# Survey of Oil Sands Environmental Management Research and Information Needs


Oil Sands Research and Information Network

University of Alberta



November 2014


OSRIN
Oil Sands Research and Information Network

## Oil Sands Research and Information Network

The Oil Sands Research and Information Network (OSRIN) is a university-based, independent organization that compiles, interprets and analyses available knowledge about managing the environmental impacts to landscapes and water affected by oil sands mining and gets that knowledge into the hands of those who can use it to drive breakthrough improvements in regulations and practices. OSRIN is a project of the University of Alberta's School of Energy and the Environment (SEE). OSRIN was launched with a start-up grant of $4.5 million from Alberta Environment and a $250,000 grant from the Canada School of Energy and Environment Ltd.

OSRIN provides:

- **Governments** with the independent, objective, and credible information and analysis required to put appropriate regulatory and policy frameworks in place
- **Media, opinion leaders and the general public** with the facts about oil sands development, its environmental and social impacts, and landscape/water reclamation activities – so that public dialogue and policy is informed by solid evidence
- **Industry** with ready access to an integrated view of research that will help them make and execute environmental management plans – a view that crosses disciplines and organizational boundaries

OSRIN recognizes that much research has been done in these areas by a variety of players over 40 years of oil sands development. OSRIN synthesizes this collective knowledge and presents it in a form that allows others to use it to solve pressing problems.

## Citation

This report may be cited as:

Oil Sands Research and Information Network, 2014. Survey of Oil Sands Environmental Management Research and Information Needs. Oil Sands Research and Information Network, University of Alberta, School of Energy and the Environment, Edmonton, Alberta. OSRIN Report No. TR-58. 67 pp.

Copies of this report may be obtained from OSRIN at osrin@ualberta.ca or through the OSRIN website at http://www.osrin.ualberta.ca/en/OSRINPublications.aspx or directly from the University of Alberta's Education & Research Archive at http://hdl.handle.net/10402/era.17507.

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## REPORT SUMMARY

As one of its last projects, the Oil Sands Research and Information Network (OSRIN) conducted this survey of oil sands environmental management research and information needs. The survey was conducted in October and early November 2014 for OSRIN by the University of Alberta's Population Research Laboratory (PRL).

The survey content was developed by OSRIN. The PRL then placed the survey into digital format and provided a link to the survey site to OSRIN. The PRL provided the raw survey results in Excel format to OSRIN in November.

A link to the survey was originally sent to 276 people and 13 organizations via e-mail on October 31, 2014. The link was also placed in the October 31, 2014 edition of the OSRIN Newsletter which was distributed to 273 people, with a reminder in the November 14 Newsletter. Recipients were encouraged to forward the survey to others in their organizations to allow us to get the broadest possible range of views. The survey officially closed November 15, 2014; however, some late submissions (as of November 25, 2014) have been included.

A total of 127 responses were received but only 88 respondents answered all of the questions. Consultants and academics formed the majority of self-identified respondents; approximately 41% of the 88 respondents had more than 15 years combined education and experience.

When offered the opportunity to allocate $100 for a variety of purposes respondents said they'd focus funding on:

- Monitoring and research
- In-situ and mining operations
- Tailings, reclamation and surface water research

Respondents were asked to identify up to five (5) priority research projects they would like to see funded. A total of 277 research project ideas were submitted. Frequently cited research subjects include:

- Greenhouse gas emissions, impacts and management
- Fish, wildlife and biodiversity
- Cumulative effects characterization and management
- Reclamation certification criteria and oil sands process-affected water release criteria
- Reclamation methods
- Tailings treatment
- Water and groundwater impacts (especially chemistry)
- Wetland impacts and reclamation

A significant majority of respondents said they would focus on large field trials or pilots rather than smaller field trials or lab/greenhouse work. Respondents felt that impact assessment and

impact mitigation *are currently* the primary area of research focus, while the majority felt it *should be* mitigation followed by avoidance.

Industry was selected most often as the preferred research funder, while Academic Institutions were selected as the preferred research performer. The two levels of government were seen as second choices for both funding and performing research.

Respondents were asked to identify up to five (5) priority information / data needs they would like to see filled. A total of 199 needs ideas were submitted, however there is some overlap with the research needs list. Frequently cited information priorities include:

- Open, accessible monitoring data portals
- GIS-based information
- Baseline and inventory data, especially for fish, wildlife, water quality and wetlands
- More knowledge synthesis
- More information on the impacts of oil sands development

Respondents said they look for information online first and indicated that some information is easier to find than others. It is clear that Peer-reviewed Journals are seen as the best information source – easiest to find, most frequently used and cited. Government Publications, Proceedings and Government Websites scored well in terms of being used for information. Almost 40% of respondents use Monitoring Data for information but only 7% said the data were easy to find. Data synthesis/presentation tools were identified as requiring additional development effort.

The extensive lists of research priorities and information needs provided by the respondents shows there is a clear need for ongoing work to support oil sands environmental management. The survey responses demonstrated the need to better communicate availability of existing information and to continue to make efforts to provide easy, timely and transparent access to monitoring and research information.

It is also evident that respondents are looking for this information online, however they often find the information difficult to access. Significant effort is required, especially in government organizations, to ensure that site and document links remain permanent rather than constantly changing.

Finally, it appears that there is value in pursuing mechanisms to provide practitioners with ongoing educational and professional development opportunities.

A survey of research and information needs should be repeated periodically to track key issues and performance in addressing them. Although we made considerable efforts to get input from a broad range of parties the survey would have benefited from more participation, especially from the Aboriginal community, monitoring agencies and government (especially the federal government).

**ACKNOWLEDGEMENTS**

The Oil Sands Research and Information Network (OSRIN), School of Energy and the Environment (SEE), University of Alberta provided funding for this project.

OSRIN is grateful to Brett Purdy (Alberta Innovates – Energy and Environment Solutions), Ellen Macdonald (University of Alberta), Kim Dacyk (Cumulative Environmental Management Association) and Richard Dixon (Alberta Energy Regulator) for providing comments on draft versions of the survey.

The University of Alberta's Population Research Laboratory provided excellent support in developing the survey tool, conducting the survey and providing the data in an easy to understand and use format.

# 1 INTRODUCTION

As one of its last projects, the Oil Sands Research and Information Network (OSRIN) conducted this survey of oil sands environmental management research and information needs. The survey was conducted in October and early November 2014 for OSRIN by the University of Alberta's Population Research Laboratory (PRL)[1].

## 1.1 Methodology

The survey content (see Appendix 1) was developed by OSRIN. The PRL then placed the survey into digital format and provided OSRIN with a link to the survey site. The PRL provided the raw survey results in Excel format to OSRIN in November.

A link to the survey was originally sent to 276 people and 13 organizations via e-mail on October 31, 2014. The link was also placed in the October 31, 2014 edition of the OSRIN Newsletter which was distributed to 273 people, with a reminder in the November 14 Newsletter. Recipients were encouraged to forward the survey to others in their organizations to allow us to get the broadest possible range of views. The survey officially closed November 15, 2014; however, some late submissions (as of November 25, 2014) have been included.

A total of 127 responses were received but only 88 respondents answered all of the questions, thus the n-value for each question varies.

# 2 SURVEY RESPONDENTS

Figure 1 shows the distribution of respondents by sector affiliation (88 respondents provided information). Consultants and academics formed the majority of the self-identified respondents.

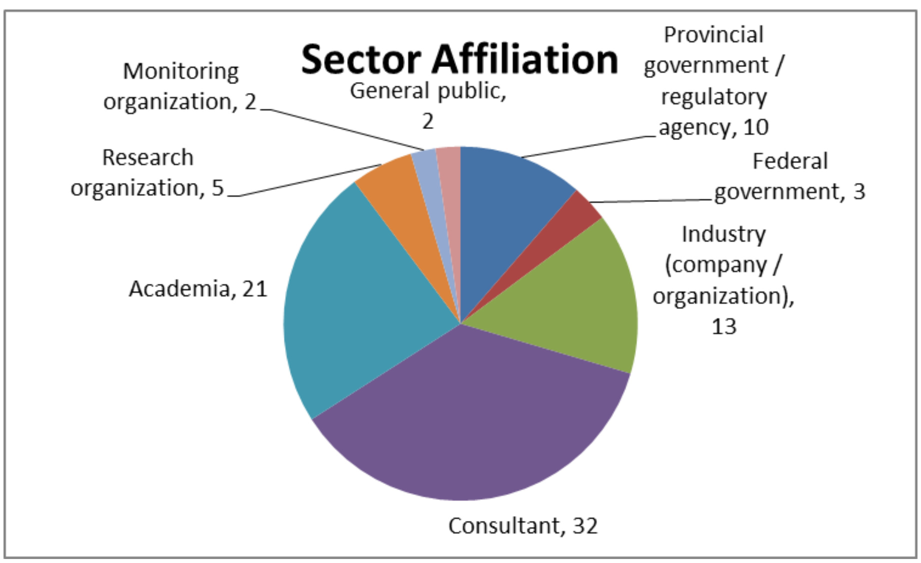


Figure 1. Distribution of respondents by sector.

[1] See http://www.prl.ualberta.ca/

Figure 2 shows the distribution of respondents by years of combined education and experience. Approximately 41% of the 88 respondents who completed the question had more than 15 years combined education and experience.

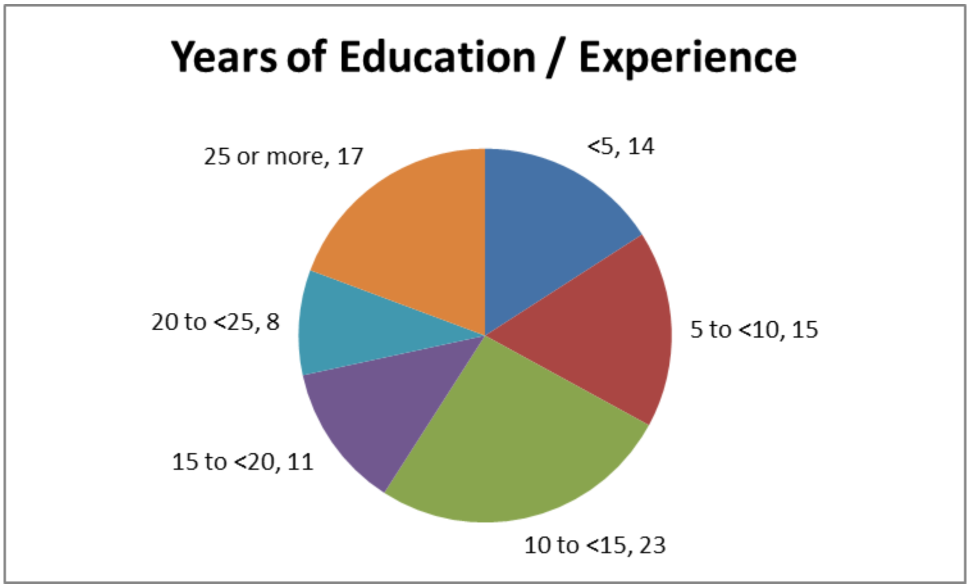


Figure 2. Distribution of respondents by combined education and experience.

## 3 RESEARCH FOCUS AREA QUESTIONS

Respondents were asked a number of questions to determine the areas where they thought research needs should be focused. The sections below summarize the answers.

### 3.1 Priority of Research Relative to Other Needs

To determine the level of support for research, respondents were asked how they would allocate $100 amongst the following priority areas:

- Research;
- Monitoring;
- Survey/Inventory;
- Public Reporting; and,
- Aboriginal / stakeholder engagement.

Figure 3 shows the funding allocation choices made by the 113 respondents who completed the question. Monitoring received the highest level of support, followed by research. Only one respondent allocated all $100 to a single priority area (research); however, all of the priority areas were assigned no funds ($0) by at least one respondent (the highest number of no-funding allocations was for survey/inventory)(Table 1). Sixteen respondents (14%) allocated at least half of their available funds to research; 19 (16%) did so for monitoring (Table 1).

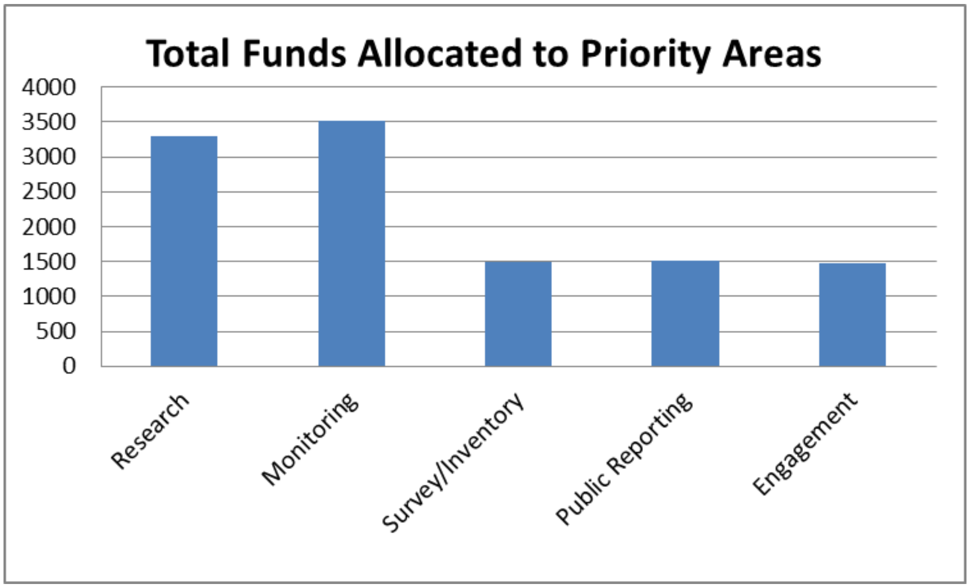


Figure 3. Allocation of funding among priority areas.

