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Criteria and Indicators Framework for Oil Sands Mine Reclamation Certification

July 2013

CONTEXT FOR USING THE FRAMEWORK

The *Criteria and Indicators Framework for Oil Sands Mine Reclamation Certification* (the Framework) is one of a suite of tools that will be used to provide direction and guidance related to oil sands mine reclamation and closure planning, and certification.

The Framework is a preliminary step in defining the information requirements for oil sands mine reclamation certification. As it stands now the Framework is not complete and requires further development before implementation. The conditions of approvals issued to each oil sands mine operator under the *Environmental Protection and Enhancement Act* continue to provide direction for reclamation and closure planning, along with other guidance documents developed by the Cumulative Environmental Management Association and implemented by Alberta Environment and Sustainable Resource Development.

Many indicators require further development and evaluation. Further, field demonstration/assessment of the indicators currently included in the Framework remains to be performed. Development of the suite of indicators is expected to continue within the Cumulative Environmental Management Association's Reclamation Working Group, as informed by field demonstration and testing.

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and the RWG Technical Sub- and Task-Groups
for their time and contributions to this report.

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DISCLAIMER

This report was commissioned by the Reclamation Working Group (RWG) of the Cumulative Environmental Management Association (CEMA), in its task of developing a framework for the use of criteria and indicators to support reclamation certification decisions on oil sands mines in Alberta.

This report has been completed in accordance with the terms of reference issued by the RWG. The RWG has closed this project and considers this report final.

The RWG may not fully endorse all of the contents of this report. The report may not necessarily represent the views or opinions of CEMA or the RWG members. The conclusions and recommendations contained within this report are those of the Reviewers and the Authors and have neither been accepted nor rejected by the RWG. Until such time as the RWG issues correspondence confirming acceptance, rejection, or non-consensus regarding the conclusions and recommendations contained in this report, they should be regarded as information only.

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DEFINITIONS

Below are definitions for terms used in the criteria and indicator framework.

Criteria and indicator hierarchy:

Goal: The final result or outcome toward which effort is directed.

Objective: A purpose toward which a reclamation effort is directed.

Criteria: (plural) A category of conditions or processes by which the achievement of a reclamation objective is assessed. A *Criterion* (singular) is characterized by one or more related *indicators* which are used to determine success or to assess change over time.

Indicator: An attribute which can be measured or described and used to evaluate if a *criterion* has been met.

Measure: A qualitative or quantitative aspect of an *indicator*; a variable which can be measured (quantified) or described (qualitatively) and demonstrates either a trend in an *indicator* or whether or not a specific *threshold* was met.

Method: A description of a way, technique, process or procedure for attaining a *measure*.

Threshold: The quantitative point which triggers an action or effect.

Standard: A definite rule established by authority. Environmental standards often take the form of prescribed numerical values set through approvals, legislation, policy, directives or codes of practice.

Other definitions:

Equivalent Land Capability means that the ability of the land to support various land uses after conservation and reclamation is similar to the ability that existed prior to an activity being conducted on the land, but that the individual land uses will not necessarily be identical (The Environmental Protection and Enhancement Act, Conservation and Reclamation Regulation, Division 1 Section 2).

Mine: Any opening in, excavation in, or working of the surface or subsurface for the purpose of working, recovering, opening up, or proving coal, a coal bearing substance, oil sands or an oil sands bearing substance and includes any associated infrastructure.

Natural Ecosystem Functions: The interaction between organisms and the physical environment such as nutrient cycling, soil development, primary productivity, or water budgeting.

Polygon: A portion of a landform reclaimed to a specific end land use or ecosite design, such as a commercial forest stand or a specific wetland type.

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EXECUTIVE SUMMARY

Reclamation certification is required under the Environmental Protection and Enhancement Act (EPEA) as a process that determines reclamation to be complete and allows reclaimed public land used for oil sand mining to pass from the operator back to the province. This document presents a process and assessment criteria to support decisions related to the readiness of a site for reclamation certification. It provides a common and practical approach to be used regionally, across oil sands mines. The framework defines some of the conditions under which operators can determine the readiness of a site for reclamation certification application, and the regulator can assess the site for certification. It should be used in conjunction with other guidance documents involving oil sands reclamation.

The framework is structured on a Goal – Objective – Criterion – Indicator hierarchy, which was adopted by the Government of Alberta A Framework for Reclamation Certification Criteria and Indicators for Mineable Oil Sands (Poscente 2009). The overarching reclamation Goal was taken from the current EPEA operating approvals and refined. Three separate objectives and sixteen criteria were determined in a collaborative manner by members of the RWG, including operators, regulators and other stakeholders. Collectively objectives describe the desired outcomes that support and demonstrate achievement of the goal. The criteria describe conditions by which achievement of a reclamation objective is assessed. Indicators define an attribute that can be measured or described and are used to evaluate if a criterion has been achieved (by comparing the value of the variable measured for the indicator against the threshold set for the indicator). Technical sub- and task-groups developed indicators, which were subsequently approved by the RWG. Indicators included in the C&I framework were those that, other than technical merit, had proven science-based thresholds and measurement methods developed. Seventeen indicators were approved to be included in the C&I framework and an additional twenty three were deemed appropriate for the framework, but required further development. These are identified as gaps in the framework, to be developed on an on-going basis.

The framework also includes a process by which criteria and indicators would be applied. Application is designed within seven existing stages, each with a distinct purpose, process elements, and process flows. The stages include:

1. Mine Planning and Reclamation Criteria;
2. Reclamation Planning;
3. Reclamation Operations;
4. Monitoring and Research;
5. Decision Process;
6. Annual Reporting; and
7. Reclamation Certificate Application.

Of particular importance are the continuous improvement cycles that ensure advances in knowledge, technology, practices and processes. This includes updating the framework with new indicators periodically and clearly specifying how the changes apply to existing and future reclaimed sites.

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INTRODUCTION

Reclamation certification is a process required under the Environmental Protection and Enhancement Act (EPEA) and applies to specified land being used for the construction, operation or reclamation of a mine or the plant site (Conservation Reclamation Regulation S. 1(t)(v)(ix)). After reclamation is complete, an operator may apply for a reclamation certificate on all or a part of the specified land and, if granted, relieves the operator of further reclamation responsibility on the certified land. Applications for reclamation certificates will increase over time in accordance with Alberta's progressive reclamation strategies (Lower Athabasca Regional Plan 2012 – 2022 p. 26). Of the 4,800 km^2 of mineable oil sands area, approximately 1,367 km^2 is approved for mining under the EPEA (Table 1). Most of the land that has been disturbed is currently in use by oil sands operations. Over time as the land is no longer required for mining or plant site purposes, progressive reclamation can occur. The criteria and indicator framework development is timely to provide tools and support for reclamation certification as reclamation activities increase. Although the requirements for a reclamation certificate application are well defined (EPEA, s. 138), specific criteria for informing a decision for issuance of a reclamation certificate are not provided under the Act or Regulations.

Table 1: Status of EPEA Approved Oil Sands Mine Footprint as of December 2011 (Source Alberta Environment and Sustainable Resource Development)

Area (km^2)	Percent	Status
605.8	44.3	Not disturbed
683.8	50.0	Cleared or disturbed for mining operations
2.5	0.2	Ready for reclamation; no longer needed for mine or plant purposes
15.1	1.1	Soils are placed (terrestrial, wetlands and aquatic)
46.9	3.4	Permanently reclaimed (terrestrial, wetlands and aquatic)
12.4	0.9	Temporarily reclaimed (will be disturbed in future)
1,366.5	100.0	EPEA approved oil sands mining footprint (excludes land certified as reclaimed)
1.0	n/a	Certified (the operator has no further reclamation liability; land can be returned to the province)

The certification process is a major effort between the operator and the regulator involving preliminary meetings to discuss process and timelines, followed by an administrative review, technical review, and field inquiry. This process is time and cost consuming for all parties involved because operators have to make the case for the outcomes of their reclamation programs while being faced with great uncertainty as to what would be deemed acceptable. Operators may be uncertain about how an application may be evaluated by regulators. In turn, under current practice regulators may experience difficulty in applying reclamation criteria in a fair and consistent manner among operators. The criteria used to assess reclamation are presently established through multiple means: EPEA approval conditions, guideline documents referenced in the approvals, and individual reclamation plans. In some cases, the criteria and means for evaluation are not well defined (e.g., a requirement in approvals that constructed landforms are naturally appearing). In other cases, the criteria may be well defined with a measure and threshold, but no common measurement method exists. Therefore, even where it exists, reclamation criteria can result in inconsistent approaches among mines. There is a need to develop a clear and consistent approach that defines performance expectations related to reclamation.

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This report describes a criteria and indicator framework to support oil sands mine reclamation certification decisions. This framework includes:

1. Reclamation objectives, criteria, indicators, measures and methods based on current knowledge, best practices and technology.
2. A management system to guide the use of criteria and indicators, compatible within Alberta's regulatory environment, to support oil sands mine reclamation certification decisions.

The intent of the framework is to provide a common approach across all oil sands mines to:

- support tracking the progress of reclamation,
- implement adaptive management actions when required,
- support determination of compliance with approval conditions and
- assess over-all reclamation success to meet the regulatory requirement of equivalent land capability.

Using the Framework

The criteria and indicators framework for oil sands mine reclamation establishes a process and assessment criteria to support decisions related to the readiness of a site for reclamation certification. In many instances, there may be unique reclamation goals or objectives established for a mine. For example, through the First Nation consultation process, an operator may identify a need to provide a particular traditional use (for instance the Syncrude Bison paddock). Site specific end land uses can be submitted for approval by the operator to the government. The framework is not designed to accommodate reclamation requirements that are unique to a single mine. However, operators can use the approach detailed in this document to define indicators for site specific end land uses.

The criteria and indicators framework was designed to be compatible with the current Alberta regulatory system, which is built around a progressive and collaborative approach. The framework is not intended to be a "checklist," where if one or more indicators are not achieved, the reclamation has failed. The framework is designed to allow adaptive management and professional judgment in response to unplanned events during the period of time that reclamation occurs. In the oil sands region, it is common for the mine reclamation phase to exceed 25 years from the time reclamation commences until the site is ready for reclamation certification. During this period of time, environmental factors, new reclamation techniques, changing stakeholder values and updates to regulatory reclamation requirements will require the use of common sense and professional judgment in assessing reclamation success and making certification decisions.

Development of the criteria and indicator framework within the Cumulative Environmental Management Association (CEMA) supports a multi-stakeholder approach. This strengthens the likelihood for acceptance of the final product by regulators, operators and stakeholders. The criteria and indicator framework provides a comprehensive, consistent, transparent process to assess performance towards achievement of reclamation goal and objectives.

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BACKGROUND

In 2010 the Government of Alberta (GOA) approved a recommendation by CEMA to adopt a criteria and indicator approach for oil sands reclamation, defined in the CEMA report, *A Framework for Reclamation Certification Criteria and Indicators for Mineable Oil Sands (Poscente 2009)*.

The criteria and indicator framework is structured on a Goal – Objective – Criterion – Indicator hierarchy (Figure 1), with each indicator having a measure, measurement method and a threshold. The regulator may formally designate a threshold as a regulatory standard that must be met by all operators.

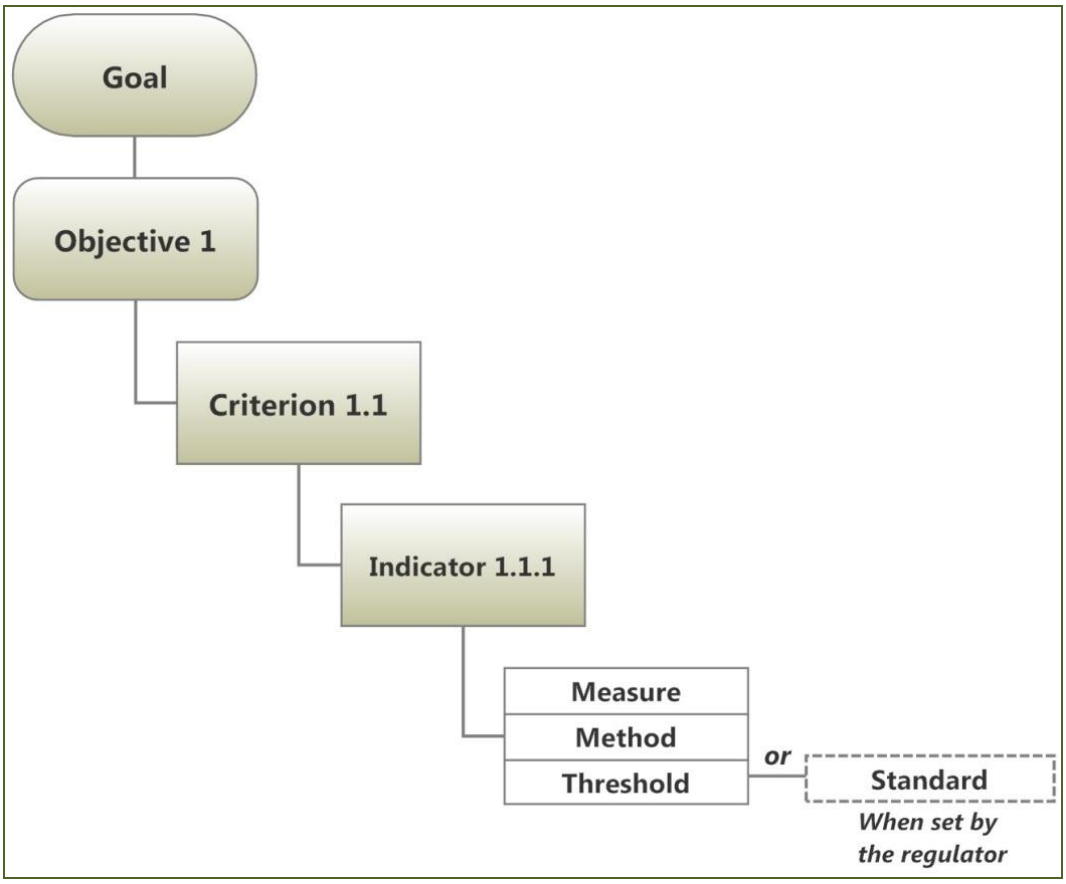

Figure 1: Criteria and Indicator Hierarchy

The regulatory standard is the only element of the framework prescribed by the regulator. When a standard is set for an indicator, it replaces the threshold.

There can be multiple objectives for a goal, multiple criteria for an objective and multiple indicators for a criterion (Figure 2).

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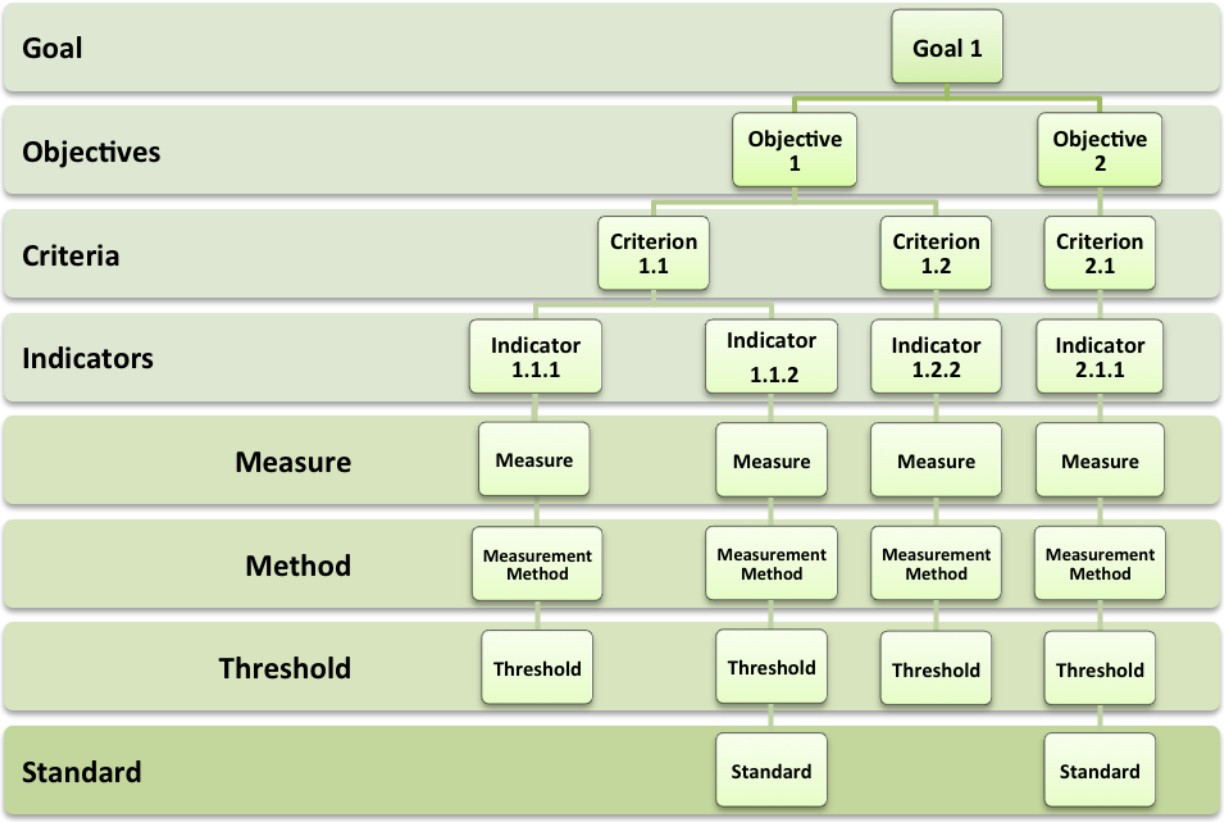

Figure 2: Criteria and Indicator Framework

Goal

The goal describes the final result or outcome of the reclamation effort. The government of Alberta prescribes a reclamation goal in the mine approval conditions.

The criteria and indicator framework defines the conditions to determine successful reclamation, meaning that a site is on track towards achieving the reclamation goal. Mine specific reclamation goals may be proposed and implemented by the operator through the Life of Mine Closure Plan and detailed Mine Reclamation Plan processes.

Objective

The objective describes the purpose towards which the reclamation effort is directed. There may be multiple objectives for a goal. Collectively objectives describe the desired outcomes that support and demonstrate achievement of the goal. Objective statements represent the mine footprint in scale (see Appendix 2, Fact Sheet 6).

The objectives were determined in a collaborative manner by members of the RWG, including operators, regulators and other stakeholders. In addition, the RWG sub-groups and task groups reviewed and provided input into the objectives.

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Criteria

The criteria describe the category of conditions or processes by which achievement of a reclamation objective is assessed. There may be multiple criteria for an objective. Criteria are representative of the mine footprint in scale.

Criteria were determined in a collaborative manner by members of the RWG, including operators, regulators and other stakeholders. In addition, the RWG sub-groups and task groups reviewed and provided input into the criteria.

Indicators

Indicators define an attribute that can be measured or described and are used to evaluate if a criterion has been achieved (by comparing the value of the variable measured for the indicator against the threshold set for the indicator). There may be multiple indicators for a criterion.

Indicators collectively form the foundation to document reclamation results. Monitoring enables the determination of a state, and/or change over time, to evaluate reclamation success and inform adaptive management responses. Methods to measure and record results, from which to determine trends, therefore need to encompass a range of spatial and temporal scales appropriate to the indicator.

Spatial and temporal considerations are important for understanding how indicators are intended to be used to document milestones, trends or performance of reclamation. Spatial use of indicators apply to the mine footprint, landform or polygon scales (e.g. absence of prohibited noxious weeds is applied throughout the mine lease and represents the mine footprint in scale, indicators of geotechnical stability such as maximum average slope apply at a landform scale, indicators for establishing a commercial forest stand apply at a polygon scale applicable only on areas designated in an approved reclamation plan as a commercial forest stand). Temporal use of indicators range from a measurement at a single point in time (e.g. measurement of maximum average cover soil depth is measured at the time of soil placement), or at multiple times (e.g. wetland hydroperiod may be measured at regular intervals over a decade).

Documentation of the results of indicator measurement during the reclamation phase of the mine life cycle supports development of a complete and comprehensive reclamation certificate application. Indicators support the measurement of milestones, trends and performance (Figure 3).

Milestone Measurement

Measurement of a milestone, a physical characteristic of reclamation work at a specific point in time in the mine life cycle, informs reclamation practitioners whether planned work has been accomplished and if a threshold or a prescribed standard was achieved. The result is documented. If the threshold or standard was met, the indicator does not have to be re-measured, unless there is a need to track changes over time (performance). Achieving reclamation milestones does not guarantee reclamation success; it documents progress at a point in time.

The EPEA includes a provision for establishing a record of progressive reclamation. For the purpose of the framework, record of progressive reclamation (RPR) milestones will be determined through the RPR process underway by the GOA. The framework is designed to accommodate a record of progressive reclamation process.

Three examples of RPR milestones are landform construction, cover soil placement, and vegetation establishment. Meeting milestones provides the reclamation practitioner with a degree of certainty to proceed

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with the next step in the reclamation process. For example, once the cover soil placement milestone is met, planting and seeding for vegetation establishment can commence.

Trend Measurement

Trend measurement corresponds to a repeated indicator measurement. Trends illustrate site changes over time, informing reclamation practitioners in their evaluation of progress toward a planned outcome. Trend results are often compared to a threshold to determine acceptance; thresholds are often established using a reference condition approach. For example, monitoring vegetation indicators for health, vigor and/or self-sustainability over a period of time without management intervention is compared to reference site conditions. Natural events such as drought have regional consequences to vegetation health and comparisons to reference sites will figure prominently to determine an adequate management response.

Performance Measurement

Indicators can be used to evaluate performance against the associated criterion. Measurement informs reclamation practitioners of the degree of performance for the indicator, measured against established thresholds, which may be based on a reference condition approach. Depending on its use, an indicator used to measure a performance metric can support a one-time measure of achieving a milestone (e.g. a commercial forest stand meeting height thresholds at the time of the performance survey) or if measured repeatedly over time, indicate a trend towards meeting a future state (e.g. water quality).

Use of Indicators

Figure 3 is an example of indicator use over the mine life cycle, for establishment of commercial forest stands. The requirements are generated from various sources:

- Approval conditions set the requirement to establish commercial forest stands, the capping and cover soil requirements and refer to other guidance sources:
    - The Alberta Pacific (ALPAC) North East Alberta Operating Ground Rules inform on operability factors such as slope and distance to surface water bodies.
    - The Alberta Timber Management Regulation sets acceptable commercial tree species.
    - The Alberta Reforestation Standard of Alberta (or approved alternate reforestation standards specific to oil sands mine reclamation currently being developed) set the stocking rate for the establishment survey and the criteria for the performance survey.
    - The Weed Control Act prescribes prohibited noxious weeds and tolerances.
- Thresholds for indicators such as soil salinity and site index are developed through oil sands mine reclamation research.

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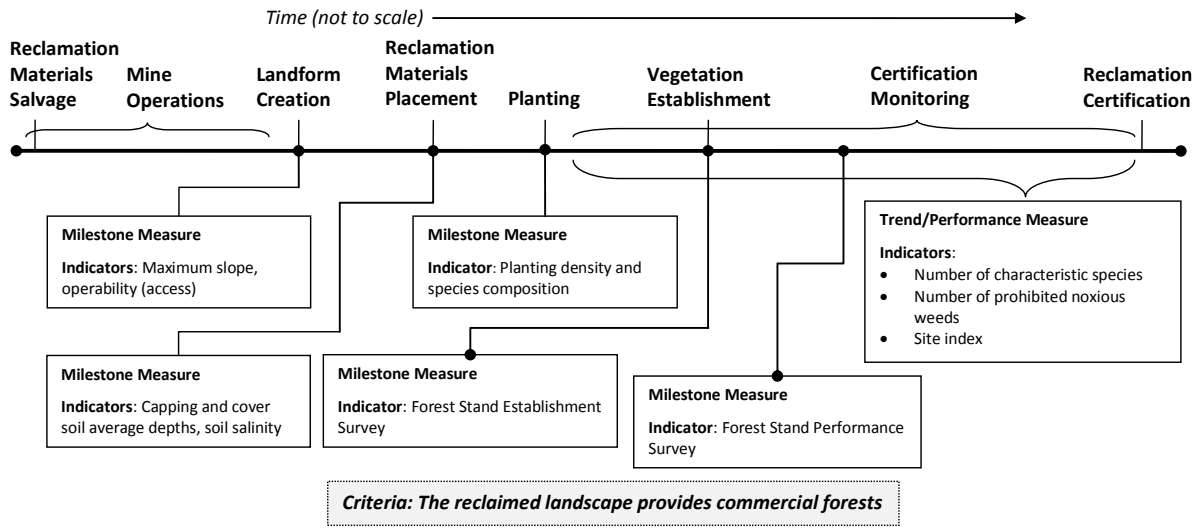

Figure 3: Example of the Use of Indicators In the Mine Life Cycle Associated With the Establishment of Commercial Forest Stands

Measure

A measure is a qualitative or quantitative aspect of an indicator; a variable which can be measured and demonstrates either a trend in an indicator or whether or not a specific standard was achieved.

The measures for an indicator were determined by the sub-groups and task groups as part of the process for identifying and recommending indicators.

Method

A method is a description of a way, technique, process or procedure for attaining a measure. By establishing common, accepted methods of measure the validity is increased and the likelihood that the regulator will accept the results is improved. Common methods enhance transparency of how the values are obtained and ensure the results are replicable within an auditable process.

Threshold

A threshold is the quantitative point that determines whether or not the reclamation outcomes are being achieved for a particular indicator. Performing better than the threshold allows signoff of the indicator. Not achieving a threshold will result in an adaptive management response. Professional judgment is applied and collaboration between the operator and Regulator will determine the appropriate management response. Each indicator will have a threshold, except where the regulator has prescribed a standard for the indicator.

Standard

A standard is established by regulatory authority, often expressed in the form of a prescribed numerical value or a range of values that a variable being measured must achieve. Standards are prescribed by the Regulator in

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approval conditions, set by the EPEA appointed Director, or may be set through legislation or regulation. Not all indicators will have a standard.

There may be circumstances that prevent the achievement of a standard on a site specific basis. For example, site conditions or reclamation material imbalances may occur that prevent an operator from achieving a standard. These conditions must be identified early in the reclamation planning process, so an alternate standard or approach can be proposed by the operator for review and authorization by the Regulator prior to the work being done.

When a standard is prescribed by the regulator for an indicator, it replaces the threshold.

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METHODOLOGY

Developing the content of the criteria and indicator framework and guidance on its use commenced in October 2010. The RWG, comprised of representatives from CEMA's member organizations, steered the project. Member organizations include industry, government, Aboriginal groups and stakeholders. RWG sub-groups and task groups, comprised of specialists and technical experts, worked under the direction of the RWG to provide input into the framework and recommendation of indicators.

As the project progressed, new information and better understanding lead to continuous refinement of the framework. The RWG reconsidered earlier products and improved upon them (Figure 4). Routine adaption to components of the framework to reflect the new information and understanding was a key element for the project moving forward, even if a member of the RWG had reservations on the content at that time.

The project followed six modules, as follows:

1. Setting the stage; understanding current initiatives.
2. Setting high level direction.
3. Selection of indicators.
4. Guidelines for the use of the criteria and indicator framework.
5. Validation of framework content.
6. Final report approval.

Each module had defined deliverables, each either contributing to populating the framework content or provided direction to accomplish upcoming tasks. Figure 5 provides a diagram of the modules, tasks and deliverables along the project timeline.

