Regional
Aquatics
Monitoring
Program

RAMP

Climate and Hydrology

Water Quality

Sediment Quality

Benthic Invertebrates

Fish Populations

Acid Sensitive Lakes

2004 Technical Report

REGIONAL AQUATICS MONITORING PROGRAM (RAMP)

2004 Technical Report

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Appendix I Acid Sensitive Lakes

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The RAMP chairperson during the 2004 program year was Terry Van Meer (Syncrude). Fred Kuzmic (Albian) was chair of the Technical Sub-committee, Laura Smithies (Suncor) was chair of the Finance Sub-committee and Michele Toma (Syncrude) became chair of the Communications Sub-committee following Eric Davey's departure (Athabasca Tribal Council).

RAMP is a multi-stakeholder environmental monitoring program that is composed of representatives from industry, provincial and federal governments, local aboriginal groups and environmental organizations. Effective implementation of the RAMP requires a number of contributors. We would like to thank the following:

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EXECUTIVE SUMMARY

OVERVIEW

The Regional Aquatics Monitoring Program (RAMP) was initiated in 1997 in response to mining development in the Athabasca oil sands region near Fort McMurray, Alberta. RAMP is an industry-funded, multi-stakeholder initiative that monitors the health of 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 addressed. In 2004, RAMP was funded by Syncrude Canada Ltd., Suncor Energy Inc. Oil Sands, Albian Sands Energy Inc., Shell Canada Limited, Canadian Natural Resources Ltd., Imperial Oil Resources, Petro-Canada Oil and Gas, OPTI Canada Inc./Nexen Inc., Husky Energy, Deer Creek Energy Ltd., and Devon Canada Corporation.

The Regional Municipality of Wood Buffalo in northeastern Alberta defines the RAMP Regional Study Area (RSA). Within this area, a Focus Study Area (FSA) has been defined and includes watersheds where oil sands development is occurring or planned. In 2004, RAMP focused on the following aquatic systems:

- Athabasca River and delta;
- Major tributary watersheds/basins of the Athabasca River system 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 Athabasca River (MacLean Creek, Beaver Creek, and Poplar Creek);
- Specific shallow lakes in vicinity of current or planned oil sands development; and
- A set of regional lakes important from a fisheries perspective, or known to be sensitive to acidifying emissions.

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 and integrate 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 quantity of water flowing through rivers and creeks in the oil sands region;

- Water and sediment quality in rivers, lakes and the delta – reflects habitat quality and potential exposure of fish and invertebrates to organic and inorganic chemicals;

- Benthic invertebrate communities in rivers, lakes and the delta – serve as a biological indicator 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.

In the past, RAMP has also monitored aquatic vegetation in select wetlands. However, this component was omitted in 2004 due to concerns regarding the objectives and design of the program. Furthermore, RAMP monitors several other biological, chemical and hydrologic assessment indicators in each wetland of interest.

The overall analytical approach for the 2004 RAMP Technical Report builds from previous RAMP programs, recommendations from the Scientific Peer Review and from a review of the oil sands EIAs. Key features of the analysis are as follows:

- Conducted at the watershed/river basin level, with an emphasis on watersheds in which development has already occurred, as well as the 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 a set of 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 within the component; and

- Component-specific classification of sampling stations and monitoring years as operational or baseline treatments to be used in the analysis for each watershed/river basin.

The following sub-sections briefly summarize results of the monitoring assessment for each watershed evaluated as part of the 2004 RAMP. Watersheds have been categorized as exposed (i.e., may be influenced by oil sands development) or reference. In addition, analyses from a regional perspective are also provided, as well as the Acid Sensitive Lakes assessment, which focuses on regional lakes.

EXPOSED WATERSHEDS

Athabasca River System

The large size and flow of the Athabasca River means that there is high year-to-year variation in RAMP aquatic resources, much of which is due to natural factors; 2004 was no exception in this regard. In 2004 there were very small and negligible calculated changes in hydrologic conditions in the Athabasca River mainstem than would have been experienced had there been no oil sands development activities within its drainage basin. There were no discernable or detectable changes in water and sediment quality conditions that could be ascribed to oil sands development activities and there is little evidence to suggest that characteristics of key indicator fish populations have changed during increasing development in the oil sands region. Any influences of oil sands development activities on the RAMP aquatic resources of the Athabasca River mainstem appear to be very minor and largely undetectable.

