1.0 INTRODUCTION

This document is the 2005 Technical Report of the Regional Aquatics Monitoring Program (RAMP), a joint environmental monitoring program with participation from the oil sands industry, Athabasca oil sands development stakeholders, and local, provincial, and federal governments, which assesses the health of rivers and lakes in the Athabasca oil sands area of northeastern Alberta.

1.1 BACKGROUND

With an estimated 270 billion m^3 (1.7 trillion barrels) of total reserves of bitumen, the Alberta oil sands are the largest component of Canada's known petroleum resources. Indeed, the Alberta oil sands are a significant component of the world's petroleum resources, with its 27.7 billion m^3 (174 billion barrels) of remaining established bitumen reserves (EUB 2005) being equivalent to approximately one-third of the world's known reserves of conventional crude oil. Total bitumen deposits in the Athabasca oil sands area are by far the largest of Alberta's three oil sands areas, containing almost 81% of the total provincial reserves, with the total deposits in the Cold Lake and Peace River areas being significantly smaller.

In 1967, Great Canadian Oil Sands Ltd. (now Suncor Energy Inc.) initiated the region's first commercially successful bitumen extraction and upgrading facility. Since that time, investment and development in the Athabasca oil sands region near Fort McMurray in the Regional Municipality of Wood Buffalo (RMWB) has increased substantially. Development is expected to continue, given that slightly more than 2% of the estimated established bitumen reserves have been extracted to date (Table 1.1-1).

Table 1.1-1 Status of bitumen reserves in the Athabasca oil sands area.

Bitumen Reserve and Production Indicators	Amount (million m^3)
Initial Volume in Place	217,480
Estimated Established Reserves	22,320[1]
Initial Established Reserves under Active Development as of 31 December 2004	1,857
Cumulative Production as of 31 December 2004	528
Remaining Established Reserves	21,792

Data from EUB (2005); all figures are as of 31 December 2004.

[1] Estimated by applying provincial ratio of established to total bitumen reserves to total reserves in Athabasca oil sands area.

In addition to the oil sands operations, other development has also increased within the RMWB, such as pipeline construction, forestry operations (sawmill, logging), drilling activities, and municipal growth/infrastructure development. Upstream of the RMWB, developments such as pulp and paper operations (five mills), agriculture and municipal wastewater facilities may also influence downstream water quality of the Athabasca River within the oil sands region.

In response to the rapid growth of mining and regional development, several organizations have been formed to address issues related to environmental integrity of the Athabasca oil sands region of northern Alberta, including:

- Cumulative Environmental Management Association (CEMA) – established to develop management recommendations on how best to reduce potential long-term environmental impacts due to industrial development. CEMA works with the Regional Sustainable Development Strategy (RSDS);

- Wood Buffalo Environmental Association (WBEA) – established to monitor and provide information on air quality and air-related environmental impacts in the RMWB. The WBEA implements three programs:

  - Air quality monitoring and reporting, conducted via a network of thirteen air quality monitoring stations in the RMWB;

  - Terrestrial Environmental Effects Monitoring (TEEM) – a program designed to detect, characterize and quantify the extent to which air emissions affect terrestrial and aquatic ecosystems and hence traditional resource use in the Athabasca oil sands region; and

  - A human exposure monitoring program, initiated in 2005, designed to monitor select air contaminants to which individuals in the RMWB are exposed; and

- Regional Aquatics Monitoring Program (RAMP) – established to integrate aquatic monitoring activities in the Athabasca oil sands region so that long-term trends and potential cumulative effects can be evaluated and communicated.

1.2 OVERVIEW OF RAMP

The Regional Aquatics Monitoring Program (RAMP) is an industry-funded, multi-stakeholder environmental monitoring program initiated in 1997. The intent of RAMP is to integrate aquatic monitoring activities across different components of the aquatic environment, geographical locations, and oils sands developments so that long-term trends, regional issues and potential cumulative effects related to oil sands development can be identified and addressed. The coordination of monitoring efforts results in the development of a more comprehensive and cost-effective regional database that may be used by oil sands operators for their environmental management programs, compliance with environmental requirements in regulatory approvals and assessments of proposed oil sands developments, as well as other stakeholders interested in the health of aquatic environments in the Athabasca oil sands region.

1.2.1 RAMP Objectives

Several objectives of RAMP have been developed to guide the scope, management and implementation of the program over time. Specifically, the objectives of RAMP are to:

- Monitor aquatic environments in the oil sands region to detect and assess cumulative effects and regional trends;

- Collect baseline data to characterize variability in the oil sands area;

- Collect and compare data against which predictions contained in Environmental Impact Assessments (EIAs) can be assessed;
- Collect data that satisfies the monitoring required by regulatory approvals of oil sands developments;
- Collect data that satisfies the monitoring requirements of company-specific community agreements with associated funding;
- Recognize and incorporate traditional knowledge into monitoring and assessment activities;
- Communicate monitoring and assessment activities, results and recommendations to communities in the Regional Municipality of Wood Buffalo, regulatory agencies and other interested parties;
- Continuously review and adjust the program to incorporate monitoring results, technological advances and community concerns and new or changed approval conditions; and
- Conduct a periodic peer review of the program's objectives against its results, and to recommend adjustments necessary for the program's success.

1.2.2 Organization of RAMP

RAMP is governed by a multi-stakeholder Steering Committee. Membership in this decision-making body is comprised of oil sands industries, government agencies (municipal, provincial and federal), First Nations representatives, environmental non-government organizations (ENGOs) and other independent stakeholders (Figure 1.3-1). RAMP also has a Technical Program Committee responsible for the development and review of the RAMP technical monitoring program from year to year. The Technical Program Committee is divided into discipline-specific sub-groups (e.g., fisheries, water quality, etc.) that develop and review their component for integration into the overall monitoring program. Investigators (i.e., the Hatfield RAMP Team, consisting of Hatfield Consultants Ltd, Stantec Consulting Ltd., Mack, Slack & Associates Inc., Western Resource Solutions, Alberta Environment (AENV), Syncrude Canada Ltd., First Nations, and other consultants) primarily carry out the fieldwork, data analysis and reporting, as defined by the program. Finance and Communications Sub-committees focus on issues related to funding and dissemination of RAMP information.

In 2005, RAMP was funded by Syncrude Canada Ltd. (Syncrude), Suncor Energy Inc. (Suncor), Albian Sands Energy Inc. (Albian Sands), Shell Canada Limited (Shell), Canadian Natural Resources Limited (CNRL), Imperial Oil Resources (Imperial Oil), Petro-Canada Oil and Gas (Petro-Canada), OPTI Canada Inc. (OPTI)/Nexen Inc. (Nexen), Husky Energy (Husky), and Total E&P Canada Ltd. (Total E&P).