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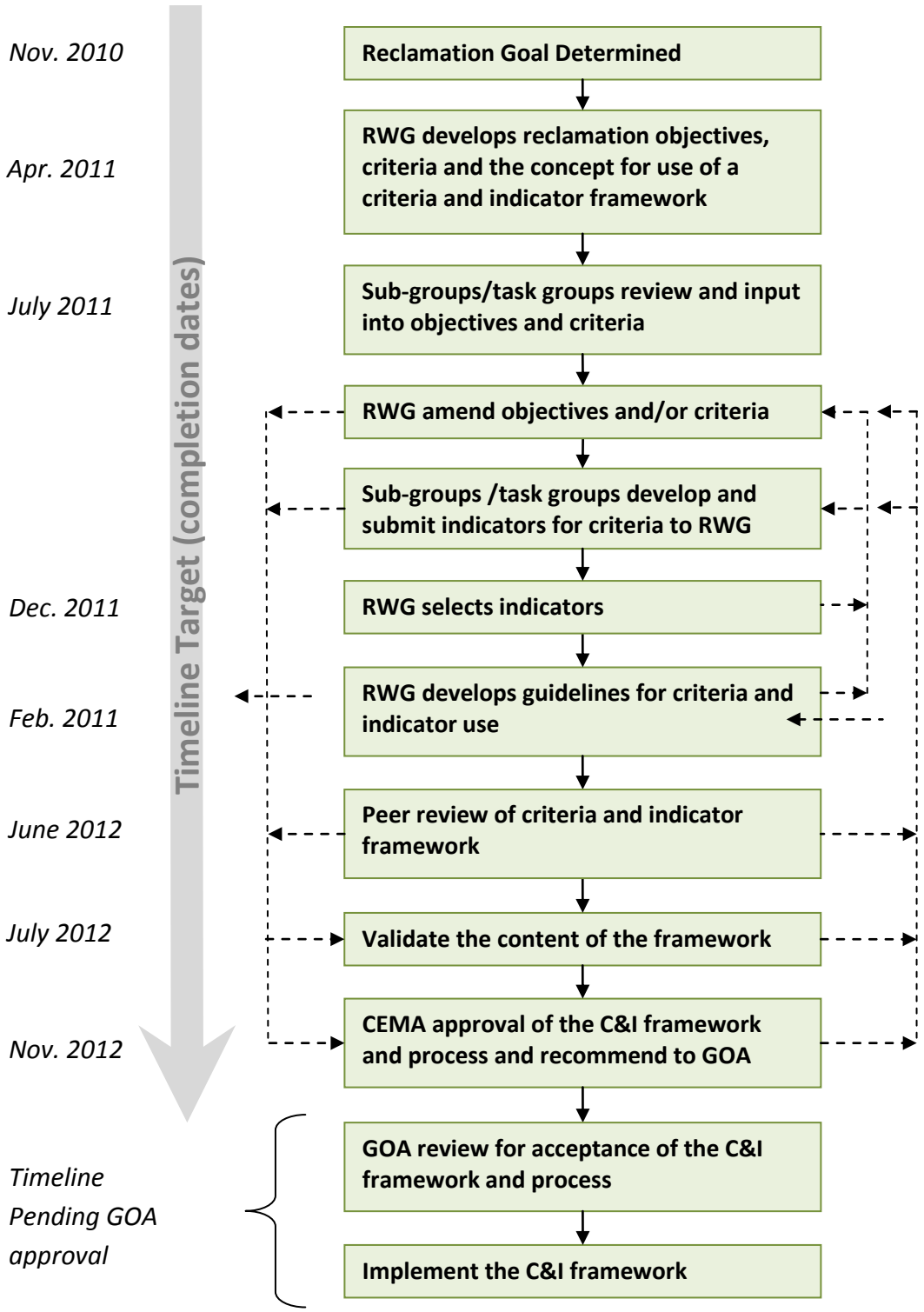

Figure 4: Project Task Flow and Improvement Loops

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Module 1: Setting The Stage; Understanding Current Initiatives

The purpose of Module 1 was to generate a solid information base of existing criteria and indicator frameworks, which would inform subsequent steps in the project. This was achieved by conducting a knowledge synthesis on how other jurisdictions use reclamation criteria and indicators. Module 1 involved two tasks. First was completing a summary for the RWG regarding ongoing initiatives by the GOA related to oil sand mine reclamation. The second task was providing the RWG with examples of how criteria and indicators are used in other jurisdictions.

The GOA summary was prepared by AESRD and was important background information for communicating the context of where the criteria and indicator framework fit into the larger picture of the reclamation program. The summary intended to provide an understanding of the alignment of the project to other government reclamation related initiatives and to clarify the scope of the criteria and indicator project to avoid duplication.

Information on how other jurisdictions use reclamation criteria and indicators within the mine closure process was compiled to inform the RWG members of options to consider in designing the framework and in determining how the framework can be used within the existing Alberta regulatory system. Information from literature reviews (see Bibliography) and case studies was summarized and presented to the RWG. The case studies originated from a CEMA Aquatics Sub-group (ASG) project titled, Process Assessment of Wetland Criteria and Indicator Frameworks (M. Poscente 2011). The ASG project enabled a close study of several examples of criteria and indicator implementation through four very different regulatory approaches. The project included reclamation site visits and interviews of government representatives, operators, and reclamation practitioners. Case studies were prepared on each jurisdiction defining how objectives and criteria are developed, the criteria used, the regulatory and policy context, and means of implementation. The report documents the key findings, including the benefits and challenges associated with the different criteria and indicator approaches.

Module 2: Setting High Level Direction

The purpose of Module 2 was to create the management structure of the project to provide direction and support for the technical groups to focus on indicator development. The outcome of this module was to ensure that the technical groups had the information and resources necessary to fulfill their mandate of indicator selection. Module 2 involved facilitating RWG discussion and decisions through workshops and meetings to:

- Develop the concepts of use for a criteria and indicator framework.
- Produce tools, method and communication needed to support the selection of indicators.
- Selection of the goal, objectives and criteria under which the indicators are to be placed.

Commencing with an ambitious two-day workshop, the RWG was first presented with the information derived from Module 1. Upon gaining an understanding for the purpose and scope of the project the RWG then:

- Examined the options for use of criteria in mine reclamation certification that have some compatibility with the Alberta legislative framework.
- Examined alignment between a criteria and indicator framework and mine approvals, reclamation plans and reference guides (all a source of reclamation objectives, criteria or indicators).
- Described the types, purpose and use of indicators.
- Discussed the scale of reclamation certification indicators, i.e. sub-regional, landscape, local, polygon and applicability in reclamation certification.
- Examined the linkage of indicators to reclamation milestones (to differentiate milestone indicators from those chosen to measure trend or performance).
- Defined decision criteria to assist in approving the framework objectives and criteria.

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- Described a management system demonstrating how a criteria and indicator framework can be used in Alberta's regulatory system to support reclamation certification decisions.

Two one-day workshops with the RWG were then conducted to populate the goal, objectives and criteria in the framework. At the first workshop the draft reclamation goal, objectives and criteria were developed. The goal was derived from the EPEA mine approval, which prescribes the outcome expected of the reclamation effort. Objectives and criteria were defined, using the draft objectives and criteria presented in the report, A Framework for Reclamation Certification Criteria and Indicators for Mineable Oil Sands (Poscente 2009), as a starting point. In between the workshops, the RWG members had an opportunity to review, rank, provide comments and propose improvement to the draft objectives and criteria. Ranking of the draft objectives and criteria was through use of the decision criteria defined in an earlier workshop (Appendix 1). The ranking was not intended to be used definitively toward a decision to accept or reject an objective or criteria, but to inform a decision based on professional judgment that included understanding all stakeholder interests.

A summary of the draft objectives and criteria including the rankings, comments and suggestions for improvement received in between workshops, was presented at the second one-day workshop. The RWG reviewed the information and refined a second draft of objectives and criteria. The RWG also discussed the communication tools and formal direction needed to assign the sub-groups and task groups[1] with development of the indicators. The information from the workshop enabled the consultant to prepare:

- A draft interim report defining the reclamation goal, objectives and criteria for the framework, including the management concepts of how it will be used.
- Communication tools in the form of Fact Sheets (Appendix 2) to support common understanding and use of terminology among the RWG members, sub-groups and task groups.
- Instructions for the sub-groups and task groups for the identification and recommendation of indicators (Appendix 3).

The products listed above were approved by the RWG at their regular monthly meeting prior to being distributed to the groups.

The final workshop conducted under Module 2 involved the RWG and representatives from the sub-groups and task groups. The reclamation goal, objectives, indicators and the concept for use of the framework were presented to the groups for the purpose of gaining their feedback. The RWG considered the feedback and revised the framework content and/or concepts as appropriate. Information on the tasks associated with the indicator selection process was also presented to the groups, including target dates by which to have indicator recommendations submitted. Feedback on the indicator recommendation and selection process was incorporated into producing products to support Module 3.

Module 3: Selection of Indicators

Module 3 involved the recommendation of indicators by the technical sub-groups and task groups, decisions by the RWG on the recommendations and the initial population of the C&I framework. The draft interim report on the criteria indicator framework and concept for use was distributed to the groups, along with RWG direction, timelines and templates for the submission of recommended indicators to the RWG. Indicator Screening Factors (Appendix 4), developed by the RWG to support their decisions on the appropriateness of an indicator and were provided to the groups for their consideration when developing an indicator for recommendation. The Aquatic

[1] The RWG groups proving indicator recommendations consist of the Terrestrial Sub-group, Biodiversity Task Group, Wildlife Task Group, and the Aquatics Sub-group.

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and Terrestrial Technical Program Managers for the RWG coordinated the indicator recommendation with their respective groups.

Indicators were recommended to the RWG by the Terrestrial sub-group, Aquatics sub-group, Wildlife task group and Biodiversity task group (Appendix 5). Decisions were made by the RWG on each indicator recommendation, using the following categories for their decisions:

> **Acceptable**: The indicator is suitable for inclusion in the framework, fully developed and ready for use.
>
> **Acceptable - Needs Work**: The indicator is suitable for inclusion in the framework, but is not fully developed and therefore not ready for use in the framework. Further work needs to be done to define the measure, develop the measurement method and/or define a threshold. Once fully developed and tested, the indicator can be included in a future revision.
>
> **Other Monitoring**: The indicator is not suitable for the framework but is useful to measure for general reclamation monitoring or research purposes that will support determining adaptive management responses, and/or indirectly support reclamation certification decisions.
>
> **Not Suitable**: The indicator is currently not suitable for use in the framework or for reclamation monitoring. Reasons may include: the indicator requires better definition, or the knowledge and/or technology are not advanced to a stage suitable for use of the indicator.

Upon receipt of the recommendations, the RWG held two workshops at which representatives from the groups presented their recommendations, explained the purpose and value of the indicator, the criteria it supports and the readiness of the indicator for use. The first workshop focused on the terrestrial indicators; the second on the aquatic indicators. RWG members had the opportunity to ask questions and discuss each indicator recommendation with the technical specialists, gaining a comprehensive understanding of the indicator recommendation prior to their deliberation and decisions. After each workshop, the RWG members individually scored and submitted comments for each indicator recommendation. Summaries of the scores and comments were presented back to the RWG at facilitated working sessions, where members reviewed, discussed and decided on the acceptability of the recommendation. Not all members of the RWG agreed to the decision made on individual indicators, however agreed to proceed with the viewpoints of the majority, knowing that there are opportunities for review and refinement of the framework and its contents in later stages of the project. The output of Module 3 was the draft content of the goal, objectives, criteria and indicators for population of the framework.

Module 4: Guidelines For Use of the Criteria and Indicator Framework

Module 4 was conducted concurrently with Module 3 and involved describing how the criteria and indicator framework can be used within the Alberta regulatory system. Guidelines in this context are suggested practices and procedures for the purpose of establishing common approaches, applied with discretion to account for site specific circumstances. The intent of Module 4 was to maintain a conceptualized approach, without delving in process details. A high level systems map was developed to describe how the framework will work. Detailed process mapping was out of scope for the project.

The guidelines for use of the framework were developed through a one-day workshop with the RWG, with follow-up facilitated working sessions to review and refine the concepts. It was important to:

- Proceed with the understanding that the framework was not intended to be a new stand-alone process in addition to existing reclamation and regulatory processes.

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- Understand how the framework can complement and be integrated into existing reclamation and regulatory process.

Therefore the facilitated discussions with the RWG were centered on existing reclamation and regulatory processes:

- Mine Closure Planning and Reclamation Criteria and Indicators
- Reclamation Planning
- Reclamation Operations
- Monitoring and Research
- Decision Process
- Annual Reporting
- Reclamation Certificate Application

The guidelines developed by the RWG to demonstrate use of the framework are of a high level and are not intended to be fully comprehensive. Process and procedures will need to be developed as part of an implementation plan, assuming the concepts are accepted by the GOA.

Module 4 concluded with an updated draft version of the Criteria and Indicators Approach for Oil Sands Mines.

Module 5: Validation of Framework Content

Validation of the framework content included two components, first a review of the draft Criteria and Indicators Approach for Oil Sands Mines report and second a co-sponsored workshop with the Oil Sands Research and Information Network (OSRIN). The first component, review of the Criteria and Indicators Approach for Oil Sands Mines report completed in Module 4 included:

- RWG member organization review.
- Review by technical specialists familiar with Alberta reclamation legislation, process and procedure.
- Peer review by external specialists

Instructions were prepared for the reviewers which included a template for responses and a summary of the oil sands mine reclamation requirements from a regulatory perspective (Appendix 6). Reviewers were allotted three weeks to provide their comments back to the RWG program manager. The review was focused on the reasonableness and practicality of the framework management system rather than on the individual indicators. This was because the indicators had been through considerable technical review through the indicator recommendation and selection process. Reviewer comments were summarized and the author reviewed and commented where appropriate, including formulating an appropriate response where specific changes were recommended. The reviewer comments, author comments and author's response were then presented to the RWG for their review. Through a facilitated working session the RWG decided on the response to recommended changes (i.e. those that significantly impacted upon the design or content of the framework).

The second component, the RWG/OSRIN joint workshop was attended by reclamation specialists and practitioners from both within and outside of government. The workshop was designed to tap into the participant's expertise to determine the information requirements to inform a decision on reclamation certification. An OSRIN report was prepared, Professional Judgment in Mineable Oil Sands Reclamation

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Certification: Workshop Summary[2] that makes observations and recommendations regarding the types of information that professional judgment would bring to the certification process. The content of the criteria and indicator framework was then considered in the context of the observations and recommendations, as a check to ensure it will capture the critical information needed to formulate a decision on reclamation certification. Identified gaps and suggested responses were presented to the RWG in a facilitated working session for decision on how to address the gap within the framework.

The outputs of the three work components of Module 5 were incorporated into the final draft of the Criteria and Indicators Approach for Oil Sands Mines report.

Module 6: Final Report Approval

Subject to the outputs of Module 5, the final draft of the Criteria and Indicators Approach for Oil Sands Mines draft report was completed and submitted to the RWG for approval. Subject to the RWG approval, the report will be submitted to the CEMA Board of Directors for their review, approval and furtherance.

[2] University of Alberta Education & Research Archive

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Project Work Plan: FRAMEWORK FOR RECLAMATION CERTIFICATION CRITERIA & INDICATORS FOR MINEABLE OIL SANDS – Production on Content and Guidance for Use

Module Completion Date

Oct.

Module 1: Setting the Stage - Understanding of Current Initiatives

Task 1.1: Summary of the current GOA initiatives underway regarding reclamation.

Task 1.2: Literature synthesis on C&I designs and their implementation in other jurisdictions.

Deliverables:
- ***Summary on the status of current GOA initiatives***
- **Presentation of C&I frameworks in use in**

June 2011

Module 2: Setting High Level Direction

Task 2.1: Develop the concepts for use of the C&I

Task 2.2: Selection of the objectives and criteria to populate the C&I framework.

Task 2.3: Subgroup and task group input into objectives and criteria.

Deliverables:
- ***Fact sheets on indicator types and their use***
- ***Selection of objectives and criteria***
- ***Draft C&I report with the framework populated to the criteria level***

April 2012

Module 3: Selection of Indicators

Task 3.1: Sub-group and task-group indicator development and submission to the RWG.

Task 3.2: RWG review of proposed indicators, indicator decisions and population of the C&I framework.

Deliverables:
- **Draft suite of criteria and indicators for inclusion in the framework**

May

Module 4: Guidelines for Use of the Criteria and Indicator Framework

Task 4.1: RWG development of how the C&I framework can be used within the Alberta regulatory framework and preparation of a draft report for review.

Deliverables:
- **Draft report for peer and CEMA member organization review**

July 2012

Module 5: Validation of Framework Content

Task 5.1: Review of the C&I framework report.

Task 5.2: Validation of the criteria and indicators to confirm the functionality for supporting certification

Deliverables:
- **Review results**
- **Validation results (through OSRIN workshop)**
- **Final report**

Nov. 2012

Module 6: Final Report Approval

Task 6.1: CEMA Board of Directors review and approval.

Deliverables:
- **Final report (including recommendations)**
- **CEMA Board of Directors approval**
- **Submit report to GOA**

Figure 5: Criteria and Indicator Project Activities and Timelines

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RECLAMATION GOAL, OBJECTIVES, CRITERIA AND INDICATORS

This section describes the outputs of the processes conducted by the RWG to populate the framework with the goal, objectives, criteria and indicators. The framework will not be fully populated for some time. Gaps will exist in the indicators. Completing a full suite of indicators is dependent upon additional work to:

- define new indicators,
- develop indicator measures,
- develop common measurement methods, and
- develop thresholds that are calibrated to and validated for the mineable oil sands region.

The goal, objectives, criteria and indicators presented in this section are draft and may be modified subject to testing and validation of the framework. Future research and monitoring of reclamation may result in development of new indicators for inclusion in later versions of the framework.

Goal

The vast majority of oil sands mine development occurs on public land, therefore a common reclamation goal is prescribed by the GOA (as the landowner representing the interests of Albertans). The goal, implemented through EPEA mine approval conditions, states:

> *The approval holder shall reclaim the land so that the reclaimed soils and landforms are capable of supporting a self-sustaining, locally common boreal forest, regardless of the end land use.*

The goal may differ slightly in individual mine approvals.

The RWG modified the goal prescribed in the EPEA mine approval conditions (additions in bold):

> *The reclaimed soils and landforms are capable of supporting a diverse self-sustaining, locally common boreal forest landscape, regardless of the end land use.*

Adding the term “diverse” into the goal reflected the requirement for diversity throughout the objectives and criteria. Establishing diversity on reclaimed lands is also a requirement of the EPEA approval. Adding the term “landscape” provides clarity to the goal. As progressive reclamation is undertaken, an operator will likely submit multiple reclamation certificate applications over time. The applications are on a landform scale. Combined, certified reclaimed land parcels will establish the end landscape.

Objectives

The RWG adapted the three reclamation objectives stated in the CEMA report, A Framework for Reclamation Certification Criteria and Indicators for Mineable Oil Sands (Poscente 2009). These objectives were modified to:

Objective 1	Reclaimed landscapes are established that support natural ecosystem functions
Objective 2	Natural ecosystem functions are established on the reclaimed landscape
Objective 3	Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses

Objective 1 represents the landform design and build phase of reclamation, important for outcomes associated to integration with adjacent land and achieving an acceptable landscape mosaic. Objective 2 represents natural ecosystems occurring on the reclaimed landscape, important for outcomes associated with achieving self-sustainability. Objective 3 represents achieving equivalent land capability, important for outcomes associated with

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the approved end land uses in the EPEA mine approval conditions, in addition to establishing diversity on the reclaimed landscape.

The reclamation objectives and criteria defined by the RWG are represented in Table 2. The premise of the framework is that if the criteria and objectives are achieved, the reclamation site is trending towards meeting the goal, subsequently fulfilling the regulatory requirement of equivalent land capability.

Criteria

The RWG reviewed and adapted the criteria stated in the CEMA report, A Framework for Reclamation Certification Criteria and Indicators for Mineable Oil Sands (Poscente 2009). Through workshops, including technical input from the RWG sub-groups and task groups, the criteria were modified. Table 2 represents the decisions of the RWG from the criteria selection process.

Table 2: Framework Goal, Objectives and Criteria

GOAL:	**The reclaimed soils and landforms are capable of supporting a diverse, self-sustaining, locally common boreal forest landscape, regardless of the end land use.**
Objective 1:	**Reclaimed landscapes are established that support natural ecosystem functions.**
Criteria	1.1 The landforms are integrated within and across lease boundaries. 1.2 The landforms have a natural appearance. 1.3 The landscape and its landforms incorporate watershed features such as surface drainage, lakes and wetlands. 1.4 The landforms have geotechnical stability. 1.5 Reclamation materials are placed appropriate to the landform. 1.6 Terrestrial and aquatic vegetation common to the boreal forest is established.
Objective 2:	**Natural ecosystem functions are established on the reclaimed landscape.**
Criteria	2.1 The reclaimed landforms have the required water quality. 2.2 The reclaimed landforms have the required water quantity. 2.3 Nutrient cycling is established on the reclaimed landscape. 2.4 Ecosystem productivity is established on the reclaimed landscape. 2.5 Reclaimed ecosystems display characteristics of resilience to natural disturbances.
Objective 3:	**Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses.**
Criteria	3.1 The reclaimed landscape provides for biodiversity. 3.2 The reclaimed landscape provides commercial forests. 3.3 The reclaimed landscape provides for fish and wildlife habitat. 3.4 The reclaimed landscape provides opportunities for traditional uses. 3.5 The reclaimed landscape provides opportunities for recreational uses.

Indicators

A summary of the indicators considered by the RWG and the decisions for use of the indicators are summarized in Table 3. Detailed indicator recommendation sheets are provided in Appendix 5, numbered in the same order as they are listed in Table 3.

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Table 3: Summary of Recommended Terrestrial and Aquatic Indicators and the RWG Decisions

TERESTRIAL INDICATORS						
		RWG Decision				
No.	**Indicator**	Acceptable	Acceptable: Needs Work	Other Monitoring	Not Suitable	**RWG Comments**
1	Soil moisture			✓		Already being assessed as part of soil placement audit.
2	Soil macronutrients (nitrogen and phosphorus)			✓		Include in monitoring program to support adaptive management processes.
3	Soil pH	✓				Can be easily assessed and adaptive management responses are reasonable.
4	Soil salinity	✓				Indicates the ability to reclaim lands to specific ecosystems.
5	Soil depth	✓				Reflects the EPEA mine approval conditions.
6	Ecosystem net primary productivity (site index)		✓			Include as an indicator, but not just specific to commercial forestry.
7	Plant community composition – characteristic species		✓			Gaps in juvenile stand data in the revegetation manual characteristic species table need to be addressed.
8	Plant community composition - weeds	✓				Deal with tolerances for non-prohibited weeds in indicator #9
9	Plant community composition - diversity, richness, evenness and abundance		✓			Account for acceptable limits of non-prohibited weeds. Need to understand reference conditions.
10	Regeneration of trees in commercial forest stands		✓			Develop the threshold for the mine reclamation context.
11	Trees are healthy and vigorous	✓				Applicable to reclaimed land designated as commercial forest end land use, part of existing establishment survey.
12	Tree height of commercial forest stands at performance age		✓			Develop the threshold for the mine reclamation context.
13	Commercial forest targets - Ecosite area summary table		✓			The threshold needs to be developed relevant to the mine reclamation context.
14	Ecosystem health		✓			Need to define the methodology and thresholds specific to the mine reclamation context.
15	Locally common soil mycorrhizal communities are established				✓	Withdrawn by submitter. Requires further research.
16	Wildlife species with an important ecological role		✓			Need to better define the scale of measurement and measure capability not actual use.

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TERESTRIAL INDICATORS (continued)						
		RWG Decision				
No.	**Indicator**	Acceptable	Acceptable: Needs Work	Other Monitoring	Not Suitable	**RWG Comments**
17	Wildlife habitat targets		✓			Need clarification from the Wildlife Task Group.
18	Wildlife habitat targets that support consumptive and non-consumptive uses		✓			Consumptive uses suggest recreation activities.
19	Wildlife habitat targets that support cultural, spiritual, medicinal and ceremonial purposes as defined through stakeholder consultation		✓			Need to develop this indicator through an indigenous research project.
20	Viable and healthy populations of wildlife		✓			Need to determine or define the "viability" part of the indicator. Certification will not be evaluated on presence of wildlife, but on habitat capability.
21	Connectivity within the landscape		✓			Have to first address requirements to include in planning.
22	Landscape mosaic		✓			Have to first address requirements to include in planning.
23	Species and community diversity		✓			Require research to develop indices to measure and evaluate diversity. Need to determine the baseline from which to compare measures against.
24	Achieve biodiversity targets that support cultural, spiritual, medicinal and ceremonial purposes		✓			Need to develop this indicator through an indigenous research project.
25	Geotechnical design	✓				Landform design requires signoff by a geotechnical engineer and the ERCB.
26	Geotechnical stability	✓				Landform stability performance requires signoff by a geotechnical engineer and the ERCB prior to reclamation certification.
27	Foliar nutrients		✓			Need to define threshold. Research is underway.
28	Resilience		✓			Resilient to natural disturbances and climatic variation.
29	Functional littoral communities				✓	Too broad, need to better define the indicator(s). Aquatic plant presence, abundance and diversity are separate indicators. Develop indicator options.
30	End pit lake percent littoral area	✓				Timing of measure is at the construction stage and the measure is up to 3 metres depth of the mean design surface water elevation.

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AQUATIC INDICATORS						
		RWG Decision				
#	Indicator	Acceptable	Acceptable: Needs Work	Other Monitoring	Not Suitable	RWG Comments
31	End pit lake littoral slope	✓				Measure from shore to 3 metres depth.
32	End pit lake littoral zone reclamation materials		✓			Needs work to define the measure (i.e. physical or chemical properties).
33	End pit lake total dissolved solids	✓				May require monitoring for a minimum 10 year period prior to mine closure. Perhaps consider defining a threshold rather than a trend.
34	End pit lake water column mixing	✓				Measure trend from the end of construction through to the time of certification.
35	End pit lake water level variability	✓				Could have a drop in elevation each year and remain within the threshold, resulting in an over-all decrease of surface elevation.
36	End pit lake water balance	✓				Focus the indicator on water quality benefits to having connectivity, not fish habitat (fish habitat will be accounted for in other indicators).
37	End pit lake bed stability		✓			More applicable to shallow systems where wind and wave action will have a greater influence on re-suspension of fine tailings.
38	Fen organic matter accumulation		✓			Specific to peatlands.
39	Fen water quality	✓				Upfront measurement of water quality is critical to determine is a fen design is viable.
40	Wetland traditional ecological plants		✓			Further work is required on traditional ecological knowledge indicators.
41	Typical fen plants		✓			Certification may require indicators associated with health/vigor (performance), abundance and percent cover.
42	Wetland hydroperiod	✓				Applies to all wetlands on the reclaimed landscape, both opportunistic and planned.
43	Marsh wet meadow plant index of biotic integrity	✓				Would need to measure all wet meadow polygons on a landform in preparation for certification.
44	Marsh open water plant index of biotic integrity	✓				Would need to measure all open water polygons on a landform in preparation for certification.

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Table 4 demonstrates how the indicators that were selected by the RWG as "acceptable" and "acceptable – needs work" fit into the framework, the scale at which they are applied (Appendix 1, Fact Sheet 6) and the type of indicator (Appendix 1, Fact Sheet 4). Table 4 demonstrates the potential completeness of the framework, assuming the RWG incorporates the indicators needing work into work plans, and develops them for inclusion into a future version of the framework.