Table 1. Summary of funding allocations for priority areas.

| | Research | Monitoring | Survey / Inventory | Public Reporting | Aboriginal / Stakeholder Engagement |
|---|---|---|---|---|---|
| # responses >$0 | 107 | 111 | 91 | 106 | 102 |
| # responses = $0 | 6 | 2 | 22 | 7 | 11 |
| # responses ≥$50 | 16 | 19 | 0 | 1 | 1 |
| Total $ | $3,300 | $3,525 | $1,490 | $1,507[2] | $1,478 |

### 3.2 Research Allocation Amongst Industry Sectors

Respondents were asked how they would allocate $100 for research to fill knowledge and technology gaps amongst the following industry sectors:

- Oil sands mines
- In-situ oil sands
- Oil sands upgraders

[2] Although survey instructions requested $5 increments some respondents chose to use different increments. This happened for a number of the funding allocation questions.

- Oil sands / diluent pipelines
- Oil sands rail transport

Figure 4 shows the funding allocation choices made by the 110 respondents who completed this question. In-situ operations received the highest level of support, though only marginally more than mining operations. Three respondents allocated all $100 to a single industry sector (in-situ). Almost 17% of respondents allocated at least half of their available funds to each of mine and in-situ operations (Table 2). Significantly fewer respondents allocated funds to the remaining three industry sectors (Table 2), although all three would receive some funding (Figure 4).

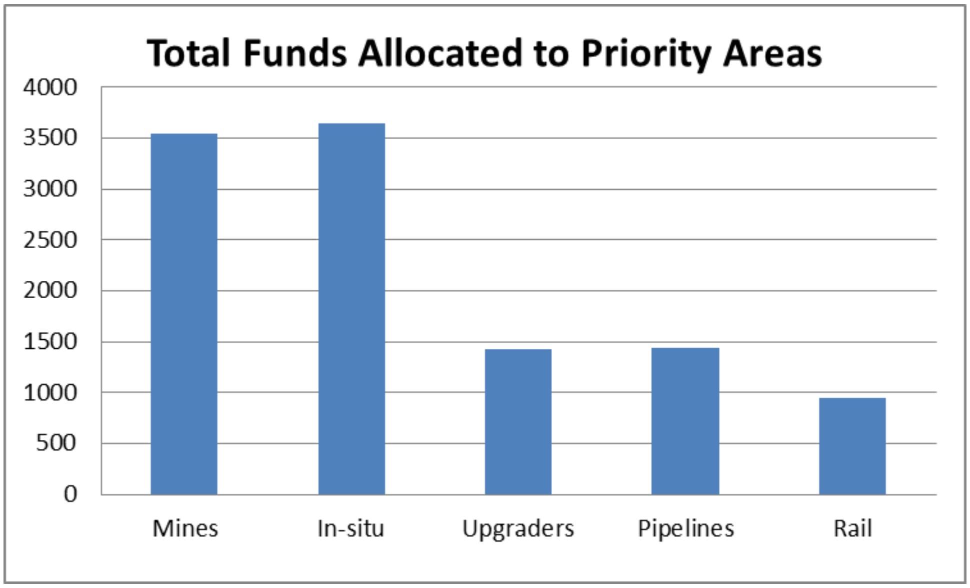


Figure 4. Allocation of research funding among industry sectors.

Table 2. Summary of funding allocations for industry sectors.

| | Mines | In-situ | Upgraders | Pipelines | Rail |
|---|---|---|---|---|---|
| # responses >$0 | 105 | 110 | 86 | 92 | 82 |
| # responses = $0 | 5 | 0 | 24 | 18 | 28 |
| # responses ≥$50 | 19 | 19 | 1 | 1 | 1 |
| Total $ | $3,550 | $3,640 | $1,430 | $1,435 | $945 |

### 3.3 Scale of Research

Respondents were asked what the *most important scale* of research we should focus on is**:**

- Lab / bench / greenhouse

- Small field trials
- Large field trials / pilots
- Full-scale demonstration

Figure 5 shows the choices made by the 106 respondents who completed the question. Large field trials/plots received the highest level of support while lab/bench/greenhouse work received the least support.

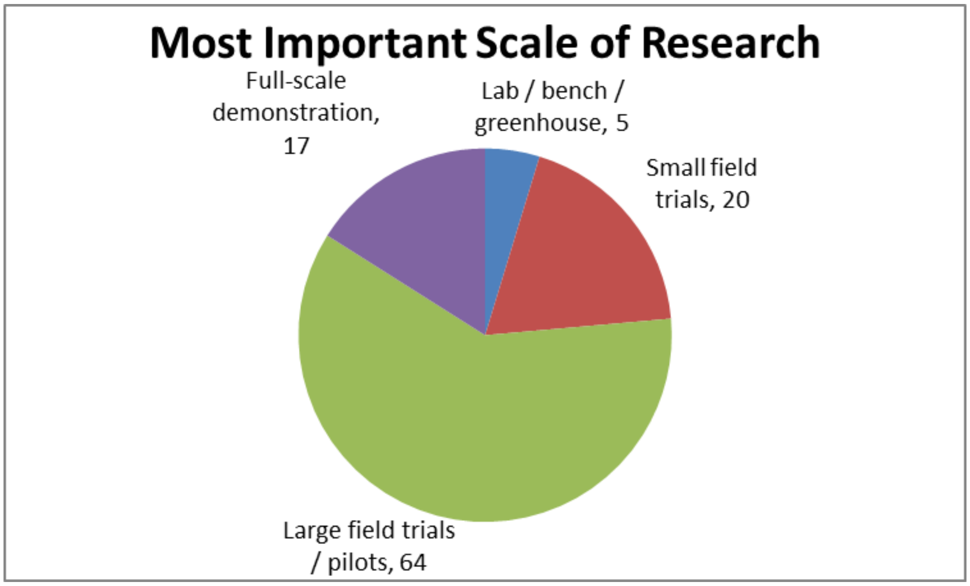


Figure 5. Responses on the most important scale of research.

### 3.4 Focus on Assessment, Avoidance, Mitigation or Compensation

Respondents were asked where they felt the current primary focus of oil sands environmental management research is and where they felt it should be. Figure 6 shows that most of the 108 respondents felt that impact assessment and impact mitigation *are currently* the primary area of research focus, while the majority felt it *should be* mitigation followed by avoidance. Very few respondents selected compensation as either a current or future focus.

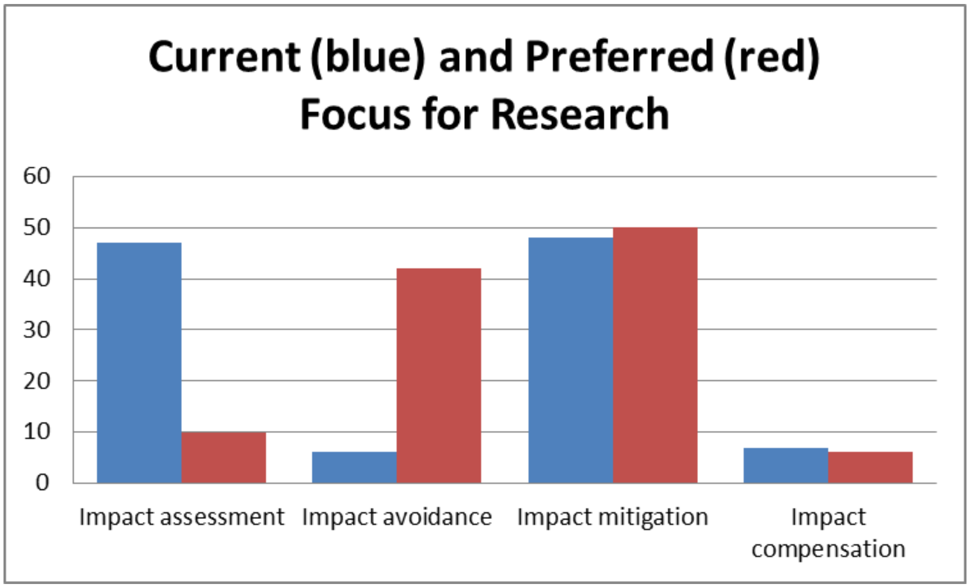


Figure 6. Percentage of responses amongst primary research focus areas.
(Blue bars) What respondents feel is currently the case;
(Red bars) What respondents think it should be.

### 3.5 Allocation Amongst Broad Focus Areas

Respondents were asked how they would allocate $100 for research among the following *broad focus areas*:

- Air emissions
- Biodiversity / fish / wildlife
- Economics
- Greenhouse gases
- Groundwater
- Human health
- Reclamation (landscape, soil, revegetation)
- Regional land use (tracking, mapping, planning, coordinating)
- Social impacts
- Surface water / wetlands / end pit lakes
- Tailings (water and solids)
- Traditional knowledge / traditional land use
- Other (respondents were asked to specify the focus area in a separate text box)

Figure 7 shows the funding allocation choices made by the 103 respondents who completed the question. Tailings, Reclamation and Surface Water received the highest level of support; Economics and Social Impacts the least. Interestingly, these funding allocations are somewhat inconsistent with the list of research priorities in Appendix 2, which appear to suggest a greater emphasis on air emissions/GHGs and Biodiversity/Wildlife.

No respondents allocated all $100 to a single focus area. Table 3 shows that very few respondents allocated at least 50% of their available funds to a single focus area whereas many allocated no funding to specific focus areas.

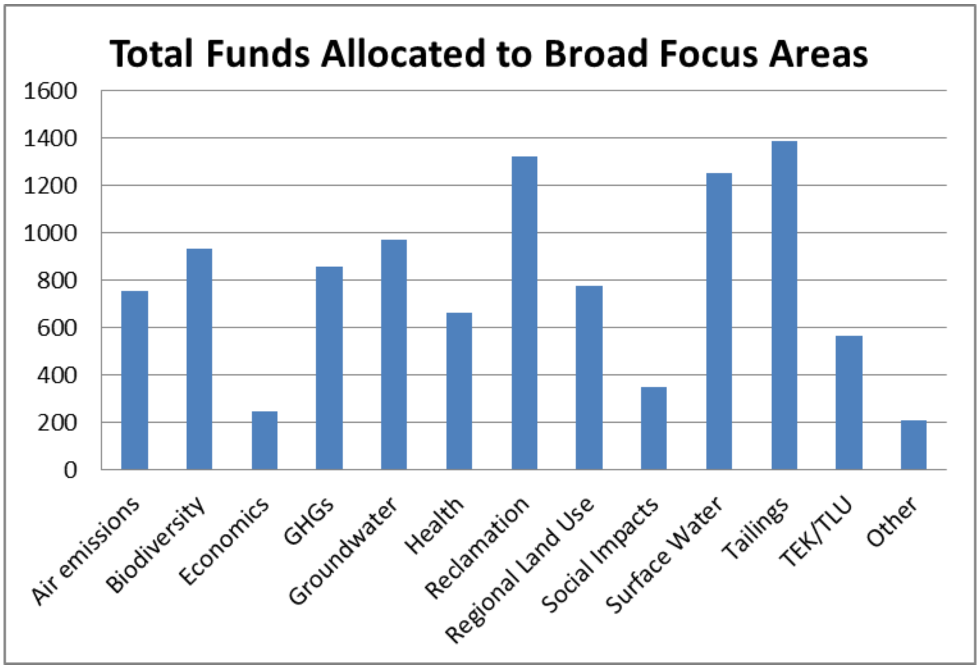


Figure 7. Research funding allocation among broad focus areas.

Table 3. Summary of funding allocations for broad focus areas.

| Focus Area | # responses >$0 | # responses = $0 | # responses ≥$50 | Total $ |
|---|---|---|---|---|
| Air emissions | 75 | 28 | 0 | $755 |
| Biodiversity | 80 | 23 | 0 | $935 |
| Economics | 43 | 60 | 0 | $248 |
| GHGs | 71 | 32 | 2 | $858 |
| Groundwater | 83 | 20 | 1 | $973 |
| Health | 66 | 37 | 0 | $663 |
| Reclamation | 88 | 15 | 1 | $1,323 |

| Focus Area | # responses >$0 | # responses = $0 | # responses ≥$50 | Total $ |
|---|---|---|---|---|
| Regional Land Use | 72 | 31 | 0 | $777 |
| Social Impacts | 53 | 50 | 0 | $352 |
| Surface Water | 88 | 15 | 2 | $1,252 |
| Tailings | 86 | 17 | 4 | $1,387 |
| TEK/TLU | 63 | 40 | 1 | $567 |
| Other | 16 | 87 | 1 | $210 |

Sixteen respondents allocated a small amount of funding to the following additional focus areas (grouped by common theme and frequency):

- Verifying environmental liability estimates used to collect financial security is a priority. Similarly verifying environmental impacts predicted by EIA in relation to actual adverse effects is a critical part of environmental management not recognized. Tailings and reclamation research are industry's responsibility and should be paid for ONLY by Industry. Verifying restoration of surface water and wetlands habitat is GOA responsibility while end pit lakes is industry's responsibility
- Need research to identify and quantify the liability to be secured for financial security deposits. Tailings and reclamation research is strictly industry's responsibility. Government should only research how to verify adequacy of Industry's work.
- Identification and quantification of environmental liability.
- To explore alternative bitumen extraction techniques that reduce environmental risk and reclamation challenge.
- Bitumen recovery from tailings ponds (surficial and submerged mats, which pose a threat to diving ducks even if a water cap is placed on "Base Mine Lake" or an end-pit lake) and from tailings pipelines.
- A publicly accessible central inventory of development plans so proponents can use reasonable cumulative effects scenarios in their planning and applications that are consistent across the board. This would facilitate regulator review and remove subjectivity from cumulative effects decisions.
- Cumulative effects.
- Long term planning.
- Long term environmental impacts of wastes and residues and how to mitigate them such as sulfur. For god's sake we don't even know how wood chips mixed with invert cuttings work – there is no science behind half of what is practiced and that is a sad legacy.

- The destruction of fresh water will be our demise.  Pure and simple.
- Data Management – most data collected have a short half-life.
- Transparency of reporting, building public literacy about balance of effects.
- Sustainable alternatives.
- Need to fully understand and tackle head on the well organized and executed anti-oil sands campaign plan funded by US foundations (Tides Foundation, Pew Foundations, Rockefeller Foundations etc.).  Their funding efforts of Canadian NGO's and lobbyists has continued to distribute incorrect and misleading information, putting into question well established regulatory approval processes with the objective of preventing Canadian oil reaching global markets.
- Politics of oil sands development.
- Is Greenhouse Gas not covered off in Air Emissions?