1.3 RAMP STUDY AREA

The RMWB in northeastern Alberta defines the RAMP Regional Study Area (RSA, Figure 1.3-2). The RMWB covers an area of 68,454 km^2, as of 2005 had a population of approximately 73,000 persons of which 61,000 persons were residents of Fort McMurray (RMWB 2005), and is bounded by the Alberta-Saskatchewan border on the east, the

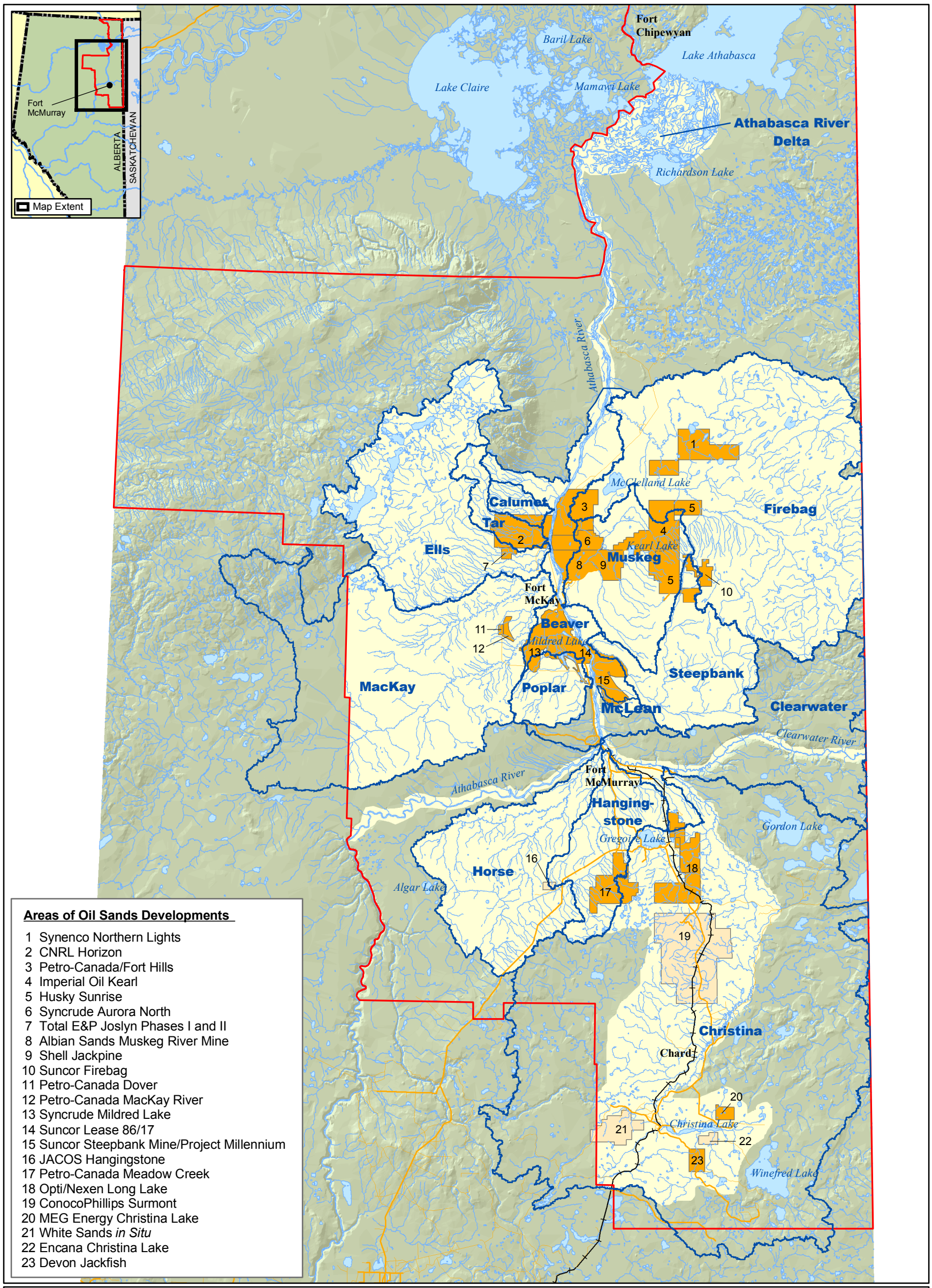
Figure 1.3-1 RAMP organizational structure.

STEERING COMMITTEE		
Industry	**Stakeholders**	**Government**
Alberta Pacific Forest Industries Inc. Albian Sands Energy Inc. Canadian Natural Resources Limited Deer Creek Energy Ltd. Devon Energy Corporation Husky Energy Imperial Oil Resources OPTI Canada Inc. Nexen Inc. Petro-Canada Oil and Gas Shell Canada Limited. Suncor Energy Inc. Syncrude Canada Ltd. (Secretary: Hatfield Consultants Ltd.)	Athabasca Chipewyan First Nations Athabasca Tribal Council Chipewyan Prairie First Nations Fort Chipewyan Metis Local #124 Fort McKay First Nations Fort McKay Metis Local #122 Fort McMurray First Nations Mikisew Cree First Nations Oil Sands Environmental Coalition Pembina Institute	Alberta Environment Fisheries and Oceans Canada Environment Canada Regional Municipality of Wood Buffalo

Finance Sub-committee	Technical Program Committee	Communications Sub-committee	Investigators
All funding participants, and any interested Steering Committee members.	Representatives from industry, communities, government, and investigators.	Representatives from industry, communities, government, and investigators.	Consultants, Aboriginal community representatives, industry representatives and Alberta Environment.

Technical Program Implementation	Communication Plan Implementation
Preparation of technical program for review by Steering Committee; Technical workshops	Annual summary report; Open house events, etc.

Figure 1.3-2 RAMP study areas.



Alberta-Northwest Territories border on the northeast, Wood Buffalo National Park on the northwest, various demarcations on the west including the Athabasca River, and the Cold Lake Air Weapons Range on the far south.

Within the RSA, a Focus Study Area (FSA) is defined by the watersheds in which oil sands development is occurring or is planned, as well as those parts of the Athabasca and Clearwater River channels within the RSA (Figure 1.3-2). Accordingly, much of the intensive monitoring activity is conducted within the RAMP FSA. The RAMP FSA is comprised of two major areas: one area upstream (south) and another area downstream (north) of Fort McMurray.

The Athabasca River is the dominant waterbody within the RAMP FSA and hydrologically links the upper (southern) portion of the RAMP FSA to the lower (northern) portion. The Athabasca River flows a distance of more than 1,200 km from its headwaters in the Columbia Ice Fields near Banff to the Athabasca River Delta (ARD) on the western end of Lake Athabasca. The Athabasca River forms part of the western border of the RAMP RSA before flowing east to Fort McMurray, where it once again flows north, draining the lower portion of the RAMP FSA.