Table 4: Reclamation Goal, Objectives, Criteria and Indicators by Indicator Type and Scale of Application (Showing Indicators Categorized as Acceptable and Acceptable-Needs Work)

Goal	The reclaimed soils and landforms are capable of supporting a diverse self-sustaining, locally common boreal forest landscape, regardless of the end land use			SCALE			INDICATOR TYPE
				Polygon	Landform	Mine Footprint	
Objective 1	***Reclaimed landscapes are established that support natural ecosystem functions***						
Criteria	**1.1**	**The landforms are integrated within and across lease boundaries**					
	Indicators	1.1.1	Connectivity of the landscape	✓			Milestone
	1.2	**The landforms have a natural appearance**					
	Indicators	1.2.1	Landscape mosaic		✓		Milestone
	1.3	**The landscape and its landforms incorporate watershed features such as surface drainage, lakes and wetlands**					
	Indicators	1.3.1	End pit lake water balance		✓		Trend
	1.4	**The landforms have geotechnical stability**					
	Indicators	1.4.1	Geotechnical design		✓		Milestone
		1.4.2	Geotechnical stability		✓		Performance
		1.4.3	End pit lake bed stability		✓		Trend
	1.5	**Reclamation materials are placed appropriate to the landform**					
	Indicators	1.5.1	Soil depth	✓			Milestone
		1.5.2	Soil pH	✓			Milestone
		1.5.3	Soil salinity	✓			Milestone
		1.5.4	End pit lake littoral zone reclamation materials	✓			Milestone
		1.5.5	End pit lake percent littoral area		✓		Milestone
		1.5.6	End pit lake littoral slope		✓		Milestone
	1.6	**Terrestrial and aquatic vegetation common to the boreal forest is established**					
	Indicators	1.6.1	Plant community composition – characteristic species	✓			Milestone
		1.6.2	Plant community composition - weeds	✓			Performance
		1.6.3	Typical fen plants	✓			Trend
Objective 2	***Natural ecosystem functions are established on the reclaimed landscape***						
Criteria	**2.1**	**The reclaimed landforms have the required water quality**					
	Indicators	2.1.1	End pit lake total dissolved solids		✓		Trend
		2.1.2	Fen water quality	✓			Milestone
	2.2	**The reclaimed landforms have the required water quantity**					
	Indicators	2.2.1	End pit lake water level variability		✓		Performance
		2.2.2	Wetland hydroperiod	✓			Performance

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Objective 2	***Natural ecosystem functions (continued)***						
	2.3	**Nutrient cycling is established on the reclaimed landscape**					
	Indicators	2.3.1	Foliar nutrients	✓			Trend
	2.4	**Ecosystem productivity is established on the reclaimed landscape**					
	Indicators	2.4.1	Marsh open-water zone plant Index of biotic integrity	✓			Trend
		2.4.2	Marsh wet meadow plant index of biotic integrity	✓			Trend
		2.4.3	End pit lake water column mixing		✓		Trend
		2.4.4	Fen organic matter accumulation	✓			Trend
		2.4.5	Ecosystem net primary productivity	✓			Trend
	2.5	**Reclaimed ecosystems display characteristics of resilience to natural disturbances and climatic variability**					
	Indicators	2.5.1	Ecosystem health	✓			Trend
		2.5.2	Resilience		✓		Trend
Objective 3	***Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses***						
Criteria	**3.1**	**The reclaimed landscape provides for biodiversity**					
	Indicators	3.1.1	Plant community composition – diversity, richness, evenness and abundance		✓		Trend
		3.1.2	Species and community diversity	✓			Trend
	3.2	**The reclaimed landscape provides commercial forests**					
	Indicators	3.2.1	Regeneration of trees in commercial forest stands	✓			Milestone
		3.2.2	Trees are healthy and vigorous	✓			Performance
		3.2.3	Tree height of commercial forest stands at performance age	✓			Performance
		3.2.4	Commercial forest targets – ecosites area summary table			✓	Milestone
	3.3	**The reclaimed landscape provides for fish and wildlife habitat**					
	Indicators	3.3.1	Wildlife habitat targets			✓	Trend
		3.3.2	Wildlife species with an important ecological role			✓	Trend
		3.3.3	Viable and healthy populations of wildlife			✓	Trend
	3.4	**The reclaimed landscape provides opportunities for traditional uses**					
		3.4.1	Wildlife habitat targets that support cultural, spiritual, medicinal and ceremonial purposes	✓			Trend
		3.4.2	Biodiversity targets that support cultural, spiritual, medicinal and ceremonial purposes	✓			Trend
		3.4.3	Wetland traditional ecological plants	✓			Trend
	3.5	**The reclaimed landscape provides opportunities for recreational uses**					
	Indicators	3.5.1	Wildlife habitat targets that support consumptive and non-consumptive uses	✓			Milestone

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Table 5 demonstrates the draft content of the framework, assuming only those indicators designated as acceptable are included. The measure, method, threshold or standard (if applicable) are shown for each indicator. Gaps in the framework will be filled as further work on indicator development proceeds.

Table 5: Draft Criteria and Indicator Framework Showing the Indicators Categorized as Acceptable by the RWG, Complete With the Measure, Method and Threshold

Goal	**The reclaimed soils and landforms are capable of supporting a diverse self-sustaining, locally common boreal forest landscape, regardless of the end land use**			
Objective 1: Reclaimed landscapes are established that support natural ecosystem functions				
Criteria	**1.1**	**The landforms are integrated within and across lease boundaries**		
	Indicators	1.1.1	To be developed	
	1.2	**The landforms have a natural appearance**		
	Indicators	1.2.1	To be developed	
	1.3	**The landscape and its landforms incorporate watershed features such as surface drainage, lakes and wetlands**		
	Indicators	1.3.1	End pit lake water balance	
			Measure	Water balance
			Method	Maidment, D.R. [Ed.]. 1993. Handbook of Hydrology. McGraw-Hill Inc. New York.
			Threshold	No surplus/outflow of water leaving the EPL (i.e., zero or negative water balance), on an annual basis, over a period of 10 years.
	1.4	**The landforms have geotechnical stability**		
	Indicators	1.4.1	Geotechnical design	
			Measure	Landform geotechnical design
			Method	Using the Landscape Design Checklist, a design team ensures the landform is integrated with the overall closure plan and adjusts the design (geometry, material placement, footprint, slope angles, morphology, reclamation material placement and revegetation) to accommodate operational, closure and reclamation goals.
			Threshold	ERCB approval of the landform design.
		1.4.2	Geotechnical stability	
			Measure	Geotechnical stability
			Method	Assessment by a professional geotechnical engineer
			Threshold	Professional sign-off by a geotechnical engineer that the geotechnical performance of the landform is suitable and ERCB acceptance of the assessment.

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Objective 1: Reclaimed landscapes (continued)				
			Measure	Depth of reclaimed soils in the oil sands region is divided according to topsoil (0-20 cm), upper subsoil (20-50 cm) and lower subsoil (50-100cm) (p. 23-24 LCCS) for assessment of land capability classes. The upper 1.5 m of soils is assessed against soil quality indicators in Tables 8 and 9 in Alberta Agriculture (1987) for suitability and methods of soil salvage.
			Method	Field soil assessments methods based on LCCS (Alberta Environment 2006), and/or by Alberta Agriculture (1987).
			Threshold	The threshold for the soil depth indicator is the specified soil depth outlined in the applicable EPEA approval condition. The soil depth threshold will depend on the coversoil materials and the reclamation objectives.
		1.5.2	Soil pH	
			Measure	Soil pH in water suspension is the accepted method in Table 5 of LCCS (2006, see page 19).
			Method	1:1 ratio of soil weight to water volume in Section 3.12 of McKeague (1978) or 1:2 of the above noted ratio as in section 16.2 of Carter (1993), both methods are referenced in Table 5 of LCCS (2006).
			Threshold	Percent deduction factor as tabulated in Table 13 of LCCS (2006, see page 47) for adjusting the Base Rating item in LCCS (ie. the sum of ratings for soil moisture regime and nutrient regime).
		1.5.3	Soil salinity	
			Measure	Electrical conductivity (EC) of topsoil expressed as dS m^{-1}
			Method	The method is described in the LCCS and referred to in the Revegetation Manual
			Threshold	Table 5-12, p. 60, Revegetation Manual, defines thresholds for target end land-use which would be applicable to Objective 1 LCCS audit results. The maximum topsoil EC for commercial forestry and a forested ecosystem are 2 and 4 dS m^{-1}, respectively.
		1.5.4	End pit lake percent littoral area	
			Measure	The lake area where sunlight penetrates all the way to the sediment
			Method	Measure the lake area where light levels of 1% or more of surface values reach the sediment.
			Threshold	Measure the lake area where light levels of 1% or more of surface values reach the sediment.
		1.5.5	End pit lake littoral slope	
			Measure	Slope in polygons classified as littoral zones.
			Method	Slope (rise over run) in polygons classified as littoral zones. Measured from the shoreline to the distance perpendicular to the shoreline where light levels of 1% of surface values reach the sediment surface.
			Threshold	Maintained at ≤ 5%
	1.6	**Terrestrial and aquatic vegetation common to the boreal forest is established**		
	Indicators	1.6.1	To be developed	

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Objective 2: Natural ecosystem functions are established on the reclaimed landscape				
Criteria	**2.1**	**The reclaimed landforms have the required water quality**		
	Indicators	2.1.1	End pit lake total dissolved solids	
			Measure	Total dissolved solids (TDS).
			Method	Surface water samples collected at least monthly for a period of at least 10 years in both the EPL and a suite of representative reference lakes. Measured with standard procedures insitu and in certified laboratory with field blanks and lab standards. EPL data to be corrected against significant trends in the reference dataset to account for the effects of climate variability. Trend analysis, as per standard methodologies, performed on the corrected EPL data to determine if there is significant change over time (at probability level of 0.05).
			Threshold	Slope of TDS concentration over time is zero or negative (P≥0.05).
		2.1.1	Fen water quality	
			Measure	pH, HCO2, specific conductivity (µS/cm2), Ca2+
			Method	All parameters are measured with standard procedures insitu (pH, conductivity) and in certified laboratory with field blanks and lab standards. For calculation of reduced conductivity, see Sjörs, H. 1950. On the relation between vegetation and electrolytes in north Swedish mire waters. Oikos, **2**(2): 241–258.
			Threshold	5.5 < pH < 9.5; 0 < HCO_3 < 550 mg/L; 17.5 < reduced conductivity < 1234 µS/cm^2; 2 < Ca^{2+} < 150 mg/L
	2.2	**The reclaimed landforms have the required water quantity**		
	Indicators	2.2.1	End pit lake water level variability	
			Measure	Lake levels and range of variation.
			Method	Water level sensor. Levels collected daily during the open-water season over a period of at least 10 years.
			Threshold	No greater than a 1 metre change in water level during any one year.
		2.2.2	Wetland hydroperiod	
			Measure	Hydroperiod
			Method	Measured in both natural reference and test wetlands during the same period of time. Minimum monitoring period of time of 10 years to account for range of variability and allow statistical comparisons. According to Mitsch and Gosselink. 2000. Wetlands. John Wiley and Sons.
			Threshold	Within the range occurring in the natural reference wetlands of the wetland type in question.
	2.3	**Nutrient cycling is established on the reclaimed landscape**		
	Indicators	2.3.1	To be developed	

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Criteria	**2.4**	**Ecosystem productivity is established on the reclaimed landscape**		
	Indicators	2.4.1	Marsh open-water zone plant Index of biotic integrity	
			Measure	1. The number of free-floating and floating-leafed species has a negative relationship to environmental stress. 2. The relative cover of alkali-tolerant species has a positive relationship to stress. 3. The relative cover of floating-leaf species has a negative relationship to stress. 4. The relative cover of C. demersum has a negative relationship to stress. 5. The % of total richness of Potamogeton spp. has a positive relationship to stress. IBI score has a negative relationship to environmental stress.
			Method	Materials: Paddle boat, paddle, anchor, and rake. In brief, 10 transects are made across the open-water zone. Along each transect a 1 m^2 quadrat is estimated. Vegetation is raked up within each quadrat and each species is identified. Relative abundances of species are estimated as the percentage of total vegetation on the rake. An average of the 10 quadrats is used to estimate species richness and relative abundances per site. Metrics can then be computed using the Appendices. Relative abundances are summed to calculate metrics based on relative abundance. Species counts are used to calculate richness metrics. Use Appendix 1 and Table A2 to standardize metrics and get IBI score.
			Threshold	If the % of total cover by *C. demersum* is >= 27%, then the site has low stress and is similar to reference sites. Less than 27% of total cover by *C. demersum* and less than 12.5% of total cover of alkali-tolerant species indicates moderate stress. Greater than 12.5% alkali-tolerant species signifies high stress. If the % of total richness constituted by *Potamogeton* spp. is >= 33%, the site is very highly stressed. Other 2 metrics do not have discernible thresholds. See Table A3 for flowchart of thresholds. A site monitored over time with an IBI score consistently higher than 200 is acceptable for certification of reclamation sites.
		2.4.2	Marsh wet meadow plant index of biotic integrity	
			Measure	1. Robel pole height has a negative relationship to stress. 2. Wet meadow zone width has a negative relationship to stress. 3. Relative richness of exotic species has a positive relationship to stress. 4. Relative richness of halophytes has a positive relationship to stress. 5. Mean C value has a negative relationship to stress. IBI score has a negative relationship to environmental stress.
			Method	A random point is chosen and the site is divided into thirds. Transects are positioned perpendicular to the shoreline. At each transect, the width of the wet meadow zone is measured. Two quadrats are spaced 5 paces apart. A 150 cm tall Robel pole is placed in the center of each quadrat. The height at which the pole is visible is estimated from 4 m away (parallel to the shoreline). In each quadrat, each plant species is identified in the comprehensive assessment. In the rapid synoptic assessment, omit species identification. Richness of exotic and halophyte species (listed in Table A4*) are expressed relative to the total richness. Every plant herbaceous plant species in the Boreal region has a C value assigned to it as listed in Forrest (2010). In comprehensive assessment (every 3-5 years), calculate mean C-value of species found in site. Use Appendix 1 and Table A6* to standardize metrics and IBI score. **A Vegetation Based Index of Biotic Integrity to Assess Marsh Reclamation Success in the Alberta Oil Sands, Canada*.

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			Threshold	A site monitored over time with an IBI score consistently higher than 173 is acceptable for certification of reclamation sites. If the Robel height is < 33 cm, then the site is in high stress and likely in poor condition. If Robel height is ≥ 33 cm and the mean C value is < 4.2, then the site is likely intermediately stressed. Sites in this category fall into two subcategories, sites with wet meadow zone width < 10 m (higher stress) and sites with wet meadow zone width ≥ 10 m (lower stress). If Robel height is ≥ 33 cm and the mean C value is ≥ 4.2, the site is likely in low stress and healthy.
		2.4.3	End pit lake water column mixing	
			Measure	Monimolimnion strata in lake.
			Method	Temperature and oxygen measurements at 1 metre depth increments monthly from June to October, at deepest point in lake.
			Threshold	Absence of layers of water that do not intermix on an annual basis, at any time, over a period of at least 10 consecutive years.
	2.5	**Reclaimed ecosystems display characteristics of resilience to natural disturbances and climatic variability**		
	Indicators	2.5.1	Plant community composition - weeds	
			Measure	Number of prohibited noxious weeds
			Method	Weed Control Act and Regulation
			Threshold	No prohibited noxious weeds (as defined by the Weed Control Act and Regulation)
Objective 3: Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses				
Criteria	**3.1**	**The reclaimed landscape provides for biodiversity**		
	Indicators	3.1.1	To be developed	
	3.2	**The reclaimed landscape provides commercial forests**		
	Indicators	3.2.1	Trees are healthy and vigorous	
			Measure	Identification of "poorly revegetated areas" (PRVs) and listing of causal codes during a performance survey (11-20 years).
			Method	The method is described in the regeneration survey manual, pages 13-16.
			Threshold	Applicable to reclaimed lands designated to commercial forest end land use only: PRVs are delineated when they are 0.5 ha or greater in size and more than 25% of the trees in the area are affected.
	3.3	**The reclaimed landscape provides for fish and wildlife habitat**		
	Indicators	3.3.1	To be developed	
	3.4	**The reclaimed landscape provides opportunities for traditional uses**		
	Indicators	3.4.1	To be developed	
	3.5	**The reclaimed landscape provides opportunities for recreational uses**		
	Indicators	3.5.1	To be developed	

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CONCEPT FOR THE USE OF CRITERIA AND INDICATORS

The criteria and indicator framework management concept (Figure 5) is designed to be compatible with and complementary to Alberta's Conservation and Reclamation Regulation and existing regulatory and administrative processes. Integration of the framework into current processes avoids the framework becoming a standalone process; it is designed to add value by documenting results and the performance of reclamation initiatives. The management concept accomplishes this through enhancing existing processes that will support the reclamation certificate application process and subsequent decisions by the regulator.

The criteria and indicator framework management concept has seven stages, each with a distinct purpose, process elements and process flows.

1. Mine Planning and Reclamation Criteria
2. Reclamation Planning
3. Reclamation Operations
4. Monitoring and Research
5. Decision Process
6. Annual Reporting
7. Reclamation Certificate Application

The framework has two adaptation cycles.

The continuous improvement cycle of the criteria and indicator framework is important to ensure the framework remains effective and relevant, adapting to advances in knowledge, technology, practices and processes. This includes updating the framework with new indicators periodically and clearly specifying how the changes apply to existing and future reclaimed sites.

The adaptive management response cycle is triggered when audit or monitoring results reveal that an indicator did not achieve the threshold (see the section on Decision Process for more detail). This cycle is important to support operational decision making by reclamation practitioners (including the regulator and operator) in response to unplanned events that will occur.

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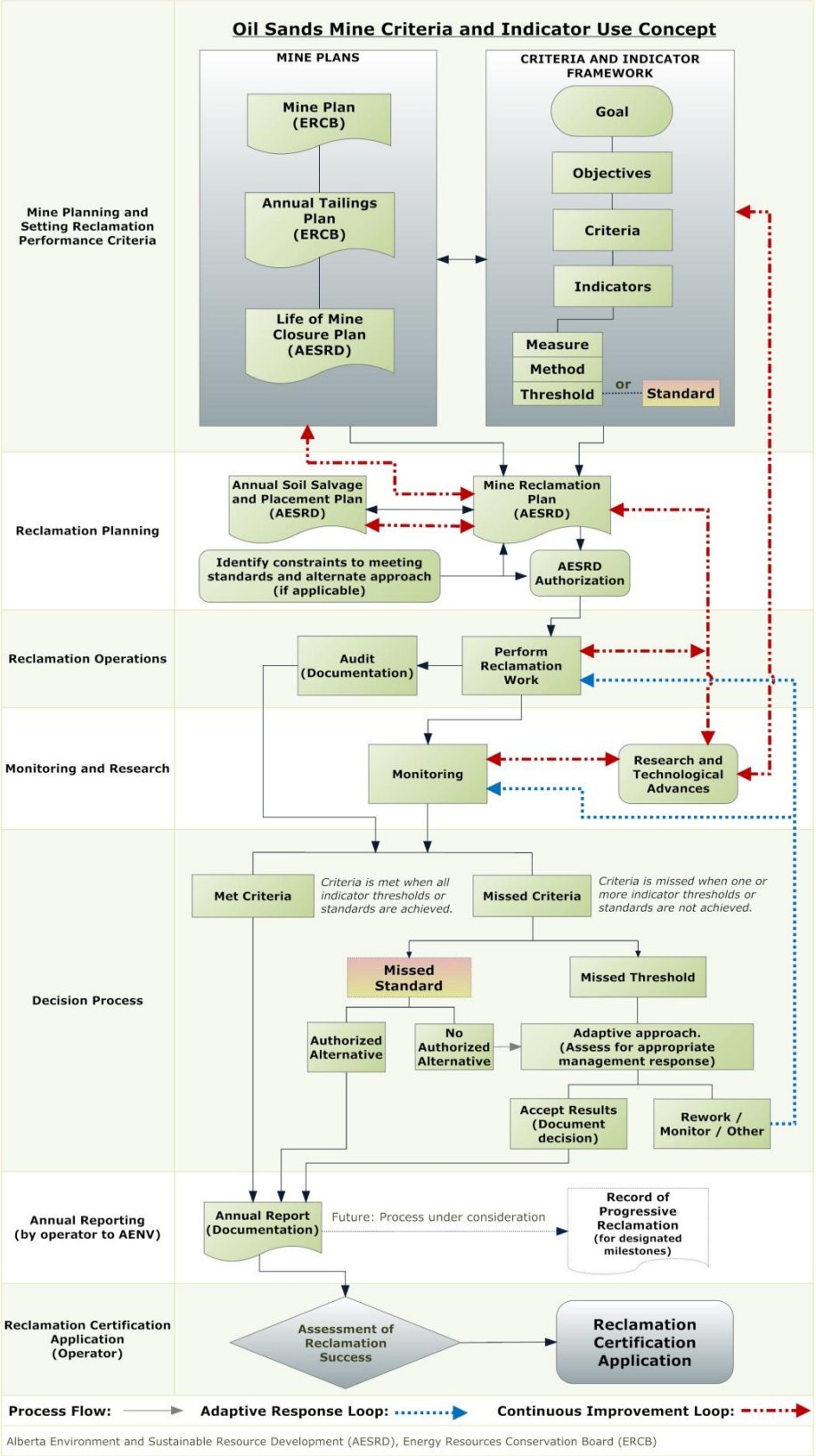

Figure 6: Concept for the Use of a Criteria and Indicator Framework for Oil Sands Mine Reclamation

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Guidelines for Use of the Criteria and Indicator Framework

The concept for the use of the criteria and indicator framework described in Figure 6 is a management system that is designed to incorporate regulatory requirements, science and professional judgment toward achieving planned outcomes. Implementing the framework will require establishment of guidelines that will provide clarity on the expectations of how the framework is to be used, how and when updates are conducted, how the framework complements and is integrated with existing processes, and how the framework supports decision making. Guidelines are suggested practices and procedures for the purpose of establishing common approaches, applied with discretion to account for site specific circumstances. Developing comprehensive guidelines is out of scope for the project. This section will focus the concepts, ideas and requirements for implementing the framework, and can form the foundation of a guideline document.

The framework is assumed to be implemented under the authority of the EPEA Director, subject to the Conservation and Reclamation Regulation:

> *3(1) The Director may establish standards, criteria and guidelines for conservation and reclamation of specified land and may develop and release information documents respecting those standards, criteria and guidelines.*
>
> *(2) An operator must*
> *(b) reclaim specified land*
> *In accordance with the applicable standards, criteria and guidelines that are established by the Director.*

Implementing the framework through the Director is advantageous in that updates to the framework, reclamation plans, approvals etc., all fall under the Director authority, thereby supporting a high level of integration and alignment of regulatory requirements.

Discussion of the use of the framework is further conducted under each of the seven stages of the criteria and indicator management concepts.

Mine Planning and Reclamation Criteria

The first stage in applying the criteria and indicator framework defines the relationship between top level mine planning and the framework (Figure 7). The framework provides guidance to Mine Plan, Annual Tailings Plan and Life of Mine Closure Plan in terms of defining the common outcomes described in the reclamation goal and objectives, and the criteria upon which success will be based. The mine plans and the criteria and indicator framework all influence the development of the Mine Reclamation Plan.

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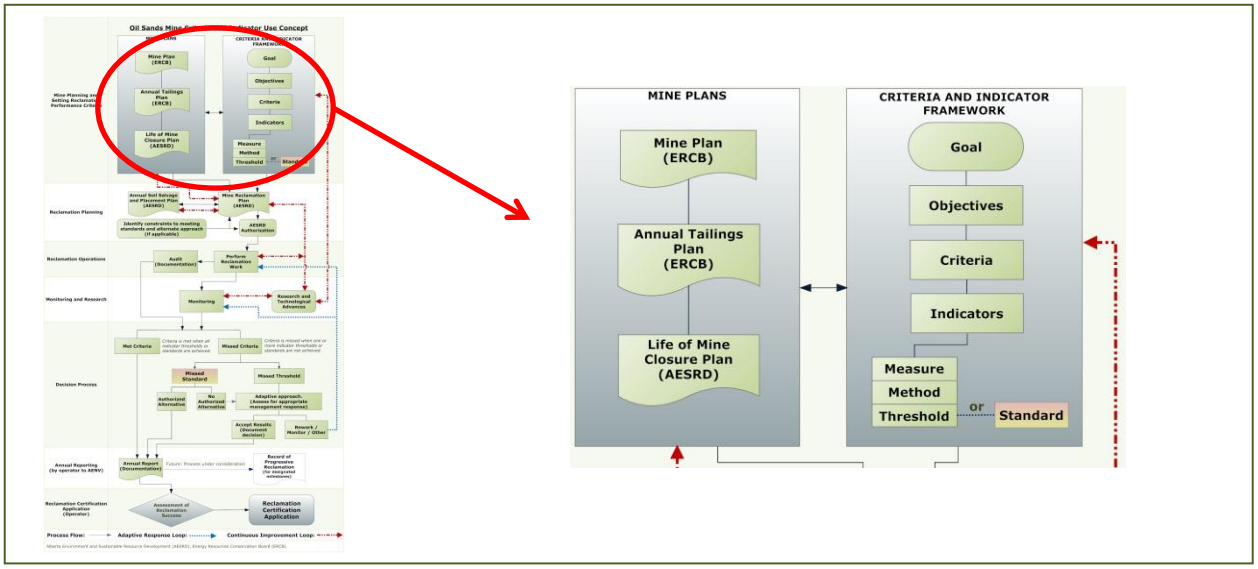

Figure 7: Mine Planning and Setting Reclamation Performance Criteria

Reclamation Planning

The relationships between the mine plans, the criteria and indicator framework, and the Mine Reclamation Plan (Figure 8) are key to applying the framework. Based on the conceptual design in the Life of Mine Closure Plan, the Mine Reclamation Plan is updated every three years and provides a rolling 10-year overview of the reclamation design at the landform and polygon scale (see Appendix 2, Fact Sheet 6). The Mine Reclamation Plan details the area and spatial distribution of planned ecosites on the landscape, including describing the work sequence, methods and technologies employed to achieve the reclamation objectives and criteria.

The Mine Reclamation Plan describes “how” the reclamation operations will be conducted to meet the reclamation criteria, and provides specific details regarding “when” and “where” the work will be performed within the 10-year outlook. Mine Reclamation Plans are typically updated every three years to enable adaptive responses that address changes to site conditions and commitments in other authorized operational plans, such as the Annual Tailings Management Plan. The Mine Reclamation Plan incorporates current best practices and evolving technologies to achieve reclamation outcomes.

The Mine Reclamation Plan is aligned to the Annual Soil Salvage and Placement Plan that includes annual tracking of reclamation material inventories. If a material imbalance is detected which negatively impacts planned work, for example an inadequate volume of cover soil, the operator must identify the constraint early in the planning process. Alternate approaches (including relaxing standards if applicable) are then proposed by the operator for authorization by the Director.

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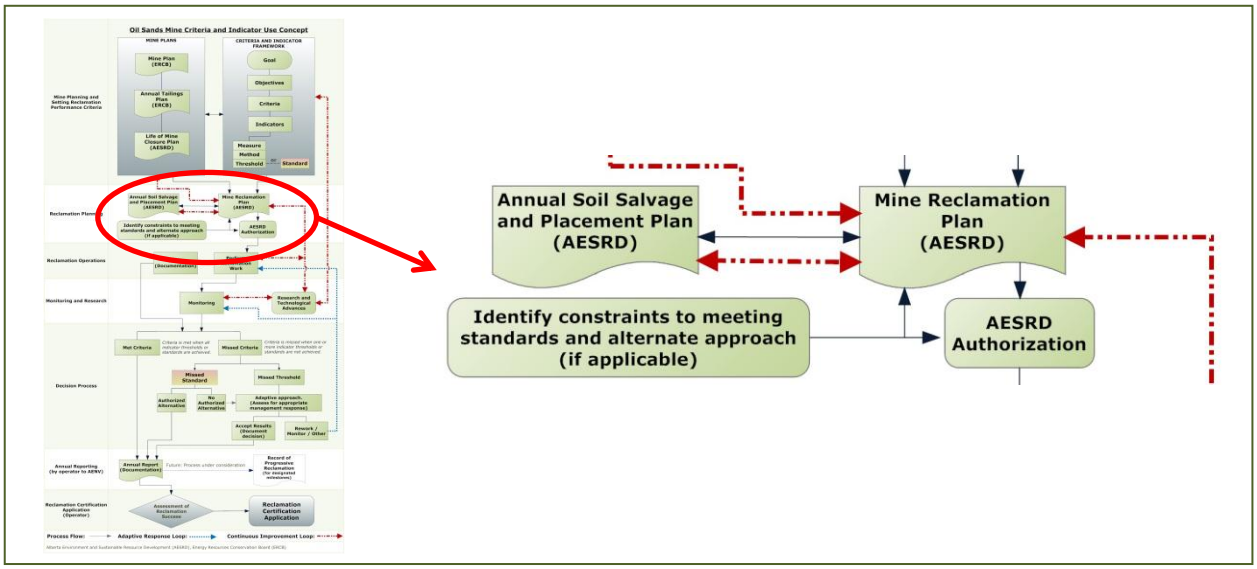

Figure 8: Reclamation Planning

Reclamation Operations

Reclamation operations (Figure 9) involve the implementation of the approved Mine Reclamation Plan utilizing cost effective reclamation procedures that reflect oil sands mine reclamation current best practices.