Athabasca River Delta

In 2004, monitoring activities in the Athabasca River Delta were limited to water quality and a benthic invertebrates survey. The status of all RAMP aquatic resources measured in the Athabasca River Delta in 2004 was ascribed to the specific hydrologic conditions that characterized the sampling period of 2004, as well as inherent natural conditions of the delta environment. There were no influences of oil sands development activities detected in the Athabasca River Delta in 2004.

Muskeg River System

Monitoring activities in the Muskeg River basin in 2004 were extensive, including hydrology, water and sediment quality, a benthic invertebrate survey, fish inventories, fish tissue chemical analyses and sentinel fish species monitoring. Comparison of the 2004 hydrograph for the Muskeg River to an estimated naturalized hydrograph (i.e., if there were no oil sands operations in the watershed) indicated a decrease of as much as 7% in several hydrologic measurement endpoints. Some uncertainty exists regarding the extent of land disturbance and the amount of water intercepted by oil sands operations. However, more detailed information will be obtained in 2005 to confirm or revise the estimated change in hydrologic conditions. Regardless, there has been little observable change in the concentrations of water and sediment quality variables; most measurement endpoints for water quality and sediment quality in 2004 were within normal ranges of baseline concentrations. In addition, benthic invertebrate communities in the Muskeg River and Jackpine Creek exhibited characteristics within the range recorded for regional reference reaches.

From the results of fish inventories in the watershed, there was little evidence suggesting that characteristics of key indicator fish populations have changed during increasing oil sands development in the watershed. Elevated concentrations of total mercury were found in muscle tissue from northern pike, which could pose a potential risk to human consumers. The 2004 levels fall within the naturally elevated range of concentrations observed in the region. No other metals or tainting compounds were present at concentrations that would pose a risk for humans.

Sentinel fish species monitoring using slimy sculpin was also conducted on the lower Muskeg River and Steepbank River. Regarding the Muskeg River, there was evidence of reduced recruitment and missing year classes (i.e., cohorts). This was also observed at the Horse River, which is designated as a reference river. The Muskeg population has experienced recruitment failure in two consecutive sampling years and warrants further detailed study to identify causes for this failure.

Steepbank River System

Monitoring activities within the Steepbank River basin included hydrology (Water Survey of Canada station), water and sediment quality, benthic invertebrate community surveys and sentinel fish species monitoring.

Although the oil sands development located adjacent to the Steepbank River commenced in 1997, there is little evidence suggesting that mining operations have influenced current hydrologic and water quality conditions. Subtle shifts in benthic community composition was observed at the exposed reach of the Steepbank River relative to the upstream reference community; however, indices of community composition were generally within the expected ranges for regional reference conditions.

Sentinel fish species monitoring using slimy sculpin was also conducted on the lower Steepbank River (and Muskeg River). Regarding the Steepbank River, there was evidence of reduced recruitment and very low abundance of young-of-the-year (YOY) sculpin. Negligible to low impact on condition factor was identified.

Tar River System

Monitoring activities in the Tar River watershed in 2004 included hydrology, water and sediment quality (with reference water quality and sediment quality stations being established), and a benthic invertebrate survey during a period when part of the watershed became designated as exposed. The Tar River watershed in 2004 showed some changes in RAMP aquatic resources from previous years. The overall effect of oil sands activities on hydrologic conditions in 2004 is determined to be negligible. Water quality conditions measured in 2004 may have been due to a combination of oil sands development activities that commenced in the Tar River watershed in the latter half of 2004 and natural environmental conditions on the specific day that 2004 sampling occurred. Sediment quality conditions measured in 2004 were within regional ranges of concentrations for reference conditions, with the exception of some of the CCME variables. Finally, while potentially subtle shifts in benthic community composition may have occurred with the commencement of oil sands development activities, indices of community composition to date remain generally within the expected ranges for regional baseline sediment quality conditions.