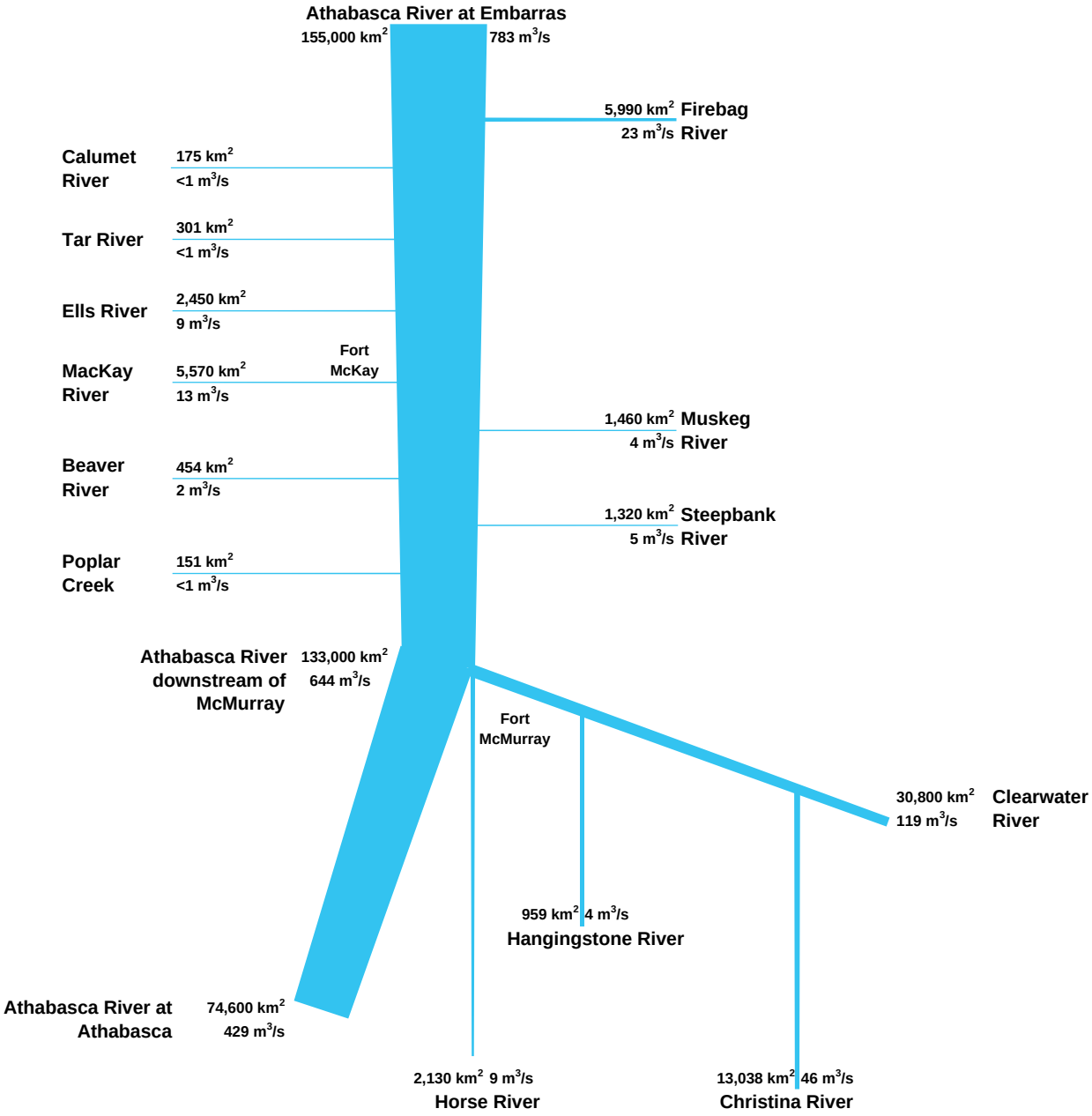
The upper portion of the RAMP FSA lies within the Mid-Boreal Uplands and Wabasca Lowland Ecoregions, both of which lie in the Boreal Plains Ecozone. This area is dominated by the Clearwater River and Christina Rivers, as well as a series of smaller rivers, primarily the Hangingstone and the Horse Rivers. The area is characterized by a predominantly subhumid mid-boreal ecoclimate, medium to tall, closed stands of trembling aspen and balsam poplar with white and black spruce, and balsam fir occurring in late successional stages, as well as cold and poorly drained fens and bogs covered primarily with tamarack and black spruce; the western part has little relief and is rather poorly drained, and organic materials covering about 50% of the area.

The downstream portion of the RAMP FSA, dominated by the Athabasca River from Fort McMurray to the Athabasca River Delta, is part of the Slave River Lowlands Ecoregion of the Boreal Plains Ecozone. It is characterized by an undulating sandy plain containing mixed boreal forest with up to 50% of the area covered by peatlands, and sporadic discontinuous permafrost. The area is partially bordered to the west by the Birch Mountains and to the east by intermittent slopes including the Muskeg Mountains, which extend northward from the Clearwater River Valley. Upon reaching the ARD, the Athabasca River becomes a vast, interconnected series of braided channels and wetlands flowing into Lake Mamawi and Lake Athabasca. The northernmost part of the RMWB lies within the Selwyn Lake Upland Ecoregion, part of the Taiga Shield Ecozone. This area experiences a low subarctic ecoclimate, with black spruce as the climax tree species, and characteristically open stands of low, stunted black spruce with dwarf birch and Labrador tea, and a ground cover of lichen and moss prevailing.

As indicated above, as the Athabasca River flows northward through the RAMP FSA, several smaller tributary streams and rivers join and contribute to the overall flow (Figure 1.3-3). Some of the larger of these tributaries include, in upstream to downstream order:

- Clearwater-Christina Rivers – the Clearwater is a large river which originates in Saskatchewan, joins the Athabasca River at Fort McMurray, and includes the contribution of the Christina River, a large tributary of the Clearwater River whose drainage includes several existing and planned *in situ* oil sands developments to the south of Fort McMurray;

Figure 1.3-3 Hydrologic schematic of RAMP Focus Study Area.



- Hangingstone River – a small river originating in the southwestern portion of the RAMP FSA, joining the Clearwater River just upstream of Fort McMurray, and whose watershed includes the Petro-Canada *in situ* Meadow Creek Project and the JACOS *in situ* Hangingstone Project;

- Steepbank River – joins the Athabasca River from the east and whose watershed includes the Suncor Steepbank/Project Millennium mines and extensions, part of the Suncor *in situ* Firebag Project, and Petro-Canada's planned Lewis project;

- Muskeg River – also flows from the east and drains several oil sands development areas, including the Albian Sands Muskeg River Mine, Syncrude Aurora North Mine, planned Aurora South Mine, part of the Suncor *in situ* Firebag Project, Shell's planned Jackpine Mine, the Imperial Oil Kearl Project, and the Husky *in situ* Sunrise Thermal Project;

- MacKay River – flows from the west and whose watershed includes the Petro-Canada MacKay River and Dover developments, portions of Syncrude's Mildred Lake lease, and portions of Lease 24 where the Total E&P Joslyn projects are located;

- Ells River – flows from the west and whose watershed lies partly within but mostly immediately adjacent to the CNRL Horizon Project and most of Lease 24, where the Total E&P Joslyn projects are located;

- Tar River – also flowing from the west, whose drainage contains most of the CNRL Horizon Project;

- Calumet River – similar to the Tar River, flowing from the west and whose drainage lies partly within the CNRL Horizon Project; and

- Firebag River – a large river flowing from Saskatchewan, whose watershed includes most of Suncor's *in situ* Firebag Project, the Petro-Canada Fort Hills Project and potential future developments such as SynEnCo's Northern Lights Project.

Other waterbodies monitored under RAMP and within existing or proposed oil sands developments include:

- Tributaries within watersheds described above (i.e., Muskeg Creek, Wapasu Creek, Gregoire River, etc.);

- Smaller river tributaries of the Athabasca River (Mills Creek, Poplar Creek, McLean Creek, and Beaver River);

- Specific lakes and wetlands such as Isadore's Lake, Shipyard Lake, McClelland Lake, and Kearl Lake; and

- A set of regional lakes important from a fisheries perspective, or known to be sensitive to acidifying emissions.

Finally, there are a number of waterbodies and watercourses monitored under RAMP that are used as reference areas for certain RAMP components, particularly the Fish Population component. This includes the Horse and Dunkirk Rivers.

1.4 GENERAL RAMP MONITORING AND ANALYTICAL APPROACH

RAMP incorporates a combination of both stressor- and effects-based monitoring approaches. The stressor-based approach is derived primarily from Environmental Impact Assessments (EIAs) prepared for each oil sands development. EIAs are undertaken in part to evaluate the potential impacts that the proposed project, alone or in combination with other developments, could have on the local and regional environment. To date, EIAs conducted for projects in the Athabasca oil sands region have used primarily a stressor-based approach. A potential stressor is any factor (e.g., chemicals, temperature, water flow, nutrients, food availability, biological competition) that currently exists in the environment and will be influenced by the proposed project. Using this approach, the impact of a development is evaluated by predicting the potential impact of each identified stressor on valued components of the environment (Munkittrick *et. al.* 2000). Using impact predictions from various EIAs prepared for specific oil sands development projects, specific potential stressors have been identified that are monitored to document baseline conditions, establish natural variation in those conditions, as well as potential changes related to development. Examples from RAMP include specific water quality variables and changes in water quantity.