Audits (broadly interpreted as either internal quality control, operator self-audits, regulator audits or regulator inspections) determine if the reclamation work is being conducted as per the approved Mine Reclamation Plan and whether the reclamation indicators achieved the threshold or standard (e.g. cover soil depth). Audits are important for the following reasons.

1. Not achieving a threshold provides an opportunity to note and correct the situation, limiting the cost of correction at a later date. For example, identifying deficiencies in cover soil depth prior to tree planting may require the implementation of alternate management inputs. This may include the addition of coversoil, the application of fertilizer to achieve growth performance, or a decision to reclassify the site to a different ecosite than what was planned.
2. Audits validate the reclamation work was conducted as per the authorized plans, met regulator expectations and supports accurate reporting of progressive reclamation in the annual report.
3. The Alberta Conservation and Reclamation Regulation require the reclamation certificate applicant to declare that the operator has complied with all terms and conditions of applicable approvals [s.12(1)(vi)]. Documentation of audit results supports the declaration that must be signed by a company official at the reclamation certification stage.

Inspections conducted by an EPEA inspector are beneficial in providing the opportunity for the operator and inspector to collaborate on solutions to site specific reclamation issues, and discuss options for adaptive management responses. Copies of inspection forms, signed by both the inspector and operator representative, provide a record documenting compliance to regulatory requirements. This is important for the reclamation certificate application.

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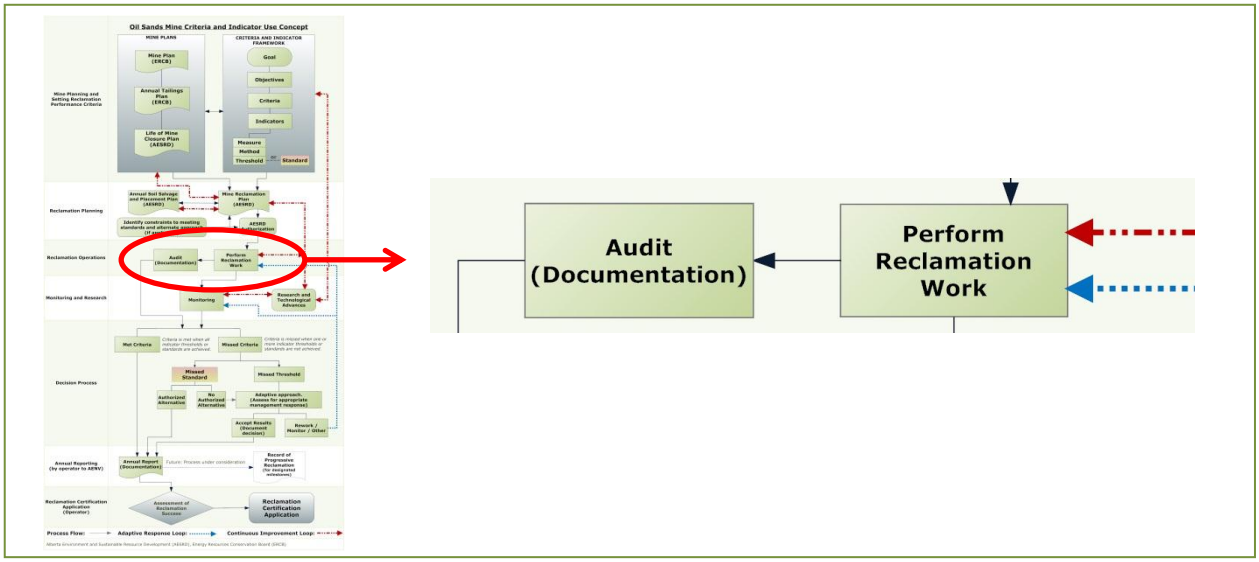

Figure 9: Reclamation Operations

Monitoring and Research

Monitoring is a critical component for evaluation of reclamation progress (Figure 10). Trend and performance indicators will be monitored over predetermined periods of time specific to the indicator. The criteria and indicator framework will establish common reclamation certification monitoring requirements among the oil sands mines. However, additional monitoring is expected to occur on the mine site and at regional scales, at the discretion of the companies who may have other commitments to fulfill. Research and innovation are aligned with the monitoring element of the framework. New knowledge and technological advances can be incorporated into adaptive processes of the framework. Research will support the development and calibration of new indicators that can be included into future framework updates.

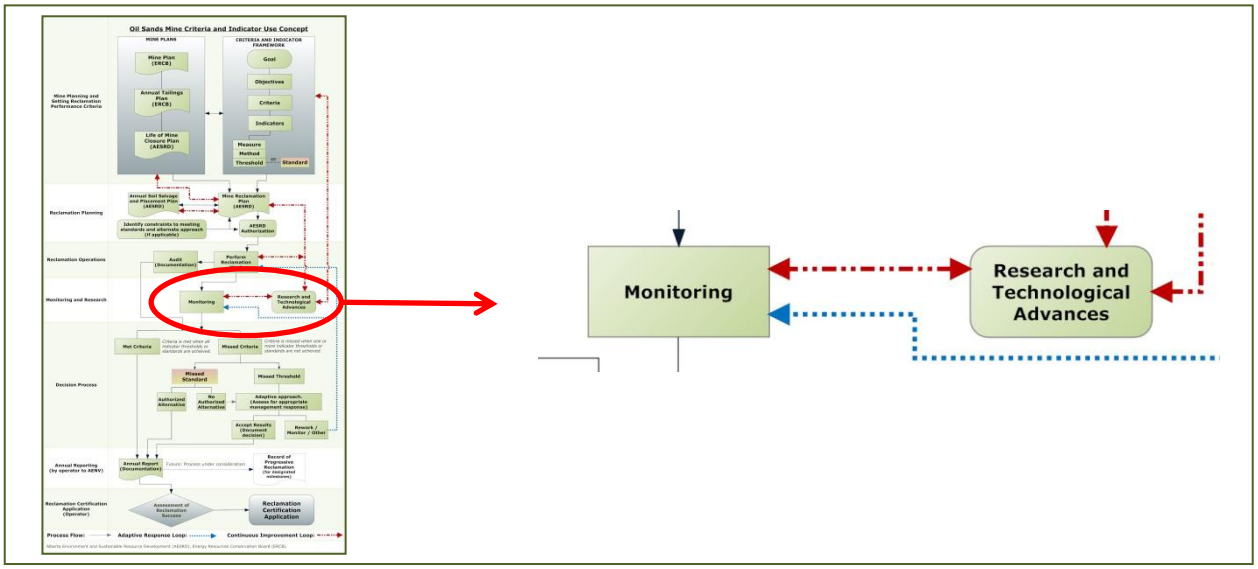

Figure 10: Monitoring, Reporting and Research

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Decision Process

Reclamation indicators are audited and/or monitored. The measurement results demonstrate progress towards achieving the criteria. Achieving the criteria implies the site is ready for reclamation certification. The decision process (Figure 11) is designed to account for the necessity of applying adaptive management responses if indicator thresholds are not achieved.

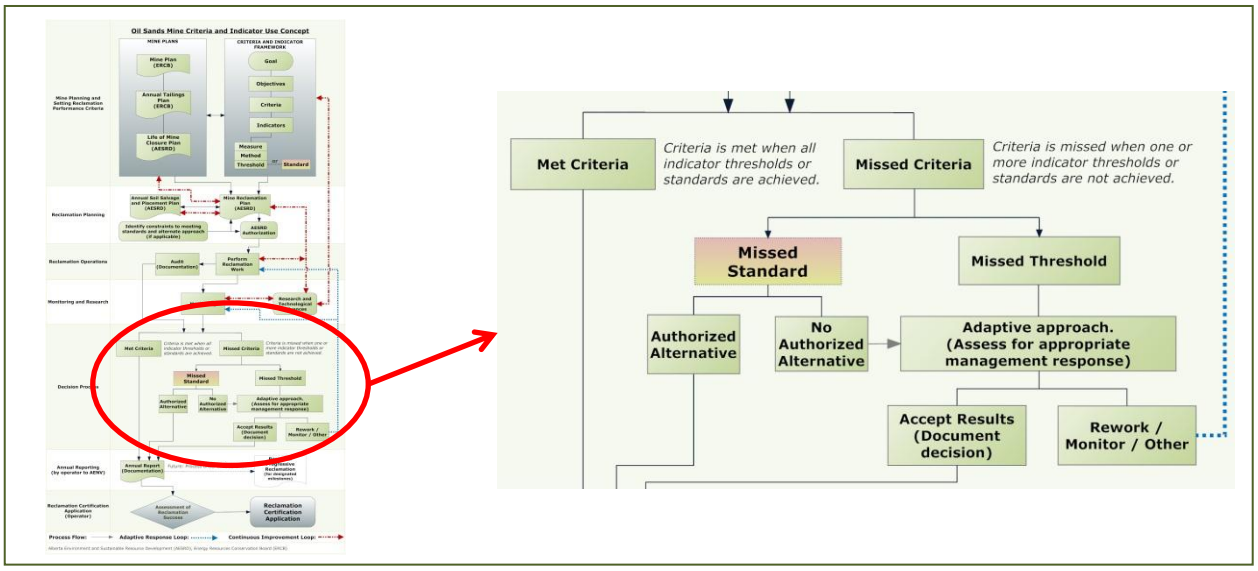

Figure 11: Criteria and Indicator Decision Process

The process flow differs depending if a standard is associated with the criteria.

Where a regulatory standard is set, the operator is responsible to achieve it, or to demonstrate that authorization was obtained for an alternate standard or approach. If authorization was obtained and the alternate requirements were achieved, the criteria are considered to be met. If authorization was not obtained, adaptive management response options will need to be considered to determine possible means to achieve the standard. The primary focus must always be to achieve compliance with standards.

If a threshold is not achieved (no standards apply), adaptive management responses can be formulated by the operator in collaboration with the regulator and stakeholders. Professional judgment is applied to identify the best adaptive management response. The decision process is adapted from processes used on surface mines in Australia (Nichols 2005) when mine completion criteria are not achieved.

Examples of adaptive management response options being considered include the following.

- Remedial work is required and suggested corrective actions are identified.
- Continued monitoring; more time may be required to properly assess a site, for example, environmental factors such as drought may have a short term negative impact on the reclamation progress.
- Reclassify an ecosite; early in the mine reclamation stages this may be a viable option, but opportunity to reclassify diminishes as the mine nears full reclamation status, especially if commitments to achieve certain ratios of ecosite are to be achieved.
- Declare an indicator not applicable.
    - The criteria and indicator framework is representative of the entire mine footprint. Applications for reclamation certification may only apply to a portion of the mine and may not represent all ecosites.

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For example, wetland reclamation indicators to establish aquatic vegetation would not be applicable for a site that is 100% upland

- For reclamation certificate applications on older reclamation sites, an indicator in the framework may not be representative of the approval conditions at the time the reclamation work was conducted. For example, criterion 1.5 Terrestrial and aquatic vegetation common to the boreal forest is established, would not apply on older reclamation sites, where non-native species were commonly planted under authorization by the regulator.

Whenever possible, the response action for not achieving an indicator, based on the predicted consequence of the failure, should be pre-determined. Using Table 6 as a template, it is possible for the operator and regulator to discuss the consequences should criteria be missed and a management response can be agreed to in advance. The table is intended to be included in the Mine Reclamation Plan, and after the plan is approved, the operator can initiate adaptive responses as required and without further authorization.

Table 6: Example of a Template for Adaptive Management Responses

Objective 1				
Criterion	**Indicator**	**Threshold**	**Regulatory Standard? Yes/No**	**Suggested Management Response (if *threshold/standard not achieved*)**
Criterion 1.1	Indicator 1.1.1			
	Indicator 1.1.2			
Criterion 1.2	Indicator 1.2.1			
	Indicator 1.2.2			
	Indicator 1.2.3			
Objective 2				
Criterion 2.1	Indicator 2.1.1			

Table 7 provides an example of a predetermined adaptive management response for missing an indicator.

Table 7: Example of an Adaptive Management Response

Objective 1: Reclaimed landscapes are established that support natural processes.				
Criterion	***Indicator***	***Threshold***	***Regulatory Standard? (Yes/No)***	***Suggested Management Response (failed threshold)***
1.5 Terrestrial and aquatic vegetation common to the boreal forest is established.	Indicator 1.5.1 Status of prohibited noxious weeds.	Absence of prohibited noxious weeds.	Yes	Herbicide or hand-pick weeds. Treat and monitor until weed free status over a two-year period is achieved.

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Annual Reporting

An annual report (Figure 12) is prepared by the operator and submitted to the regulator. Documentation can include:

- descriptions of the Mine Reclamation Plan implementation progress,
- plan adjustments to account for operational constraints,
- authorized alternate reclamation approaches, thresholds, or standards for a specific site,
- progress towards achieving the reclamation criteria based on monitoring and audit , and
- record of progressive reclamation milestones achieved (possible future process).

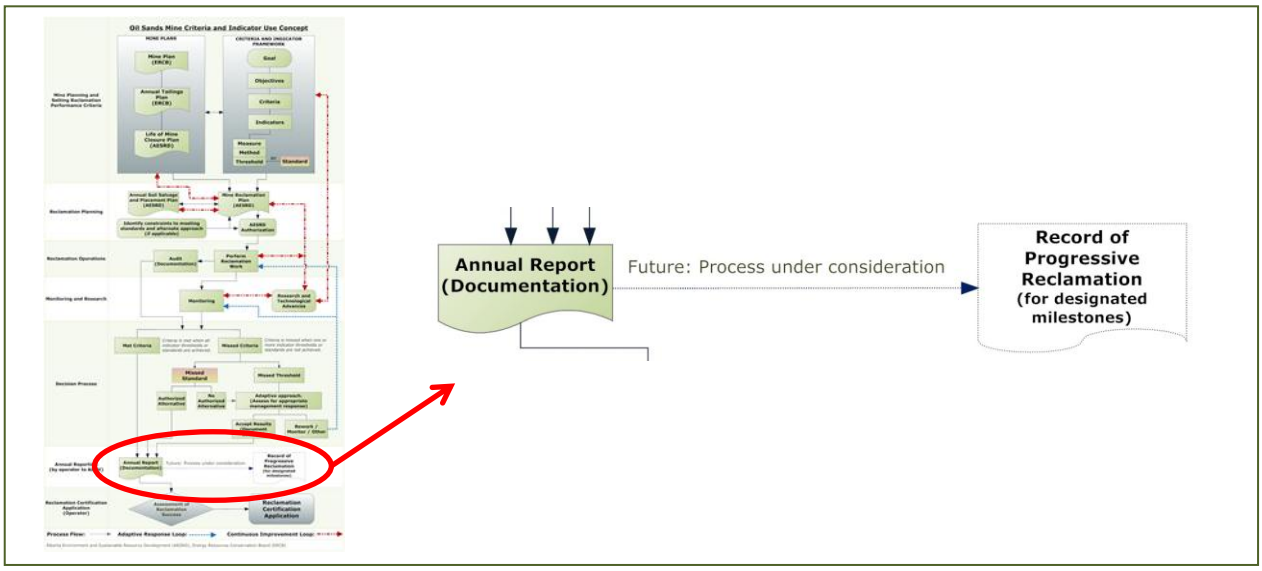

Figure 12: Annual Reporting

NOTE: Alberta's Environmental Protection and Enhancement Act refers to a Record of Progressive Reclamation (RPR) [s. 146(n.1/n.2/n.3)]. At this time, the GOA has committed to the principle of the RPR, but no regulatory process has been established. If the RPR was developed by the regulators, the framework could provide a structure for measure of the RPR milestones. Components of an RPR may include landform construction, cover soil placement & revegetation, all of which can be addressed within the framework. In the future, the RPR could be used to provide the regulators with a process to evaluate reclamation progress, clearly demonstrate milestone measures, and provide the necessary feedback regarding the achievements and expectations throughout the reclamation timeline. The criteria and indicator framework is being developed with the expectation that it will provide some of the components required to develop the milestone indicators and support the RPR process.

Reclamation Certificate Application

The reclamation certificate application is a formal regulatory process. Obtaining certification releases the operator from further reclamation obligations on the reclaimed land.

The oil sands mine reclamation certification criteria and indicators will support the reclamation certificate application by demonstrating that the regulatory requirements have been achieved and that the site is successfully reclaimed (Figure 13). Documenting the achievement of reclamation thresholds and standards in

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effect at the time the work was performed is a critical information requirement of the reclamation certificate application.

The operator is responsible for determining the readiness of a site for certification and completing the reclamation certificate application. The reclamation certification process includes the following.

- A pre-meeting.
- Submission of the reclamation certificate application.
- An administrative review of the application.
- A technical review of the content of the application.
- The field inquiry on the reclamation site.
- A decision on issuance of a reclamation certificate.

Key points of how the framework benefits the reclamation certification process includes the following.

- The framework will establish the scope of criteria on which the land parcel will be assessed.
- Documentation of the reclamation work conducted and results achieved are important aspects of the framework, which support the description of the history of reclamation work including the physical, chemical and land capabilities of the reclaimed land.
- The framework is aligned with regulatory requirements, therefore demonstrates that the approval conditions and regulatory requirements were complied with, supporting the operator's declaration.
- The framework criteria and indicators form the basis of the assessment, managing the risk of individual opinions imposing assessment criteria that may not be appropriate during the technical review.
- Formalizing the criteria for certification promotes fairness and equality between operators and transparency for government decisions.
- The framework will support a degree of consistency on the format and content of reclamation certificate applications, thereby streamlining the administrative and technical review processes.

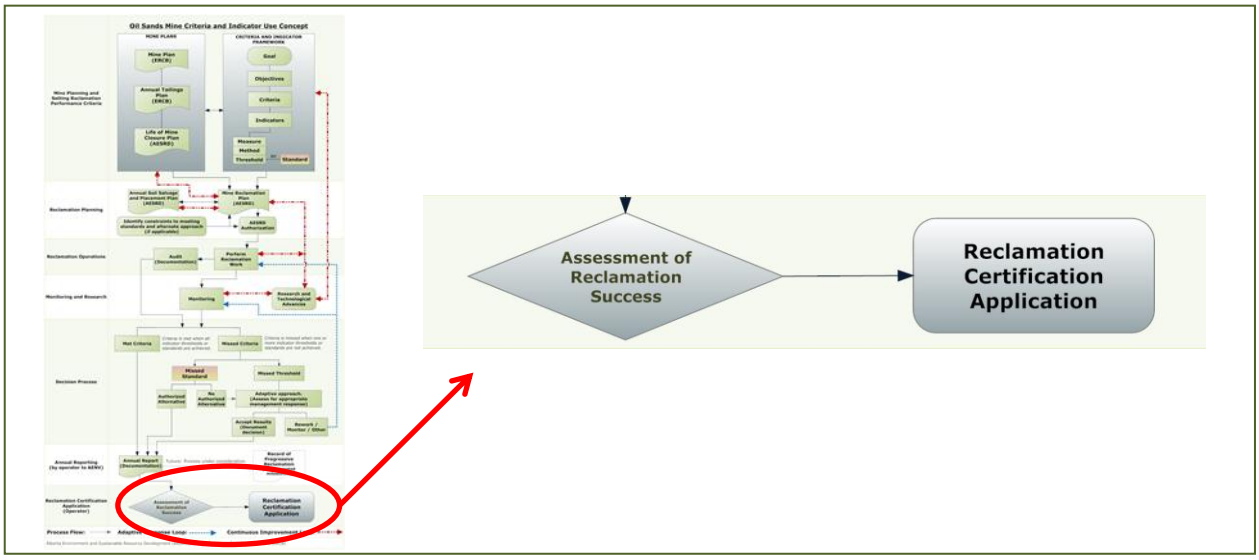

Figure 13: Reclamation Certificate Application

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CONSIDERATIONS FOR IMPLEMENTING THE CRITERIA AND INDICATOR FRAMEWORK

This report proposes an oil sands mine reclamation criteria and indicator framework design, including general concepts for its use, which are compatible with existing planning, regulatory and administrative processes. Implementing the framework will require further clarity and development of processes for consistency of its use. The framework must be both effective and implemented with efficiency to add value and provide benefits to both the operators and Regulators. The following represent some key considerations to guide the preparation of an implementation plan.

1. **Guidance Manual**

   A procedures manual would be beneficial to describe expectations of integrating the outputs of the framework into existing reclamation administration, regulatory and planning processes. For example the guidance manual could detail:
   a. Use of the framework on old reclamation sites verses new.
   b. How the outputs of the framework support reclamation certificate application and technical review process.
   c. How the adaptive management (decision) process will be used including:
      i. Use of the proposed adaptive management response template (Table 6) in the mine reclamation plans.
      ii. Expectations for collaboration between the operator and the regulator on adaptive management responses.

2. **Reclamation Monitoring**

   Reclamation monitoring protocols should be established in relation to the accepted indicators for consistent application across oil sands mines.

3. **Results Verification**

   Processes for verification of results are required. Verification on a routine basis should result in a streamlined reclamation certificate technical review. Verification can include any of the following examples:
   a. Audit
   b. Inspection
   c. Third party review and sign-off
   d. Professional sign-off

4. **Continuous Improvement**

   Establishing routine review periods for updating the framework content to account for new knowledge and technological advances in reclamation techniques will ensure the framework remains credible and defendable as a decision support tool.

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Indicator Gaps

Seven criteria have no indicators ready for use:

Number	Criteria
1.0	The landforms are integrated within and across lease boundaries
1.2	The landforms have natural appearance
2.3	Nutrient cycling is established on the reclaimed landscape
3.1	The reclaimed landscape provides for biodiversity
3.3	The reclaimed landscape provides for fish and wildlife habitat
3.4	The reclaimed landscape provides for opportunities for traditional uses
3.5	The reclaimed landscape provides opportunities for recreational uses

The RWG will need to critically review the twenty-three indicators classified as “acceptable – needs work” (Table 3) to determine which of those to include on future work plans and will support filling indicator gaps in the framework.

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CLOSING

The oil sands mines have a common reclamation goal established by government and a majority of the conditions on recent approvals are identical or very similar. Currently, each operator addresses the common mine approval conditions independently within their respective reclamation plans, risking a duplication of effort on development of reclamation criteria and measurement methods. This risk is increased particularly where objectives and criteria have not been fully developed within the common guidance documents in use (e.g. the Guideline for Wetland Establishment on Reclaimed Oil Sands Leases (2nd edition).

Benefits

The benefits for using the Oil Sands Mine Criteria and Indicator Framework within the current regulatory approach include:

- establishing common reclamation objectives,
- establishing common reclamation criteria,
- selecting common indicators, measures, and measurement methods,
- removing ambiguity and subjective interpretation of the approval conditions,
- encouraging collaboration between the operator and regulator on adaptive management responses,
- adapting management responses to achieve the reclamation objectives, and
- informing decisions through research and innovation.

Operator and regulator documentation that records reclamation progress and indicator measurements, especially the future progressive reclamation milestone indicators, will be critical for use of the framework to support reclamation certification decisions.

Use of the criteria and indicator framework informs the operator and regulator as to the readiness of the site for reclamation certification. By developing a criteria and indicator framework the focus of the Mine Reclamation Plan will shift to “how” the objectives will be achieved rather than on development of criteria, indicators and measurement methods.

Challenges

The challenges associated with implementing a criteria and indicator framework are primarily associated with the processes and procedures within Alberta’s regulatory environment and include the following.

- Oil sands mine approvals are updated every ten years and the timing of renewals is staggered between the mines; adding or changing approval clauses for one mine may impact the common criteria and indicators in the framework.
- The GOA does not have a specific list or document defining the oil sands reclamation standards; however some approval clauses specify standards that must be met.
- Reclamation plans (Mine Plan, Life of Mine Closure Plan, Mine Reclamation Plan etc.) are where operators define their landscape design, techniques and practices for achieving the reclamation objectives. The plans are approved by the regulator. Currently reclamation criteria may or may not be similar between the mines where the approval does not set specific standards, or where common reclamation guideline documents do not exist.
- Implementing the criteria and indicator framework will require a dedicated collaboration between government representatives and the operators to determine adaptive management responses.

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- Policy gaps cannot be addressed fairly and systematically without a framework that defines the approach. For example defining when new reclamation requirements take effect.
- The reclamation objectives and criteria are established for the footprint of the mine. The challenge is that reclamation certificate applications only represent a portion of the mine footprint. Determining whether objectives and criteria in the reclamation certificate application have been met may not be clear when only a portion of the mine site being assessed. For example, criteria for integrating the surrounding landscape may not be achievable if the adjacent landscape is actively being mined.

The challenges can be appropriately addressed within an implementation plan for the framework that includes defining appropriate direction and procedures in response to the challenges. The result will be greater clarity on the process and requirements for a parcel of land to be certified, benefiting both the operators and regulators.

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APPENDICES

Appendix 1 **Objective and Criteria Decision Factors**

Appendix 2 **Fact Sheets**

Appendix 3 **Instructions for the Recommendation of Indicators**

Appendix 4 **Indicator Screening Factors**

Appendix 5 **Indicator Recommendation Sheets**

Appendix 6 **External Review Instructions**

Appendix 7 **Additional Indicators Suggested During the Project**

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APPENDIX 1 - OBJECTIVES AND CRITERIA DECISION FACTORS

Decision factors for setting objectives:

- Consultation – the objectives meets the expectations of regulators and public.
- Objectives describe the range of what needs to be accomplished to achieve the goal.
- Objectives are attainable using cost effective best practice reclamation techniques.
- Objectives allow for technical limitations.
- Objectives reflect a whole-of-lease perspective.

Decision factors for selecting criteria:

- Consultation – the criteria meets the expectations of regulators and public.
- The suite of criteria selected includes both milestone criteria (to confirm that certain actions have been carried out at a point in time) and performance criteria (to confirm that restored natural functions or conditions attained and agreed threshold or standard).
- Criteria are aligned with regulatory requirements.
- Criteria, where appropriate is linked to reclamation milestones.
- Able to develop “triggers” towards response actions, i.e. if a criterion is not met (determined through not achieving one or more indicators), the cause can be determined and a risk assessment completed to determine response actions.

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APPENDIX 2 - FACT SHEETS

Fact sheets were developed early in the project to be used as a communication tool for informing project participants of the project and to establish common terminology and understanding of concepts.

Fact Sheet 1 *Criteria and Indicator Project Overview*

Fact Sheet 2 *Process for the Development of Criteria and Indicators for Oil Sands Mine Reclamation*

Fact Sheet 3 *Criteria and Indicator Framework Definitions*

Fact Sheet 4 *Use of Indicators*

Fact Sheet 5 *Factors for Indicator Selection*

Fact Sheet 6 *Scale*

Note: The Fact Sheets were written early in the project as communication tool between the RWG and sub-groups. Some definitions, process and diagrams may differ between the fact sheets and the final report content because of the iterative nature of the project. The main body of this report represents the final project results.

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RWG C&I Fact Sheet #1

May 25, 2011

Reclamation Working Group

Framework for Reclamation Certification Criteria and Indicators for Mineable Oil Sands—Production of Content and Guidance for Use

What is the criteria and indicator framework project and why is it important?

http://cemaonline.ca/

The oil and gas industry and the public share an expectation that reclamation of the oil sands mines will result in site conditions acceptable to stakeholders and fulfill regulatory requirements. The framework for oil sands mine reclamation certification will establish realistic and achievable objectives, criteria and indicators by which to measure reclamation success. The framework supports transparent decision processes and stakeholders will have a better understanding of how reclamation success and regulatory requirements will be measured.

The framework supports a common approach across all oil sands mines to:

- track the progress of reclamation,
- implement adaptive management actions when required,
- determine compliance with approval conditions and
- assess over-all reclamation success.

Development of the criteria and indicator framework within the Cumulative Environmental Management Association (CEMA) supports multi-stakeholder approach to the framework development. This approach strengthens the likelihood for acceptance of the final product by regulators, operators and stakeholders.