MacKay River System

The MacKay River watershed in 2004 showed, at most, negligible and subtle changes in all RAMP aquatic resources from previous years. Slight changes in hydrologic conditions were observed relative to what would have been expected had there been no oil sands development activities (i.e., naturalized hydrograph). Few changes were evident in either water or sediment quality. Subtle changes in benthic invertebrate communities

were observed in the lower reach of the river, but they were still within the regional reference range. The relatively small scale of oil sands development activities in the watershed to date suggests that, if oil sands development is having effects on RAMP aquatic resources in the MacKay River watershed, these effects are minor and insignificant at most.

Miscellaneous Exposed Aquatic Systems

This section includes Mills Creek, Poplar Creek, McLean Creek, Beaver River, Isadore's Lake and Shipyard Lake. These various waterbodies in the RAMP FSA exhibited a range of conditions. The designated aquatic systems sampled for water quality in 2004 exhibited limited exceedances of CCME guidelines for the protection of aquatic life and most of the measurement endpoints had values within the normal range of regional baseline conditions for reference waterbodies and watercourses. Similarly, designated aquatic systems sampled for sediment quality in 2004 exhibited limited exceedances of CCME ISQG guidelines for the protection of aquatic life in 2004. However, there was a wide variation in the location of the sediment quality measurement endpoints with respect to the normal range of regional baseline conditions for reference waterbodies and watercourses. With respect to benthic invertebrate communities, Shipyard Lake is in relatively good condition, with indices of composition and diversity similar to what has been found at Kearl Lake and McClelland Lake (both reference lakes). Trends over time indicate that benthic community diversity has been increasing in Shipyard Lake relative to Kearl Lake, but the trends to date have been quite subtle.

REFERENCE WATERSHEDS

Clearwater-Christina River System

Monitoring activities in the Clearwater River and Christina River basins in 2004 focused on collecting baseline data for hydrology, water and sediment quality, benthic invertebrate communities and fish populations. Winefred Lake, outside the RAMP FSA, was sampled as part of the regional lakes tissue monitoring program.

In contrast to the river basins north of Fort McMurray, runoff volume in both the Clearwater River and Christina River basins were above normal in 2004. Water and sediment quality measurement endpoints were generally within historical ranges, and the range for regional reference stations. However, concentrations of water and sediment quality endpoints on the upper Christina River were often dissimilar from concentrations observed at the lower station near the mouth. As well, benthic invertebrate abundance and richness have consistently been higher in the upper Christina reach relative to the mouth, although still within the range for regional reference conditions. As a result, the suitability of the upper Christina River station as a future reference station is uncertain.

A second year of fish inventory work on the Clearwater River was conducted to expand the baseline dataset for this river. Fish community composition was similar to what was recorded in 2003, and what has been found in the Athabasca River (with the exception of lake whitefish in the Athabasca River). Elevated concentrations of mercury were found in the muscle tissue of northern pike and walleye, which could pose a risk to human consumers. 2004 results were consistent with naturally elevated levels in fish from the Athabasca River and other waterbodies in the oil sands region. Tissue concentrations of

metals and tainting compounds were not sufficient to pose a risk to human health; however, arsenic was seen as a potential risk to subsistence fishers. Concurrent work evaluating the suitability of a non-lethal biopsy needle for fish tissue sampling was successful, but refinement of the approach is necessary to minimize sample variability.

A reconnaissance fish inventory on the upper Christina River was hampered by exceptionally high flows and water levels occurring during the latter half of September and early October. Depending on the importance of this system as a future RAMP fish inventory monitoring site, a second reconnaissance inventory program may be required.

Mercury concentrations in the majority of fish evaluated from Winefred Lake pose a potential health risk to subsistence fishers and sensitive populations; there also are potential risks to wildlife that consume fish from Winefred Lake. However, it must be emphasized that all findings to date strongly indicate that mercury concentrations in fish tissue are naturally high in the oil sands region and are not related to current oil sands development activities.

Hangingstone River System

This was the first year of RAMP monitoring in the Hangingstone River watershed and 2004 activities included hydrology, water and sediment quality and a benthic invertebrate survey. Results of 2004 sampling indicate the Hangingstone River is a typical Athabasca River basin watershed, with RAMP aquatic resources in 2004 being within the range of regional reference conditions for similar watersheds and habitat types. It appears that the selected sampling sites are suitable sites at which to monitor for possible influences of upstream oil sands development activities.