Although the stressor-based impact assessment has been successful, the inherent risk of the approach is that it assumes that all potential stressors can be identified and evaluated. More recently, an effects-based approach has been advocated for impact assessments and subsequent monitoring efforts (Munkittrick *et. al.* 2000). This approach focuses on evaluating the performance of biological components of the environment (e.g., fish, benthic invertebrates, vegetation) because they integrate the potential effects of complex and varied stressors over time. This approach is independent of stressor identification, and focuses on understanding the accumulated environmental state resulting from the summation of all stressors. For example, the current federal Environmental Effects Monitoring (EEM) program for the pulp and paper and metal mining industries incorporates an effects-based monitoring approach (Environment Canada 1992, 2002, 2003, 2005). 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.

Details on the monitoring design and rationale are described in the following document: "RAMP: Technical Design and Rationale" developed by the RAMP Technical Program Committee (RAMP 2005b).

RAMP in 2005 focused on six components of boreal aquatic ecosystems:

- 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 some wetlands – reflects habitat quality and potential exposure of fish and invertebrates to organic and inorganic chemicals;
- Benthic invertebrate communities in rivers/streams and wetlands – serves as a biological indicator and is an important component of fish habitat;

- Fish populations in rivers and lakes – biological indicators of ecosystem integrity and 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.

1.5 MONITORING APPROACHES FOR RAMP COMPONENTS IN 2005

1.5.1 Climate and Hydrology

The quantity of water in a system affects its capacity to support aquatic and terrestrial biota. Changes in the amount or timing of water flow may occur due to natural fluctuations related to climate, or due to human activities such as discharges, withdrawals or diversions. Accordingly, climate and hydrologic data are collected as part of RAMP to:

- Provide a basis for verifying EIA predictions of hydrologic changes;
- Facilitate the interpretation of data collected by the other RAMP components by placing them in the context of current hydrologic conditions relative to historical mean and extreme conditions;
- Document stream-specific baseline climatic and hydrologic conditions to characterize natural variability and to allow detection of regional trends;
- Support regulatory applications and to meet requirements of regulatory approvals; and
- Support calibration and verification of regional hydrologic models that form the basis of environmental impact assessments, operational water management plans and closure reclamation drainage designs.

The RAMP Climate and Hydrology component focuses on key elements of the hydrologic cycle, including rainfall, snowfall, streamflow and lake water levels. Climate, streamflow and lake levels are monitored to develop an understanding of the hydrologic system, including natural variability, short and long-term trends, and potential changes related to development.

Streams in the same region may have different hydrologic characteristics related to differences in topography, vegetation, surficial geology, lake storage, groundwater-surface interaction and geographic effects on precipitation. Accordingly, the scope of the RAMP Climate and Hydrology component has gradually expanded geographically to include catchments affected, or expected to be affected, by oil sands development in the area around Fort McMurray. Some catchments outside the oil sands developments are also monitored to provide baseline data. The monitoring program includes the Athabasca River, numerous smaller rivers and streams, and some mine water releases to receiving streams. Data from long-term Environment Canada climatic and hydrologic monitoring stations in the region are also integrated into the RAMP database to provide greater spatial and temporal context.

Some streams are monitored year-round, while others, particularly smaller streams that tend to freeze completely in winter, are monitored only during the open-water season.

RAMP also monitors winter (November to March) flows on some streams that Environment Canada monitors during the open-water season.

1.5.2 Water Quality and Sediment Quality

RAMP monitors water and sediment chemistry in order to identify human and natural factors affecting the quality of streams and lakes in the oil sands region. Monitoring the chemical signatures of water provides point-in-time measurements, while sediment analyses provide information on the rate of chemical accumulations over time. Together, these data help identify potential chemical exposure pathways between the physical environment and biotic communities relying on aquatic resources.

Specific objectives of the Water Quality and Sediment Quality components include:

- Develop a water and sediment quality database to verify EIA predictions, support regulatory applications and to meet requirements of regulatory approvals;
- Monitor potential changes in water and sediment quality that may identify chemical inputs from point and non-point sources;
- Assess the suitability of waterbodies to support aquatic life; and
- Provide supporting data to facilitate the interpretation of biological surveys.

In order to determine if and how a development may be affecting water and sediment quality, stations potentially influenced by the development are compared to upstream reference stations (where possible), located beyond the influence of the development, and against an appropriate range of regional natural variability. Stations are monitored over time to characterize natural temporal variability in baseline conditions, and to identify potential trends in water and sediment quality related to increasing anthropogenic activity, including oil sands development.

A range of compounds are measured in the Water Quality and Sediment Quality components, including:

Water Quality

- Conventional variables
- Major ions
- Nutrients
- Biological Oxygen Demand
- Other organics
- Total and dissolved metals

Sediment Quality

- Particle size
- Carbon content
- Target and alkylated PAHs
- Total hydrocarbons
- Metals

Sublethal bioassay tests also are conducted to assess potential toxicity related to chronic exposure of different aquatic organisms to ambient river water or sediment from selected stations.

RAMP water quality stations are located throughout the RAMP study area, from the upper Christina River to the ARD. Water quality stations are monitored annually each fall when water flows are generally low, and the resulting assimilative capacity of a receiving waterbody is limited. New water quality stations located in waterbodies already

monitored by RAMP, are sampled seasonally (i.e., in winter, spring, summer and fall) in the first year to determine seasonal variations in water quality. Three years of seasonal baseline data are collected at stations established in new waterbodies added to RAMP.

RAMP Sediment Quality stations in the Athabasca River were historically monitored annually in the fall to take advantage of the accumulation of fine sediments that occurs from late spring to late fall. Beginning in 2005, bottom sediments in the lower Athabasca River are no longer sampled by RAMP, as they are very transient and are almost completely flushed by high flows related to spring freshet. Sediment quality sampling is conducted in the ARD (where upstream Athabasca River sediments are transported during high flows accumulate over time), throughout tributaries of the Athabasca River, and in regional lakes/wetlands. New sediment quality stations are monitored every fall for the first three years, with toxicity testing being conducted for the first two years to establish baseline conditions. After this time, sampling becomes periodic, with each station typically sampled on a three-year rotation.

1.5.3 Benthic Invertebrate Communities

Benthic macroinvertebrates are a commonly-used indicator of aquatic environmental conditions. Benthic invertebrate communities are included as a component of the RAMP for a variety of reasons. First, they integrate biologically relevant variations in water and habitat quality. Second, they are limited in their mobility and, therefore, reflect local conditions. They can thus be used to identify point sources of inputs or disturbance. The short benthic invertebrate life span (typically about one year) allows them to integrate the physical and chemical aspects of water quality over annual time periods and provide early warning of impending effects on fish communities (Kilgour and Barton 1999). Finally, based on known tolerances of benthic taxa, it is possible to re-create the environmental conditions by determining what animals are present (Rooke and Mackie 1982a, b).

The RAMP Benthic Invertebrate Community component has three general objectives:

- Collect scientifically defensible baseline and historical data to characterize variability in the oil sands area;
- Monitor aquatic environments in the oil sands area to detect and assess cumulative effects and regional trends; and
- Collect data against which predictions contained in environmental impact assessments can be verified.

The Benthic Invertebrate Community component focuses on tributaries of the Athabasca River and regional wetlands (shallow lakes). Historically, sampling was also conducted on the mainstem Athabasca River, but was discontinued in 1998 because of problems related to the transient/shifting nature of bottom sediments in the river. Samples are collected from three areas within the ARD because that is an area of significant deposition, and an area that is considered to have the potential to be affected by long-term development in the oil sands area.