The criteria and indicator framework provides a comprehensive, consistent, transparent process to assess performance towards achievement of the reclamation goal and objectives, thereby informing decisions on the readiness of a site for reclamation certification.

Reclamation Working Group

For additional information contact:
RWG Program Administrator

Phone: 780-881-4943

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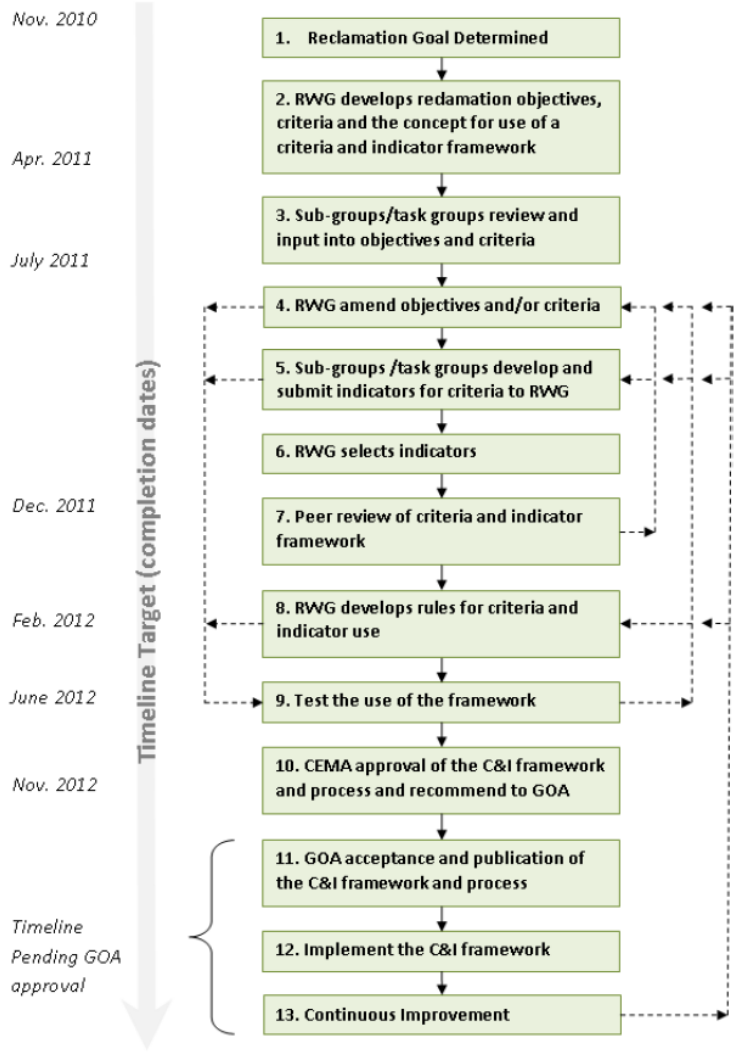
RWG C&I Fact Sheet #2

May 25, 2011

Reclamation Working Group

Process for the Development of Criteria and Indicators for Oil Sands Mine Reclamation

The process used to develop a criteria and indicator framework and project timelines are portrayed in the flow diagram, followed by a brief description of each step.



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RWG C&I Fact Sheet #2

January 11, 2011

Reclamation Working Group

Criteria and Indicator Project - Step Description

Step 1—The common reclamation goal determined to be appropriate for the framework is, *"Reclaim the land so that the reclaimed soils and landforms are capable of supporting a diverse, self-sustaining, locally common boreal forest, regardless of the end land use."*

Step 2—The Reclamation Working Group (RWG) will initially define the objectives, criteria and concept for use of a criteria and indicator framework. Reclamation objectives define the planned outcomes to achieve the goal. Objectives are set in the context of the region and are consistent with the reclamation plans. Objectives must be attainable using best reclamation practices, existing technology, and have a broad perspective over the mine footprint. Criteria describe the conditions to be met to determine achievement of the objective. The concept for using a criteria and indicator framework will be designed to support decisions as to readiness of a site for reclamation certification .

Step 3—The RWG will meet with the sub-groups and task groups to present results to date and obtain feedback into the objectives, criteria and concept for use of the criteria and indicator framework. This will occur through a one-day workshop.

Step 4—Feedback obtained in step 3 is considered by the RWG in their decisions to refine the objectives, criteria and concept for use of the criteria and indicator framework. The output of step 4 is a populated framework (goal, objectives and criteria) and use concept upon which to commence defining the indicators.

Step 5—The RWG will meet with the Sub-groups and task groups to provide direction for development of the indicators. Indicators define the measures to evaluate if a criterion has been met. Follow-up presentations to individual groups will be conducted for consistent messaging of the assignment and concepts for use of the framework.

Step 6—The RWG will review the indicators recommended by the Sub-groups and task groups and select indicators for inclusion into the framework using the screening factors described in Fact Sheet #3.

Step 7—The RWG will initiate a peer review (process to be defined) of the criteria and indicator framework and concept for use that will validate the soundness of the framework for it's use in measuring reclamation performance towards achieving the goal. Feedback from the peer review will be considered by the RWG and amendments made to the framework accordingly.

Step 8—Building on the use concept, the RWG will develop the process and associated rules for implementing the criteria and indicator framework within the Alberta regulatory system. This includes formalizing the process for determining response actions if a criterion is not met, the frequency of reviewing and updating the criteria, monitoring requirements etc.

Step 9—Testing (to be defined) will determine the practicality, cost effectiveness, monitoring requirements and potential constraints of implementing the criteria and indicator framework.

Step 10—The criteria and indicator framework final report , including the RWG recommendations, will be presented to the CEMA Board of Directors. The Board of Directors will review the final report and CEMA stakeholders will have opportunity to comment prior to the Board's decision on whether to accept the recommendations or not.

Step 11— Subject to the CEMA Board of Directors approval, the final report and recommendations will be submitted to the Government of Alberta (GOA), through Alberta Environment, for GOA review and consideration for acceptance as a GOA document.

Step 12—Assuming GOA acceptance, the criteria and indicator framework will be implemented among the oil sands mines. The GOA may need to develop guidelines or processes to support implementation.

Step 13—The criteria and indicator management concept has a continuous improvement cycle for regular review and improvement to criteria and indicators based on new knowledge, new technology or policy changes.

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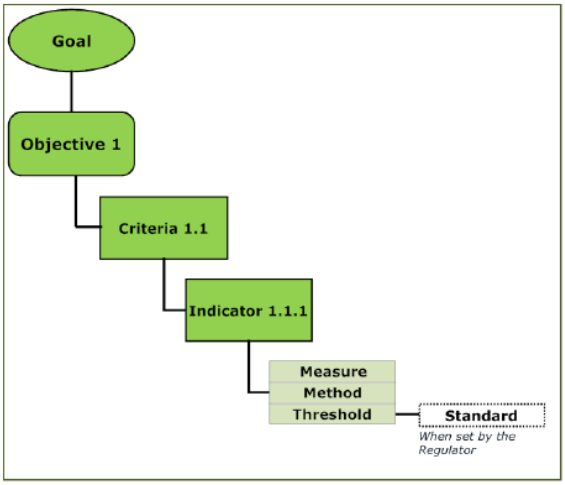
RWG C&I Fact Sheet #3

May 25, 2011

Reclamation Working Group

Criteria and Indicator Framework Definitions

What are the definitions of terms used in the criteria and indicator framework?



Goal: The final result or outcome toward which effort is directed.

Objective: A purpose toward which a reclamation effort is directed.

Criteria: (plural) A category of conditions or processes by which the achievement of a reclamation objective is assessed. A *Criterion* (singular) is characterized by one or more related *indicators* which are used to determine success or to assess change over time.

Indicator: An attribute which can be measured or described and used to evaluate if a *criterion* has been met.

Measure: A qualitative or quantitative aspect of an *indicator*; a variable which can be measured (quantified) or described (qualitatively) and demonstrates either a trend in an *indicator* or whether or not a specific *threshold* was met.

Method: A description of a way, technique, process or procedure for attaining a *measure*.

Standard: A definite rule established by authority. Environmental standards often take the form of prescribed numerical values that must be met.

Threshold: The quantitative point at which an action is triggered.

Natural Ecosystem Functions: The interactions between organisms and the physical environment, such as nutrient cycling, soil development, primary productivity or water budgeting.

http://cemaonline.ca/

Reclamation Working Group

For additional Information contact: RWG Program Administrator

Phone: 780-881-4943

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RWG C&I Fact Sheet #4

May 25, 2011

Reclamation Working Group

Use of Indicators

For what purpose are indicators used in the framework?

Indicators define an attribute that can be measured or described and are used to evaluate if a criterion has been achieved (by comparing the value of the variable being measured against the threshold value set for the indicator). Indicators support the measurement of milestones, performance and trends:

Milestone Measurement

Measurement of a milestone, a physical characteristic of reclamation work at a specific point in time in the mine life cycle, informs reclamation practitioners that planned work was conducted and a prescribed standard was met. The result is documented and the indicator does not have to be re-measured, unless there is a need to track changes over time. Meeting reclamation milestones does not guarantee reclamation success; reclamation performance will need to be demonstrated.

For the purpose of the framework, milestones will be determined through the RPR process under consideration by the GOA. The three RPR milestones, used as examples at this time are landform construction, cover soil placement and revegetation. Meeting milestones provides the reclamation practitioner with a degree of certainty to proceed with the next step in the reclamation process. For example, upon meeting the landform construction milestone criteria, cover soil placement can commence.

Performance Measurement

Indicators not associated with the RPR are used to evaluate reclamation performance for the associated criterion. Performance measurement informs reclamation practitioners of the level of performance for the indicator, measured against established thresholds.

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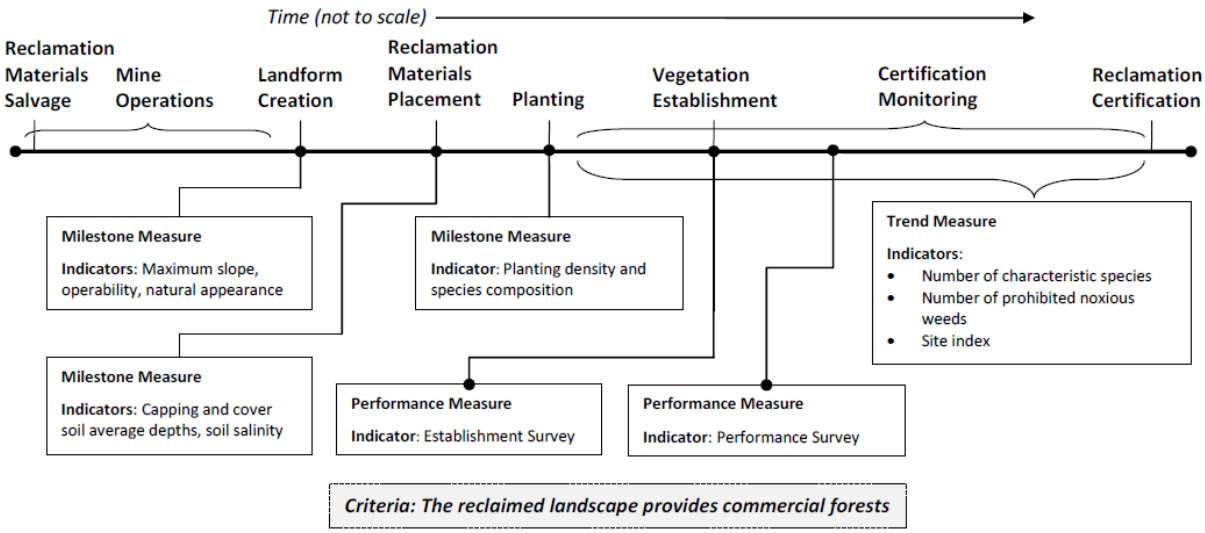
Trend Measurement

Trend measurement is conducted through repeated measurement of indicators over a period of time. Understanding trends informs reclamation practitioners that the site is trending towards achieving a planned outcome. Trend results are often compared to a threshold for determining success. The threshold is established through using a reference condition approach. For example, monitoring indicators of vegetation health and/or vigour over a period of time without management intervention, as a determination of self-sustainability, would be compared to reference site conditions. Should a natural event such as a drought occur, with negative regional consequences to vegetation health, such comparisons will figure prominently in determining an adequate management response.

Below is an example of the use of milestone and trend based indicators in the mine life cycle for the establishment of a commercial forest stand.



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RWG C&I Fact Sheet #5

May 25, 2011

Reclamation Working Group

Factors for Indicator Selection

What are the factors that the RWG will consider during the indicator selection process?

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The Reclamation Working Group (RWG) will evaluate and select a suite of indicators from those recommended by Sub-groups and task groups. The selected indicators will be included in the reclamation certification criteria and indicator framework.

A priority is to identify indicators aligned to the EPEA approval. Reclamation certification is in part dependent upon the operator demonstrating that the EPEA approval conditions have been met. Proposed indicators do not have to be aligned with an EPEA approval condition; if they are not, an explanation of the indicator value in determining reclamation success is required.

There may be indicators recommended that are not ready for implementation, but are of a high interest and value. For example, an indicator may not have an established standard or measurement method. In such cases the RWG will require an explanation of the outstanding work and time required to prepare the indicator for use.

Information will be provided to Sub-groups and task groups on the submission process and development of indicators, including guidance on choosing a variable as an indicator and use of the reference condition approach. Indicators already in use, recognized in existing guidance documents, should be identified for inclusion in the framework.

The Reclamation Working Group (RWG) will consider the following factors when screening the indicators for inclusion into the framework:

Reclamation Working Group

For additional information contact:
RWG Program Administrator

Phone: 780-881-4943

Category	RWG Screening Considerations for Indicator Selection	Yes	No
Effectiveness	Is the indicator useful/definitive, when used in the prescribed circumstances, in distinguishing that the criterion was met?		
	Does it draw a distinct line between what is acceptable and what is not acceptable?		
Soundness	Is the indicator based on scientific research or widely held or accepted principles?		
	Is the indicator measureable?		
	Is the measurement of the indicator replicable?		
	Does an acceptable common measurement method exist?		
	Is the indicator responsive (high signal to noise ratio)?		
Practicality	Is measurement of the indicator technically feasible?		
	Can the indicator be applied now using existing technology and methods?		
	Is the effort and cost to measure the indicator reasonable in relation to its value?		
	Is the indicator aligned to an EPEA approval condition?		

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RWG C&I Fact Sheet #6

Date: April 20, 2011

Reclamation Working Group

Scale

What are the various scales that influence criteria and indicator design?

Scale is an important consideration for the design and use of criteria for oil sands mine reclamation. Criteria and indicators will not be developed for each scale. Policy and plans at the provincial, regional and sub-regional scales will often influence reclamation objectives rather than the criteria. Reclamation criteria and indicators will be designed to accommodate reclamation measurement at the *mine footprint* scale, with the understanding that some indicators may only be applied at a landform or polygon scale.

Following are descriptions and examples of scale:

Regional: A portion of the province, such as the Lower Athabasca Region, defining administrative boundaries for specific purposes, such as the Land Use Framework planning.

Sub-region: A portion of a region defining administrative boundaries for specific purposes, such as the mineable oil sands area, where a higher level of planning can occur.

Mine Footprint: The land on which an operator has applied and received regulatory approval for, under the *Environmental Enhancement and Protection Act* (EPEA), for the development of a mine and/or processing plant. A *Surface Minerals Lease*, overlapping the mine footprint, is issued subject to the *Public Lands Act* authorizing surface access to the land.

Landform: A portion of the mine footprint, often determined by mining operational uses such as an overburden dump, tailings area, etc. that are progressively reclaimed upon completion of their operational use. The mining operational use will often influence the type of '*landform*' that can be reclaimed on the site, for example an upland area such as a hill on a tailings dump, verses a wetland complex on a relatively level tailings area.

Polygon: A portion of a landform reclaimed to a planned ecotype, such as a commercial coniferous forest or a specific wetland type.

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Reclamation Working Group

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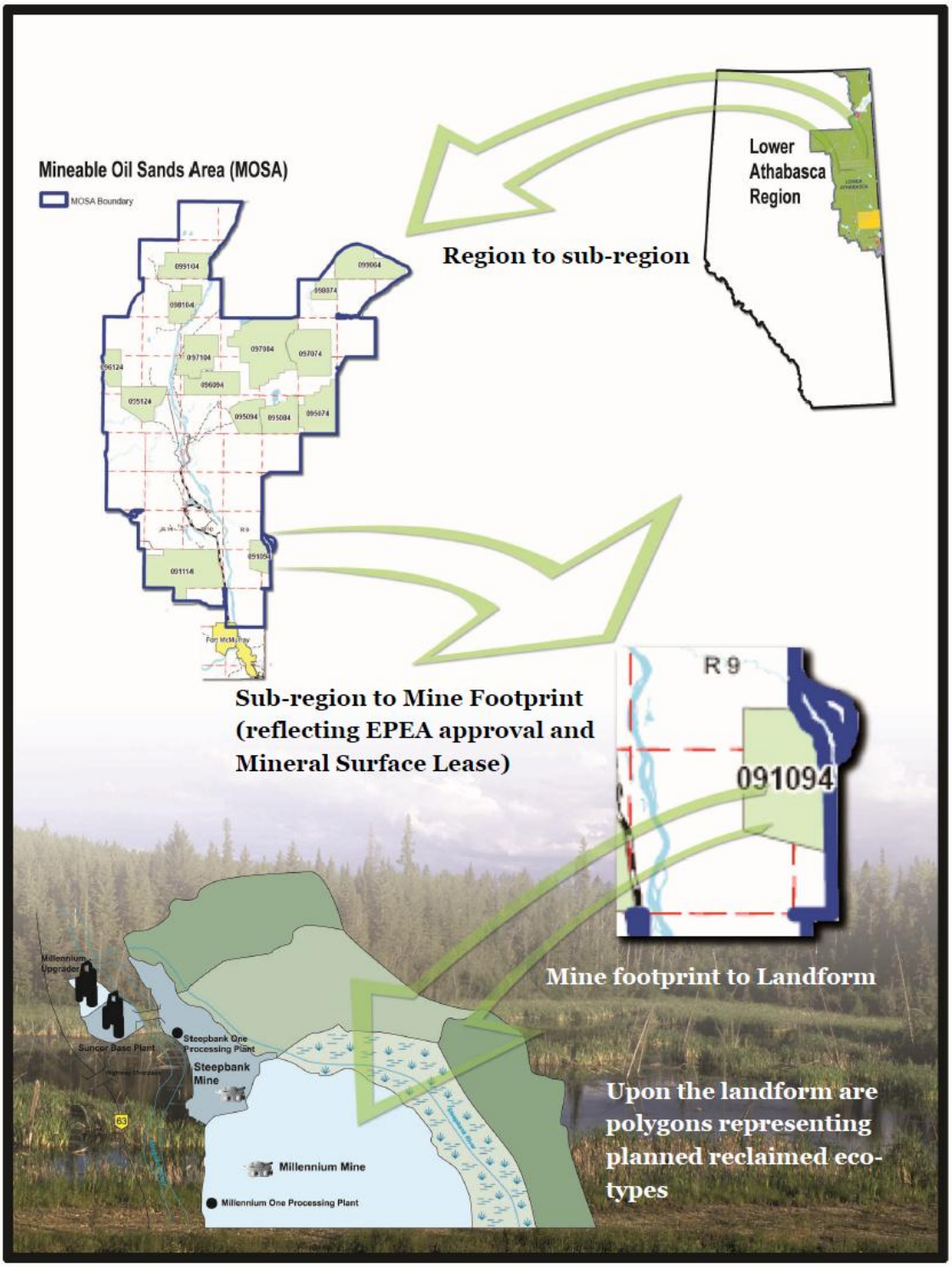

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APPENDIX 3 - INSTRUCTIONS FOR THE RECOMMENDATION OF INDICATORS

Indicator Recommendation Process

On June 22, 2011 the RWG will assign its sub-groups and task groups to identify and recommend indicators for the reclamation criteria listed in Table 1.

Table 8: Oil Sands Mine Reclamation Goal, Objectives and Criteria

GOAL: The reclaimed soils and landforms are capable of supporting a diverse, self-sustaining, locally common boreal forest landscape, regardless of the end land use.	
Objective 1:	**Reclaimed landscapes are established that support natural ecosystem functions.**
Criteria	1.1 The landforms are integrated within and across lease boundaries. 1.2 The landforms have a natural appearance. 1.3 The landscape and its landforms incorporate watershed features such as surface drainage, lakes and wetlands. 1.4 Reclamation materials are placed appropriate to the landform. 1.5 Terrestrial and aquatic vegetation common to the boreal forest is established. 1.6 The landforms have geotechnical stability.
Objective 2:	**Natural ecosystem functions are established on the reclaimed landscape.**
Criteria	2.1 The reclaimed landforms have the necessary water quality. 2.2 The reclaimed landforms have the necessary water quantity. 2.3 Nutrient cycling is established on the reclaimed landscape. 2.4 Ecosystem productivity is established on the reclaimed landscape. 2.5 Reclaimed ecosystems display characteristics of resilience to natural disturbances and climatic variability.
Objective 3:	**Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses.**
Criteria	3.1 The reclaimed landscape provides for biodiversity. 3.2 The reclaimed landscape provides commercial forests. 3.3 The reclaimed landscape provides for fish and wildlife habitat. 3.4 The reclaimed landscape provides opportunities for traditional uses. 3.5 The reclaimed landscape provides opportunities for recreational uses.

Considerations for indicator identification include:

- alignment to approval condition requirements,
- indicators from existing guideline documents,
- indicators presently being developed within RWG work plans.

The first priority is to identify indicators that are fully developed and ready for implementation, having an established measure, method, and threshold. The RWG is also interested in reviewing valid indicators that are not ready to implement. Direction will be provided on recommended indicators not selected for the first version of the framework. The expectation is that some indicators will be included into the framework in future updates after they have been fully developed.

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IMPORTANT DATES

Groups will submit their recommendations to the RWG by **October 31, 2011** using the template example in this document for each indicator being recommended. A separate template will be provided after the June 22, 2011 workshop.

The groups will present their recommendations to the RWG at a workshop on **November 15, 2011**. Greater detail on the recommended indicators can be provided through the presentations than is being requested in the template.

In **December 2011** the RWG will finalize the criteria and indicator framework based on the recommendations from the groups and subject to approval by the RWG.

The RWG will select the indicators to be included in the framework considering the factors presented in Table 2. Groups do not have to complete Table 2 but should be aware of its use by the RWG.

Table 9: Reclamation Working Group Screening Considerations for Indicator Selection

Category	RWG Screening Considerations for Indicator Selection	Yes	No
Effectiveness	Is the indicator useful/definitive, when used in the prescribed circumstances, in distinguishing that the criterion was met?		
	Does it draw a distinct line between what is acceptable and what is not acceptable?		
Soundness	Is the indicator based on scientific research or widely held or accepted principles?		
	Is the indicator measureable?		
	Is the measurement of the indicator replicable?		
	Does an acceptable common measurement method exist?		
	Is the indicator responsive (high signal to noise ratio)?		
Practicality	Is measurement of the indicator technically feasible?		
	Can the indicator be applied now using existing technology and methods?		
	Is the effort and cost to measure the indicator reasonable in relation to its value?		
	Is the indicator aligned to an EPEA approval condition?		

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Following is an example of the template, including instructions on the information to be submitted and the process for submission.

Group Name [1]		Submitted by [2]		Date [3]	
Objective [4]		Criterion [5]			
Describe the indicator being recommended. [6]					
Provide a brief statement on the value of the indicator. [7]					
Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]				**Yes** ☐	**No** ☐
If yes, state the document and page number: [9]					
List references related to the recommended indicator (research paper, journal article etc.): [10]					
Does the indicator need to be measured in every polygon? [11]				**Yes** ☐	**No** ☐
Briefly explain: [12]					
Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]				**Yes** ☐	**No** ☐
Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]					
Measure:					
Method:					
Threshold:					
If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]					
Is the indicator aligned to an EPEA approval condition? [16]				**Yes** ☐	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]					

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General Instructions:

- Recommendations must be received by the RWG by **October 31, 2011**.
- Email the completed recommendations to Theo.Charette@cppenv.ca
- Complete a template for **each indicator** being recommended.
- Direct questions to **Theo Charette**, RWG Technical Program Manager, ph. 780-701-7716 or email.
- Submit your recommendation in a concise manner; maximum two pages. Groups will have opportunity to present their recommendations in detail directly to the RWG at a working session on **November 15, 2011**.

Instructions for completing the template for indicator recommendations:

1. Enter the sub-group or task group name.

2. Enter the name of the individual submitting the indicator recommendation for the group. This individual will be the primary contact for questions or inquiries regarding the recommendation.

3. Submission date.

4. State the most appropriate objective of the three framework objectives that the indicator supports (see page 10 of the Criteria and Indicators Approach for Oil Sands Mine Reclamation for a list of the objectives and criteria). For example, *Objective 1: Reclaimed landscapes are established that support natural ecosystem functions.*

5. State the most appropriate criterion from those under the objective you selected in #4. For example, *Criterion 1.1 The landscape and landforms are integrated within and across lease boundaries.*

6. Describe the indicator being recommended.

7. Provide a brief statement of the value of the indicator. Examples of value are means to measure achievement of a specific milestone or demonstration of an important characteristic of reclamation performance.

8. Disclose whether the indicator is presently in use in the oil sands mines, answer yes or no (*double click on the desired check box and select "checked" as the default value*).

9. If the answer to #8 is yes, reference the guideline document or mine reclamation plan, including page numbers.

10. List references supporting the development or use of the indicator.

11. Indicate if the indicator needs to be measured on every polygon, answer yes or no.

12. Briefly explain your answer to #11.

13. Disclose if the indicator is fully developed; meaning it has an established measure, method and threshold as defined in the criteria and indicator framework, answer yes or no.

14. Describe the **existing** or **proposed** measure, method and threshold for the indicator in the appropriate fields. For **proposed** measures, methods and thresholds indicate whether they are ready to implement or will need to be further developed. If they need to be developed, provide details in field #15.

15. If the indicator is not fully developed, briefly summarize the estimated effort, time and direct costs to fully develop the indicator.

16. Disclose if the indicator is aligned to an EPEA approval condition, answer yes or no.

17. If you answered yes to #16 provide the condition number and corresponding EPEA approval.

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APPENDIX 4 - INDICATOR SCREENING FACTORS

Indicator:_____

Category	RWG Screening Considerations for Indicator Selection	Score (circle your choice)
Effectiveness	Is the indicator useful/definitive, when used in the prescribed circumstances, in distinguishing that the criterion was met?	Not useful----------Somewhat useful----------Very useful 1 2 3 4 5
	Does it draw a distinct line between what is acceptable and what is not acceptable?	Not distinct---------Somewhat distinct--------Very distinct 1 2 3 4 5
Soundness	Is the indicator based on scientific research or widely held or accepted principles?	Not widely accepted -----Somewhat (research -----Very accepted ongoing) 1 2 3 4 5
	Is the indicator measureable?	Very difficult----------Results uncertain-------Results very certain 1 2 3 4 5
	Is the measurement of the indicator replicable?	Not replicable--------Somewhat replicable----------Very replicable 1 2 3 4 5
	Does an acceptable common measurement method exist?	No method---Method under development---Established method 1 2 3 4 5
	Is the indicator responsive (high signal to noise ratio)?	Not responsive-------Somewhat responsive-------Very responsive 1 2 3 4 5
Practicality	Is measurement of the indicator technically feasible?	Not feasible----------Somewhat feasible----------Very feasible 1 2 3 4 5
	Can the indicator be applied now using existing technology and methods?	No----------Technology/methods under development----------Yes 1 2 3 4 5
	Is the effort and cost to measure the indicator reasonable in relation to its value?	Not reasonable-------Somewhat reasonable------Very reasonable 1 2 3 4 5
	Is the indicator aligned to an EPEA approval condition?	No alignment----------Indirect Alignment-------Specific Alignment 1 2 3 4 5
Reviewer Comments		

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APPENDIX 5 - INDICATOR RECOMMENDATION SHEETS

Indicator 1: Soil Moisture

Group Name [1]	**Terrestrial Sub-Group**	Submitted by [2]	*Names removed*	Date [3]	August 23, 2011
Objective [4]	1. Reclaimed landscapes are established that support natural ecosystem functions. 2. Natural ecosystem functions are established on the reclaimed landscape.	Criterion [5]	1.4 Reclamation materials are placed appropriate to the landform. 2.2 The reclaimed landforms have the necessary water quantity. 2.5 Reclaimed ecosystems display characteristics of resilience to natural disturbances and climatic variability.		