### 3.6 Importance of Developing Tools, Standards and Capacity Priority

Respondents were asked how important it is to develop tools, standards and capacity for a variety of tools that support research, monitoring and information sharing.  Table 4 summarizes the results (100 or 101 respondents provided answers, depending on the topic).  Data Synthesis/Presentation received the highest number of Very Important ratings (71).  Remote Sensing received the least (39) which seems surprising given the level of research effort and piloting work underway to develop applications for this tool.  In retrospect it would have been good to ask respondents if each option was already developed or required further work; that may have helped better understand the remote sensing response.

Table 4. Importance of developing tools, standards and capacity.

| | Not Important | Somewhat Important | Very Important | Don't Know/ Unsure |
|---|---|---|---|---|
| Modelling | 3 | 40 | 53 | 5 |
| Mapping / GIS | 6 | 41 | 48 | 5 |
| Remote sensing | 6 | 48 | 39 | 7 |
| Sample collection / preservation / transportation | 8 | 36 | 50 | 6 |
| Analytical methods | 4 | 46 | 48 | 2 |
| Data warehousing | 3 | 36 | 54 | 8 |
| Data synthesis / presentation | 2 | 23 | 71 | 5 |

## 4 PRIORITY RESEARCH PROJECT NEEDS

Respondents were asked to identify up to five (5) priority research projects they would like to see funded. A total of 277 research project ideas were submitted. Appendix 2 provides the full list of responses, organized by topic. Frequently cited research themes include:

- Greenhouse gas emissions, impacts and management
- Fish, wildlife and biodiversity
- Cumulative effects characterization and management
- Reclamation certification criteria and oil sands process-affected water release criteria
- Reclamation methods
- Tailings treatment
- Water and groundwater impacts (especially chemistry)
- Wetland impacts and reclamation

## 5 PRIORITY INFORMATION / DATA NEEDS

Respondents were asked to identify up to five (5) priority information / data needs they would like to see filled. Appendix 3 provides the full list of responses, organized by topic. A total of 199 information needs ideas were submitted, however there is some overlap with the research needs list. Frequently cited information priorities include:

- Open, accessible monitoring data portals
- GIS-based information
- Baseline and inventory data, especially for fish, wildlife, water quality and wetlands
- More knowledge synthesis work
- More information on the impacts of oil sands development

## 6 WHO SHOULD FUND AND PERFORM RESEARCH

Respondents were asked to identify who should fund research and who should perform it (they were able to select as many as applicable). Choices for both questions were:

- Provincial government
- Federal government
- Oil sands companies
- Industry organizations (e.g., COSIA)
- Multi-stakeholder organizations (e.g., CEMA)
- Other organizations (e.g., ENGOs, NGOs, not-for-profits)

Table 5 shows the distribution of the choices from the 128 respondents completing the question. Industry (individual companies) was selected most often as the preferred research funder, while Academic Institutions were selected as the preferred research performer. The two levels of government were seen as second choices for both funding and performing research.

Table 5. Respondent preferences for research funders and research performers. Shaded cells in each column were not provided as choices for that question.

| Organization | Funder | Performer |
|---|---|---|
| Provincial government | 76 | 65 |
| Federal government | 69 | 59 |
| Oil sands companies | 81 | 54 |
| Industry organizations (e.g., COSIA) | 65 | |
| Multi-stakeholder organizations (e.g., CEMA) | 37 | |
| Other organizations (e.g., ENGOs, NGOs, not-for-profits) | 22 | 38 |
| Consultants | | 50 |
| Academic institutions | | 85 |

## 7 INFORMATION SOURCES, USES AND OPPORTUNITIES

Several questions were asked to set the stage for organizations[3] to understand what kinds of information people are looking for, where they are looking for it and how they would like to get it. The results are summarized below.

### 7.1 Value of Various Information Sources

Respondents were asked if they agree that a variety of information sources were easy to find, if they used them for information, and if they cite them as sources. Figure 8 and Table 6 summarize the results from the 89 respondents who provided information on at least one information source.

It is clear that Peer-reviewed Journals are seen as the best information source – easiest to find, most frequently used and cited. Government Publications, Proceedings and Government Websites scored well in terms of being used for information. Almost 40% of respondents use Monitoring Data for information but only 7% said the data were easy to find.

[3] For example, government, industry, academic institutions, professional associations

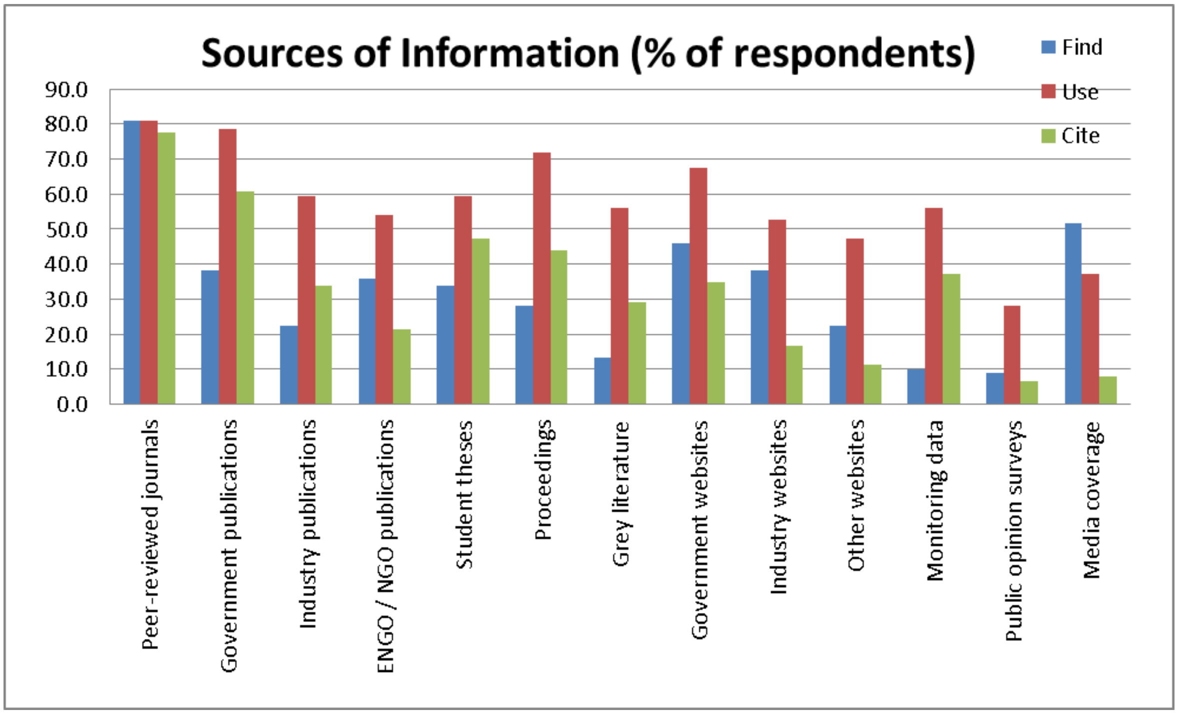


Figure 8. Sources of information – ease of finding, use and citing.

Table 6. Information source summary.

| Source | Easy To Find | Use For Info | Cite Them |
|---|---|---|---|
| Peer-reviewed journals | 72 | 72 | 69 |
| Government publications | 34 | 70 | 54 |
| Industry publications | 20 | 53 | 30 |
| ENGO / NGO publications | 32 | 48 | 19 |
| Student theses | 30 | 53 | 42 |
| Conference / seminar / workshop proceedings | 25 | 64 | 39 |
| Other "grey literature" sources | 12 | 50 | 26 |
| Government websites | 41 | 60 | 31 |
| Industry websites | 34 | 47 | 15 |
| Other websites | 20 | 42 | 10 |
| Monitoring data | 9 | 50 | 33 |
| Public opinion survey results | 8 | 25 | 6 |
| Media coverage | 46 | 33 | 7 |

Fifteen respondents identified other sources that they use or provided additional comments and observations:

- First hand data collection.
- Direct observation is underrated and is amongst the best sources of 'information', at least when the observers have sufficient background and experience. Go look at the mines, or the in-situ pads, look at the debris placement, try and walk on the tailings ... no substitute if you know what you are looking at given experience. How do you provide this opportunity in the absence of a field trip? In today's exciting modern age of information technology you would think something was possible and of some value, working remotely so to speak.
- Project technical reports.
- Recent environmental impact assessment documents, CEMA documents, etc.
- Government data; technical books/manuals.
- Work conducted as a consultant.
- In-house database of oil sands information.
- Traditional knowledge, local knowledge, interviews and discussions with land-users and elders, personal observations.
- Insider knowledge – personal accounts/experience of those within the sectors.
- Information might be synthesized from a variety of sources that aren't directly related to the topic of study, but sill inspire new approaches or interpretations.
- Google Alerts, Google Scholarly Alerts, Government and Academic Libraries.
- Tweets, government speeches.
- Although some of the sources checkmarked above are easy to find, some are full of nonsense. This question was not well-worded, as it doesn't let me indicate whether I WOULD use the sources if they were easy to find. For example, conference/ seminar/workshop proceedings and other 'grey literature' sources can be informative, but they are typically difficult to access unless you know which conference has been held and whether they are publishing publicly available proceedings. Even government publications, which can be very useful even if they are carefully couched, can be hard to track down through the government websites (see my rant on the previous page).
- There is almost too much information out there. Need a common repository and more syntheses.
- I wish we had more.

### 7.2 Use of Information Types and Sources

Respondents were asked to indicate their level of support for several statements about how they use information and whether they use specific oil sands sources. Table 7 summarizes the results from the 88 respondents who completed the question.

People are more comfortable making environmental management decisions based on data/information less than 10 years old (79%), compared to older information (56%) or only more recent information (15%). The majority of people noted they first look to the Internet for their information.

More people have used the Oil Sands Information Portal (56) than the Canada-Alberta Oil Sands Environmental Monitoring Information Portal (30) or the National Pollutant Release Inventory site (21). A majority of respondents (51%) prefer not to use raw monitoring data (14% were unsure).

Respondents use the CEMA/OSRIN Oil Sands Environmental Management Bibliography (60%) and OSRIN's digitized reports (67%) as information sources.

Table 7. Information types and sources.

| Statement | Agree/ True | Disagree/ False | Don't Know/ Unsure |
|---|---|---|---|
| I would only rely on recent information (less than 5 years old) to base environmental management decisions on | 13 | 71 | 4 |
| I would be comfortable relying on somewhat older information (more than 5 years but less than 10 Years old) to base environmental management decisions on | 70 | 9 | 9 |
| I would be comfortable relying on older information (more than 10 years old) to base environmental management decisions on | 49 | 24 | 14 |
| I am aware that OSRIN made digital copies of older oil sands research and policy documents accessible online | 53 | 21 | 14 |
| The first place I look for information is online | 76 | 9 | 1 |
| I have accessed or used the Oil Sands Information Portal | 56 | 25 | 4 |
| I have accessed or used the Canada-Alberta Oil Sands Environmental Monitoring Information Portal | 30 | 48 | 8 |
| I have accessed or used the National Pollutant Release Inventory site | 21 | 60 | 5 |
| I prefer to get raw monitoring data rather than have them summarized / synthesized for me | 30 | 45 | 12 |
| I have accessed or used the online CEMA/OSRIN Oil Sands Environmental Management Bibliography | 56 | 25 | 2 |

### 7.3 Information Source Opportunities

Respondents were asked asked to indicate their level of support for several potential means of accessing information to keep current with oil sands environmental management information. Table 8 summarizes the results (between 84 and 88 respondents replied to each option). Having a central place for current research information was the most frequently cited opportunity, followed by having a short synthesis of research results.

It is clear from the results that there is a business need to be filled to develop and push information out to the oil sands community. This mirrors the results from the 2012 workshop held by OSRIN to discuss the need for a Knowledge Exchange Network for the reclamation community (Alberta Innovates – Technology Futures 2012).

Table 8. Information source opportunities.

| Statement | Agree/ True | Disagree/ False | Don't Know/ Unsure |
|---|---|---|---|
| I use mailing lists, RSS feeds, newsletters, discussion groups and similar digital tools to help me keep current | 46 | 37 | 3 |
| I would participate in field tours to help me keep current | 73 | 9 | 3 |
| I would take professional development courses to help me keep current | 67 | 11 | 8 |
| I would be interested in online courses and videos to help me keep current | 70 | 10 | 6 |
| I would find it useful to have short syntheses of research results to help me decide if I want to read the detailed report / paper | 84 | 2 | 1 |
| I would find it useful to have a central place where I can find out what research is underway | 85 | 0 | 2 |
| I would find it useful to have a directory of researchers and their areas of expertise | 77 | 5 | 5 |
| I would find it useful to have a directory of research funders and their funding requirements / opportunities | 73 | 5 | 9 |

## 8 ADDITIONAL COMMENTS

Respondents were given the opportunity to provide additional comments on oil sands environmental management research and information needs. Appendix 4 provides the full list of 23 comments; key themes are listed below:

- The survey should be repeated but more work is required to clarify the purpose of some of the questions and make it easier for respondents to provide meaningful input

- More research is needed but should be done with a clear purpose and intended use and with greater (or clearer) oversight
- Recognizing the differences and roles for research, monitoring and information collection/dissemination
- Research is a valuable tool to support *social licence*

# 9 CONCLUSIONS AND RECOMMENDATIONS

## 9.1 Comparison with Previous Work

OSRIN recently held a workshop to discuss our collective state of readiness to deal with oil sands environmental management challenges that were expected to arise in the next 10 years (Oil Sands Research and Information Network 2014). Key themes in the workshop are mirrored in the survey, in particular the need for more clarity on reclamation certification and oil sands process-affected water release criteria. However, the workshop had a much stronger emphasis on social and economic issues than is found in the survey. Stakeholder input to OSRIN's early workshops on reclamation (Jones and Forrest 2010), monitoring (James and Vold 2010) and surface water / groundwater interaction (Oil Sands Research and Information Network and Canadian Environmental Assessment Agency 2012) are also consistent with the survey results.

OSRIN commissioned a public opinion survey in 2010 (Chapman and Das 2010). In that survey the respondents identified reclamation, wildlife habitat, ecological monitoring and greenhouse gases as key *value drivers* (Figure 9). Those results are consistent with the results of this survey, with perhaps greater emphasis in the survey on greenhouse gases.