With ongoing expansion of oil sands operations, the program has expanded to include new tributaries and additional stations on tributaries near active oil sand extraction sites. The tributary monitoring approach adopted by RAMP focuses on characterizing benthic

communities on the basis of total abundance, taxonomic richness, and relative dominance within the lower reach of each river (i.e., downstream of development) relative to communities found in an upper, reference reach. A reach consists of relatively homogeneous stretches of river ranging from 2 to 5 km in length, depending on habitat availability. Within reaches, samples are collected from either erosional or depositional habitats, depending on which is the dominant habitat type within a tributary.

Within lakes, sampling effort is distributed over the entire open-water area, but restricted to a narrow range in water depth to minimize natural variations in communities.

Benthic sampling is conducted in the fall of each year to limit potential season-associated variability in composition of the benthic community. Where available, historical data collected in previous years through RAMP are used to place current results in context with historical trends in community structure that may be occurring.

1.5.4 Fish Populations

The goal of the RAMP Fish Population component is to monitor the health and sustainability of fish populations within the oil sands region. Monitoring activities focus on the Athabasca River and its main tributaries potentially influenced by current or future development. Fish populations are monitored because they are key components of the aquatic ecosystem and important ecological indicators that integrate effects from natural and anthropogenic influences. Fish also represent a highly valued recreational and subsistence resource. In this regard, there are expectations from regulators, First Nations and the general public with respect to comprehensive ongoing monitoring of fish populations in the oil sands region.

The specific objectives of the Fish Population component are to:

- Collect fish population data to characterize natural or baseline variability, assess EIA predictions, and meet requirements of regulatory approvals;
- Monitor fish populations for changes that may be due to stressors or impact pathways (chemical, physical, biological) resulting from oil sands development by assessing attributes such as growth, reproduction and survival; and
- Assess the suitability of fisheries resources in the oil sands region for human consumption.

The first two objectives derive from the overall objectives of RAMP, whereas the third objective addresses local community and First Nation concerns regarding the quality and safety of fish captured in the region for consumption.

To meet the specific component objectives, RAMP conducts a range of core monitoring activities that are intended to assess and document ecological characteristics of fish populations, chemical burdens, and migration patterns in the Athabasca oil sands area. The core elements of the Fish Population component are:

- Fish inventories and spawning surveys;
- Tissue sampling for organic and inorganic chemicals;

- Monitoring of fish health through evaluation of performance indicators (physical condition, population age, and length/weight comparisons) in sentinel fish species; and

- Monitoring of fish population movements using fish fences.

Specific key indicator fish species (or key indicator resources, KIRs) have been identified for the Athabasca River and select tributaries. These species were selected through consultation with First Nations, government and industry representatives, and include goldeye, lake whitefish, longnose sucker, northern pike, trout-perch, and walleye (CEMA 2001, RAMP 2005). Although the Fish Population component evaluates the integrity of the total fish community, particular emphasis is placed on the selected key fish species based on their ecological importance and value to local communities.

RAMP conducts fish tissue assessments to quantify and monitor chemical levels in relation to the suitability of the fish resource for human consumption and to identify potential direct or indirect toxicity effects on fish. As part of the ongoing program, muscle tissues are collected from lake whitefish and walleye from the Athabasca River and northern pike from the Muskeg River. Tissues are analyzed for metals, including mercury, and specific organic compounds known to cause tainting of fish flesh. Fish tissue analyses (mercury only) are conducted in conjunction with sampling programs conducted by other agencies (e.g., Alberta Sustainable Resources Development [ASRD]), either through opportunistic sampling, or in conjunction with fisheries investigations mandated separately from RAMP. The program, known as the "Regional Lakes Program", to date has included analysis of fish tissue Gregoire Lake (2002), Lake Claire (2003), Christina Lake (2003), and Winefred Lake (2004). This program was not conducted in 2005 as no fish tissues were submitted.

General fish inventories are conducted to monitor and assess temporal and spatial changes in species presence, relative abundance and population parameters in selected watercourses. In the Athabasca River, the inventory is conducted annually in the spring and fall and is designed to assess populations of large-bodied key indicator species in the vicinity of oil sands development. Other watercourses such as Muskeg River, MacKay River, Clearwater River, Christina River and the Firebag River have been surveyed in the past as part of the RAMP Fish Population component. In addition to the scientific value of the work, the fish inventories provide useful information to local stakeholders on species diversity, the relative strength of age classes, and the frequency of fish abnormalities.

Sentinel fish species monitoring is part of the RAMP Fish Population component to assess the potential effects of stressors on wild fish populations. The approach evaluates the performance (characterized by growth, survival, condition, and reproduction) of a specific sentinel species potentially influenced by development relative to reference and/or historical performance data. The underlying premise of the approach is that the health of the selected sentinel species reflects the overall condition of the aquatic environment in which the fish resides. The approach has also been included as part of the federal government's EEM programs under the pulp and paper (Environment Canada 1992, 2005) and metal mining (Environment Canada 2002, 2003) effluent regulations. Sentinel species monitoring is conducted at regular intervals at several sites in the Athabasca River (trout-perch, longnose sucker), as well as several Athabasca tributaries including the Muskeg and Steepbank Rivers (slimy sculpin), and the Ells River (longnose dace).

Fish fence monitoring by RAMP, to date limited to the Muskeg River, is used to generate data on the biology and movement of spawning populations of large-bodied fish species that use the Muskeg River drainage. These data assist in the identification and quantification of local and watershed-level environmental changes in the Muskeg River drainage.

1.5.5 Acid-Sensitive Lakes

Potential effects of oil sands development include the acidification of regional lakes. This effect occurs through increased emissions of acidifying substances that include oxides of nitrogen and sulphur.

The RSDS identified the importance of protecting the quality of water, air and land within the Athabasca oil sands area (AENV 1999a). The effects of acid deposition on sensitive receptors were identified in the RSDS as a regional issue or "theme". Actions taken to address this issue were designed to support the goal of conserving acid-sensitive soils, rivers, lakes, wetlands and associated vegetation complexes under the cumulative impacts of deposition of acidifying materials. The RSDS called for the collection of information on this issue through long-term monitoring of regional receptors of acidifying emissions under TEEM for terrestrial receptors and RAMP for aquatic receptors.

The Acid-Sensitive Lakes (ASL) component under RAMP was initiated in 1999 to conduct annual monitoring of water chemistry in regional lakes to determine the long-term effects of acid deposition on these lakes and their catchment basins. The objectives of the ASL component are to:

- Establish a database of water quality to detect and assess cumulative effects and regional trends. In the case of the ASL program, these data would provide specific measurement endpoints capable of detecting incipient lake acidification;
- Collect scientifically defensible baseline and historical data (both chemical and biological) to characterize the natural variability of these measurement endpoints in the ASL lakes;
- Collect data on the regional lakes against which predictions contained in environmental impact assessments (EIAs) could be verified; and
- Quantify and document individual lake sensitivity to acidification.

Lakes are monitored for various chemical and biological variables that are capable of indicating long-term trends in acidification, including: pH, total alkalinity and Gran alkalinity (acid-neutralizing capacity), base cations, sulphate, chloride, nitrates, dissolved organic carbon, dissolved inorganic carbon and chlorophyll.