Calumet River System

The RAMP aquatic resources of the Calumet River system in 2004, designated for 2004 as a reference watershed, were found to have similar conditions to previous years. Relatively few measurement endpoints sampled in 2004 exceeded existing environmental guidelines and all but one measurement endpoint were within the normal range of expected reference conditions for similar river systems and habitats in the RAMP FSA.

Firebag River System

The RAMP aquatic resources of the Firebag River system in 2004, designated as a reference watershed, were found to have similar conditions to previous years. Only one measurement endpoint sampled in 2004 exceeded existing environmental guidelines, some measurement endpoints exhibited declines from previous years (particularly water quality variables) and all measurement endpoints were within the normal range of expected reference conditions for similar river systems and habitats in the RAMP FSA.

Ells River System

The RAMP aquatic resources of the Ells River system in 2004, designated for 2004 as a reference watershed, were found to have similar conditions to previous years. Relatively few measurement endpoints sampled in 2004 exceeded existing environmental guidelines and all water quality, sediment quality, and benthic invertebrate measurement

endpoints were within the normal range of expected reference conditions for similar river systems and habitats in the RAMP FSA. The river appears to meet basic criteria for the establishment of a fish fence, although any fish fence design and deployment will need to consider discharge, particularly in the early spring period, as well as erosion and scouring issues. Finally, it appears that a sentinel species monitoring program using longnose dace could be established in this watershed.

Miscellaneous Aquatic Systems

This section included Kearl Lake and McClelland Lake. The RAMP aquatic resources of Kearl Lake and McClelland Lake in 2004 were found to have similar conditions to previous years. Only one water quality and sediment quality measurement endpoint sampled in 2004 exceeded existing environmental guidelines and all water quality and sediment quality measurement endpoints were within the normal range of expected reference conditions for aquatic systems in the RAMP FSA.

REGIONAL PERSPECTIVE

Climate and Hydrology

All hydrologic measurement endpoints for the Athabasca River mainstem were estimated to be lower than what they would have been in the absence of oil sands development activities. However, the percent change varies from -0.2% in the case of 2004 maximum daily discharge to -1.7% in the case of mean 2004 winter discharge, because the more or less constant withdrawals are proportionately larger during low-flow rather than high-flow periods. This was considered a conservative estimate because clearing and de-watering in some parts of the RAMP FSA likely had ameliorating effects on Athabasca mainstem flows. Overall, it appears that changes in hydrologic conditions up to and including 2004 have been negligible in the Athabasca River mainstem.

In 2004, the surface water hydrology of the RAMP FSA was relatively unchanged from what it would have been in the absence of oil sands developments; 80% of the area of the RAMP FSA experienced no hydrologic effect, while 14% was assessed to have experienced a negligible effect, and 6% a low effect. At a regional level, there was little change in surface water hydrology throughout the RAMP FSA in relation to oil sands developments.

Water Quality

In 2004, a similar percentage of results from exposed (45%) and reference stations (53%) fell between the 25th and 75th percentiles (i.e., within the central 50% of observations, or the inter-quartile range) of relevant regional reference observations made by RAMP since 1997. A somewhat higher percentage of 2004 values fell outside 5th or 95th percentile of regional reference observations at exposed stations (21%) relative to reference stations (11%). Percentages of observations that fell outside the central 50% of observations but within the 5th and 95th percentiles were similar for exposed (34%) and reference (36%) stations.

The distributions of water quality values in exposed and reference stations were not statistically different. Based on these comparisons, there was little or no difference in overall water quality between areas of the RAMP FSA designated as exposed and areas designated as reference.

Sediment Quality

There was practically no difference in the percentage of sediment quality measurement endpoints whose 2004 values fell outside the 5th or 95th percentiles of relevant regional baseline values for exposed stations (12.5%) or reference stations (12.8%). A lower percentage of observations from exposed stations (58%) relative to reference stations (62%) fell outside the regional reference inter-quartile range but within the 5th and 95th percentiles. Similar percentages of observations from both exposed (29%) and reference (26%) stations fell within the inter-quartile range (i.e., central 50%) of regional reference values observed by RAMP since 1997.