Describe the indicator being recommended. [6]

Soil moisture - Available water-holding capacity (AWHC) is estimated for the profile (1.0 m) based primarily on texture and depth of reclamation materials, with modification for organic horizons, coarse fragments, impermeable layers and layering.

Provide a brief statement on the value of the indicator. [7]

For Objective 1, Criterion 1.4, soil moisture is considered a hard, milestone indicator to be measured in every polygon. Under this objective, soil moisture provides a preliminary check on whether the AWHC of the reclamation cover and underlying substrate aligns with the revegetation target. Profile AWHC including adjustment for layering may be more useful than soil moisture regime (SMR), if the focus is solely on capacity without the landscape effect which accounts for receipt and withdrawal through slope position and aspect, respectively. This needs to be debated. Soil moisture regime supports decision making for Revegetation Purposes. Revegetation Plan is based on SMR. Audit of reclamation materials placement could potentially be used as a milestone indicator to support achieving targets.

For Objective 2, Criteria 2.2 and 2.5, soil moisture is considered an intermediate indicator to be measured in a research and monitoring program for the purpose of conducting trend analysis to support adaptive management processes.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

Land Capability Classification for Forest Ecosystems in the Oil Sands, Volume 1, 3rd edition, (LCCS), pp. 25-37. AWHC is part of the determination of SMR.

List references related to the recommended indicator (research paper, journal article etc.): [10]

References are included in the aforementioned document.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐

Briefly explain: [12]

This is indicator is part of the LCCS audit that typically follows placement of reclamation material.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Available Water Holding Capacity.
Method:	The method is described in the LCCS. As indicated above, we need to resolve whether profile AWHC with adjustment for layering is more useful than SMR.
Threshold:	Thresholds would be defined contingent on the revegetation target.

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If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
AWHC with adjustment for layering should be formalized as a pedotransfer function under the criteria described by: McBratney, A.B., B. Minasny and G. Tranter. 2011. Necessary meta-data for pedotransfer functions. Geoderma 160:627-629. As such, it might provide input data for using a scheme like that of: Elshorbagy, A. and S.L. Barbour. 2007. Probabilistic approach for design and hydrologic performance assessment of reconstructed watersheds. Journal of Geotechnical and Geoenvironmental Engineering 133:1110-1118. Further development is within the scope of routine work carried out for TSG.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☐	**No** ☒
If yes, what is the condition number and corresponding EPEA approval? [17]		
N/A		

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Indicator 2: Soil Macronutrients (Nitrogen and Phosphorus)

Group Name [1]	**Terrestrial Sub-Group**	Submitted by [2]	*Names removed*	Date [3]	August 23, 2011
Objective [4]	1. Reclaimed landscapes are established that support natural ecosystem functions. 2 - Natural ecosystem functions are established on the reclaimed landscape.	Criterion [5]	1.4 Reclamation materials are placed appropriate to the landform. 2.3 Nutrient cycling is established on the reclaimed landscape. 2.4 Ecosystem productivity is established on the reclaimed landscape.		

Describe the indicator being recommended. [6]

For Objective 1, Criterion 1.4, soil macronutrients (Total nitrogen (N) and phosphorus (P) pool) are considered as a soft, milestone indicator to be measured in every polygon.

For Objective 2, Criteria 2.3 and 2.4, available N and P are considered as intermediate indicators to be measured in a research and monitoring program for the purpose of conducting trend analysis to support adaptive management processes.

Nitrogen (N) availability can be assessed by various measurements. In this case a laboratory-based incubation method (either aerobic or anaerobic) is recommended. Any chemical measurement is used to assess the mineral N made available over time through turnover of litter and soil organic matter. An indicator of this type would provide what is currently lacking in the Land Capability Classification for Forest Ecosystems in the Oil Sands, Volume 1, 3rd edition,)—a scientifically defensible, empirical assessment of soil nutrient regime.

Phosphorus is a major plant nutrient. Unlike other nutrients such as nitrogen, it cannot be added to the reclaimed landscape by biological processes. Moreover, even P added as fertilizer tends to be tied up in soil before reaching the plant. Hence cycling and availability of P are particularly important.

Provide a brief statement on the value of the indicator. [7]

Objective 1:

Total N and P are to be measured as part of the LCCS audit to provide a preliminary check on whether the total nutrient pool of the reclamation cover and underlying substrate aligns with the revegetation target.

Objective 2:

Nitrogen is the primary (but not the only) nutrient determining plant productivity in the boreal forest. While N availability at a specific site can be best assessed through foliar analysis, a complementary soil measurement is required for a preliminary assessment of N availability before vegetation becomes fully established. It may inform a management response.

Measurement of available P content would (a) confirm the capacity of reclamation materials to supply P for plant growth and (b) indicate re-establishment of effective nutrient cycling. As vegetation develops on reclaimed lands, foliar analysis can provide an alternative for objective (a).

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☐	**No** ☒

If yes, state the document and page number: [9]

N/A

List references related to the recommended indicator (research paper, journal article etc.): [10]

Available nitrogen was recommended by the following study carried out for TSG and other funding sources (AERI Agreement Number 1719): Chang, S.X., E. Yan and Y. Hu. 2010. Soil nitrogen indicators for land reclamation policy development for forest ecosystems in the oil sands regions of Alberta.

Fact Sheet 23: Lanoue 2003. Phosphorus content in boreal forest soils. In "Soil Capping Reclamation Research," Volume 2: Fact Sheets, March 2007. Other literature complements some of the measurements made on natural sites. The fact sheet provides a basis for asking other relevant questions and then searching the current literature.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☒

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Briefly explain: [12]		
For Objective 1, Criteria 1.4, soil macronutrients should be measured in every polygon to document soil nutrient regime as a milestone indicator following placement. For Objective 2, Criteria 2.3 and 2.4, available N and P should be measured in a research and monitoring program which could be applied to every polygon. Yet it may be adequate to apply the indicator to a subset of polygons that represent combinations of type of reclamation cap, underlying substrate and landscape location. As vegetation develops, nutrient availability will be more dependent on turnover of recent litter. As indicated above, as vegetation develops this indicator will be superseded by foliar analysis. Available P might better focus on the different kinds of soil cover designs, rather than every polygon. While it is already measured for the long-term plot network, a better methodology is needed.		
Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒
Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]		
Measure:	Objective 1: Total N – Kjeldahl method as described in the LCCS (AENV 2006) Objective 2: Available N – The proposed measure is the laboratory-based incubation method, which may be aerobic or anaerobic (see Chang et al. 2011). Available P content – How this is measured depends to some extent on the kind of soil.	
Method:	Objective 1: Total N use method in LCCS (AENV 2006). Total P – to be determined Objective 2: Available N – This is a standard method in soil science, described in various methods manuals and the scientific literature. Available P – For soils where most of the available P is derived from a sparingly soluble inorganic pool, a chemical extraction such as the Kelowna method may be adequate. For soils where P is made available from organic pools such as recent plant litter and microbial biomass, a simple chemical extraction may not be adequate. In this case it may be as important to assess turnover rate as well as pool size. In both cases the significance of mycorrhizae must be considered.	
Threshold:	Objective 1: The threshold would be that Total N and P at placement align with the revegetation target based on soil nutrient regime and edatopic grid. Objective 2: Available N may lend itself to categories (rich versus poor), rather than a numerical threshold. Would it also be specific to a particular stand type (e.g., aspen, white spruce or jack pine)? Available P - It would be difficult to define a threshold for this measure. It is likely unnecessary if foliar analysis is also used.	

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If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
Objective 1: method for measuring Total P needs to be developed. Objective 2: Available N as an indicator is in the early stages of development. The next step would be to apply the approach used in the study of Chang et al. (2010) to the reclaimed plots of the long-term plot network, focusing on older sites. At the very least, the range of values obtained on reclaimed plots can be compared with those obtained for natural plots by Chang et al. (2010). Attention must also be given to whether the indicator is informative across different soil moisture regimes or significant differences in soil texture, or whether it is only informative when these conditions are relatively uniform. Available P as an indicator is in the early stages of development. Further study is required to identify the best method and could be integrated into the long-term plot network through the Plot Network Task-Group of TSG. The question of whether sampling for effective mycorrhizae is necessary and if so how to do it must also be addressed. While phosphatase activity measurements have been used to infer availability of P, it is only in the rare (exceptional) study where this enzyme activity was not regulated by organic C content (at either proximate or distal scales). Where the cycling of P through the developing vegetation strongly influences P availability, any assessment early in the sequence of reclamation may not provide much assurance.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☐	**No** ☒
If yes, what is the condition number and corresponding EPEA approval? [17]		
N/A		

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Indicator 3: Soil pH

Group Name [1]	**Terrestrial Sub-group**	Submitted by [2]	*Names removed*	Date [3]	Oct 11, 2011
Objective [4]	1. Reclaimed landscapes are established that support natural ecosystem functions. Objective 2 - Natural ecosystem functions are established on the reclaimed landscape.	Criterion [5]	1.4 Reclamation materials are placed appropriate to the landform. 2.3 Nutrient cycling is established on the reclaimed landscape. 2.5 Reclaimed ecosystems display characteristics of resilience to natural disturbances and climatic variability.		

Describe the indicator being recommended. [6]

Soil pH

Provide a brief statement on the value of the indicator. [7]

Soil pH is a required parameter for assessing the land capability subclass (V) in LCCS (2006, see page 47). Typically, this indicator is used to calculate the land capability % deduction factor due to limiting conditions of soil reaction (Fig. 2 of section 4.1, p 23 of LCCS). This indicator affects the bioavailability of soil nutrients through chemical speciation or nutrient bio-cycling. It is also used to evaluate the quality and suitability of soil materials for material salvage and land reclamation.

Objective 1:

Soil pH is defined as a milestone, hard indicator to be measured in every polygon as part of the placement LCCS audit to provide a preliminary check on whether the soil pH of the reclamation cover and underlying substrate aligns with the revegetation target. The EPEA approvals set limits around soil pH regarding placement of reclamation materials.

Objective 2:

Soil pH is defined as an intermediate indicator to be measured in a research and monitoring program for the purpose of conducting trend analysis to support adaptive management processes.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

Land Capability Classification System for Forest Ecosystems in the Oil Sands (LCCS) (Alberta Environment 2006), see pages 6, 23, 47 etc.

Soil Quality Criteria Relative to Disturbance and Reclamation (Alberta Agriculture 1987), see page 20, Table 5, page 27, Table 8.

List references related to the recommended indicator (research paper, journal article etc.): [10]

References are included in the above noted documents. Also see Best Management Practices for Conservation of Reclamation Materials in the Mineable Oil Sands Region of Alberta (Alberta Environment and Water 2012), pages 32-33 under "soil characterization" and page 34 under "adaptive management". The indicator is widely recognized in mainstream publications in soil, forest and ecology fields.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐

Briefly explain: [12]

The indicator needs to be determined for all principal soil horizons for each pedon for determination of land capability classes within a map polygon (pages 16 and 19 of LCCS). It is part of the minimum analytical requirements for assessing disturbed lands and non-selective handling areas (see pages 20 and 27 in the Soil Quality Criteria Relative to Disturbance and Reclamation document).

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Soil pH in water suspension is the accepted method in Table 5 of LCCS (2006, see page 19).

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Method:	1:1 ratio of soil weight to water volume in Section 3.12 of McKeague (1978) or 1:2 of the above noted ratio as in section 16.2 of Carter (1993), both methods are referenced in Table 5 of LCCS (2006).
Threshold:	Percent deduction factor as tabulated in Table 13 of LCCS (2006, see page 47) for adjusting the Base Rating item in LCCS (i.e. the sum of ratings for soil moisture regime and nutrient regime).

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

CEMA stakeholders agreed that quantitative relationships between the soil pH factor and land capability classification system are yet to be established for the oil sand region of Alberta. A phased-research approach has been adopted to address the issue. Currently, a research team at U of A is conducting two major projects to advance the work, under the guidance of CONRAD, with CEMA fund.

Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐

If yes, what is the condition number and corresponding EPEA approval? [17]

The indicator is found in the approval for "Total", on page 7 (item kkk) to define "suitable overburden" mentioned in sections 6.3.1 (page 56) and 6.3.15(a) (page 56) for considering possible adjustments of minimum average depths for coversoils and subsoils. It should normally be used to assess the soil chemical properties after placement of reclamation materials required in section 6.3.23(c). The Soil Quality Criteria Relative to Disturbance and Reclamation and LCCS documents are entrenched in slightly older approvals, such as that for "Fort Hills", in section 2.3.1(e)iii, and sections 5.2.10 (Table 5.2A) and 5.2.40 for land capability class determination.

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Indicator 4: Soil Salinity

Group Name [1]	**Terrestrial Sub-Group**	Submitted by [2]	*Names removed*	Date [3]	August 23, 2011
Objective [4]	Objective 1 - Reclaimed landscapes are established that support natural ecosystem functions. Objective 2 - Natural ecosystem functions are established on the reclaimed landscape.	Criterion [5]	1.4 Reclamation materials are placed appropriate to the landform. 2.4 Ecosystem productivity is established on the reclaimed landscape. 2.5 Reclaimed ecosystems display characteristics of resilience to natural disturbances and climatic variability.		

Describe the indicator being recommended. [6]

Salinity of topsoil as defined for the reconstructed profile in Land Capability Classification for Forest Ecosystems in the Oil Sands, Volume 1, 3rd edition, (LCCS). While the method of measurement is described in the LCCS, its interpretation follows that in Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands (Revegetation Manual).

Defined in Section 5.5 of the Revegetation Manual: "For reclamation purposes, forested habitat can be established over reclaimed landforms anticipated to be saline; however, there are limits to acceptable surface soil salinity (e.g., 4 dS/m) for the establishment and growth of tree species, and expectations for productive stands or commercial forestry would be unrealistic…. Although salinity is a soil property covered in the LCCS, it is included as a hard indicator in this manual because of its direct implications for successful establishment of vegetation communities, as above."

Provide a brief statement on the value of the indicator. [7]

Objective 1:

Soil salinity is defined as a hard, milestone indicator to be measured in every polygon as part of the placement LCCS audit to provide a preliminary check on whether the soil pH of the reclamation cover and underlying substrate aligns with the revegetation target. The Revegetation Manual sets limits around soil pH regarding placement of reclamation materials.

Objective 2:

Soil salinity is considered as an intermediate indicator to be measured in a research and monitoring program for the purpose of assessing salinity risks (i.e., saline sodic overburden dump) to support adaptive management processes. Salts will be prevalent in the reclamation material cap at some positions on the reconstructed landscape.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (AENV 2010) Section 5.4, p. 55

List references related to the recommended indicator (research paper, journal article etc.): [10]

References are included in the aforementioned document.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐

Briefly explain: [12]

Objective 1:

Soil salinity is part of the LCCS audit that typically follows placement of reclamation material

Objective 2:

In the context of the Revegetation Manual see Section 5.5.2:

"For the purpose of application of this manual, soil salinity would only be tracked on polygons where existing information or previous experience would indicate that it could present a limitation to vegetation growth. In all other cases, the only monitoring necessary would

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be a one-time post-placement confirmation of low salinity levels (e.g., through an LCCS audit)."			
Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]		**Yes** ☒	**No** ☐
Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]			
Measure:	Electrical conductivity (EC) of topsoil expressed as dS m^{-1}.		
Method:	The method is described in the LCCS and referred to in the Revegetation Manual.		
Threshold:	Table 5-12, p. 60, Revegetation Manual, defines thresholds for target end land-use which would be applicable to Objective 1 LCCS audit results. The maximum topsoil EC for commercial forestry and a forested ecosystem are 2 and 4 dS m^{-1}, respectively.		
If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]			
Reclamation Classification System Task Group has identified soil salinity as a component of a reclamation classification system which requires a method to be defined to describe the spatial extent of soil salinity across a reclamation classification unit. Revegetation Manual states that methods to describe soil salinity are undergoing assessment and may be modified. No specific TSG project is addressing soil salinity measurement methods at this time. Thresholds may differ based on soil texture. Salinity in coarse-textured subsoil may affect vegetation more than in fine-textured subsoil. No metric defined for subsoil.			
Is the indicator aligned to an EPEA approval condition? [16]		**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]			
Indirectly. The Total approval specifies a limit of 5 dS m^{-1} for EC in suitable overburden that may contribute to the reclamation material cap, but not for topsoil per se.			

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Indicator 5: Soil Depth

Group Name [1]	**Terrestrial Sub-group**	Submitted by [2]	*Names removed*	Date [3]	April 18, 2012
Objective [4]	Objective 1- Reclaimed landscapes are established that support natural ecosystem functions.	Criterion [5]	1.4 Reclamation materials are placed appropriate to the landform.		

Describe the indicator being recommended. [6]

Soil Depth

Provide a brief statement on the value of the indicator. [7]

Soil depth is a milestone indicator assessed at placement as part of an LCCS audit. Soil depth provides documentation that (1) the coversoil placement strategy is sufficient to support the establishment of land capability appropriate to the specified reclamation outcomes and (2) that coversoil placement aligns with EPEA approval conditions.

The Best Management Practices for Conservation of Reclamation Materials in the Mineable Oil Sands Region of Alberta (Alberta Environment and Water 2012) provides guidance for soil placement to address the following:

1. EPEA approvals require operators to place soil covers that provide similar land capability classes to pre-disturbance land capabilities. The Revegetation Manual (Alberta Environment 2010) directs operators to utilize the LCCS in the development of an appropriate soil-cover design to reclaim similar ecosystem structure and function to that of native plant communities.
2. EPEA approvals require operators to place a minimum depth of 1.0 m of suitable overburden or tailings sand on substrates such as: lean oil sands, rock, rejects from the oil sands conditioning and transport system, consolidated tailings, Clearwater overburden, material from processing plant areas and coke.
3. EPEA approvals require operators to place a minimum depth of coversoil over suitable overburden and tailings sand.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

Land Capability Classification System for Forest Ecosystems in the Oil Sands (LCCS) (Alberta Environment 2006), see p. 5 (Fig. 1) for general profile illustration, p. 8, Table 1 to p. 24, Fig. 2 on impact to soil water availability, and p. 40 section. 4.3.3 on nutrient retention, etc.

Soil Quality Criteria Relative to Disturbance and Reclamation (Alberta Agriculture, 1987), see p. 10 soil profile characterization, p. 11-15 regarding soil assessments and Table 3 regarding soil depth and salvage methods for soils.

Best Management Practices for Conservation of Reclamation Materials in the Mineable Oil Sands Region of Alberta (Alberta Environment and Water 2012), pp. 104-128.

List references related to the recommended indicator (research paper, journal article etc.): [10]

1. The Canadian System of Soil Classification (Soil Classification Working Group 1998);
2. Soil Quality Criteria Relative to Disturbance and Reclamation (Alberta Agriculture 1985);
3. Land Capability Classification System for Forest Ecosystems in the Oil Sands (Alberta Environment 2006;
4. Best Management Practices for Conservation of Reclamation Materials in the Mineable Oil Sands Region of Alberta (Alberta Environment and Water 2012)

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐

Briefly explain: [12]

The LCCS provides operators a tool to help determine placement depths of coversoil (Alberta Environment 2006).

The indicator needs to be determined for all principal soil horizons for each pedon for calculation of land capability classes within a map polygon (p. 20, section 3.5.2, p 23-24 of LCCS for assessment of soil available water).

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Depth of reclaimed soils in the oil sands region is divided according to topsoil (0-20 cm), upper subsoil (20-50 cm) and lower subsoil (50-100cm) (p. 23-24 LCCS) for assessment of land capability classes. The upper 1.5 m of soils is assessed against soil quality indicators in Tables 8 and 9 in Alberta Agriculture (1987) for suitability and methods of soil salvage.
Method:	Field soil assessments methods based on LCCS (Alberta Environment 2006), and/or by Alberta Agriculture (1987).

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Threshold:	The threshold for the soil depth indicator is the specified soil depth outlined in the applicable EPEA approval condition. The soil depth threshold will depend on the coversoil materials and the reclamation objectives.

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
Oil sands stakeholders under CEMA and CONRAD have arranged various applied research projects to study the effects of thickness and different placement arrangements of LFH materials, peat mineral mix, top soil and subsoil, and soil capping depth to advance our understanding on the effects and use of this indicator.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
The indicator is found in the Total approval on pp. 55-56 to define the depth of soil placement for reclamation (e.g., an averaged min. of combined depth of 50cm cover soil and subsoil over reclaimed areas, and an averaged min. capping depth of 1.0m of tailing sands or suitable overburden materials over a list of undesirable materials.). Similar requirements are also found in Horizon's approval (pp. 43-44 to define depth requirements in soil placements for reclamation.).		

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Indicator 6: Ecosystem Net Primary Productivity (Site Index)

Group Name [1]	**Terrestrial Sub-group**	Submitted by [2]	*Names removed*	Date [3]	Sep 7, 2011
Objective [4]	Objective 2 - Natural ecosystem functions are established on the reclaimed landscape. Objective 3 - Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses.	Criterion [5]	2.5 Reclaimed ecosystems display characteristics of resilience to natural disturbances and climatic variability. 3.2 The reclaimed landscape provides for commercial forests.		

Describe the indicator being recommended. [6]

Ecosystem Net Primary Productivity (NPP)

Provide a brief statement on the value of the indicator. [7]

Defined in the Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (AENV 2010), herein referred to as the Revegetation Manual. From Section 5.4 of the Revegetation Manual: "Due to the limitations … in measuring or estimating actual NPP, this manual adopts site index as a proxy measure of NPP. Site index is defined as the height of top-height trees (the 100 largest-diameter, dominant or co-dominant, undamaged/unsuppressed trees per ha) in a relatively pure, even-aged, well- stocked stand, at breast height age 50 years. Site index is considered a useful measure of productivity because it is relatively density independent, and because no other single measure better reflects the inherent capacity of a site for forest production (Huang 1994). It should be noted that the TSG is actively exploring more direct metrics/estimates of NPP for future use.

Objective 2:

To evaluate Objective 2, Criterion 2.5, site index is defined as a soft indicator to be assessed in every polygon. The results would demonstrate that the reclaimed landscape is achieving site index values within the natural range of variation of the reference conditions.

Objective 3:

To evaluation Objective 3, site index is defined as a hard indicator and is restricted to reclaimed sites with a target primary end land-use of commercial forestry. Sites designated for wildlife habitat or traditional use will be evaluated based on Objective 2.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (AENV 2010) Section 5.4, p. 55

List references related to the recommended indicator (research paper, journal article etc.): [10]

References are included in the aforementioned document.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☐	**No** ☒

Briefly explain: [12]

See Revegetation Manual Section 5.4.2. – only those designated to commercial forest end land use.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Site Index

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Method:	See Section 5.4.2, p. 56 Site index should be assessed using standard forestry mensuration methods on the same plots used for plant community composition (Section 5.3.1).
Threshold:	Objective 2: Thresholds to be determined. Objective 3: Applicable to reclaimed sites designated to commercial forest end land use only. See Table 5.11, p. 58 Threshold site index values are based on minimum/mean values for the ""Fair" " Timber Productivity Rating (TPR) Class, converted to be applicable to top-height, growth-intercept site index estimates on reclaimed sites. For each assessed reclamation polygon, the mean site index for the leading species must meet or exceed the specific minimum value referenced in Table 5-11.

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
FPTG is developing a vegetation re-establishment and modelling approach for reclaimed landscapes which includes defining a monitoring program to collect site index data to develop and calibrate a model to predict site index on reclaimed lands. Total investment in five year work plan is: $240,000		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
Total approval states: Condition 6.3.28 "The approval holder shall reclaim disturbed land to achieve, at a minimum, the site index and other growth and yield attributes specified in any ecosite phase growth and yield table template provided by the Director, unless otherwise authorized in writing by the Director." The phrase site index is not in the Fort Hills approval.		

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Indicator 7: Plant Community Composition - Characteristic Species

Group Name [1]	**Terrestrial Sub-group**	Submitted by [2]	*Names removed*	Date [3]	Sep 7, 2011
Objective [4]	Objective 1 - Reclaimed landscapes are established that support natural ecosystem functions.	Criterion [5]	1.5 Terrestrial and aquatic vegetation common to the boreal forest is established.		

Describe the indicator being recommended. [6]

Plant Community Composition – Characteristic Species

Provide a brief statement on the value of the indicator. [7]

Characteristic species is defined as a hard indicator to be measured in every polygon and to be compared to the thresholds defined in Table 5.3 of the Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (AENV 2010), herein referred to as the Revegetation Manual. From Section 5.3 of the Revegetation Manual: "one of the primary goals of revegetation programs is re-establishment of vegetation communities characteristic of the locally common boreal forest. This indicator and the designated measures are intended to assess the success of reclamation actions in reaching this goal. In this manual, the term "plant community composition" refers to both presence and abundance of species."

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (AENV 2010) Section 5.3, p. 45

List references related to the recommended indicator (research paper, journal article etc.): [10]

References are included in the aforementioned document.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐

Briefly explain: [12]

See Revegetation Manual Section 5.3.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Characteristic species
Method:	Characteristic Species: 100 m^2 species inventory; sample intensity level to be determined (Contract 2011-0016)
Threshold:	Characteristic Species: thresholds in Table 5.3 in Revegetation Manual; currently under review in Contract 2011-0029

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

1. Characteristic Species: Contract 2011-0016=$147,305; Contract 2011-0029=$120,710

Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☐	**No** ☒

If yes, what is the condition number and corresponding EPEA approval? [17]

N/A

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Indicator 8: Plant Community Composition – Weeds

Group Name [1]	**Terrestrial Sub-group**	Submitted by [2]	*Names removed*	Date [3]	Sep 7, 2011
Objective [4]	Objective 2 - Natural ecosystem functions are established on the reclaimed landscape.	Criterion [5]	2.5 Reclaimed ecosystems display characteristics of resilience to natural disturbances and climatic variability.		

Describe the indicator being recommended. [6]

Plant Community Composition - Weeds

Provide a brief statement on the value of the indicator. [7]

Weeds are defined as a hard indicator to be measured in every polygon and to be compared to the thresholds defined in the Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (AENV 2010), herein referred to as the Revegetation Manual. From Section 5.3 of the Revegetation Manual: "one of the primary goals of revegetation programs is re- establishment of vegetation communities characteristic of the locally common boreal forest. This indicator and the designated measures are intended to assess the success of reclamation actions in reaching this goal. In this manual, the term "plant community composition" refers to both presence and abundance of species."

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (AENV 2010) Section 5.3, p. 45

List references related to the recommended indicator (research paper, journal article etc.): [10]

References are included in the aforementioned document.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐

Briefly explain: [12]

See Revegetation Manual Section 5.3.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☒	**No** ☐

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Number of Restricted Weeds (which as of 2010 are known as Prohibited Noxious Weeds)
Method:	Number of Prohibited Noxious Weeds – Follow *Alberta Weed Control Act*
Threshold:	Number of Prohibited Noxious Weeds – zero; as defined by the act and Revegetation Manual

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

not applicable

Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐

If yes, what is the condition number and corresponding EPEA approval? [17]

With respect to the Soil Salvage Plan there is a condition that states:

"The Soil Salvage Plan referred to in subsection 3.6.26 shall include, at a minimum, all of the following, unless otherwise authorized in writing by the Director:

… the methods to be used to prevent and/or mitigate the presence of weeds on stockpiles and disturbed lands."

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Indicator 9: Plant Community Composition - Diversity, Richness, Evenness and Abundance

Group Name [1]	**Terrestrial Sub-Group**	Submitted by [2]	*Names removed*	Date [3]	Sept. 28, 2011
Objective [4]	Objective 1 - Reclaimed landscapes are established that support natural ecosystem functions. Objective 3 - Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses.	Criterion [5]	1.5 Terrestrial and aquatic vegetation common to the boreal forest is established. 3.1 The reclaimed landscape provides for biodiversity.		