The ASL component, as designed, contains the following features:

- The locations of the lakes are selected to represent a gradient in acid deposition from both current and anticipated oil sands developments;
- For scientific validity, the lake selection includes reference lakes in the Caribou Mountains and Canadian Shield that are distant from the sources of acidifying emissions;

- Certain regional lakes, which have been the subject of long-term monitoring by AENV, are included to maintain the continuity of their data and additional information on potential trends;

- The lakes selected for monitoring exhibit moderate to high sensitivity to acidification as defined by a total alkalinity less than 400 µeq/L;

- A fall sampling program is implemented to capture a picture of lake water chemistry after conditions have stabilized; and

- In recent surveys (2002 to 2005), small water bodies (ponds), previously ignored, were included in the program because of their proximity to oil sands developments and belief that they might be low in alkalinity and hence highly sensitive to acid deposition.

The 2005 ASL component had a similar design as that used in 2004 in that same set of 50 study lakes in 2004 was sampled during August and September, 2005. The emphasis in 2005 was on the detection and evaluation of potential trends in chemical parameters in the RAMP lakes that would indicate incipient acidification. In addition, in 2005, metal concentrations in the RAMP lakes were examined from data collected by AENV over three years.

1.6 ANALYTICAL APPROACH FOR 2005

For the 2005 RAMP Technical Report, the overall approach to the analysis of collected RAMP data builds from analytical approaches used in RAMP in previous years and the RAMP: Technical Design and Rationale report (RAMP 2005b). Key features of the overall analytical approach are as follows.

First, the analysis of RAMP results for 2005 is conducted at the watershed/river basin level, with an emphasis on watersheds and river basins in which development has already occurred, as well as the Athabasca River at the regional level. Results for other watersheds/river basins in which development has not yet started are also included to establish levels of natural variation in those drainages. River systems within whose drainages oil sands development has already occurred are: Athabasca River (mainstem and delta); Muskeg River; Steepbank River; Tar River; Calumet River; MacKay River; as well as a series of smaller rivers and lakes throughout the RAMP FSA. River systems within whose watersheds oil sands development has not yet significantly commenced are: Hangingstone River; Firebag River; Ells River; and the Christina-Clearwater River System; as well as a series of smaller waterbodies throughout the RAMP FSA.

Second, the analysis for each RAMP component uses a set of measurement endpoints (Table 1.6-1) representing the health and integrity of valued environmental resources within the component. These are essentially the same measurement endpoints that were used in the RAMP 2004 Technical Report (RAMP 2005a).

Third, the analysis for each RAMP component uses a set of criteria for determining whether or not a change in the measurement endpoints has occurred and whether the change is significant with respect to the health and integrity of valued environmental resources within the component (Table 1.6-1). Again, these are essentially the same effects criteria that were used in the RAMP 2004 Technical Report (RAMP 2005a).

Table 1.6-1 Measurement endpoints and criteria for determination of change used in the analysis for the RAMP 2005 Technical Report.

RAMP Component	Measurement Endpoints Used in 2005 Technical Report	Criteria for Determining Change Used in 2005 Technical Report
Climate and Hydrology	• Mean open-water season discharge • Mean winter discharge • Annual maximum daily discharge • Open-water season minimum daily discharge	• Differences between observed, operational and calculated basleine hydrographs (i.e., the hydrograph that would have been observed had oil sands development not occurred in the drainage, so that changes in water withdrawals, discharges, and diversions are accounted for)
Water Quality	• pH • Total suspended solids • Dissolved phosphorus • Total nitrogen and nitrate-nitrite • Various ions (sodium, chloride, sulphate) • Total alkalinity • Total dissolved solids • Dissolved organic carbon • Total and dissolved aluminum • Total boron • Total molybdenum • Naphthenic acids • Overall ionic composition	• Comparison to natural range of regional baseline conditions • Comparison to CCME and other water quality guidelines

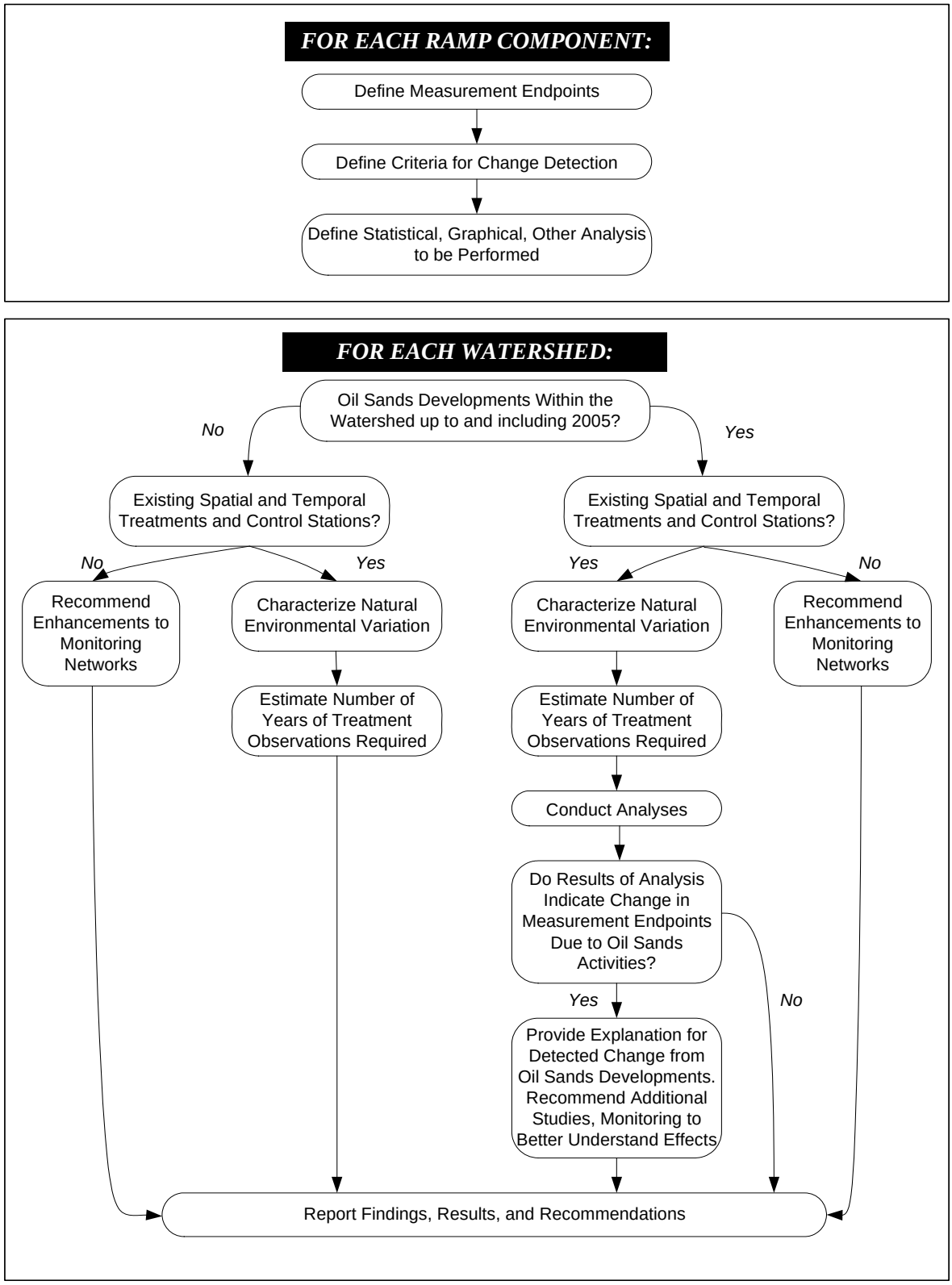
Sediment Quality	• Particle size distribution (clay, silt and sand)
	• Total organic carbon
	• Total hydrocarbons (CCME and Alberta Tier 1)
	• Various PAH end-points, including:
	  • Total PAHs
	  • Total Low-Molecular Weight PAHs
	  • Total High-Molecular Weight PAHs
	  • Naphthelene
	  • Retene
	  • Total dibenzothiophenes
	• Predicted PAH toxicity
	• Metals
	• Chronic toxicity
		• Comparison to natural range of regional baseline conditions
		• Comparison to CCME Interim Sediment Quality Guidelines (ISQG) and other guidelines

Benthic Invertebrate Communities	• Abundance • Richness (number of taxa) • Simpson's Diversity • Evenness • Abundance of EPT (mayflies, stoneflies, caddisflies)	• Exceedance of regional range of natural variability for the selected measurement endpoints based on the mean and standard deviation, with regional range defined as $\overline{X} \pm 2SD$

Table 1.6-1 (Cont'd.)