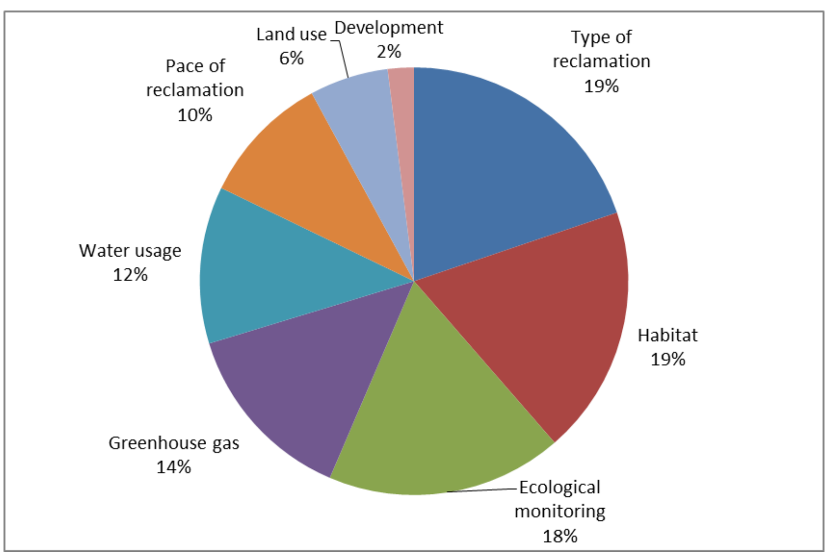


Figure 9. Relative ranking of Albertan's value drivers.
From Chapman and Das (2010).

In 1999, the Reclamation Research Technical Advisory Committee (RRTAC) undertook a survey of province-wide reclamation research needs, and provided the top 10 needs for each of RRTAC's program areas including the oil sands (Smith 1999). While significant progress has been made in many of the areas identified in the 1999 survey many are still reflected in the current survey. To a large extent this reflects the complexity of the problems related to tailings reclamation and the long-term nature of oil sands reclamation outcomes.

### 9.2 Conclusions

The extensive lists of research priorities and information needs provided by the respondents shows there is a clear need for ongoing work to support oil sands environmental management. The survey responses demonstrated the need to better communicate availability of existing information and to continue to make efforts to provide easy, timely and transparent access to monitoring and research information.

It is also evident that respondents are looking for this information online, however they often find the information difficult to access. Significant effort is required, especially in government organizations, to ensure that site and document links remain permanent rather than constantly changing.

Finally, it appears that there is value in pursuing mechanisms to provide practitioners with ongoing educational and professional development opportunities.

### 9.3 Recommendations

A survey of research and information needs should be repeated periodically to track key issues and performance in addressing them. Although we made considerable efforts to get input from a broad range of parties the survey would have benefited from more participation, especially from the Aboriginal community, monitoring agencies and government (especially the federal government).

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# 11 GLOSSARY

## 11.1 Terms

**Environmental Management**

All of the actions taken to identify, characterize, assess, track, manage and mitigate the environmental impacts of oil sands development.

**Monitoring**

A range of data gathering and synthesis activities that are ongoing and geared to describing environmental condition and trends.

**Research**

A range of data/information gathering and synthesis activities that address a specific question over a specified (usually short) timeframe.

## 11.2 Acronyms

| | |
|---|---|
| 3PC | Third-Party Contracting (EIA reviews) |
| AER | Alberta Energy Regulator |
| BMP | Best Management Practices |
| C&R | Conservation and Reclamation |
| CAPP | Canadian Association of Petroleum Producers |
| CCME | Canadian Council of Ministers of the Environment |

| | |
|---|---|
| CEMA | Cumulative Environmental Management Association |
| CNRL | Canadian Natural Resources Limited |
| COC | Chemical of Concern |
| CONRAD | Canadian Oil Sands Network for Research and Development |
| COSIA | Canada's Oil Sands Innovation Alliance |
| CSS | Cyclic Steam Stimulation |
| CT | Composite or Consolidated Tailings |
| DNA | Deoxyribonucleic Acid |
| EIA | Environmental Impact Assessment |
| ENGO | Environmental Non-Government Organization |
| EPEA | *Environmental Protection and Enhancement Act* |
| ERCB | Energy Resources Conservation Board |
| FAQ | Frequently Asked Questions |
| FM | Unclear from context if respondents meant Fort McMurray or Fort McKay |
| GIS | Geographic Information System |
| GHG | Greenhouse Gases |
| GOA | Government of Alberta |
| IFN | Instream Flow Needs |
| LCCS | Land Capability Classification System |
| LFH | Litter, Fibric, Humic |
| LiDAR | Light Detecting and Ranging |
| MFT | Mature Fine Tailings |
| NE | Northeast (Alberta) |
| NGO | Non-Government Organization |
| NST | Non-Segregating Tailings |
| O&G | Oil and Gas (industry) |
| OSE | Oil Sands Exploration |
| OSIP | Oil Sands Information Portal |
| OSPW | Oil Sands Process-affected Water |

| | |
|---|---|
| OSRIN | Oil Sands Research and Information Network |
| PDA | Pre-Disturbance Assessment |
| QA/QC | Quality Assurance / Quality Control |
| RRTAC | Reclamation Research Technical Advisory Committee |
| RSDS | Regional Sustainable Development Strategy |
| SAGD | Steam Assisted Gravity Drainage (likely intended by respondents to mean in-situ) |
| SCO | Synthetic Crude Oil |
| SEE | School of Energy and the Environment |

## APPENDIX 1: Survey Questions

### OSRIN Survey of Oil Sands Environmental Management Research and Information Needs

The Oil Sands Research and Information Network (OSRIN) is winding down at the end of 2014 after five years of creating and sharing oil sands environmental management knowledge. As one of our legacy projects we are conducting this survey to identify oil sands environmental management research and information needs. The Population Research Laboratory at the University of Alberta IS managing this on-line survey on a secure server at the University of Alberta.

In this survey we use the term **research** to encompass a range of data/information gathering and synthesis activities that address a specific question over a specific (usually short) timeframe. We use the term **monitoring** to encompass a range of data gathering and synthesis activities that are ongoing and geared to describing environmental condition and trends. We use the term **environmental management** to mean all of the actions taken to identify, characterize, assess, track, manage and mitigate the environmental impacts of oil sands development.

The survey should take about 15 minutes to complete. We begin the survey with questions about research priorities, then ask for your top five research ideas and information/data needs, then ask who should fund and perform research, then ask about your information sources/use, and end with two demographic questions.

Responses will not be attributed to individuals or organizations – we only ask which type of sector you belong to and how much education/experience you have to give context to the results. All data will be collected, stored and reported according to the Freedom of Information and Protection of Privacy (FOIP) guidelines. The plan for this study has been reviewed for its adherence to ethical guidelines by a Research Ethics Board at the University of Alberta. For questions regarding participant rights and ethical conduct of research contact the Research Ethics office at (780) 492-2615.

We are looking to get responses from a large number of people with a variety of perspectives so we encourage you to share the survey link with others in your organization and professional network. Because we are asking participants to share the link it may mean that you get more than one request to participate but please only complete the survey once!

The survey will be open until November 15, 2014. Within a few weeks after closing we will release the results as an OSRIN report at our website. You may withdraw from the study at any time until December 1, 2014 providing that you are able to provide the date and time of your submission. However, there is a possibility that with multiple submissions at a specific date and time, this may not be accomplished.

**Clicking on the button to start the survey implies consent.**

Any questions on the content of the survey can be directed to Chris Powter, Executive Director/OSRIN at 780-248-1865

**If you had $100 for environmental management work, how would you allocate it amongst the following *activities* (select as many as you want – $5 increments please)**:

[ANSWERS MUST ADD TO 100]

| | |
|---|---|
| Research | ______ |
| Monitoring | ______ |
| Survey/Inventory | ______ |
| Public Reporting | ______ |
| Aboriginal / stakeholder engagement | ______ |
| | Total $100 |

**If you had $100 for research to address knowledge and technology gaps, on which of the following *industry sectors* would you spend the funds (select as many as you want – $5 increments please):**

[ANSWERS MUST ADD TO 100]

| | |
|---|---|
| Oil sands mines | ______ |
| In-situ oil sands | ______ |
| Oil sands upgraders | ______ |
| Oil sands / diluent pipelines | ______ |
| Oil sands rail transport | ______ |
| | Total $100 |

**The *most important scale* of research we should focus on is (*select one*):**

- ☐ Lab / bench / greenhouse
- ☐ Small field trials
- ☐ Large field trials / pilots
- ☐ Full-scale demonstration

**The *primary* focus for oil sands environmental management research *currently is*:**

- ☐ Impact assessment (e.g., survey, inventory, catalogue, risk analysis)
- ☐ Impact avoidance (e.g., shared infrastructure, coordinated development, constraints mapping)
- ☐ Impact mitigation (e.g., decontamination, reclamation / restoration)
- ☐ Impact compensation (e.g., offsets, off-site enhancement / replacement)

**The *primary* focus for oil sands environmental management research *should be*:**

- ☐ Impact assessment (e.g., survey, inventory, catalogue, risk analysis)
- ☐ Impact avoidance (e.g., shared infrastructure, coordinated development, constraints mapping)
- ☐ Impact mitigation (e.g., decontamination, reclamation / restoration)
- ☐ Impact compensation (e.g., offsets, off-site enhancement / replacement)

**If you had $100 for research, how would you allocate it amongst the following *broad focus areas* (select as many as you want – $5 increments please):**

[ANSWERS MUST ADD TO 100]

Air emissions ........................................................................ ______

Biodiversity / fish / wildlife .............................................................. ______

Economics ........................................................................ ______

Greenhouse gases ................................................................ ______

Groundwater ........................................................................ ______

Human health ........................................................................ ______

Reclamation (landscape, soil, revegetation) ..................................... ______

Regional land use (tracking, mapping, planning, coordinating) ......... ______

Social impacts ........................................................................ ______

Surface water / wetlands / end pit lakes ............................................ ______

Tailings (water and solids) ................................................................ ______

Traditional knowledge / traditional land use .................................... ______

Other (specify in box below) ............................................................ ______

.................................................................................................... Total $100

Other specified *(500 characters max)*______________________________________________

**How important is it to *develop tools, standards and capacity* for the following activities:**

| | NOT IMPORTANT | SOMEWHAT IMPORTANT | VERY IMPORTANT | DON'T KNOW/ UNSURE |
|---|---|---|---|---|
| Modelling | ☐ | ☐ | ☐ | ☐ |
| Mapping / GIS | ☐ | ☐ | ☐ | ☐ |
| Remote sensing | ☐ | ☐ | ☐ | ☐ |
| Sample collection / preservation / transportation | ☐ | ☐ | ☐ | ☐ |
| Analytical methods | ☐ | ☐ | ☐ | ☐ |
| Data warehousing | ☐ | ☐ | ☐ | ☐ |
| Data synthesis / presentation | ☐ | ☐ | ☐ | ☐ |

**Describe up to five (5) *priority research projects* you'd like to see funded (NOTE – the next question is on information / data needs so these do not need to be addressed here For example, in this question you might want to test the effects of soil pH on tree growth; in the next question you might want a publicly accessible database of soil chemistry).**

Project 1: ____________________________________________

Project 2: ____________________________________________

Project 3: ____________________________________________

Project 4: ____________________________________________

Project 5: ____________________________________________

**Describe up to five (5) *priority information / data needs* you'd like to see filled:**

Information Need 1: ___________________________________________

Information Need 2: ___________________________________________

Information Need 3: ___________________________________________

Information Need 4: ___________________________________________

Information Need 5: ___________________________________________

**Who do you think should *fund* oil sands environmental management research (select all that apply)?**

- ☐ Provincial government
- ☐ Federal government
- ☐ Oil sands companies
- ☐ Industry organizations (e.g., COSIA)
- ☐ Multi-stakeholder organizations (e.g., CEMA)
- ☐ Other organizations (e.g., ENGOs, NGOs, not-for-profits)

**Who do you think should *perform* oil sands environmental management research (select all that apply)?**

- ☐ Provincial government
- ☐ Federal government
- ☐ Oil sands companies
- ☐ Industry organizations (e.g., COSIA)
- ☐ Multi-stakeholder organizations (e.g., CEMA)
- ☐ Other organizations (e.g., ENGOs, NGOs, not-for-profits)

**For each of the environmental management information sources below check the box if you agree that: they are easy to find, you use them to get information, and you cite them as sources:**

| | EASY TO FIND | USE FOR INFO | CITE THEM |
|---|---|---|---|
| Peer-reviewed journals | ☐ | ☐ | ☐ |
| Government publications | ☐ | ☐ | ☐ |
| Industry publications | ☐ | ☐ | ☐ |
| ENGO / NGO publications | ☐ | ☐ | ☐ |
| Student theses | ☐ | ☐ | ☐ |
| Conference / seminar / workshop proceedings | ☐ | ☐ | ☐ |
| Other "grey literature" sources | ☐ | ☐ | ☐ |
| Government websites | ☐ | ☐ | ☐ |
| Industry websites | ☐ | ☐ | ☐ |
| Other websites | ☐ | ☐ | ☐ |
| Monitoring data | ☐ | ☐ | ☐ |
| Public opinion survey results | ☐ | ☐ | ☐ |
| Media coverage | ☐ | ☐ | ☐ |