These distributions of results for exposed and reference stations were statistically identical. Therefore, it was concluded there was no difference in overall sediment quality between areas of the RAMP FSA designated as exposed and areas designated as reference in 2004.

Benthic Invertebrate Communities

In 2004, the percentage of benthic invertebrate community indices whose observed values were greater than 2 standard deviations from their regional baseline median in exposed locations was low and basically the same as for reference stations. The distributions in exposed and reference stations were identical, and it was concluded there was no difference in benthic invertebrate communities between areas of the RAMP FSA designated as exposed and areas designated as reference in 2004.

Fish Populations

Assessing the status of fish populations at a regional level in the RAMP FSA and possible relationships to oil sands development activities at a regional level is challenging due to the limited spatial coverage of the programs within the Fish Populations component, limited number of years of information gathered and alterations to the sampling design between years for some elements. These factors make it difficult to establish the level of natural variability at the regional level associated with impact parameters or measurement endpoints defined for the Fish Populations component.

It may be tentatively concluded that, at a regional level, fish population parameters in the RAMP FSA, as measured in the RAMP fish inventory programs, exhibit expected natural variability in relative abundance and condition, little of which to date appears to be in relation to oil sands development activities.

In 2004, tissue mercury concentrations in sampled fish pose a high risk for subsistence use, a variable risk for recreational fishing use, and variable risk for general consumer use. However, mercury concentrations observed in 2004 were similar to those recorded historically. Concentrations of metals (other than mercury) and tainting compounds in tissues of sampled fish generally pose a low risk to human health. From a regional

perspective, the observed mercury concentrations in fish tissue are naturally high in this region and are not related to oil sands developments.

Because of the limited regional scope of the sentinel species program, it is not possible at this time to extrapolate these results to the level of the RAMP FSA. The 2004 population data do provide some indication of potential effects at two sites designated as exposed, and effort to further quantifying these results and expanding the spatial scope of the sentinel species program is warranted.

Acid Sensitive Lakes

In 2004, the Acid Sensitive Lakes component of RAMP incorporated specific analyses in response to the Scientific Peer Review comments, and discussions within the NOxSOx Management Working Group.

The 50 RAMP lakes were compared to the database of 450 regional lakes compiled by the NOxSOx Management Working Group to provide regional context for the RAMP lakes and ensure that they were representative. The vast majority of the regional lakes are of the Ca-Mg-Bicarbonate type with a smaller number having a significant contribution of sulphate/chloride to the anion charge and sodium/potassium to the cation charge. Similarly, the RAMP lakes are also dominated by Ca-Mg-Bicarbonates with fewer of the more extreme lake types identified in the large database. Chemical differences between the RAMP lakes and the population of regional lakes reflect a bias in the selection process for the RAMP program. Most of the RAMP lakes were selected for study because they were thought to represent lakes that are potentially sensitive to acid deposition. In practice, the selection of lakes that were the most poorly buffered and had the lowest values of pH appears to have provided a suitable spectrum of lake chemistry that will allow RAMP to evaluate potential changes in response to acid deposition.

The Henriksen critical load model was modified to account for the contributions of both strong and weak organic acids, as determined from the derived equations relating these parameters to pH and DOC. At low pH, the reduction in ANC from strong acids was dominant over the increase in ANC from weak organic acids (buffering) and the critical load was decreased. At pH 7.8 and greater, the reverse was true and the critical load increased. Overall, application of the modified model to the 2004 data decreased the median critical load by 0.108 keq/ha/y. An additional nine lakes (20 in total) had values of the critical load exceeded by the potential acid input from all developments and industries. The significant decreases in the critical loads under the modified model imply that these lakes are much more sensitive to acidification than was previously anticipated.

Using the Mann-Kendall trend analysis, an attempt was made to detect trends in measurement endpoint parameters that would indicate incipient acidification. Unfortunately, additional years of data are required to detect definitive trends. However, parallel decreases in the sum of base cations and Gran alkalinity were observed at the highest rates of acidic deposition.

Following the watershed-specific assessments and regional assessments, a number of recommendations were identified for the purpose of refining the program and increasing the monitoring value of RAMP activities. These recommendations were outlined in detail in Section 7 for each RAMP component for consideration during the design of the 2005 monitoring program.