RAMP Component	Measurement Endpoints Used in 2005 Technical Report	Criteria for Determining Change Used in 2005 Technical Report
Fish Populations: Fish Inventory	• Relative abundance (catch per unit effort) • Length-frequency • Percent composition • Condition factor	• The RAMP fish inventory activity is generally considered to be a stakeholder-driven activity that is best suited for assessing trends in abundance and population parameters for large-bodied species. It is not specifically designed for assessing environmental effects of oil sands activities.
Fish Populations: Fish Tissue Sampling	• Range of metals (including mercury) and tainting compounds (PAHs) in fish muscle tissue	**Protection of Human Health** *Negligible-Low*: Fish tissue concentrations for all analytes below USEPA and Health Canada criteria for recreational and subsistence fishers and the general consumer. *High (subsistence)*: Fish tissue concentrations for one or more analytes above USEPA and Health Canada criteria for subsistence fishers, but below criteria for recreational fishers and general consumers. *High (general)*: Fish tissue concentrations for one or more analytes above USEPA and Health Canada criteria for general consumers, and recreational and subsistence fishers. **Protection of Fish Health** *Negligible-Low*: Fish tissue concentrations for all analytes below literature-based criteria for sublethal and lethal effects on fish. *Moderate*: Fish tissue concentration for one analyte above literature-based criteria for sublethal effects. *High*: Fish tissue concentrations for more than one analyte above literature-based criteria for effects on fish. **Tainting** *Negligible-Low:* Fish tissue concentrations for tainting compounds below criteria for palatability of fish (Jardine and Hrudey 1993). *Moderate-High:* Fish tissue concentrations for tainting compounds above criteria for palatability of fish.
Fish Populations: Regional Lakes Fish Tissue	• Mercury concentration in food fish muscle tissue	**Protection of Human Health** *Negligible-Low:* Fish tissue concentrations for mercury below USEPA and Health Canada criteria for recreational and subsistence fishers and the general consumer. *High (subsistence):* Fish tissue concentrations for mercury above USEPA and Health Canada criteria for subsistence fishers, but below criteria for recreational fishers and general consumers. *High (general):* Fish tissue concentrations for mercury above USEPA and Health Canada criteria for general consumers, and recreational and subsistence fishers.
Fish Populations: Sentinel Species	**Lethal Sampling Approach** • Condition factor • Relative gonad size (Gonad Somatic Index) • Relative liver size (Liver Somatic Index) **Non-Lethal Approach** • Condition factor	**Lethal Sampling Approach** • Condition factor at exposure site ± 10% difference from exposure site • Relative gonad size at exposure site ± 25% difference from exposure site • Relative liver size at exposure site ± 25% difference from exposure site **Non-Lethal Approach** • Condition factor at exposure site ± 10% difference from exposure site
Acid-Sensitive Lakes	• Critical Load of acidity • pH • Gran alkalinity • Base cation concentrations • Nitrate plus nitrite concentrations • DOC • Aluminum	• Exceedance of Critical Load of acidity of a particular lake by the measured or modeled value of the Potential Acid Input (PAI) to that lake. • A statistically significant change in any of the measurement endpoints beyond natural variability, resulting in a reduction of lake pH, Gran alkalinity, Critical Load or base cation concentrations or an increase in nitrates or aluminum concentrations.

Figure 1.6-1 Overall analytical approach for RAMP 2005.



Fourth, the analysis for each RAMP component is based on a selection of sampling stations and monitoring years to be used in the analysis for each watershed/river basin. For the analysis, the selected sampling stations and monitoring years are categorized into combinations of spatial and temporal treatments and controls. This enables statistical analyses to be conducted on the collected RAMP data.

These features of the overall analytical approach for RAMP 2005 are integrated into an overall framework that has been used for all RAMP components; this framework is presented in Figure 1.6-1 as a sequence of steps undertaken by all RAMP components which guided their contribution to the RAMP 2005 Report.

1.6.1 Definition of Terms

The RAMP 2005 Technical Report uses the following definitions for monitoring status:

- ***Potentially influenced-oil sands*** is the term used in this report to describe aquatic resources and physical locations (i.e., stations, reaches) that may be influenced by oil sands developments. The use of this term does not imply or presume that effects of oil sands developments are occurring or have occurred, but simply that data collected from these locations are to be designated as ***operational*** for the purposes of data analysis (see below);

- ***Reference*** is the term used in this report to describe aquatic resources and physical locations that are not yet influenced by oil sands developments and that data on aquatic resources collected from these locations are to be designated as ***baseline*** for the purposes of data analysis (see below). The terms ***potentially influenced-oil sands*** and ***reference*** do not depend solely on location of the aquatic resource in relation to the location of the oil sands developments, but to the possible effects of oil sands developments that are being considered and the potential impact pathway. For example, Lake A29 (one of the ASL lakes) is characterized as ***reference*** with respect to possible effects on water quality via changes in hydrologic conditions, but is designated as ***potentially influenced-oil sands*** with respect to possible effects related to acid deposition;

- ***Potentially influenced-other*** is the term used to describe aquatic resources and physical locations that remain uninfluenced by oil sands activities, but are potentially influenced by other activities such as logging, quarrying, etc. Data on aquatic resources collected from these locations are designated as ***baseline*** for the purposes of data analysis. The term ***potentially influenced-other*** is intended to assist in interpretation of data and results, rather than the setting up of different development conditions for statistical analysis;

- ***Baseline*** is the term used to characterize data and information gathered from stations that are designated as ***reference*** or ***potentially influenced-other***; and

- ***Operational*** is the term used to characterize data and information gathered from stations that are designated as ***potentially influenced-oil sands***.

1.7 COMMUNITY ISSUES AND RAMP

An important focus of RAMP is to communicate monitoring and assessment activities, results and recommendations to communities in the Regional Municipality of Wood Buffalo. In 2005, this goal was achieved using a number of engagement mechanisms that

provided both a forum for interested stakeholders to present their concerns regarding regional development and the effects these may be having on the aquatic environment, and by utilizing various media to disseminate current and past technical findings and activities.

In late 2004, the RAMP Communications Sub-committee inducted a number of new members and elected a new chairperson to guide future communications initiatives. A communications strategy framework was developed for the purpose of scoping future engagement strategies, providing clarity on approved methods for implementation of specific communications outputs, and identifying criteria for evaluating performance. The communications strategy framework outlines methods for increasing public awareness of the following key messages:

- RAMP is a multi-stakeholder initiative committed to long-term monitoring of aquatic resources in the RMWB;
- The mandate of RAMP is exclusive to oil sands development and their potential impacts on aquatic resources;
- RAMP is locally-based and is the formal conduit for submission of aquatic monitoring activities to regulators on behalf of the oil sands industry;
- RAMP encourages open and ongoing dialogue and interaction with regional stakeholders to ensure their interests and concerns are addressed;
- Since its inception in early 1997, RAMP has been a progressive organization that continually grows and diversifies in parallel with regional development;
- RAMP uses state-of-the-art technology for year round collection of scientifically defensible data; and
- RAMP is managed by a cross-section of stakeholders that represent a variety of backgrounds to ensure a balance between technical and non-technical knowledge and experience.