**What other information sources do you use (*specify*)? ________________________________**

**Please indicate your level of support for the following statements:**

| | AGREE/ TRUE | DISAGREE/ FALSE | DON'T KNOW/ UNSURE |
|---|---|---|---|
| I would only rely on recent information (less than 5 years old) to base environmental management decisions on | ☐ | ☐ | ☐ |

| | AGREE/ TRUE | DISAGREE/ FALSE | DON'T KNOW/ UNSURE |
|---|---|---|---|
| I would be comfortable relying on somewhat older information (more than 5 years but less than 10 Years old) to base environmental management decisions on | □ | □ | □ |
| I would be comfortable relying on older information (more than 10 years old) to base environmental management decisions on | □ | □ | □ |
| I am aware that OSRIN made digital copies of older oil sands research and policy documents accessible online | □ | □ | □ |
| The first place I look for information is online | □ | □ | □ |
| I have accessed or used the Oil Sands Information Portal | □ | □ | □ |
| I have accessed or used the Canada-Alberta Oil Sands Environmental Monitoring Information Portal | □ | □ | □ |
| I have accessed or used the National Pollutant Release Inventory site | □ | □ | □ |
| I prefer to get raw monitoring data rather than have them summarized / synthesized for me | □ | □ | □ |
| I have accessed or used the online CEMA/OSRIN Oil Sands Environmental Management Bibliography | □ | □ | □ |
| I use mailing lists, RSS feeds, newsletters, discussion groups and similar digital tools to help me keep current | □ | □ | □ |
| I would participate in field tours to help me keep current | □ | □ | □ |

| | AGREE/ TRUE | DISAGREE/ FALSE | DON'T KNOW/ UNSURE |
|---|---|---|---|
| I would take professional development courses to help me keep current | ☐ | ☐ | ☐ |
| I would be interested in online courses and videos to help me keep current | ☐ | ☐ | ☐ |
| I would find it useful to have short syntheses of research results to help me decide if I want to read the detailed report / paper | ☐ | ☐ | ☐ |
| I would find it useful to have a central place where I can find out what research is underway | ☐ | ☐ | ☐ |
| I would find it useful to have a directory of researchers and their areas of expertise | ☐ | ☐ | ☐ |
| I would find it useful to have a directory of research funders and their funding requirements / opportunities | ☐ | ☐ | ☐ |

**Which category best describes you (*select one*)**:

☐ Provincial government / regulatory agency

☐ Federal government

☐ Industry (company / organization)

☐ Consultant

☐ Academia

☐ ENGO / NGO

☐ Aboriginal

☐ Research organization

☐ Monitoring organization

☐ General public

**How many years of education and experience do you have in the oil sands environmental management field?**

☐ Less than 5

☐ 5 to <10

☐ 10 to <15

☐ 15 to <20

☐ 20 to <25

☐ 25 or more

**Please provide any additional thoughts on oil sands environmental management research and information needs:** ____________________________________________

## APPENDIX 2: Priority Research Needs

Survey respondents were given the opportunity to provide up to five (5) priority research needs they would like to see funded. The 278 research needs have been sorted into common theme areas[4]. Where multiple themes could be inferred for a specific research need OSRIN selected only one to reduce duplication in this list.

***Air emissions / GHG***

Test emissions.

Intensity and dispersal of airborne particulates from oil sands operations in the region.

Development of source apportionment methods to identify the relative contribution of different sources of atmospheric emissions in the oil sands. (better characterization of different source signals, and method development for source apportionment studies).

Air emissions – our industry versus China's pollution that's carried over – coal versus industry. It would be nice to have facts rather than rhetoric.

Detection, measurement, and reduction of fugitive emissions, flares, and venting.

Test the effects of tailing pond emission on air quality.

What are the life-cycle emissions of oil sand production (including diluent production, transportation etc.)?

GHG emissions and land / water disturbance.

GHG/emissions verification.

Reduction of greenhouse gas emission.

Investigate how greenhouse gas emissions from petroleum operations can be reduced to meet and exceed Kyoto protocols.

Determining the most effective ways to reduce carbon emissions from all oil sands sources.

Carbon dioxide reduction strategies.

Carbon sequestration opportunities and innovation within the oil sands.

***Biodiversity / fish / wildlife***

Effects on wildlife and fish.

Caribou habitat restoration – particularly predator reduction mitigations – at a regional scale

Caribou habitat restoration – from landscape level planning tools to local scale silvicultural treatment that supports the defragmentation of highly fragmented boreal landscapes.

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[4] One suggestion was not relevant to oil sands: Effects of ocean acidification on Alaskan fish stocks.

Assessment of the temporal changes in post-fire landscapes for use as caribou habitat.

Accommodating Species at Risk within in-situ oil sands developments.

Reclamation methods for restoring biodiversity.

Investigate how shared impact avoidance (especially shared infrastructure, aerial seismic surveys instead of seismic lines, etc.) affects biodiversity relative to current practice.

Long-term biodiversity effects and changes in the boreal oil sands region.

Assessment of biodiversity on oil sands mine reclamation – what is good enough, when is it good?

Detailed (competent, thorough, and adequate) inventory of biodiversity in areas where development is proposed or will have an impact. Specific focus on wetlands, peatlands, and rare species that are difficult to detect with traditional or superficial survey methods.

Will current re-vegetation practices and standards support genetic diversity needs in the mineable oil sands area. Given that most of the revegetation material is human-selected (i.e. based upon seed collection and cost-effective available plant material), what evidence is there that normal gene flow, and genetic diversity is being re-established in the area? Is there sufficient pollen/seed movement from outside the area (given the large contiguous disturbance patterns) to support continues evolutionary development? Are we creating essentially "island" populations with limited genetic diversity? Are the selected deployed materials also selected to support resiliency in the light of climate change? Has anyone thought of the long-term impact of the vegetative material selection process currently in play?

Research the minimum amounts and types of woody debris which would have a significant positive impact on biodiversity (plant arrays), compare this to the remaining woody debris opportunities from all mines.

Documenting how changes in water and soil chemistry alter conditions for biodiversity above and beyond those caused by habitat change.

Determining impacts of oil sands development on bird life, with specific focus on whether historical migration routes have changed, in correspondence with increased oil sands development.

Develop comprehensive understanding of environmental effects of bird protection programs.

Figure out how to reduce bitumen interactions with wildlife without creating a soundscape that reduces quality of habitat around the mines.

Effects of oil sands in situ development on wildlife habitat land use before and after development. There are a lot of leases out there, lease holders can start monitoring before they apply to develop.

What impact does extensive, landscape level linear restoration have on wildlife populations?

Documenting the spatial scale at which impacts are occurring to the size of wildlife populations that are measurable as an actual numerical and observable change.

The importance of upland features on the landscape to wildlife.

The effects of naphthenic acid on fish stocks in the Athabasca River.

Cumulative effects of current land management on the population of wildlife and birds, with a special emphasis on migratory birds.

How various environmental inputs (natural and industrial) influence the functional response and numerical response within dominant boreal food chains.

**Climate change**

The impact of climate change on long-term reclamation objectives and planning.

Impact of climate change on biodiversity.

Climate change effects on the regional water balance. How does this affect current frequency analysis using long term data.

Are the currently developing ecosystems (whatever these may be, see above) resilient in the face of climate change? Have we built soil, vegetation, and hydrologic systems that will support ecosystem development given the likely climate change impacts on the landscape?

Development of best management practices under risk of climate change.

**Cumulative effects / impacts / sustainability**

Cumulative impact from oil sands in situ projects.

Identify cumulative environmental effects of oil and gas development.

What are the cumulative effects of activity on key environmental performance areas.

Has true cumulative impact planning and operations been implemented to ensure that development doesn't case death by a thousand cuts, for our ecosystems? Given the very wide range of industry-specific regulator approaches, that some industries are 'more important' than others (e.g. O&G vs. grazing), and given single-sector practice guidelines, what evidence is there that cumulative impacts are being mitigated/avoided, and are there sufficient incentives and disincentives to manage this thorny issue?

In my view the a significant effort should be directed to a regional study of all-encompassing cumulative effects of the development of oil sands, particularly looking at aquatic ecosystem and effects of the removal of multitude of small tributaries for the development of oil sands mines. Part of this consideration should be the effect of the changes on the hydrology and the biology of fish populations.

Methods to determine appropriate balance of social, economic and environmental issues.

Cumulative effects and regional management/mitigation of effects.

How do we distribute cumulative effects responsibility when attribution of impacts is difficult.

Opportunities for landscape scale compensation mechanisms to cumulative effects.

Impact of industry on biodiversity and air/water quality with the methods of research (and data and results) open to the public.

Impact of in-situ oil sands extraction on ecosystem development and diversity.

Characterization of natural bitumen release to surface land and water environment.

Cumulative impacts of linear features on boreal wetlands: hydrology, vegetation, GHG, and habitat.

Effects of continued in-situ oil sands development (SAGD, CSS) on ecology and habitat.

A retrospective analysis of SAGD environmental issues and linkage to techniques being used (formations, depths, pressures, drilling modes, "overburden" characteristics, landforms etc.

What is the assimilative capacity of the Athabasca River?

Behavior and environmental effects of various oil sands pipeline products (e.g., SCO, dilbit, diluent) within environmental components under spill conditions under different weather/climate conditions.

Determine possibility sustainable alternatives.

***Economics / cost-benefit / liability management***

Develop full-cost accounting of environmental costs and benefits of remediation strategies.

Cost-benefit analyses of fine tailings management. Directive 074 requires abandonment of 35-years of tailings research (deep disposal in end pit lakes), forcing operators into a land-farming approach. One cannot avoid the water cycle, and land farming results in effluents that must be managed, no different than managing the amelioration of end pit lake water quality over time. The fiscal cost-benefit should be integrated with environmental cost-benefit analyses that consider the additional land required for surface management of fine tails, water requirements to fill completely empty mine pits (since fluid fine tailings can't be stored in them).

Determine the cost-benefit relationships of alternative rate of development scenarios for the oil sands over time periods of several decades.

SAGD industry should work to replace the Alberta Energy Regulator's Licensee Liability Ratio and Orphan Fund with a permanent liability management solution. If there is a desire to improve the reputation of the oil sands industry I suggest that SAGD producers be seen to be prompting improved liability management that protects the tax payers from the liability not only of in-situ – but of the O&G sector as a whole.

In regard to water capping of oil sand mine tailings or the permanent storage of tailings in end pit lakes: (A) Quantify the liability to the Crown in accepting that end point: specifically the costs for perpetual on-going care, custody, maintenance and monitoring when the operator goes defunct AND (B) report the associated cost of that responsibility as liability to the Crown in the GOA's annual financial statements.

**Government policy / processes**

Development of release standards for oil sands process-affected water.

Evaluate the options for release of water from oil sands mining leases – what are the targets for water quality and how can they be reached? Contaminants such as salt, PAHs, metals would be evaluated with respect to concentrations, loading, toxicity and fate in receiving waters. Industry needs to be thinking about treatment options and what effluent quality would look like. More work on public policy research, especially policy design.

Release water from the post reclamation landscape will need to be connected with existing watercourses. The development of suitable criteria will provide the guidance for companies to implement the treatment systems needed to meet these criteria for release waters.

Characterize naphthenic acids sufficiently to allow rational development of water quality discharge criteria.

Naphthenic acid reduction strategies to enable environmental discharge of tailings water.

How to treat process-affected water effectively so it can be released to the environment.

Heavy metal assessment and innovative methods of removal to enable environmental discharge of tailings water.

Development of better criteria for Upstream Oil and Gas – Forested Criteria.

Development of reclamation criteria for certification.

Development of reclamation criteria for oil sands mining.

Develop a tool to allow for evaluation of the trade-offs amongst the Criteria and Indicators proposed by CEMA – currently they are proposed as individual assessments with their own pass/fail value; we need to know how to aggregate these assessments and when to let one Criteria/Indicator result override another.

A formal definition of "equivalent capability". As the early mine projects reach the point of initiation of reclamation over significant land areas, knowing with certainty what is meant by this vague, undefined but legally-entrenched term will be critical in reclamation planning, stakeholder confidence in reclamation programs, and ultimately, regulatory acceptance of a reclamation outcome. This would require establishment of criteria, at a level of detail and authority that has not been achieved to date.

Take a reclaimed area and attempt to certify it – alongside a policy research project to look at what the barriers are and how they could be overcome.

An assessment of the value of the current regulatory approval requirement for reclamation material depth placement to verify that the regulatory "precautionary approach" is providing the people of Alberta with the postulated benefit. A cost benefit analysis needs to be implemented to demonstrate the true value and cost of this approach.

Development of EIA review capacity INTERNAL to the regulator to avoid the inconsistency of 3PC reviews that we are experiencing right now. If standards are going to evolve over time it is imperative that the feedback to consultants and industry is consistent. That is not the case with 3PC reviewers.

Provenance trials with native boreal plants to determine appropriate transfer guidelines (and relate to climate change).

Development of policy criteria for establishing conservation offsets.

Focus on how to overcome political/institutional obstacles to preventing development in or adjacent to certain areas of natural importance (e.g., home range of the Ronald Lake Bison Herd, Richardson Dunes).

Update the Mining End Land Use Committee report to reflect current values, and the process that would be required for an operator to propose an alternate land use and for the AER to review and adjudicate the request.

***Human health***

Human Health Study.

Human health impact assessments of downstream and down gradient effects of oil sands development.

Factors that affect human health in communities in the oil sands that include social factors like diet, lifestyle, substance abuse, etc. This is a key piece missing from the discussions about human health.

Long-term fatigue health effects of working Fort McMurray shift work.

Dose-receptor modelling analysis of potential human health pathways from oil sands and epidemiological health study of upstream human communities.

Contaminant exposure pathways to human receptors characterized by direct measurements rather than reliance on modeling predictions.

Toxicology research on humans and wildlife species.

**Knowledge management / transfer**

With many very senior researchers and engineers retiring over the next few years there is a risk that much of the existing research will be lost, as often these people recall previous research. A knowledge database is required, which catalogues all the existing relevant research into its relevant.

Enhance industry institutional memory – evaluate methods to improve study results and data management and reporting to improve the industry institutional memory.

How to effectively apply lessons learned from previous reclamation projects to novel reclamation projects, e.g., reclamation of dry/wet tailings deposits.

Coordinate, house and use all of the baseline data collected in the EIAs and PDA/C&Rs (& any other), so that it can be referred to and used for regional planning, constraints mapping and reclamation purposes.

An integrated, managed database of environmental data and information pertaining to regulatory approvals. Submission, QA/QC, management and export for use the incredible amount of data being generated in the region in support of applications for approvals and approval, compliance-based monitoring programs. The RSDS outlined an approach, and several others have promoted similar ideas, but this is chronically under-resourced and consequently fails.

A feasibility study on the potential success of an oil sands focused research institute, built and operated in the region. Almost all research programs are currently led from afar. Most research initiatives are thought out elsewhere, brought into the region for execution, and then written up from elsewhere. This does not promote residency of the knowledge in the region, at great loss of value.

