (and lakes). By using the estimated 95% region for the reference data to quantify the normal range of variability, about 5% of observations of both reference and exposure data would be expected to fall outside the normal range. There was, thus, a percentage (not estimated) of records falling outside the normal range in almost each year for almost each measurement endpoint. The distributions of index values, however, were similar for reference and exposure designated reaches (and lakes), suggesting a lack of obvious impairment among the reaches (and lakes) within the RAMP FSA as a result of focal project and other oil sands development activities.

The conclusion of no major effects is supported by the watershed- and lake-specific analyses. Detailed statistical analyses within reaches (and lakes) provided no convincing evidence of effects of focal projects and other oil sands developments of a magnitude that are of concern. There were statistically significant differences in some benthic invertebrate community measurement endpoints that were consistent with effects in some reaches, but effects were within the normal range of variation.

Fish Populations

Fish Tissue A regional context for results obtained under RAMP was obtained by comparing 2007 fish tissue results relative to mercury concentrations in fish tissue from regional waterbodies not currently impacted by focal projects and from previous RAMP sampling. Mercury concentrations in waterbodies downstream of focal projects and other oil sands developments (i.e., lower Athabasca River, Lake Athabasca, Lake Claire and the Muskeg River) fall within the range of regional mercury concentrations from fish in waterbodies beyond the influence of oil sands developments. The limited temporal data available of mercury concentrations in fish tissue suggest that the variability in mercury concentrations over time can be high, with no consistent pattern among species or direction. Concern regarding mercury from a fish and fisher perspective arises because mercury bioaccumulates in fish in the toxic form of methyl-mercury when it is transformed microbially in sediments. Mercury levels are higher in a number of species of interest in the RAMP study areas (i.e., northern pike and walleye) because these species are piscivorous and therefore relatively high in the food chain and with therefore a high potential for bioaccumulation of contaminants. While there is no known evidence indicating that oil sands developments contribute to atmospheric mercury, the factors mentioned, the temporal and spatial variability of mercury in fish in the region, and the influence of natural versus anthropogenic sources on levels of mercury observed in fish in the RAMP study areas all merit further research.

Fish Inventory Catch per unit effort (CPUE) in all areas in the RAMP fish inventories has fluctuated over time with no clear decreasing or increasing trends. On a temporal scale, comparisons of CPUE in years prior to RAMP (1987-1996) showed that the CPUE in 2007 either fell within or exceeded historical ranges. Given all areas on the Athabasca River are classified as *potentially influenced*, comparisons with CPUE from the Clearwater River (*reference*) were evaluated. Mean CPUE in all areas in the Athabasca River fell within the range of CPUE in the Clearwater River across sampling years indicating a consistent natural range of variability in relative abundance. Generally, species diversity at all sampling reaches has shown large fluctuations over time. With the exception of the Poplar area of the Athabasca River fish inventory, species diversity in 2007 was within the historical range (i.e., prior to 1997). On the Athabasca River, across all years in each *potentially influenced* area, species diversity was within the *reference* area range.

Sentinel Species A review of the results of previous sentinel species programs conducted under RAMP indicates changes in measurement endpoints (condition factor (K) for lethal and non-lethal

sampling programs, and gonadosomatic index (GSI) and liver somatic index (LSI) for lethal sampling programs) variable with respect to target species, location, time and possible influence of focal projects and other oil sands developments. No consistent patterns in the changes in the measurement endpoints can be discerned, and measurement endpoint values in sentinel species monitored in *potentially influenced* sites have not exhibited consistent differences in comparison to *reference* sites.

Acid-Sensitive Lakes

The results of the analysis of 2007 RAMP ASL lake data in conjunction with historical RAMP ASL lake data suggest that there has been no significant change in the overall chemistry of the RAMP ASL lakes in 2007 compared to previous years. There is also no evidence to conclude that there have been any significant changes in lake chemistry in the RAMP ASL lakes over the monitoring period.

The report concludes with a number of recommendations directed towards refining the monitoring program and increasing the value of RAMP monitoring activities. These recommendations are outlined in detail in Section 7 for each RAMP component for consideration during the design of monitoring in future years of RAMP.