Describe the indicator being recommended. [6]

Plant community composition (diversity, richness, evenness, abundance)

Provide a brief statement on the value of the indicator. [7]

Plant community composition - diversity, richness, evenness and abundance is defined as intermediate indicator to be measured in a research and monitoring program for the purpose of plant community composition to support adaptive management processes.

Reclamation practices need to support the establishment, growth and reproduction of native boreal forest plant species in order to establish critical components of biodiversity and to meet broader reclamation objectives such as self-sustaining boreal forest ecosystems.

The Revegetation Manual describes the hard indicator "characteristic species" as one measure of plant community composition. However, the characteristic species indicator is mostly relevant in measuring whether plant community organization is similar to desired and specific site type targets. Measuring and reporting on values of plant community composition may be used to simply report on the return of plant biodiversity to the reclaimed landscape without making specific reference to the community organization of plant species in relation to the abiotic soil and nutrient conditions associated with target site types. In addition, rather than strict interpretation of plant community composition in terms of meeting threshold values of characteristic species, trends can be described over time – e.g., native boreal species richness at the plot, polygon or landform scale; plant community similarity indices which compare reclaimed plots or polygons with those from reference systems (plot, stand, landform).

Plant community composition can be a trend based indicator – these are measures for which collection and interpretation is required on all reclaimed polygons, but for which certification thresholds do not exist at this time. Because these measures are trend-based, as opposed to threshold-based, their interpretation requires repeated data collection over time. These measures are included because they are central to the concept of demonstrating that reclaimed vegetation communities are on a trajectory towards communities more like those that existed prior to disturbance. However, these measures do not require dedicated data collection, as they can be calculated from the same information used for the threshold-based indicators (e.g., from plot data providing species presence and abundance).

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (2010)

Page 54 section 5.3.7

Page 83 appendix B Table B.4

List references related to the recommended indicator (research paper, journal article etc.): [10]

See appendix B in revegetation manual (Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region) for a detailed description along with some references.

Additional synthesis work could be done to more closely look at plant community development after fire and after harvest in NW Alberta experimental plots or in NE Alberta in the context of making the data of relevance to reclamation objectives.

See:

- emendproject.org, or
- http://www.alpac.ca/content/files/Boreal%20Forest%20Fire%20and%20Harvest%20Residual%20Comparison.pdf

for two examples of comprehensive studies on early stand development in Alberta boreal forest stands.

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Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐
Briefly explain: [12]		
This measure has relevance at the polygon scale since local performance will not only be a function of soil handling and revegetation practices. Establishment of broader plant communities will rely on sustained immigration and establishment over time.		
Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒
Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]		
Measure:	See Table B.4 revegetation manual (Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region 2010). Species richness Species diversity (Shannon diversity index) Species evenness Species abundance Alien species abundance	
Method:	See section 5.3.1 of the revegetation manual (Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region 2010). For alien species abundance (nonnative species, abundance / native species, abundance + non-native species, abundance) is a simple ratio which needs to be calculated and reported. The expectation is that this ratio will decline over time as native locally common boreal forest species establish and become more abundant through time following reclamation.	
Threshold:	None (but expected trends can be measured and described) … Whereas species richness may initially increase and then decrease following reclamation, over longer time periods the expectation is that greater diversity of boreal plant species will become established on reclaimed sites making them more similar to boreal forest stands not disturbed by intensive industrial practices. Since diversity measures can be affected by the distribution of rare and abundant species, interpretation is required to understand the comparison of values which may be derived over time within reclamation polygons and among reclamation polygons and values derived from natural stands.	
If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
Some review / synthesis work could be undertaken which focuses on the scientific literature available from studies conducted in northern Alberta and/or adjacent Saskatchewan (for example). Most of the revegetation manual calibration has come by establishing relationships associated with data derived from various long term monitoring networks and not from directed studies looking explicitly at ecosystem responses after natural or anthropogenic disturbance.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
… reclaimed landforms shall be capable of supporting self-sustaining boreal forest ecosystems … … reclamation shall target the establishment of locally common boreal forest species …		

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Indicator 10: Regeneration of Trees in Commercial Forest Stands

Group Name [1]	**Terrestrial Subgroup**	Submitted by [2]	*Names removed*	Date [3]	Sept. 8, 2011
Objective [4]	3 - Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses	Criterion [5]	3.2 The reclaimed landscape provides for commercial forests		

Describe the indicator being recommended. [6]

Acceptable regeneration of trees in commercial forest stands

Provide a brief statement on the value of the indicator. [7]

Acceptable regeneration of trees in commercial forest stands is defined as a milestone, hard indicator to be measured in reclaimed polygons designated for commercial forest end land use. This indicator is a milestone because tree stocking is measured at establishment age (4-8 years) and at performance age (11-20 years). A polygon that is occupied by trees meets the minimum stocking requirements for a commercial forest.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

Alberta Regeneration Standards for the Mineable Oil Sands, Data Collection Protocols ("regeneration survey manual") Pages 2-3.

List references related to the recommended indicator (research paper, journal article etc.): [10]

As above.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☐	**No** ☒

Briefly explain: [12]

The indicator needs to be measured only in polygons which have a targeted end land use of commercial forestry.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Stocking (the percentage of a polygon that contains acceptable tree regeneration).
Method:	The method is described in the regeneration survey manual.
Threshold:	Minimum stocking for the forest industry is 80%; however, the required percentage for the mineable oil sands is not stated in the manual.

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

Unknown—minimum stocking is a component of the administrative process for regeneration surveys, currently being completed by AESRD.

Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐

If yes, what is the condition number and corresponding EPEA approval? [17]

E.g. Suncor 94-02-00 2007, 6.1.50 (d) "…proposal to submit completed regeneration surveys…on reforestation areas of commercial forest land use in a manner acceptable to the Director."

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Indicator 11: Trees are Healthy and Vigorous

Group Name [1]	**Terrestrial Subgroup**	Submitted by [2]	*Names removed*	Date [3]	October 6, 2011
Objective [4]	Objective 3 - Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses.	Criterion [5]	3.2 The reclaimed landscape provides for commercial forests.		

Describe the indicator being recommended. [6]

The trees on reclaimed polygons are healthy and vigorous

Provide a brief statement on the value of the indicator. [7]

Trees on reclaimed polygons are healthy and vigorous is defined as a milestone, hard indicator to be measured in reclaimed polygons designated for commercial forest end land use. The indicator is a milestone because it is measured as part of the establishment and performance surveys of the *Alberta Regeneration Standards for the Mineable Oil Sands, Data Collection Protocols.*

Trees are healthy and vigorous when they are free from damage by abiotic (e.g., weather, environment) and biotic (e.g., animals, insects, diseases) factors. Healthy stands are more likely to be resilient to disturbances, and are more likely to be self-sustaining.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

Alberta Regeneration Standards for the Mineable Oil Sands, Data Collection Protocols ("regeneration survey manual") Page 2, Pages 13-16.

List references related to the recommended indicator (research paper, journal article etc.): [10]

See above mentioned guidance document.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☐	**No** ☒

Briefly explain: [12]

The indicator needs to be measured only in polygons which have established terrestrial (forested) vegetation designated to commercial forest end land use.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☒	**No** ☐

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Identification of "poorly revegetated areas" (PRVs) and listing of causal codes during a performance survey (11-20 years).
Method:	The method is described in the regeneration survey manual, pages 13-16.
Threshold:	Applicable to reclaimed lands designated to commercial forest end land use only: PRVs are delineated when they are 0.5 ha or greater in size and more than 25% of the trees in the area are affected.

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

The regeneration survey manual's method for assessing PRVs is very general and is designed only to identify areas that are obviously different; surveyors may not always be able to identify the underlying forest health causal factor. Further work could be conducted to review provincial and/or forest industry forest health survey methods, and determine applicability/adaptability for oil sands mine reclamation. A measure of resiliency for terrestrial forest vegetation not designated to commercial forest end land use requires development (see Indicator_2 4 x_ForestHealth_Purdy (10.17.11).doc).

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Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒ **No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]	
(e.g.) Suncor 94-02-00 2007, 6.1.50 (d) "…proposal to submit completed regeneration surveys…on reforestation areas of commercial forest land use in a manner acceptable to the Director."	

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Indicator 12: Tree Height of Commercial Forest Stands at Performance Age

Group Name [1]	**Terrestrial Subgroup**	Submitted by [2]	*Names removed*	Date [3]	Sept. 8, 2011
Objective [4]	3 Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses	Criterion [5]	3.2 The reclaimed landscape provides for commercial forests		

Describe the indicator being recommended. [6]

Tree height of commercial forest stands at performance age

Provide a brief statement on the value of the indicator. [7]

Tree height of commercial forest stands at performance age is defined as a milestone, hard indicator to be measured in reclaimed polygons designated for commercial forest end land use. This is a milestone indicator because it is assessed to evaluate that the trees in a polygon targeting an end land use of commercial forestry have continued to grow at performance age (11-20 years). A polygon with trees that are growing as expected meets the requirements of a commercial forest.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

Alberta Regeneration Standards for the Mineable Oil Sands, Data Collection Protocols ("regeneration survey manual") Pages 2-4.

List references related to the recommended indicator (research paper, journal article etc.): [10]

As above.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☐	**No** ☒

Briefly explain: [12]

The indicator needs to be measured only in polygons which have a targeted end land use of commercial forestry.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Top height (used to calculate Site Index). (Note: for the forest industry, top height data is used to generate a forecast Mean Annual Increment based on forecasts from the GYPSY model—see *Reforestation Standard of Alberta* May 2011)
Method:	The method is described in the regeneration survey manual (for the largest diameter tree in each 100m^2 plot, the total height and total age to the end of the last growing season are measured).
Threshold:	Threshold Site Index values are not established in the regeneration survey manual and a forest growth & yield model has not been calibrated for reclaimed oil sands mining areas.

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

The Forest Productivity Task Group (FPTG) is developing a vegetation monitoring approach for reclaimed lands, which includes defining a monitoring program to collect Site Index data and calibrate a model to predict Site Index on reclaimed lands. The total investment in the FPTG 5-year work plan is $240,000.

Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐

If yes, what is the condition number and corresponding EPEA approval? [17]

Eg. Suncor 94-02-00 2007, 6.1.50 (d)

"…proposal to submit completed regeneration surveys…on reforestation areas of commercial forest land use in a manner acceptable to the Director."

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Indicator 13: Commercial Forest Targets - Ecosite Area Summary Table

Group Name [1]	**Terrestrial Sub-group**	Submitted by [2]	*Names removed*	Date [3]	Nov. 1, 2011
Objective [4]	Objective 3: Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses.	Criterion [5]	3.2 The reclaimed landscape provides commercial forests.		

Describe the indicator being recommended. [6]

Ecosite Area Summary Table – Commercial Forest Targets

Provide a brief statement on the value of the indicator. [7]

Ecosite Area Summary Table – Commercial Forest Targets is defined as an intermediate indicator to be assessed at the lease level as part of closure certification. This is a trend-based indicator to assess over time that reclamation is progressing towards the commercial forest targets proposed in the ecosite area summary table.

Mine operators are also required to revegetate disturbed land to target the establishment of boreal forests that are capable of producing merchantable timber if the area is designated to commercial forest end land use. The proper establishment of these forests is ensured by the adherence to revegetation guidelines and regeneration survey requirements as described by the current Alberta regeneration standards.

The Forest Productivity Task Group developed the ecosite area summary table to address limitations to the timber productivity rating tables in some Environmental Protection and Enhancement Act (EPEA) approvals. The ecosite area summary table presents mean site index by species and ecosite and an entry site index value for commercial forestry purposes (minimum site index). Mine operators are required to partition their land base into commercial and non-commercial forest end land-use and all data are to be presented by ecosite phase based on the reclamation hectares at closure. Beginning with the December 31, 2011 Forest Resource Plan submissions, the ecosite area summary table must be included for most company leases.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

From Total-EP approval:

Revegetation Plan

Forest Resource Plan

List references related to the recommended indicator (research paper, journal article etc.): [10]

Please see references in documents below:

TECO Natural Resource Group Limited. 2011. Developing Baseline Site Index Estimates for the Ecosite Area Summary Table. Prepared for the Forest Productivity Task Group of the Reclamation Working Group of the Cumulative Environmental Management Association. Fort McMurray, Alberta. 32 pp.

Timberline Natural Resource Group Ltd. 2010. Strategic Recommendations for a Growth and Yield Program in the Mineable Oil Sands Area. Technical Document. Prepared for the Cumulative Environmental Management Association, Reclamation Working Group, Terrestrial Subgroup, Fort McMurray, Alberta. pp. 43.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☐	**No** ☒

Briefly explain: [12]

Applies to land designated for commercial end land use only.

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Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]		**Yes** ☐	**No** ☒
Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]			
Measure:	Hectares of commercial forest per ecosite phase identified in the ecosite area summary table.		
Method:	Compare hectares per ecosite on reclaimed lands designated for commercial end land use to predicted hectares reported in the ecosite area summary table presented in the Forest Resource Plan.		
Threshold:	To be determined.		
If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]			
The FPTG is developing a monitoring program to evaluate the growth and yield attributes of reclaimed lands. Based on the data emerging from this program, the development of thresholds will proceed.			
Is the indicator aligned to an EPEA approval condition? [16]		**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]			
From Total-EP approval (note: only Total-EP approval as reviewed): 6.3.26 The Revegetation Plan referred to in subsection 6.3.25 shall comply with the Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region, 2009, as amended, and shall at a minimum: (e) establish commercially-viable forest ecosystems in extent equivalent to the pre-disturbance areas outlined in the pre-disturbance ecosite phase table and having productivity consistent with pre-disturbance forest growth, as reconciled as per subsection 6.2.5; 6.3.28 The approval holder shall reclaim disturbed land to achieve, at a minimum, the site index and other growth and yield attributes specified in any ecosite phase growth and yield table template provided by the Director, unless otherwise authorized in writing by the Director. 6.3.30 The Forest Resource Plans referred to in subsection 6.3.29 shall include the following, unless otherwise authorized in writing by the Director: (b) a description of how the pre-disturbance forest characteristics (including equivalent areas and types of ecosystems, forest stand structure, and forest growth and yield) will be reflected in the reclamation areas;			

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Indicator 14: Ecosystem Health

Group Name [1]	**Terrestrial Sub-Group**	Submitted by [2]	*Names removed*	Date [3]	Sept. 28, 2011
Objective [4]	Objective 1 - Reclaimed landscapes are established that support natural ecosystem functions. Objective 2 - Natural ecosystem functions are established on the reclaimed landscape. Objective 3 - Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses.	Criterion [5]	1.5 Terrestrial and aquatic vegetation common to the boreal forest is established. 2.5 Reclaimed ecosystems display characteristics of resilience to natural disturbances and climatic variability. 3.1 The reclaimed landscape provides for biodiversity.		

Describe the indicator being recommended. [6]

Ecosystem health

Provide a brief statement on the value of the indicator. [7]

Ecosystem health is defined as an intermediate or soft indicator depending on the measure. The measures should be assessed at the polygon level and be included in a research and monitoring program to provide data informing on ecosystem health.

Reclamation practices need to support the establishment of healthy and self-sustaining boreal forest ecosystems. Ecosystem health can be reported on using relative indicators such as leaf area index (LAI), foliar chlorophyll content, foliar nutrient content.

Below we propose to use remote sensing approaches to collect and report on trends associated with LAI, foliar chlorophyll content, and foliar nutrient content from upland forest stands as measures of forest health in reclamation areas. Following ground based calibration of these indicators, they can readily be reported on through time and they can be compared to a variety of reference stands derived from natural stands affected by natural or anthropogenic disturbance and at various stages of stand development.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☐	**No** ☒

If yes, state the document and page number: [9]

NA

List references related to the recommended indicator (research paper, journal article etc.): [10]

Remote sensing has demonstrated its ability to provide forest health-relevant data. Examples include Leaf Area Index (LAI) and leaf loss (Brandtberg et al., 2003; Lefsky et al., 1999; Schaepman et al., 2004), chlorophyll (Malenovský et al., 2009, Zarco-Tejada et al., 2004), foliar nutrients (Martin and Aber, 1997), and identification of trees having root diseases (Leckie et al., 2004).

Brandtberg, T., Warner, T., Landenberger, R. and McGraw, J., 2003. Detection and Analysis of Individual Leaf-off Tree Crowns in Small Footprint, High Sampling Density Lidar Data from the Eastern Deciduous Forest in North America, Remote Sensing of Environment, vol. 85, no. 3, pages 290-303.

Lefsky, M., Cohen, W., Acker, S., Parker, G., Spies, T. and Harding, D. 1999. Lidar Remote Sensing of the Canopy Structure and Biophysical Properties of Douglas-Fir Western Hemlock Forests, Remote Sensing of Environment, vol. 70, no. 3, pages 339-361.

M. Schaepman, B. Koetz, G. Schaepman-Strub, N. E. Zimmermann, and K. I. Itten,. 2004. Quantitative retrieval of biogeophysical characteristics using imaging spectroscopy - a mountain forest case study," Community Ecology, 5, 93-104, 2004.

Malenovský Z., Mishra K.B., Zemek F., Rascher U., Nedbal L., 2009. Scientific and technical challenges in remote sensing of plant canopy reflectance and fluorescence. Journal of Experimental Botany, 60(11), 2987-3004.

Zarco-Tejada, P.J., Miller, J.R., Morales, A., Berjón, A. and Agüera, J. 2004. Hyper-spectral indices and model simulation for chlorophyll estimation in open-canopy tree crops. Remote Sensing of Environment 90, 463-476.

Martin, M.E. and Aber, J. D. 1997. High spectral resolution remote sensing of forest canopy lignin, nitrogen, and ecosystem processes. Ecological Applications 7: 431-443.

Ferwerda, J.G. and Skidmore, A.K. 2007. Can nutrient status of four woody plant species be predicted using field spectrometry?. ISPRS Journal of Photogrammetry and Remote Sensing, 62: 406-414.

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Leckie, D.G., Jay, C., Gougeon, F.A., Sturrock, R.N. and Paradine, D. 2004. Detection and assessment of trees with Phellinus weirii (laminated root rot) using high resolution multi-spectral imagery. International Journal of Remote Sensing 25, 793-818.		
Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐
Briefly explain: [12]		
This measure has relevance at the polygon scale since local performance will not only be a function of soil handling and revegetation practices but also landform position, landform type and current and historic climatic factors among other parameters. As such, concurrent measurement of relevant reference areas will be critical along with ground based calibration in order to use this indicator.		
Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒
Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]		
Measure:	LAI (leaf area index) Foliar (canopy) chlorophyll Foliar (canopy) nutrients (nitrogen, phosphorus)	
Method:	High resolution LIDAR (1-2 m pixel size) combined with hyperspectral sensor image acquisition is required to characterize the measures at the level of calibration and resolution desired for reporting on the health of reclamation areas at the polygon scale.	
Threshold:	None (but expected trends can be measured and described) … Interpretation will be required to understand the comparison of values which may be derived over time within reclamation polygons and among reclamation polygons and values derived from natural stands.	
If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
Some review / synthesis work could be undertaken which evaluates this approach as a measure of reclamation performance although the general methods are well established elsewhere in the world including work already conducted for mines in Canada (e.g., Logan Lake BC, Sudbury ON). Considerable work needs to be undertaken to calibrate the methodology to local conditions. An opportunity exists to collaborate with Canadian Centre for Remote Sensing (CCRS), the Alberta Geological Survey (AGS), Alberta Environment (AENV), Tecterra, and the Universities of Lethbridge, Calgary and Victoria to evaluate and calibrate airborne LIDAR-Hyperspectral airborne remote sensed data for the purposes or reporting on the proposed metrics.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
… reclaimed landforms shall be capable of supporting self-sustaining boreal forest ecosystems …		

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Indicator 15: Locally Common Soil Mycorrhizal Communities are Established

Group Name [1]	**Terrestrial Sub-Group**	Submitted by [2]	*Names removed*	Date [3]	Sept. 28, 2011
Objective [4]	Objective 1 - Reclaimed landscapes are established that support natural ecosystem functions. Objective 2: Natural ecosystem functions are established on the reclaimed landscape. Objective 3 - Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses.	Criterion [5]	1.5 Terrestrial and aquatic vegetation common to the boreal forest is established. 2.4 Ecosystem productivity is established on the reclaimed landscape 3.1 The reclaimed landscape provides for biodiversity.		

Describe the indicator being recommended. [6]

Locally common soil mycorrhizal communities are established which support productive forest ecosystems

Provide a brief statement on the value of the indicator. [7]

Reclamation practices need to support the establishment, growth and reproduction of native boreal forest plant species in order to establish critical components of biodiversity and to meet broader reclamation objectives such as self-sustaining boreal forest ecosystems. Having functional soil microbial and fungal communities including established functional mycorrhizal relationships is critical in supporting these reclamation goals.

Fact - Tree responses to adverse environmental conditions are affected by the presence of mycorrhizal associations.

Mycorrhizal associations supply trees with:

a) essential nutrients (Marschner and Dell 1994; Smith and Read 1997)

b) enhanced water uptake (Landhausser et al. 2002; Muhsin and Zwiazek 2002a, b).

Mycorrhizae also alleviate:

a) metal toxicity (Jones and Hutchinson 1988; Jentschke and Goldbold 2000)

b) injury to salts (Muhsin and Zwiazek 2002a; Nguyen et al. 2006)

Survivorship to environmental stress and productivity is thus dependant to some extent on functional soil fungal relationships, when comparing to reference or benchmark conditions.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☐	**No** ☒

If yes, state the document and page number: [9]

NA

List references related to the recommended indicator (research paper, journal article etc.): [10]

Bois, G., A. Bertrand, Y. Piché, M. Fung, and D.P. Khasa. 2006. Growth, compatible solute and salt accumulation of five mycorrhizal fungal species grown over a range of NaCl concentrations. Mycorrhiza 16: 99–109.

Bois, G., Y. Piché, M.Y.P. Fung and D.P. Khasa. 2005. Mycorrhizal inoculum potentials of pure reclamation materials and revegetated tailing sands from the Canadian oil sand industry. Mycorrhiza 15: 149–158.

Calvo Polanco M, Jones MD, Zwiazek JJ 2009. Effects of pH on NaCl resistance of American elm (Ulmus americana) seedlings inoculated with Hebeloma crustuliniforme and Laccaria bicolor. Acta Physiologiae Plantarum 31:515-522.

Calvo Polanco M, Zwiazek JJ, Jones MD, MacKinnon MD. 2008. Responses of mycorrhizal jack pine (Pinus banksiana) seedlings to NaCl and boron. Trees – Structure and Function 22: 825-834.

Calvo Polanco M, Zwiazek JJ, Jones MD, MacKinnon. 2009. Effects of NaCl on responses of ectomycorrhizal black spruce (Picea mariana),

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white spruce (Picea glauca) and jack pine (Pinus banksiana) to fluoride. Physiol. Plantarum 135: 51-61.

Danielson RM (1984) Ectomycorrhizal associations in jack pine stands in northeastern Alberta. Can J Bot 62:932–939

Danielson RM, Visser S (1989) Host response to inoculation and behavior of introduced and indigenous ectomycorrhizal fungi of jack pine grown on oil-sands tailings. Can J Res 19:1412–1421.

Landhäusser SM, Muhsin TM, Zwiazek JJ (2002) The effect of ectomycorrhizae on water relations in aspen (Populus tremuloides) and white spruce (Picea glauca) at low soil temperatures. Can J Bot 80:684–689.

Kernaghan., G., B. Hambling, M.Fung and D.P. Khasa. 2002. In vitro selection of boreal ectomycorrhizal fungi for use in reclamation of saline-alkaline habitats. Restoration Ecology 10: 43–51.

Muhsin TM, Zwiazek JJ (2002a) Ectomycorrhizae increase water conductance and protect white spruce (Picea glauca) seedlings against salt stress. Plant Soil 238:217–225.

Muhsin TM, Zwiazek JJ (2002b) Ectomycorrhizas increase apoplastic water transport and hydraulic conductivity in Ulmus americana seedlings. New Phytol 153:153–158.

Nguyen H, Calvo Polanco M, Zwiazek JJ (2006) Gas exchange and growth responses of ectomycorrhizal Picea mariana, Picea glauca and Pinus banksiana seedlings to NaCl and Na2SO4. Plant Biol 8:646–652.

Yi H, Calvo Polanco M, MacKinnon MD, Zwiazek JJ (2008) Ectomycorrhizal Laccaria bicolor and Hebeloma crustuliniforme improve NaCl resistance but do not reduce sodium uptake in Populus tremuloides and Betula papyrifera seedlings. Environ Exp Bot 62:357–363.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☐	**No** ☒
Briefly explain: [12]		
Whereas the indicator may have relevance at the polygon scale, demonstration of mycorrhizal community establishment can likely be performed and reported on using a long-term monitoring component,		
Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒
Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]		

Measure:	Typical mycorrhizal measures include: Percent of active root tips colonized by mycorrhize (seedling scale) Species richness (morphotypes) seedling scale Species richness (morphotype richness) stand or polygon level Species similarity to reference conditions
Method:	Several methods are available to measure soil mycorrhizae. These include: a) taking soil cores and identifying fine root tips and then describing morphotypes (species) of mycorrhizal fungi that have colonized root tips b) using sterile bait plants, planting into experimental areas, extracting the plants after 1 or 2 growing seasons, and identifying mycorrhizae on colonized root tips. See Purdy et al 2002 (Silva Fennica) for application of this approach in the boreal forest.
Threshold:	None (but expected trends can be measured and described) … It is unlikely that this would be measured at the stand level. However, understanding the effects of disturbance and reclamation on soil fungal communities is critical to understanding cumulative environmental effects of oil sands development and the response of rehabilitated land to be resilient and capable of self-sustainability. Results from reclaimed areas should be compared to knowledge derived from published literature and data associated with reference conditions of juvenile stands of similar age following harvest or fire.

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If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
Whereas some research has demonstrated that mycorrhizal communities are established after oil sands reclamation, the majority of recent mycorrhizal research has been of a more fundamental nature using lab-based approaches. Specific to field-based programs, natural colonization of a variety of disturbed soils including reclaimed areas has been documented. While newly placed consolidated tailings appear devoid of mycorrhizae, older tailings sand, overburden, as well as 2, 13 and 18 year old reclaimed soils have been found to have mycorrhizal fungi present. This indicates potential for natural re-establishment of mycorrhizal relationships during reclamation of mined sites. Research gaps include: 1) Greenhouse based studies have been performed using sterile seedlings to test for the presence of mycorrhizal fungi in various reclamation materials. A similar study using sterile "bait plants" could be performed in the field where sterile seedlings are planted into actual reclamation sites and left for 1-2 growing seasons. These seedlings, when harvested, would be sampled for the presence and abundance of mycorrhizal fungi on their roots. It would be anticipated that a greater diversity and abundance of mycorrhizal species would be detected using this approach. 2) It is unclear from historic research which reclamation soils and reclamation prescriptions were sampled in the study design. In addition, control soils from either naturally-disturbed or undisturbed boreal forest stands would have added additional information on differences in inoculum potential of the reclamation materials.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
… reclaimed landforms shall be capable of supporting self-sustaining boreal forest ecosystems … … reclamation shall target the establishment of locally common boreal forest species …		

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Indicator 16: Wildlife Species with an Important Ecological Role

Group Name [1]	**Wildlife Task Group (WTG)**	Submitted by [2]	*Names removed*	Date [3]	October 20, 2011
Objective [4]	Objective 2: Natural ecosystem function are established on the reclaimed landscape. Objective 3: Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses.	Criterion [5]	2.4 Ecosystem productivity is established on the reclaimed landscape. 2.5 Reclaimed ecosystems display characteristics of resilience to natural disturbance and climatic variability. 3.3 – The reclaimed landscape provides for fish and wildlife habitat.		