***Land / land use / footprint / landscape – regional scale***

Land use analysis for future reclamation and adaptive re-use.

In-situ footprint assessment and inventory: Understanding the exact ecological and economic footprints by in-situ O&G exploration.

Development of common functional criteria (as opposed to area-based criteria) assessment of land condition or 'footprint'.

An understanding of landscape-scale connectivity.

When is a disturbance no longer a disturbance due to reclamation or natural recovery.

Investigate how landscape-scale reclamation approaches (including regional scale reclamation planning, road and feature decommissioning, and seismic line recovery) affect wildlife recolonisation of disturbed areas, and recovery of rapidly declining species at risk - notably, woodland caribou.

Project Level Closure Plan modelling incorporating cumulative effects of multiple operations on the landscape.

Development of a comprehensive regional reclamation and restoration plans.

Alternative approaches in handling mine overburden materials to reduce mining foot-print, transportation cost and speed up land reclamation.

Faster forests – large-scale, economic deployment of planting to reduce seismic footprint.

**Monitoring / reporting**

Using remote sensing to replace Alberta Energy Regulator reporting requirements.

Develop remote sensing tools for tracking reclamation progress and effectiveness.

Use of remote sensing to provide high-level health assessment of oil sands. This remote sensing could track visual disturbances (and bbl/d intensity of disturbance area), GRACE data on water table levels, and be applied to other use cases that be identified in the future.

An online, centralized, publicly available, searchable repository for environmental data (raw data, and summaries) and reports (metadata, publications, technical reports, EIAs, etc).

Publicly accessible disturbance mapping, including age of disturbance, type of disturbance, and "ownership" of disturbance at a regional scale.

Improved/automated methods for oil sands measurement and monitoring.

The utility of using poplar suckers as biomonitors.

Real time monitoring, how to do it.

***Reclamation***

Reclamation.

Reclamation methods of disturbed land.

When is a reclaimed site actually reclaimed ... from regulatory approval to functional ecosystems – we need to better understand when a reclaimed system is meeting its targeted end land use goals.

Examine the opportunities for material sharing (direct place LFH primary, woody debris also) by developing a spatial 'gaming' system which would run on the data inputs from the approved closure plans, with varying assumptions about how far material could be transferred.

Comprehensive reclamation prescriptions for re-creation of ecological systems that closely resemble undisturbed systems in the oil sands region. At present, the focus is on canopy structure and harvestable forests. A holistic approach that considers ground cover, the vertical layering of the forest, in addition to canopy trees is critical.

Operational scale trial for combustion of wood residuals (mill waste, harvest debris) and wood from biomass plantations for in-situ steam generation.

Capping performance in terms of upland vegetation development and land-use objectives.

The long-term successional trajectories of reclaimed oil sands.

Longer-term forest ecosystem development on reclaimed oil sands mines.

Game the creation of different ecosites, based on basic soil profiles from native sites (fairly pure deep sands = A, some B, clayey or fine textured substrates = D, D ecosites with clean seepage = E, F etc.) and compare this to soil availability and contrast with current soil handling practise, why are ecosites deemed to be 'hit and miss' and semi random outcomes?

Coversoil placement has defined benefits that have been noted as advantages to the establishment of ecosystems. The reclamation completed at a number of the oil sands operations should be available to document and demonstrate the success of the methods. Tabulation of this information into a public available report for researchers and the communities would be very beneficial.

Consolidation of tailings materials for reclamation.

Tailings reclamation to a dry landscape.

Oil sands tailings reclamation strategies.

Continued focus on "Reclamation Ready Tailings" – enough Directive 074. Take a more research look at what tailings need to look like to support different types of reclamation.

Effect of process affected water on long term reclamation and revegetation of oil sands mines.

Effect of process affected water on reclamation success, including vegetation growth.

Regulatory approvals require a one metre cover of tailings sand or suitable overburden prior to the placement of the coversoil. This is a challenging requirement which supports initiating tailings related CT/NST materials reclamation technique development and testing.

Long-term (e.g. >20 years) continued monitoring of "reclaimed" sites, assessing them in terms of how they differ from "reference" conditions (non-impacted areas), and how they differ from reference sites in terms of their Invite a suite of experts from numerous disciplines to tour reclaimed sites and record their observations - what they are looking for, what they like, what they think is missing, and their overall impression of "success".

Ability to provided ecosystem services and ecological function.

Deep rooting is common in biomes world wide, including the boreal. Examine, via literature search and by selection of some of the oldest reclamation areas in the mining area, the role of these deep roots and what impacts result from differing clean soil depths on forest productivity, in the long run (greater than 50 years, therefore literature search and inference on observed trends in younger reclamation, if any).

Development of robust modeling tools to provide information on the likely/possible future ecosystems that are being current 'set-up'. We know very little about the possible future ecosystems given the current reclamation, soil and vegetation performance and as such have a very poor understanding of how these ecosystems will both continue to develop and what services they might provide. The synthetic nature of both the landscapes and the soils (particularly within the mineable oil sands area), is uniquely novel, how vegetation and biota will develop (even a best guess) is poorly appreciated.

Long term effectiveness of current reclamation practices (soil productivity and capability, vegetation).

Effects of elevated soil pH on vegetation establishment considering understory species. The trees generally do well, what about the understory species? The pH issue has been addressed but lab findings don't support what is observed in the field.

How to actively establish desirable plant species in a reclaimed landscape beyond the "business as usual" approach, which is to plant the same 5 to 10 trees and shrubs in every reclaimed landscape in the absence of a thorough understanding of vegetation species optimal growth requirements.

Long term effectiveness of current reclamation/remediation/revegetation practices for oil sands mines.

Impact of soil depth to long-term survival, growth, yield of vegetation, stand development, plant community development and ecosystem functions.

What is the status/quality of "topsoil" (LFH plus Ae) stored in stockpiles for 20 or more years? Early findings seem to indicate that much of the organic matter is decomposed and lost resulting in inferior soil structure that is erodible and a poor growing medium. Is there a better way to manage topsoil salvage and replacement? Practices employed on the prairies don't necessarily work as well in the boreal.

Fundamentals of reclamation (wet options like end pit lakes; and dry options like upland revegetation).

Reclamation at a watershed scale – integrating uplands and wetlands, considering salinity, other possible contaminants, water allocation (upland vegetation, groundwater, wetland hydrology and vegetation, etc., considering wet and dry climatic cycles). Successional vegetation should be an integral part of this work.

Full scale planning and execution of landform scale reclamation of challenging materials including sodic overburden or consolidated fine tailings that include a mixture of dry and wet ecosites as well as wetland and aquatic habitats.

Landform integration for reclaimed oil sands mines.

Looking to relic grasslands in northern Alberta for analogs for reclamation of harsh environments.

Research on the carbon balance of different reclaimed site types and vegetation communities.

Investigate ecosystem functions of different reclaimed systems in relation to natural systems.

Prioritizing legacy areas for reclamation/restoration.

Continue/enhance research into the fate of salty substrates in subsoil positions (e.g., Clearwater, also dried tailings), what is the risk of diffusion in wet years and surface seepage in lower slope positions? Plenty of examples currently exist, sort by 2 or 3 textural categories. Empirical primarily.

Shrub propagation techniques to enhance reclamation biodiversity.

Propagation and establishment of native boreal plants over and above those already know.

Evaluation of the development of viable soil/vegetation systems in the different reclamation scenarios at oil sands mines.

***Social impacts / issues / values***

Decision on what government and society deems an acceptable loss and the spatial scale over which society is willing to accept that loss.

Probably not "research" but more important in many ways ... Develop and agree visions, goals and objectives for the future landscape, after the mines are decommissioned. This would be difficult work involving regulatory agencies, industry, stakeholders and First Nations. We can't "have it all" and we also can't keep pretending that currently-stated goals are realistic. When goals are agreed – then refocus research/policy on aligning mine plans with those goals in a practical sense.

Research into why Albertans are willing to accept destruction of environment for economic gain. Ecological economics.

***Tailings***

Tailings ponds 101 – not only emissions but how much leaks and why and how to fix the situation. Not only for FM but all mining operations in Canada should have 30 to 40 years to eliminate any liquid or sludge storage and should have to pay a toll for every cubic metre they store for now – environmental insurance *per se*.

Research to development new tailing technologies. Research to scale up promising technologies from the laboratory to commercial operations.

Oil sands tailings management.

Dry tailings.

Tailings ponds reclamation.

Reclamation for tailings ponds.

Methods to dewater and consolidate tailings.

What compounds are the main cause of toxicity in oil sands process waters?

Tailings reprocessing to remove additional hydrocarbons from tailings.

Geotechnical stability and properties of treated mine tailings.

We need more information on long term behaviour characteristics of new tailings technologies (centrifuge cake, composite tailings, MFT, etc.). Need directions on how to prepare the deposits for closure.

The oil sands mining legacy issue (tailings ponds) is front and centre of things that must be corrected. How do we handle the existing inventory of tailings ponds and how can they be eliminated in the future.

Focused industry group on polymer testing/development for tailings.

Water treatment technologies for organic reduction in oil sands process-affected water.

Field implementation of tailings research and reclamation of fine tailings deposits. Understanding of costs and assumptions involved.

Winter monitoring of pond bottom strength and fines capture within tailings ponds.

Tailings reclamation – need to develop a cost effective approach, and should also deal with potential groundwater contamination from tailings ponds.

Cycloning and other techniques to minimize volumes of water sent to tailings ponds.

Big data on tailings.

**Technology**

In the oil sands, current production methods mean that more energy is needed to produce a barrel of oil than conventional oil. Develop technology to reducing the energy for oil sands recovery.

Development of alternative sources of energy.

Road map the next generation of in-situ central processing unit technologies to develop a flow scheme which can run over 135 deg C under pressure.

Alternative bitumen extraction techniques that are environmentally friendly and reduce tailing problems.

Treatment and upgrading of recovered bitumen from tailings pipelines.

Bitumen recovery techniques from tailings ponds (surficial and submerged).

Recovering floating bitumen from tailings ponds sufficient to avoid the duck oiling disasters when ducks land on tailings ponds.

Treatment and upgrading of recovered submerged bitumen from tailings ponds.

Upgrade Alberta crude and investigate custody transfer issues in transporting raw and process crudes.

Partial upgrading technologies.

What more effective ways can we upgrade the bitumen locally to produce higher value products from our resources and reduce shipping.

Process technology research to avoid or sharply reduce production of liquid tailings.

Oil sands in-situ research especially environmentally friendly methods. Collaboration with US based top universities.

Zero water use in-situ development.

Innovative, low-impact construction technologies to mitigate ecological impacts.

Automation of methylene blue titrations.

More effective mining methods.

Alternative energy sources to reduce the need for petroleum based energy.

Energy efficiency advances to make in situ SAGD production greenhouse gas emissions substantially lower.

***Traditional knowledge / traditional land use***

Traditional Land Use studies focusing not on particular aboriginal groups but the general traditional land use on a regional scale.

Collection of detailed and thorough information on extent and nature of traditional land use in oil sands region, and expectations/desired regarding future use of these areas.

Identification of traditional land use objectives to inform integrated land use management plans.

How to use Traditional Ecological Knowledge, Traditional Knowledge and Traditional Land Use in decisions.

How do we integrate traditional western science with Traditional Ecological Knowledge.

Research on reclamation of oil sands disturbances to conditions that will facilitate the reestablishment of traditional use species, including forbs and shrubs.

**Wastes / waste management**

Sulfur and how to manage and dispose of properly. The Alberta guidelines are based on very weak reference material and most are for surface – not long term storage or disposal. Try and meet with the ASRC[5] – I am sure they could assist.

Wood chips and what kind work the best and why for drilling wastes – not just a FM problem.

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[5] Not sure if this is what was meant - http://www.albertasulphurresearch.ca/

***Water / groundwater / end pit lakes***

Groundwater pollution reduction.

Contaminant aqueous transport in reclaimed areas.

Assess and address where needed regional groundwater contamination from tailings ponds leachate. Better characterize all the contaminants of potential concern in tailings, clarifying environmental fate and transport, and better distinguish anthropogenic from natural sources and assess environmental and human health risk to receptors.

The effects of naphthenic acid on groundwater in the oil sands region.

Assess the impacts of tailings pond seepage on ground water.

Groundwater modelling and monitoring to determine extent and speed of movement out of and under tailings ponds.

Characterization of potential tailing ponds seepage to Athabasca River through groundwater pathways.

What is the fate and transport of those compounds (causing toxicity) in groundwater and surface water?

Contaminant mobilization in thermal in situ oil sands development.

Increase understanding of ground water contamination stemming from in situ extraction methods.

Interaction of SAGD chambers with water pressure in aquifers. This is relevant to active SAGD operations where water balance is in jeopardy and in the evaluation of future voidage replacement when many SAGD chambers are "turned off" at the same time.

SAGD industry should better assess and address as needed regional contaminant concerns such as: (1) better detection of and implementation of plans to address ‘breakthrough’ such as that which occurred at CNRL Primrose. i.e., assess and hopefully address the effect of pressurization and chemical modification of cap formations AND (2) better characterization and assessment of environmental fate, transport and risk of oxyanions such as arsenic, selenium, chromium etc. to groundwater and surface water due to liberation caused by SAGD production.

Develop publicly accessible database for water quality.

Understandable abstracts of all water research in the area of the oil sands. A good literature review across areas of contamination of water, leaking tailings ponds and access to studies that you don't have to pay for.

Impacts of daylighting groundwater on vegetation species, e.g. at bases of engineered/designed hummocks, from water quality and quantity perspectives.

Do in situ oil sands projects (ground water withdrawals, water disposal) affect surface water levels and surface water level quality?

Are current proposed end pit lakes in the oil sands sustainable for a given watershed?

Pit lakes validity and success.

Research on reclamation of end pit lakes to functional viable ecosystems.

Is revolatilization of chemicals in end pit lakes a long term management concern?

Demonstration scale "water capped tailings and pit lake" research that includes active treatment systems to ameliorate water quality faster than passive treatment systems as proposed in base mine lake scenarios.

Sustainable defined from a water balance, water quality, and fisheries aspects.

Landform and ground water development quality and quantity in mining.