The Communications Sub-committee has developed a working relationship with the WBEA and CEMA to allow collaboration and streamlining of public engagement, and to enable a comprehensive approach to the communication of environmental management initiatives in the RMWB.

1.7.1 Issues Identified in 2005

Currently, the primary avenue for concerned stakeholders to bring forth concerns to RAMP is through the Steering Committee. In 2005, issues raised at the Steering Committee level included the inclusion of groundwater monitoring in the RAMP framework and increasing the level of TEK contributions to RAMP.

Members of the RAMP Steering Committee are currently in discussion with a number of non-RAMP oil sands developers, particularly SAGD operators located south of Fort McMurray, to assess the feasibility of including a regional groundwater monitoring component in RAMP.

At the RAMP Technical Program Committee meeting in the spring of 2005, a request was made to increase the use of TEK in RAMP monitoring and reporting activities, particularly in relation to increasing First Nations assistance/observance in regular field

data collection activities, and increasing information transfer between First Nations and RAMP. Members of the RAMP Steering Committee are currently reviewing issues related to insurance and guarantees of personal liability that may apply to field program observers, and members of the Technical Program Committee and participating industry relations corporations (IRCs) have been assigned the task of reviewing RAMP components to determine where TEK may add value to technical programs; any recommendations arising from the RAMP Steering Committee and IRC findings will be reviewed in the spring of 2006, during the 2007 RAMP technical study design workshop.

1.7.2 Ongoing RAMP Initiatives

Joint open houses for outlying communities in the RMWB, initiated in 2004 with visits to Anzac and Fort McKay, continued in 2005 with a February visit to Fort Chipewyan. The goal of the open houses was to provide an opportunity for First Nations communities, students and the general public to meet people involved in managing various environmental activities undertaken in the RMWB, and to express any concerns they may have on how regional developments may be affecting the environment. Additional open houses are planned for 2006.

On June 5, 2005 RAMP representatives participated in the Green Sunday information session at Father Mercredi School in Thickwood, which provided the public with information of various regional environmental initiatives, including RAMP.

In support of public open houses, RAMP has produced a variety of posters and flysheets outlining monitoring activities, results and recommendations and community contact information. These materials have been circulated to representatives from each of the communities visited, and are available to all interested parties upon request.

A summary report of the RAMP 2004 technical document was produced and circulated to the general public of Fort McMurray as an insert in the *Fort McMurray Today* newspaper. The revised format, which consists of a four-page document, in comparison to much larger summaries in previous years, is considered less technical and more accessible to the public. Summary reports are publicly available from RAMP upon request, and a digital version can be downloaded from the RAMP website at www.ramp-alberta.org.

The RAMP fish abnormality program provides training to IRC members from outlying communities so that any fish legally captured in the area can be scientifically assessed for potential abnormalities. Due to changing membership in IRCs, RAMP is scheduled to offer re-certification of dangerous goods handling programs and abnormality training in the spring of 2006. This program will provide local representatives with the skills necessary to identify common abnormalities, and dissect, preserve and ship any unidentified fish to a representative at the Fisheries and Oceans Canada in Winnipeg for more detailed analysis.

A number of fish in the Athabasca River have been fitted with radio transmitters and/or external tags. The tagged fish are part of a collaborative fish movement study conducted on behalf of RAMP and CEMA. Members of the public can be an integral part of this study by reporting any tagged fish that are caught. The tag number, tag colour, and the fish's length and weight are important details to report. In 2005, tag recapture information from 21 fish was reported back to RAMP.

The River Response Network was established by RAMP to respond to reports of non-spill type phenomena on the lower Athabasca River. In the event that a report is made, RAMP will provide a coordinated investigation into the scope and nature of the incident. Currently, the program is intended to operate only during the open-water season on the Athabasca River mainstem below Fort McMurray. In 2005, no reports of non-spill events were received by RAMP.

The RAMP website (www.ramp-alberta.org) continues to provide useful tools and easy access to community members or other interested parties. The website provides current news, maps, sample site locations, past RAMP reports and current contact information. There also are online reporting forms for people to fill out in the event a fish with abnormalities or a tag is observed.

1.8 ORGANIZATION OF THE RAMP 2005 TECHNICAL REPORT

Together with this Introduction, the RAMP 2005 Technical Report contains nine sections within which the results of the 2005 RAMP monitoring program developed by the RAMP Technical Program Committee and implemented by the Hatfield RAMP Team are presented.

Section 2: Status and Activities of Athabasca Oil Sands Developments in 2005 – This part of the report contains a description of the activities of:

- Each of the oil sands projects financed by RAMP member companies that occurred in 2005;
- Oil sands projects in the RAMP study areas financed by companies that are not members of RAMP; and
- Other developments in the RMWB.

This provides a synthesis of information related to development pressures that may be influencing aquatic environmental resources within RAMP study areas.

Section 3: Summary of 2005 RAMP Monitoring Program – This section of the report contains concise descriptions of the RAMP monitoring program that was conducted in 2005 for each RAMP component, and includes:

- An overview of the 2005 program;
- A description of any other information that was obtained (i.e., information from regulatory agencies, the oil sands operators, knowledge obtained from local communities, and other sources);
- A short overview of field methods;
- A description of changes in monitoring network from the 2004 field program;
- A description of the challenges and issues encountered during 2005 and the means by which these challenges and issues were addressed; and
- A summary of the component data that are now available.

Each component section of Section 3 contains a description of the detailed approach used for analyzing the RAMP data; this includes:

- A description and explanation of the measurement endpoints that were selected;
- A description and explanation of the criteria that were used in assessing whether or not changes in the selected measurement endpoints have occurred; and
- A description of the statistical, graphical, or other analyses that were performed on the monitoring data to assess whether or not changes in the selected measurements endpoints have occurred.

Section 4: Climatic and Hydrologic Characterization of Oil Sands Development Area in 2005 – This section of the report describes the 2005 hydrologic year and how 2005 compares with previous years. This helps set the context for the results, analyses, and conclusions presented in Section 5.

Section 5: Regional-Level Assessment of 2005 Results – This is the main results section, consisting of two major parts:

- Sections 5.1 to 5.8 focus on watersheds in which oil sands developments were underway as of 2005 and there are areas in which RAMP monitoring stations are designated as *potentially influenced-oil sands*; and
- Sections 5.9 to 5.13 focus on watersheds in which there has been no significant oil sands development to date and these watersheds therefore contain no RAMP monitoring stations designated as *potentially influenced-oil sands*.

Each of these sections presents the RAMP results for the particular watershed for each RAMP component following the analytical approaches contained in each of the component sections of Section 3, as described above. Each section concludes with a summary assessment of the overall status of aquatic environmental resources within the watershed and possible relation to oil sands developments on those resources.

Section 6: Regional-Level Assessment of 2005 Results – This part of the report presents regional assessments of the status of aquatic environmental resources and the possible influence of oil sands developments at the regional level.

Section 7: Conclusions and Recommendations – This section of the report contains a summary of the findings, conclusions, and recommendations from RAMP 2005. The recommendations include proposed changes to the RAMP monitoring network for future years based on the results for 2005.

Throughout the report, where possible and appropriate, recommendations are made for modifications to RAMP based on findings and conclusions. In addition, TEK is included in the RAMP 2005 Technical Report to the extent possible.

The main report concludes with Section 8: References and Section 9: Glossary and List of Acronyms. The main report is supported by a series of technical appendices that present the detailed analytical results for each RAMP component.