How can we minimize impacts on landscape level water movement in highly fragmented landscapes (e.g., mitigating impacts of roads, pipelines, etc.).

Development of in-stream flow needs for rivers and creeks. If IFNs were established by a central authority all industry parties would be forced to follow that approach and it would not be up to consultants to try and convince operators to 'raise the bar', especially in the complex interdisciplinary world of groundwater - surface water interactions.

Surface and groundwater cycling parameterization to improve landscape based models for reclaimed tailings deposits. Restore hydrological regime.

The long-term effects of salinity on groundwater and surface water.

How do water quality and quantity change over a given watershed from "sources" through to future discharge points to natural environments from a given lease? Looking at this question would perhaps involve a mass balance approach for water chemistry, water volumes, etc. What will the water balance be on the future landscape? What will water quality be post-certification?

Test impact on Athabasca.

Groundwater mapping on a large scale.

Develop a Manual for Stream Reconstruction, with a detailed literature review, sample plans/diagrams and case studies (with photos) of successes and failures in mined lands.

Geomorphic landform analysis / feasibility and watershed planning.

Develop hydrological models for reclaimed landscapes.

Bioengineering incorporation into facility design and operations – with respect to surface water run-off and management.

Watershed scale hydrologic systems (minable oil sands area focused) – are these being developed appropriately given the normal practice of reclamation addressed only at the single operator/disposition level ... again a question focussed in the mineable oil sands area. Are the current inter-mine interactions, development and reclamation planning systems sufficiently integrated to allow good inter-mine integration? Can regulatory tools be used better, or need to be developed to ensure inter-mine development and reclamation create landscape level hydrologic functioning?

Development of landforms and watersheds.

**Wetlands / peatlands**

Can peatland ecosystems be restored?

Wetlands (particularly peatlands) reclamation.

Wetland/peatland reclamation.

Reclamation of peatlands.

Artificial development of wetland systems.

Advancing reclamation strategies for wetlands and disturbed land.

The establishment of a robust and self sustaining wetland complex is the next challenge.

Wetland/peatland impact avoidance / impact mitigation in in situ oil sands.

Possible beneficial effects of integrating more small to mid-size wetlands into reclaimed upland landscape. This should be able to alleviate moisture stress to upland vegetation and enhance biodiversity development after land reclamation.

Establishment of saline wetlands, i.e., how to create a saline marsh in a reclaimed saline landscape, in an effort to maximize species richness and biodiversity.

Does obstruction of surface water flow in fen/peatland ecosystems caused by in situ oil sands infrastructure influence carbon storage and carbon dioxide release from peatlands?

Development and evaluation of equipment for silvicultural treatment (scarification) of wooded bog and fen terrain during non-frozen conditions.

Building fens in the oil sands with minimal construction/infrastructure.

Restoration techniques of functional (e.g., self-sustaining) and equivalent peatland ecosystems. In this context I mean equivalent to mean having the same biogeochemical cycling, soil characteristics, and vegetation characteristics as pre-disturbed ecosystems.

Develop a series of targets and metrics for vegetation and abiotic factors (pH, conductivity, etc.) for peatland ecosystems in northern Alberta. Possibly pulling together a large database to assess baseline data.

Reclamation of pads built on fens and bogs (wetlands) in in-situ operations. When should pads be removed and wetlands re-established vs reclaiming pads to uplands.

Reclamation of in situ oil sand disturbances in peatlands to return them to conditions that will successfully support the growth of desired wetland vegetation and the return of peat accumulation.

Development of more detailed successional models for wooded bog and fen sites in the boreal.

Research and public awareness on the importance of peatlands with respect to biodiversity and surface water.

Define the different types of wetland and how we can predict these in the future closure landscape.

Impact of in-situ oil sands extraction on recovering peat land ecosystems.

Peat forming wetland systems.

***Other***

The relationships between various environmental inputs (natural and industrial), water quality (surface, subsurface, and surface-subsurface interactions), and bioaccumulation in plants, wildlife and humans.

Impact of salts from oil sands mining processes to vegetation, soil, groundwater, surface water and practical salt avoidance techniques for land reclamation.

Comparisons of the toxic components of oil sands bitumen versus that of conventional oil.

Environmental fate and transport management and awareness of chronic spills and leaks, and understanding the environmental fate of ALL chemicals used on the facilities – no exceptions. No use of "proprietary" chemicals.

I think most of the research has been done. I think it is time to apply that research and monitor the results as part of a full adaptive management program.

What are the real drivers for US foundations funding anti-oil sands campaigns (including oil sands projects, and pipelines) and how does industry take corrective action?

Research into battle of the biologists or water experts.  Who is credible and can be believed.

Inter-discipline prioritization: prioritization of various disciplines, given the occ.  of prioritization across.

Public user friendly, plain language database of commitments list from the each of the proponents/developers, and a scorecard on how they are performing against those commitments.

Development of evaluation criteria, predictive models, and an inventory of sites exhibiting arrested succession (successional stagnation) in NE Alberta.

A comparison of effectiveness of all of the monitoring agencies that have flared up and subsided or been replaced by the latest and greatest (CEMA, OSRIN, COSIA ... next?).

I'm sure CAPP should have some more ideas but for me its more tangible things like above but all issues need to be addressed whether popular or not – everyone seems to care about Bambi but doesn't understand how all the issues relate.  Maybe emissions of the gas industry including pipelines versus oil should be monitored rather than calculated.

Effects of the structural collapse of cap rock and regional aquitards above salt dissolution areas.

Have the oil sands industry conduct and pay for all oil sands tailings research (dewatering, detoxification and reclamation to a sustainable, useable end point) except that which should be conducted by GOA to verify industry's work.

## APPENDIX 3: Priority Information / Data Needs

Survey respondents were given the opportunity to provide up to five (5) priority information / data needs they would like to see filled. The following list has been sorted into common theme areas. There is overlap with the research needs identified in Appendix 2.

### General / Comments

I don't see the difference between research needs (to generate needed data and information) and data needs (which by default are embedded in the defined research needs).

Research must be peer reviewed by external experts to ensure high quality work.

All research and monitoring data should be freely available to the public – raw data, summarized data, metadata, methods, and reports.

Information and data must be collected by arms length organizations with no financial or political conflicts of interest.

More user-friendly access to data; OSIP website is impenetrable and AER is even worse. I had to phone AER librarian to obtain data that they archive, and even she had to call someone else who knew how the ERCB information was migrated to AER to get the data for me.

More in-depth information for the public. Most of the FAQ sites on oil sands are at Grade 8 level. It would be nice for the public if there was more detailed information and statistics available about oil sands development at a level between Gr. 8 and technology specialist – something that the Press could also use as a source of valid, updated information.

A benefit/cost analysis of research and monitoring combined with risk analysis would be very beneficial. There should be a solid business case for research/monitoring/adaptive management so that companies, the public, universities and government have a greater quantifiable appreciation for efforts in the "environmental" arena.

Which US foundations have contributed to the anti-oil sands campaign and how much have they contributed? Who are their recipients of these funds and how much is provided by whom? Which lobbyist are these US foundations funding? There needs to be a full and complete transparency on these transactions, and a strategy and tactical plan developed and implemented.

### Data / Information Management

Development of a data portal that includes industry and public monitoring data. Historical data would also be included. Allow proponents to conduct their own research and analysis with the comprehensive data set. Increased regional monitoring would feed into the portal and the resolution would be such that enforcement actions due to impacts could be attributed to a specific land user. 100% transparent and mandatory participation into the database.

A data warehouse where information can be used by anyone that wants to.

A standard data base which all companies contribute to/participate in – for terrain, soils, vegetation, water, etc., including natural and reclaimed landscapes.

Integration/sharing/data repository of baseline/monitoring data.

Open source database of empirical, modelled and mapped data in oil sands region.

A publicly accessible portal to access and view monitoring data collected by regulators.

Shared data bases of environmental attributes – sub-regional and local (i.e., mineable oil sands area, in-situ oil area etc.).

Public portal to demonstrate that areas disturbed have been/are being/ are planned to be reclaimed ... What has been reclaimed to what standard, when will the current disturbance be reclaimed, where are all these disturbances?

Standard site-specific monitoring information submitted and publicly reported on the state of reclamation.

Regional GIS information.

Common GIS reporting for all oil and gas sector development ... e.g., as built footprints.

GIS platform of ALL monitoring done by operators.

Independent planning and collection of LiDAR/remote sensing survey of oil sands area – and then GIS-based mapping of current status for each relative to mine plans.

Publicly accessible electronic geospatial database for accessing and submitting environmental impact assessment data, this would also include data from pre-site assessments and detailed site assessments.

Spatially and temporally explicit information water inputs and outputs.

Publicly accessible data base on surface water quality, quantity and disposition (spatially referenced – i.e., all wetlands/lakes/streams/rivers pre and post disturbance) to track efficacy of landscape reconstruction in re-establishing key processes quality/quantity/flux/disposition. Data collected and uploaded annually, rolled up and reported every three years on a single oil sands website like OSRIN's.

A Water Registry with a listing of all oil company water licenses and then how much they are using and who is monitoring this.

Publicly accessible data base on groundwater quality, quantity and disposition (spatially referenced, i.e., all wetlands/lakes/streams/rivers pre and post disturbance). Data collected and uploaded annually, rolled up and reported every three years on a single oil sands website like OSRIN's.

Publicly accessible data base on soil resource quality, quantity and disposition (spatially referenced – pre and post disturbance/reclamation). Data collected and uploaded annually, rolled up and reported every three years on a single oil sands website like OSRIN's.

Publicly accessible data base on plant community trajectory (spatially referenced – pre and post disturbance/reclamation) from permanent sample plots in the region. Data collected and uploaded annually, rolled up and reported every three years on a single oil sands website like OSRIN's.

Look at the environmental quality on-lease of air, water, soil and sediment in a given landform, in a watershed concept. Collect a good dataset that can be used for multiple purposes (e.g., developing conceptual model for contaminants, mass balance from source to eventual fate).

OV/OSE program boundary data.

Remote sensing data and interpretation tools to support monitoring disturbance and reclamation status in the boreal forest.

Information storage and management.

Data evaluation and project trends.

Provide timely access to digital copies of the Closure and Reclamation plans submitted by mine operators.

Catalogue of monitoring/research underway and how to access data.

**Economics**

Oil sands profitability factoring in environmental costs.

What would be the economic costs, and technical impediments, of closing down portions of mine pits and backfilling? This is about the only thing which could speed the rate of reclamation and provide some landscapes with gentler slopes than typical dumps.

Under scenarios of abrupt company failures prior to planned closure, what is the impact on unfunded reclamation of the current liability model? Varying scenarios of youngish and maturing mines.

**Guidance / How To**

Efficient, robust models for long term monitoring and data collection.

Uniform analytical methods for all reporting requirements for the Alberta Energy Regulator.

Closure planning tools – in the absence of LCCS, how do we measure equivalent capability and assign targets?

A narrower list of land uses and how to achieve them.

Landform design guide that is data rich.

Expectations for certification criteria.

Reclamation BMP's focused on techniques.

Plan's to reclaim hydrological regime to a self sustaining landform.

How to build wildlife habitat.

What constitutes as a critical habitat for Species At Risk and other wildlife species.

Propagation needs for a wide variety of native boreal plant species.

Wetland restoration; operational level proof of concept.

**Health**

The government needs to collect more data on community health including social factors/influences to determine the role of these influences on health. This piece needs to be added to information being collected on the role of oil sands pollutants and health.

Personal contaminant exposure levels for "downstream" residents.

Impact of oil sands and in-situ mining on human health. The ecological community should provide its perspective, not just the medical profession.

Human health and environmental risk of mine tailings leachate.

What is the impact of mining on the health of the populations affected both indigenous and workers in the oil sands industry?

Toxicity challenges and ecological effects of release/treated OSPW human health effects of low level organic materials ecological markers of integrity/reclamation.

**Impacts / Effects**

There is a substantial need for improved study and reporting of uncertainties and limitations of current oil sands air emission impacts to the atmosphere.

Effects of low levels of airborne particulates on vegetation, wildlife, birds and fish in long term exposure.

There is a substantial need for improved study and reporting of uncertainties and limitations of surface water impacts from oil sands development activities and releases.

What are the impacts of oil sands development on water quality and wildlife health in areas further downstream? (e.g., Peace-Athabasca Delta). Need formal collection of traditional knowledge, and information on water quality and wildlife health – Should focus on wildlife that are consumed (e.g., pickerel, moose, ducks).

There is a substantial need for improved study and reporting of uncertainties and limitations of groundwater impacts from oil sands development activities and releases.

Effects on ground water.

There is a substantial need for improved study and reporting of uncertainties and limitations of impacts to fish and vegetation from oil sands development activities and releases.

What levels of naphthenic acid can have an effect on the biota in the Athabasca.

What is the impact of mining on the local biodiversity?

Reclaimed soil chemistry vegetation growth/productivity for vegetation on reclaimed oil sands mine sites.

There is a substantial need for improved study and reporting of uncertainties and limitations of impacts to humans from oil sands development activities and releases.

We need to understand how reclamation can be effectively achieved to reduce the extent of existing footprint by at least 50%.

To what extent well and facility location for in-situ is constrained by efficiency of extraction, context is wetland avoidance and therefore reduced borrow and padding in wetlands is possible but to what degree is it a function of geology?

Information, approaches and models that other agencies have used to balance effects of industrial activity on a community.

Central inventory of cumulative effects scenarios. e.g., for hydrogeology assessments and planning it is imperative that neighboring projects are considered because changes in pressure due to pumping are a regional effect. The current practice is for consultants to guess at strategies at neighboring projects or to connect the dots in public applications from other operators. The result is an inconsistent accounting of cumulative effects between projects and impaired decision making.

**Inventory / Baseline / Footprint / Mapping**

Baseline data inventory.

Water and air quality baseline monitoring data.

Baseline air quality information.

Updated, finer resolution footprint inventory.

Inventory of linear features and associated infrastructures.

Detailed winter exploration footprints.

Detailed land cover / land use footprint.

We need to understand how impacts can be markedly reduced (through infrastructure sharing, aerial seismic surveying) can be achieved to reduce the rate of new footprint by 75%.

Mapped quantification of anthropogenic disturbances in oil sands region.

Disturbance mapping that shows details about the spatial location, temporal component, and specific attributes about each disturbance. For example, is when was a specific 3D seismic line last used for reservoir monitoring and where is it relative to meaningful soil and vegetation conditions.

Updated finer resolution habitat.

Information on animal corridors is the oil sands region.

Produce and maintain a publicly accessible list of all fauna found on reclaimed mine lands.

Provincial wildlife sighting tracking system.

Population estimates of bears in the oil sands region, and estimates of their food sources i.e., how much of their diet consists of caribou, deer, moose.

Need spatial inventories of rare or difficult-to-detect species (e.g., Yellow Rail) and poorly-studied taxa (e.g. terrestrial and aerial invertebrates, pollinators, plants, and songbirds). These must be HIGH QUALITY data, collected by highly trained and experienced experts.

Spatial information on wolf movements in the oil sands regions, how many packs, how many individuals are in the packs, and where are they located.

Accurate and timely population estimates of caribou populations, preferably using DNA from pellets, not aerial surveys.

Status of fish populations downstream from the oil sands area.

Baseline biodiversity data from microscopic to macroscopic for comparative purposes in future monitoring efforts.

Water (surface and ground).

Water consumption.

Inventory of eliminated watercourses and existing water diversions.

Water chemistry for in situ oil project areas.

Make available the water chemistry of the sand-bearing units below and surrounding operating SAGD facilities. Both baseline (pre-operation phase) and existing chemical signatures should be made available. All known and potential bitumen diluents should be tested for and reported. This is the starting point to deal with any potential treatment of contaminated groundwater.

Listing of publicly accessible registry of water analysis and contamination of the Athabasca River and surrounding area.

Instream flow needs and other aquatic info for the in-situ area.

Regional groundwater quality in a spatial context around both oil sands mines and SAGD sites.

Regional data on groundwater surface water interaction.

Groundwater information.

An assemblage or inventory of soil survey maps that have been produced for northeastern Alberta.

Baseline information for surface water levels and quality in wetlands.

Wetlands and water connectivity mapping.

Comprehensive wetland data.

Baseline information of vegetation community composition in wetlands.

Vegetation mapping and development.

Produce and maintain a publicly accessible list of all flora found on reclaimed mine lands.

Reclamation rates vs. land disturbance rates.

Spatial inventory and functional characteristics of sites with arrested succession in NE Alberta.

Ecosite information – inventory or predictive.

**Knowledge Synthesis / Access**

State of the Environment Report.

Coordinate library of oil sand research and conferences: it's not that hard – pdf, title, searchable, 5 keywords, data type, author, organization/institution, customer, a few others. Keep it simple. $100k. Add GIS interface – start slow, and build it up.

Documents and cumulative released materials lists (sector wide).

Easy access to all academic reports and literature on oil sands work.

Research information in all key subject areas should be synthesized and provided to companies in a manner that can be more readily implemented.

Digitize the Northern River Basins Study series of reports and make them publicly accessible.

Digitize and make publicly accessible the CONRAD reports.

Using historical knowledge to inform current practices (i.e., lets not reinvent things we already know don't work).

Transferring reclamation and restoration knowledge from one generation to the next (i.e., ensuring flow of information as retirements dramatically change the look of the workforce).

With many very senior researchers and engineers retiring over the next few years there is a risk that much of the existing research will be lost, as often these people recall previous research. A knowledge database is required, which catalogues all the existing relevant research into its relevant categories such that it is easily searched.

Historical records of progressive reclamation, reflecting a range of site status in reclamation.

Synopsis of oil sands reclamation research and trials.

Application of lessons learned to new reclamation projects.

Level of reclamation efforts and effectiveness of particular approached to restoration and reclamation.

Reclamation performance of upstream oil and gas sites – are we getting what we anticipated or planned for?

Alberta-wide data on long-term success of the various reclamation standards/guidelines/ practices.  Where is the evidence that all industries that create a disturbance have conducted necessary steps to lead to an appropriately reclaimed site?

Information on the establishment of effective reclamation soil/vegetation/groundwater systems in oil sands mine reclamation areas.

Information on recovery rates and trajectories of reclaimed oil sands.

Long-term data on soil pH vs vegetation performance and succession of plant communities.

Long-term data on soil depth vs vegetation performance and succession of plant communities.

Detailed growth rate and vegetation establishment rates of various vegetation species in a reclaimed tailings deposit landscape.

Information on stand dynamic characteristics of reclaimed areas, including productivity, root morphology, plant diversity, soil characteristics including pH and salinity, soil microorganism diversity and abundance.

Information on 'natural' recovery of legacy footprint.

Reclamation research.

More detailed data on recovery trajectories of reclaimed areas – mining and in-situ.

Landscape development and how landscapes features are connected.

Native plants – how to grow them, propagation, germination requirements, etc.

Sources of vegetation propagules in the oil sands regions.

Wetland compensation opportunities within the NE boreal.

ESRD needs to get more wildlife population data so that there can be reasonable predictions made.

How have bird populations changed historically in the oil sands region?  Have migration routes shifted from where they were in the past?(Need traditional knowledge of migration routes/hunting locations, and development of MAPS banding stations for migratory birds).

Wildlife mapping and trends over the last 50 years. GIS data.

Priority zones and minimum functional patch size for caribou habitat restoration.

Social research synthesis of the priority traditional use species that can be used in reclamation for different target site types.

Knowledge of surface and subsurface flow on reclaimed systems.

Results of the various tailings management techniques in terms of achievement of targets, annual dates when they work, issues and results to date.

Operational methods for tailings capping and reclamation. Costs are also required. How to plan for settlement and consolidation of tailings deposits.

Develop a clear understanding of the origin of organics in river whether anthropogenic or coming from exposed deposits, monitored following heavy rains, etc.

Liberation of oxyanions like arsenic from SAGD production.

Salinity management.

**Modeling**

Actual field data to parameterize models.

Dispersion models for downstream movements of effluents.

Region-specific climate modelling data (not weather data) for incorporation into, for example, hydrologic models.

Dispersion models for down wind movements of emissions.

End pit lakes – modelling of water quality and application of mitigation measures to bring water quality to the CCME levels.

**Monitoring**

Real time monitoring of reclaimed areas, with data on the internet annually.

Reclamation status of disturbance footprints over time (i.e., what has been done, and what is the current status).

Need repeated re-sampling of "reclaimed" sites, and comparison to reference (non-impacted) sites.

Long-term monitoring data on mycorrhizal communities and functions in reclaimed lands vs. natural sites.

Regional monitoring data.

Real time data available publically.

Emissions.

Air quality measurements in oil sands operations (historical and ongoing).

Field based GHG emission based on different types of linear disturbances.

Regional air, water pathway based chemical analysis and multi-year/multi-media deposition analysis.

Selection of sample plots for air and water pathway exposure monitoring.

Airborne mass contaminant emission rates from tailings ponds.

Groundwater mass contaminant emission rates from tailings ponds.

Greenhouse gas emissions.

Groundwater chemistry surrounding tailings ponds.

Groundwater quality around oil sands operations (historical and ongoing).

Water chemistry for reclaimed oil sands mine sites.

Source characterization of different anthropogenic and natural sources of organics and salinity in the region.

**Rules / Processes**

Streamlining of regulations: many differences between older and newer projects, mines vs. in-situ, etc.

Research, monitoring, restoration and compensation policy updates.

Common standards for some specific data collection (such as soil replacement measurements) so performance of sites can be compared against similar sites later in time.

Standardized guideline systems – if something is required in an EPEA approval, the government should have guidelines in place for how to meet that requirement (e.g., reclamation monitoring, wetland trial reclamation, wetland monitoring, etc.)

Definition of standards/criteria for caribou habitat restoration.

**Social / Aboriginal**

A study of the beliefs of those who work for oil and gas companies. I have a friend senior in industry who was told that water in the Athabasca River was so polluted naturally with bitumen that additional pollution didn't matter because "you can't use the water anyway." And that company's tailings ponds 'never" leak.

How have First Nations used and accessed land in the oil sands region in the past? How do they wish to use and access the land in the future? How has oil sands development impacted this, and how is it expected to impact it in the future? Need interviews, particularly with elders and youth.

Population mapping / projection 20, 40, 60, 80 years into the future and carrying capacity of the region.

**Tailings / Bitumen / Wastes**

Tailings info.

Tailings research.

Tailings pond composition and properties.

Historical data on tailings pond water chemistry LINKED to process condition and ore type.

How big of a tailings deposit can be created at full scale production while controlling the segregation potential, fines capture and rapid strength development? Once this is determined, budgets should be adjusted to include the required increase in containment berm construction within large "mega-ponds".

Enhanced online analytical methods to assess the type of clays in ore bodies and tailings to enable rapid operator response to processes involved in bitumen extraction and tailings consolidation procedures.

Determine the operational process necessary to regulate the energy of deposition and associated densities and flow rates ON A CONTINUOUS BASIS to create laminar flow on a large scale, and minimize segregation of deposited tailings. (Monitoring, communication, reporting, and accountability processes).

Settlement rates, i.e. cm/year or a similar rate of change of time, of wet/dry tailings deposits.

Tracer material (radioactive isotopes, etc.) for COC from tailings storage areas.

Energy consumption of oil sands tailings operation.

Water contaminant levels of potential oil sands process origin as a function of time and distance from source.

Alternative bitumen extraction techniques.

Screening chemicals and dosages required to treat recovered bitumen from tailings ponds such that they can be upgraded.

Screening chemicals and dosages required to treat recovered bitumen from tailings pipelines such that they can be upgraded.

In-situ bitumen production produced water quality.

In-situ technology research.

**APPENDIX 4: Additional comments**

Survey should be redone periodically to check progress

I found it tough to answer these questions. Many seemed either too broad or too dichotomized (especially the last set). The survey was useful for revealing the breadth of issues that must be considered and probably few have a clear sense of how great that breadth is.

There should be an independent "Senior Institute" established in the province to focus on ecological/environmental issues and initiatives, including a long term perspective--to advise the public, government, industry, academia, etc. A "Fraser Institute" for the environment. Keep up the great work.

In my experience in the oil sands and elsewhere, many organizations seem to focus on 'information needs' without a clear purpose for said information. I want to see a vision, clear objective, and concrete plan before for research and information before it is prioritized.

In some areas we have an information or knowledge gap, in others, we have an information communication deficit, meaning that we need to get existing information collated and used. It was expensive to gather and has value but too often we spend money gathering information already gathered.

Focus on easy stuff rather than trying to find the silver bullet. Easy stuff is cataloguing what we have already.

OSRIN has sure played an important role, but is leaving the stage too soon. There are more acts to follow. I think the focus on research should be largely on developing technical people who can become important in industry, academia, government, and consulting (and NGOs). I think the focus should now switch to exquisite monitoring and true adaptive management.

The focus needs to be equally on environmental monitoring as well as cause and effect research. The two are complimentary and go hand in hand. The feds are screwing things up royally. Let’s decouple from any structured agreement.

Any research on oil sands tailings, reclamation, performance bonds, climate change, impact on oil sands profitability based on adding environmental costs will be all useful information

I would like to see research describing the impact of research. If we do research and it has no impact on the environment because of resistance to implementation, then what's the point. If the government continues to shut down its own scientists, then that's an issue.

What OSRIN is doing is one essential component of a needed larger management response. Not enough otherwise is being done. A comprehensive, fully funded, peer vetted and publically open research, monitoring and management program is still very much needed. Find any environmental problems and deal with them (not the reverse, which is more the case); this will reap enormous future dividends, including public understanding (clearly not there) and possibly even acceptance.

We are a small size company which expertise is mostly based in oil sands mining and tailings projects. We would like and we think we are capable to contribute to finding solutions for mitigation of environmental impact of oil sands mining operations. Our opinion is that the resources are in place to support research and innovation, more work is needed to make the resources effectively available to smaller organizations.

Traditional knowledge did not seem to be considered as a source of valuable information for environmental management. "Aboriginal/stakeholder engagement" as it is often done does not adequately cover this. Enabling first nations to participate meaningfully in management and data-collection is key to success of oil sands monitoring and management.

Oil sands development and the transportation and marketing of its products has come under increasing scrutiny via well organized and funded campaign. The issue appears to have shifted from a technical/ science debate into that of social media and 'social licence'.

It is rather important that appropriate research is done for Canada's international reputation. The Dirty Oil bandwagon has a lot of power and strength in the public's vision. Decent work needs to be done and communicated appropriately to the common folk to change some pretty bad perceptions.

If there is a desire to improve the environmental reputation of the oil sands industry, I suggest that the industry be seen to be accepting responsibility for their environmental obligations and acting to reclaim oil sands tailings to an end point where Albertan’s do not feel cheated, tax payers do not pay for the reclamation research and the GOA does not become liable for the long term or perpetual care of the site upon final reclamation. The oil and gas industry and CAPP in particular has spent millions in PR advertising that they are leaders in terms of Corporate Social Responsibility – well lets see it! That leadership in social responsibility. It is not apparent in the oil sand industry. Instead of the constant lobbying by industry to downgrade their environmental requirements, industry should demonstrate that they are responsible to meet and where possible exceed their obligations and actually demonstrate that they are doing so. Shell's recent claim in the media that they are unable to adequately reduce tailings volumes as required by ERCB now AER is a case in point. After Albertan's have reimbursed Shell for the capital costs of construction of their oil sands facility, for Shell to claim that it cannot afford to meet their tailings requirements is a slap in the face to all Albertans.

I think that there has been too much of a push to have industry fund work and then regulators turn around and criticize it as being biased. This maligns university researchers, consultants and industry. Government can't/won't fund all the work that needs to be done and that is its responsibility (wildlife surveys, etc.). Further, when industry does fund projects, sometimes they do not get near the value for what they put in. So when industry goes on their own, they get criticized. Something needs to be done about this situation. Industry is responsible to its stockholders to prove that their money is well spent. Let industry fund work, good work, defensible work, and get governments to start being more efficient with the work that they are in charge of.

OSRIN has done a great job of providing links to internal reports and other websites/resources of interest. I have used it frequently, as it is more accessible (although much more limited in scope) than the government websites.

Keep up the great work.

Thanks for your contributions over the past 4+ years

Thanks to Chris and OSRIN for the excellent efforts over the years OSRIN existed.

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