Describe the indicator being recommended. [6]		
Reclaimed areas sustain wildlife species with an important ecological role.		
Provide a brief statement on the value of the indicator. [7]		
This indicator is derived from the Sustainable Ecosystems Working Group's goals and indicators for wildlife which are presented in Appendix D - Wildlife Populations and Habitat Capability in the Oil Sands Region of the Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (referred to subsequently as the Revegetation Manual; AENV 2010).		
Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐
If yes, state the document and page number: [9]		
Table D.24, p. 163 of the Revegetion Manual (AENV 2010) presents 14 species and 2 species guilds and recommends monitoring techniques for estimating population densities and individual survival.		
List references related to the recommended indicator (research paper, journal article etc.): [10]		
Please refer to the Revegetation Manual.		
Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐
Briefly explain: [12]		
The survey intensity level will vary depending on the site characteristics, targeted end land use, species group(s) being monitored and area covered.		
Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒
Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]		

Measure:	The proposed measures in the Revegetation Manual are: • -presence of key mammal predator/prey dynamics in the region (i.e., lynx and snowshoe hare) • -creation of habitat for cavity-nesting birds & mammals • -habitat modification and manipulation of the distribution of water & soil nutrients (i.e., beaver) Other proposed measures: • -existence of trophic linkages (i.e., insects as a food source for birds and/or bats; predatory fish/aquatic invertebrates) • -arthropod contribution to ecosystem processes (e.g., decomposition, pollination, nutrient cycling, predation, and parasitism) The selected measures would depend on the study area characteristics.
Method:	To be developed.
Threshold:	No thresholds.

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If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
1. The WTG is conducting a pilot study to monitor early successional wildlife species on young reclaimed areas. This monitoring program includes small mammal trapping, winter tracking surveys and spring and summer bird counts. The results of the first year of monitoring are documented in Muir et al 2011 (CEMA Contract 2010-0023). The pilot study will continue for two more years and an annual report will be issued each year in the fall (i.e., 2012, 2013). The program is testing the field protocols developed to implement some of the recommendations in Table D.24. Total funding for the 3-year pilot program is approximately $330,000. 2. The WTG pilot monitoring program year 1 report provided recommendations for monitoring insect-bird/bat dynamics and terrestrial arthropods. The Soil Biodiversity Background (Paragon 2009, CEMA Contract 2008-0020) recommended monitoring techniques to study soil fauna and flora contributions to ecosystem processes. 3. The Wildlife Task Group will develop monitoring protocols to quantify species with an important ecological role to address the recommendations noted in #2 above. 1. 4. The work underway in the Ecological Monitoring Committee for the Lower Athabasca may be related to this indicator.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
From the Total-EP approval (N.B. – the Total-EP approval was reviewed for this question because it is the most recent approval; no other approvals were reviewed and approval conditions may be different in other approvals): There is reference in the Total-EP approval to ecological function for forests and wetlands; the role of species in supporting the function is related to these conditions. The ecological role of species in supporting functions and processes is also related to the goal of the C&I Framework and the goal in the EPEA approvals: supporting a self-sustaining, locally common boreal forest landscape…" 6.3.35 The Wetland Reclamation Plan referred to in subsection 6.3.34 shall comply with Guideline for Wetland Establishment on Reclaimed Oil Sands Leases, 2007, as amended, and shall include at a minimum, all of the following: (l) performance measures to assess wetland reclamation success including measures of wetland sustainability (including water quality and quantity), ecological function, traditional use, and biodiversity 6.4.18 The Wetland Research Plan referred to in subsection 6.4.17 shall consider the objectives of the Wetland Reclamation Plan referred to in subsection 6.3.34 and shall include, at a minimum, the following: (d) expected criteria and performance measures for reclaimed wetlands including measures of wetland sustainability (including water quality and quantity), ecological function, traditional use, and biodiversity; 6.4.28 The approval holder shall document wildlife and fish habitat utilization on the reclaimed land by monitoring wildlife and fish species typically associated with and naturally occurring in the wildlife and fish habitat types present. 6.4.32 The approval holder shall participate in regional initiatives through CEMA or CONRAD that assess wildlife and fish resources, to the satisfaction of the Director, to accomplish the following: (a) analysis of regional data sets, supplemented by additional field data where necessary, to validate wildlife habitat suitability index (HSI) models; and (b) long-term monitoring of specifically selected species and species at risk to quantify cumulative impacts on wildlife and fish populations in the region; 6.4.36 The approval holder shall participate in the regional Ecological Monitoring Committee for the Lower Athabasca, or any other regional initiative that may be developed within CEMA or CONRAD, to monitor the long-term cumulative effects on biodiversity and wildlife in the region, to the satisfaction of the Director.		

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Indicator 17: Wildlife Habitat Targets

Group Name [1]	**Wildlife Task Group (WTG)**	Submitted by [2]	*Names removed*	Date [3]	October 20, 2011
Objective [4]	Objective 3: Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses.	Criterion [5]	3.3 – The reclaimed landscape provides for fish and wildlife habitat.		

Describe the indicator being recommended. [6]
Reclaimed areas achieve wildlife habitat targets for wildlife species outlined in approval conditions.
Provide a brief statement on the value of the indicator. [7]
This indicator is derived from the revegetation planning guidance and end land-use planning options provided in Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (referred to subsequently as the Revegetation Manual; AENV 2010) and the approval conditions identified below.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]
See Section 2 of the Revegetion Manual (AENV 2010) and the approval conditions identified below.
List references related to the recommended indicator (research paper, journal article etc.): [10]
Please refer to the Revegetation Manual and EPEA approvals.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐

Briefly explain: [12]
The survey intensity level will vary depending on the site characteristics, area covered and targeted end land use.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]	
Measure:	Wildlife habitat mapping.
Method:	To be developed.
Threshold:	No thresholds.

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]
The WTG will develop a wildlife habitat mapping procedure based on the foundations of the Reclamation Classification System under development in the Reclamation Classification System Task Group. This is part of the WTG 5-year work plan.

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Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
From the Total-EP approval: 6.3.26 The Revegetation Plan referred to in subsection 6.3.25 shall comply with the Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region, 2009, as amended, and shall at a minimum: (b) incorporate vegetation and vegetation communities that establish habitat for wildlife, including birds;… 6.4.24 The approval holder shall re-establish wildlife and fish habitat levels, at a minimum, similar to that which existed prior to disturbance, in proportions appropriate relative to the approved Life of Mine Closure Plan. 6.4.25 The approval holder shall demonstrate, through monitoring, progress in achieving the wildlife and fish habitat levels as outlined in subsection 6.4.24. 6.4.26 The approval holder shall re-establish a diversity of wildlife and fish habitats similar to those that existed prior to disturbance, in proportions appropriate relative to the approved Life of Mine Closure Plan. 6.4.27 The approval holder shall demonstrate, through monitoring, progress in achieving a diversity of wildlife and fish habitats as outlined in subsection 6.4.26.		

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Indicator 18: Wildlife Habitat Targets That Support Consumptive and Non-Consumptive Uses

Group Name [1]	**Wildlife Task Group (WTG)**	Submitted by [2]	*Names removed*	Date [3]	October 20, 2011
Objective [4]	Objective 3: Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses.	Criterion [5]	3.5 – The reclaimed landscape provides opportunities for recreational uses.		

Describe the indicator being recommended. [6]

Reclaimed areas achieve wildlife habitat targets outlined in approval conditions that support consumptive and non-consumptive uses.

Provide a brief statement on the value of the indicator. [7]

This indicator is derived from the revegetation planning guidance and end land-use planning options provided in Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (referred to subsequently as the Revegetation Manual; AENV 2010), the Sustainable Ecosystems Working Group goals and indicators for wildlife (see Table D.1 in the Revegetation Manual) and the approval conditions identified below.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

See Section 2 and Table D.1 of the Revegetion Manual (AENV 2010) and the approval conditions identified below.

List references related to the recommended indicator (research paper, journal article etc.): [10]

Please refer to the Revegetation Manual and EPEA approvals.
Mine Reclamation Plan
Life of Mine Closure Plan

Does the indicator need to be measured in every polygon? [11]	**Yes** ☐	**No** ☒

Briefly explain: [12]

Only on polygons designated for recreational use.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	To be developed.
Method:	To be developed.
Threshold:	No thresholds.

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

No items in RWG work plan to develop indicators for recreation.

Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐

If yes, what is the condition number and corresponding EPEA approval? [17]

From the Total-EP approval (N.B. – the Total-EP approval was reviewed for this question because it is the most recent approval; no other approvals were reviewed and approval conditions may be different in other approvals):

6.2.8 The Mine Reclamation Plan referred to in subsection 6.2.6 shall address, at a minimum, the following:
(l) land uses including traditional land use, recreation, commercial/industrial, miscellaneous, etc.;

6.2.12 The Life of Mine Closure Plan referred to in subsection 6.2.10 shall address, at a minimum, the following:
(k) land uses including traditional land use, recreation, commercial/industrial, miscellaneous, etc.;

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Indicator 19: Wildlife Habitat Targets That Support Cultural, Spiritual, Medicinal and Ceremonial Purposes as Defined Through Stakeholder Consultation

Group Name [1]	**Wildlife Task Group (WTG)**	Submitted by [2]	*Names removed*	Date [3]	October 20, 2011
Objective [4]	Objective 3: Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses.	Criterion [5]	3.3 – The reclaimed landscape provides for fish and wildlife habitat. 3.4 – The reclaimed landscape provides opportunities for traditional uses.		

Describe the indicator being recommended. [6]

Reclaimed areas achieve wildlife habitat targets outlined in the Life of Mine Closure Plan, Mine Reclamation Plan, Wetland Revegetation Plan, and Revegetation Plan that support cultural, spiritual, medicinal and ceremonial purposes as defined through stakeholder consultation.

Provide a brief statement on the value of the indicator. [7]

This indicator is derived from the revegetation planning guidance and end land-use planning options provided in Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (referred to subsequently as the Revegetation Manual; AENV 2010), the Sustainable Ecosystems Working Group goals and indicators for wildlife (see Table D.1 in the Revegetation Manual) and the approval conditions identified below.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

See Section 2 and Table D.1 of the Revegetion Manual (AENV 2010) and the approval conditions identified below.

Mine Reclamation Plan
Life of Mine Closure Plan
Revegetation Plan
Wetland Reclamation Plan
Wetland Revegetation Plan
Wetland Research Plan

List references related to the recommended indicator (research paper, journal article etc.): [10]

Refer to the Revegetation Manual and EPEA approvals.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐

Briefly explain: [12]

The survey intensity level will vary depending on the site characteristics, area covered and targeted end land use.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Indigenous research methodologies to assess reclamation areas based on traditional knowledge need to be developed.
Method:	To be developed.
Threshold:	No thresholds.

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

The results of the Biodiversity Traditional Knowledge Study (CEMA Contracts 2008-0032 and 2010-0022) conducted by the Biodiversity Task Group conclude that indigenous research methodologies for assessing reclamation based on traditional knowledge need to be developed. The Biodiversity Task Group 5-year work plan includes budget to continue to develop indigenous research methodologies for assessing reclamation success and the Terrestrial Sub-group 5-year work plan includes budget to continue to develop guidance for reclamation planning based on traditional knowledge to address the recommendations of the Phase II report forwarded to the CEMA Board. The Wildlife Task Group will evaluate indigenous research methodologies for wildlife and reclamation planning guidance as part of

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the 5-year work plan.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
From the Total-EP approval (N.B. – the Total-EP approval was reviewed for this question because it is the most recent approval; no other approvals were reviewed and approval conditions may be different in other approvals): 6.2.8 The Mine Reclamation Plan referred to in subsection 6.2.6 shall address, at a minimum, the following: (l) land uses including traditional land use, recreation, commercial/industrial, miscellaneous, etc.; 6.2.12 The Life of Mine Closure Plan referred to in subsection 6.2.10 shall address, at a minimum, the following: (k) land uses including traditional land use, recreation, commercial/industrial, miscellaneous, etc.; 6.3.26 The Revegetation Plan referred to in subsection 6.3.25 shall comply with the Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region, 2009, as amended, and shall at a minimum: (a) incorporate vegetation and vegetation communities of traditional value characteristic of the locally common boreal forest ecosystems; 6.3.35 The Wetland Reclamation Plan referred to in subsection 6.3.34 shall comply with Guideline for Wetland Establishment on Reclaimed Oil Sands Leases, 2007, as amended, and shall include at a minimum, all of the following: (h) a Wetland Revegetation Plan that shall include at a minimum, the following: (ii) incorporation of vegetation and vegetation communities of traditional value that are characteristic of the locally common boreal forest; (l) performance measures to assess wetland reclamation success including measures of wetland sustainability (including water quality and quantity), ecological function, traditional use, and biodiversity 6.4.18 The Wetland Research Plan referred to in subsection 6.4.17 shall consider the objectives of the Wetland Reclamation Plan referred to in subsection 6.3.34 and shall include, at a minimum, the following: (d) expected criteria and performance measures for reclaimed wetlands including measures of wetland sustainability (including water quality and quantity), ecological function, traditional use, and biodiversity;…		

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Indicator 20: Viable and Healthy Populations of Wildlife

Group Name [1]	**Wildlife Task Group (WTG)**	Submitted by [2]	*Names removed*	Date [3]	October 20, 2011
Objective [4]	Objective 3: Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses.	Criterion [5]	3.3 – The reclaimed landscape provides for fish and wildlife habitat.		

Describe the indicator being recommended. [6]

Reclaimed areas sustain viable and healthy populations of wildlife.

Provide a brief statement on the value of the indicator. [7]

This indicator is derived from the Sustainable Ecosystems Working Group's goals and indicators for wildlife which are reprinted in Appendix D - Wildlife Populations and Habitat Capability in the Oil Sands Region of the Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (referred to subsequently as the Revegetation Manual; AENV 2010) and related to the approval conditions identified below.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

Table D.24, p. 163 of the Revegetation Manual (AENV 2010) presents 14 species and 2 species guilds and recommends monitoring techniques for estimating population densities and individual survival.

Life of Mine Closure Plan

List references related to the recommended indicator (research paper, journal article etc.): [10]

Please refer to the Revegetation Manual.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐

Briefly explain: [12]

The survey intensity level will vary depending on the site characteristics, targeted end land use, species group being monitored and area covered.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	See Table D.24 in the Revegetation Manual. The proposed species are: moose, woodland caribou, beaver, muskrat, red-backed vole, snowshoe hare, black bear, lynx, fisher, river otter, old growth birds, mixed wood birds, ruffed grouse, pileated woodpecker, boreal owl, Canadian toad. The selected measures would depend on the study area characteristics.
Method:	See Table D.24, monitoring techniques are suggested for each measure.
Threshold:	No thresholds.

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

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1. The WTG is conducting a pilot study to monitor early successional wildlife species on young reclaimed areas. This monitoring program includes small mammal trapping, winter tracking surveys and spring and summer bird counts. The results of the first year of monitoring are documented in Muir et al 2011 (CEMA Contract 2010-0023). The pilot study will continue for two more years and an annual report will be issued each year in the fall (i.e., 2012, 2013). The program is testing the field protocols developed to implement some of the recommendations in Table D.24. Total funding for the 3-year pilot program is approximately $330,000.
2. The Wildlife Task Group will develop monitoring protocols for the remaining species in Table D.24 and any other species identified as important to monitor in the future.
3. The comparison of the data collected on the young reclaimed sites to data collected on young natural sites needs to be incorporated into the scope of the pilot monitoring program. The Terrestrial Sub-group is identifying candidate juvenile natural stands to establish permanent sample plots for the long-term plot network. The intention of the WTG is to apply the same monitoring techniques to these sites once the plots are established.
4. The WTG will implement the guidance being developed by the Biodiversity Task Group to use the reference condition approach as the experimental design model for evaluating reclamation success. Based on this guidance, the methods presented for evaluating the monitoring data will be applied to determine how to proceed with developing thresholds.
2. 5. The work underway in the Ecological Monitoring Committee for the Lower Athabasca may be related to this indicator.

Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐

If yes, what is the condition number and corresponding EPEA approval? [17]

From Total-EP approval (NB – only the Total-EP approval was reviewed as this is the most recent approval):

6.4.25 The approval holder shall demonstrate, through monitoring, progress in achieving the wildlife and fish habitat levels as outlined in subsection 6.4.24.

6.4.28 The approval holder shall document wildlife and fish habitat utilization on the reclaimed land by monitoring wildlife and fish species typically associated with and naturally occurring in the wildlife and fish habitat types present.

6.4.32 The approval holder shall participate in regional initiatives through CEMA or CONRAD that assess wildlife and fish resources, to the satisfaction of the Director, to accomplish the following:

(a) analysis of regional data sets, supplemented by additional field data where necessary, to validate wildlife habitat suitability index (HSI) models; and

(b) long-term monitoring of specifically selected species and species at risk to quantify cumulative impacts on wildlife and fish populations in the region;

6.4.36 The approval holder shall participate in the regional Ecological Monitoring Committee for the Lower Athabasca, or any other regional initiative that may be developed within CEMA or CONRAD, to monitor the long-term cumulative effects on biodiversity and wildlife in the region, to the satisfaction of the Director.

6.4.38 The approval holder shall participate in regional research and monitoring programs to monitor potential effects to terrestrial and aquatic ecosystems, and fish and wildlife health, to the satisfaction of the Director. The approval holder shall use information gathered by these studies to modify the planning, operations, and reclamation management systems.

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Indicator 21: Connectivity within the Landscape

Group Name [1]	**Biodiversity Task Group (BTG)**	Submitted by [2]	*Names removed*	Date [3]	October 21, 2011
Objective [4]	Objective 1 – Reclaimed landscapes are established that support natural ecosystem functions. Objective 2 – Natural ecosystem functions are established on the reclaimed landscape. Objective 3 – Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses.	Criterion [5]	1.2 – The landforms have a natural appearance. 1.3 – The landscape and its landforms incorporate watershed features such as surface drainage, lakes and wetlands. 1.4 – Reclamation materials are place appropriate to the landform. 1.5 – Terrestrial and aquatic vegetation common to the boreal forest is established. 2.2 The reclaimed landforms have the necessary water quantity. 2.5 – Reclaimed ecosystems display characteristics of resilience to natural disturbance and climatic variability. 3.1 – The reclaimed landscape provides for biodiversity.		

Describe the indicator being recommended. [6]

Connectivity within the landscape.

Provide a brief statement on the value of the indicator. [7]

BTG adopted a hierarchical framework to evaluate biodiversity to address the spatial scale of measurement (see BTG mandate letter). The hierarchy includes the following levels: species, community, habitat, landscape and regional. The BTG is defining guidance for implementing the reference condition approach to monitor biodiversity within the hierarchical framework (CEMA Contract 2010-0025). Connectivity is a measure for how well the landscape will function for various biological attributes that are relevant to the approval conditions listed below.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

Guideline for wetland establishment on reclaimed oil sands leases (2nd edition; AENV 2008) – See Section 4.2.4

From Total-EP approval:

Mine Reclamation Plan
Life of Mine Closure Plan
Soil Placement Plan
Revegetation Plan
Forest Resource Plan
Wetland Reclamation Plan
Wetland Revegetation Plan
End Pit Lake Research and Development Report
Wetland Research Plan
Plan for Reclamation Biodiversity

List references related to the recommended indicator (research paper, journal article etc.): [10]

Alberta Biodiversity Monitoring Institute (ABMI). 2009. ABMI's Habitat Pyramid: Definitions and Element Lists (20039), Version 2009-04-20. Alberta Biodiversity Monitoring Institute, Alberta, Canada. Report available at: abmi.ca [Date Cited].

Ciborowski, J.J.H.; M. Kang; D. Raab; S.E. Bayley; and A.L. Foote. 2011. Synthesis: Applying the Reference Condition Approach for Monitoring Reclamation Areas in the Athabasca Oil Sands Region Final Report Draft 1.0 April 8, 2011. Prepared for the Cumulative Environmental Management Association, Fort McMurray, AB. CEMA Contract 2010-0025.

Kirk, D.A.; J. Schieck; and B. Eaton. 2009. Biodiversity review for the Guidelines to Reclamation to Forest Vegetation in the Alberta Oil Sands. Prepared for the Biodiversity and Wildlife Task Group of the Reclamation Working Group of the Cumulative Environmental Management Association. Final Version December 22, 2009. (CEMA Contract 2008-0031).

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐

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Briefly explain: [12]		
Each polygon contributes to the connectivity within the landscape. The survey intensity level of each polygon will differ depending on the measure and the scale the measure represents (i.e., community, habitat, landscape, regional).		
Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]	
Measure:	To be developed.
Method:	To be developed.
Threshold:	To be determined.

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

The BTG is developing guidance for implementing the reference condition approach as the experimental design model to monitor biodiversity in the reclaimed areas. The measures for evaluating connectivity within the landscape will be determined through the work of this project. Some proposed measures for connectivity within the landscape are:

- Fragmentation – targeting similar fragmentation and edge metrics as existed in the pre-disturbance or adjacent non-mined landscape.
- Connectivity – integrated landscape mosaic that resembles natural conditions and allows for movement of wildlife
- Hydrology linkages

The Reclamation Classification System Task Group is developing a classification system for the reclaimed areas to describe homogeneous reclamation units that are defined by hydrology, position on the landscape and biological response. The classification system will support closure planning and assist in mapping the reclamation areas which will facilitate a regional evaluation of the connectivity within reclaimed areas among leases.

Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐

If yes, what is the condition number and corresponding EPEA approval? [17]

From Total-EP approval:

6.2.7 The Mine Reclamation Plan referred to in subsection 6.2.6 shall provide the detailed operational plan for development and reclamation for the next ten year period of operation of the plant. The plan shall:
(f) illustrate integration with the Life of Mine Closure Plan referred to in subsection 6.2.10.

6.2.8 The Mine Reclamation Plan referred to in subsection 6.2.6 shall address, at a minimum, the following:
(a) integration of landforms, topography, vegetation, waterbodies, and watercourses with adjacent undisturbed areas within or adjacent to the plant, and mine areas adjacent to the plant;

6.2.12 The Life of Mine Closure Plan referred to in subsection 6.2.10 shall address, at a minimum, the following:
(a) integration of landforms, topography, vegetation, waterbodies, and watercourses with adjacent undisturbed areas within or adjacent to the plant, and mine areas adjacent to the plant;

6.3.4 The approval holder shall design all landforms to have self-sustaining and integrated surface drainage systems to convey surface runoff to adjacent watercourses, waterbodies, or wetlands.

6.3.5 The approval holder shall establish surface drainage on disturbed land that is integrated with undisturbed land.

6.3.26 The Revegetation Plan referred to in subsection 6.3.25 shall comply with the Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region, 2009, as amended, and shall at a minimum:
(d) establish continuity of vegetation patterns, where practicable, between the reclaimed lands and:
(i) adjacent undisturbed lands; and
(ii) the lands of adjacent lease holders (whether reclaimed or in the planning stage);

6.3.35 The Wetland Reclamation Plan referred to in subsection 6.3.34 shall comply with Guideline for Wetland Establishment on Reclaimed Oil Sands Leases, 2007, as amended, and shall include at a minimum, all of the following:
(h) a Wetland Revegetation Plan that shall include at a minimum, the following:
(vii) re-establishment of the continuity of vegetation patterns, where practicable, between the reclaimed lands and adjacent undisturbed lands;

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	(viii)	establishment of the continuity of vegetation patterns, where practicable, between the reclaimed lands and the lands of adjacent lease holders (whether reclaimed or in the planning stage);
6.4.13	The End Pit Lake Research and Development Report referred to in subsection 6.4.12 shall address, at a minimum, all of the following with specific reference to the tailings technology used by approval holder:	
(e)	the role of wetlands and littoral zone in creating continuity between the reclaimed landscape and the EPL;	
6.4.18	The Wetland Research Plan referred to in subsection 6.4.17 shall consider the objectives of the Wetland Reclamation Plan referred to in subsection 6.3.34 and shall include, at a minimum, the following:	
(d)	expected criteria and performance measures for reclaimed wetlands including measures of wetland sustainability (including water quality and quantity), ecological function, traditional use, and biodiversity;	
(i)	assessment of ecological function of wetland types and potential to maintain and enhance biodiversity;	
6.4.33	The approval holder shall submit a Plan for Reclamation Biodiversity to the Director by December 31, 2014, unless otherwise authorized in writing by the Director.	
6.4.34	The Plan for Reclamation Biodiversity referred to in subsection 6.4.33 shall include, at a minimum, all of the following unless otherwise authorized in writing by the Director:	
(a)	a determination of the technology required to establish best practices for development of biodiversity for a range of target ecosystems through reclamation;	
(b)	a determination of reclamation coversoil and subsoil composition and key vegetation species and their roles in supporting the return of biodiversity and native ecosystems in the reclaimed landscape;	
(c)	a plan and schedule to monitor and document the return of biodiversity in the reclaimed landscape; and	
(d)	a plan and schedule to evaluate and compare changes in biodiversity on reclaimed sites and in the region.	
6.4.35	The approval holder shall implement the Plan for Reclamation Biodiversity referred to in subsection 6.4.33 as authorized in writing by the Director.	
6.4.36	The approval holder shall participate in the regional Ecological Monitoring Committee for the Lower Athabasca, or any other regional initiative that may be developed within CEMA or CONRAD, to monitor the long-term cumulative effects on biodiversity and wildlife in the region, to the satisfaction of the Director.	
6.4.37	The approval holder shall participate in regional oil sand industry initiatives for establishing benchmark sites in ecosystems that are to be re-established on reclaimed sites on the oil sands leases to evaluate and monitor changes in biodiversity, to the satisfaction of the Director.	
6.4.44	The Wildlife Habitat Corridor Research and Monitoring Program referred to in subsection 6.4.43 shall include, at a minimum, all of the following:	
(a)	a description of proposed research techniques to determine appropriate wildlife habitat corridor widths, setback distances and mitigation strategies that will provide effective habitat and connectivity for wildlife adjacent to active oil sands mines;	
(b)	proposals and actions to include other research partners in the oil sands area, including regional initiatives such as encompassed within CEMA and CONRAD;	
(c)	a description of proposed monitoring studies to assess and compare wildlife use from the project boundary to the Athabasca River and within the Ells River valley; and	
(d)	a schedule for implementation of research and monitoring.	
6.4.45	The approval holder shall participate in the continued implementation of the Wildlife Habitat Corridor Research and Monitoring Program referred to in subsection 6.4.43, as authorized in writing by the Director.	

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Indicator 22: Landscape Mosaic

Group Name [1]	**Biodiversity Task Group (BTG)**	Submitted by [2]	*Names removed*	Date [3]	October 21, 2011
Objective [4]	Objective 1 – Reclaimed landscapes are established that support natural ecosystem functions. Objective 2 – Natural ecosystem functions are established on the reclaimed landscape. Objective 3 – Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses.	Criterion [5]	1.2 – The landforms have a natural appearance. 1.3 – The landscape and its landforms incorporate watershed features such as surface drainage, lakes and wetlands. 1.4 – Reclamation materials are place appropriate to the landform. 1.5 – Terrestrial and aquatic vegetation common to the boreal forest is established. 2.5 – Reclaimed ecosystems display characteristics of resilience to natural disturbance and climatic variability. 3.1 – The reclaimed landscape provides for biodiversity.		

Describe the indicator being recommended. [6]

Landscape mosaic.

Provide a brief statement on the value of the indicator. [7]

BTG adopted a hierarchical framework to evaluate biodiversity to address the spatial scale of measurement (see BTG mandate letter). The hierarchy includes the following levels: species, community, habitat, landscape and regional. The BTG is defining guidance for implementing the reference condition approach to monitor biodiversity within the hierarchical framework (CEMA Contract 2010-0025). Landscape mosaic addresses habitat, landscape and regional level biodiversity and components of the approval conditions identified below.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

From Total-EP approval:

Mine Reclamation Plan
Life of Mine Closure Plan
Soil Placement Plan
Revegetation Plan
Forest Resource Plan
Wetland Reclamation Plan
Wetland Revegetation Plan
Wetland Research Plan
Plan for Reclamation Biodiversity

List references related to the recommended indicator (research paper, journal article etc.): [10]

Alberta Biodiversity Monitoring Institute (ABMI). 2009. ABMI's Habitat Pyramid: Definitions and Element Lists (20039), Version 2009-04-20. Alberta Biodiversity Monitoring Institute, Alberta, Canada. Report available at: abmi.ca [Date Cited].

Ciborowski, J.J.H.; M. Kang; D. Raab; S.E. Bayley; and A.L. Foote. 2011. Synthesis: Applying the Reference Condition Approach for Monitoring Reclamation Areas in the Athabasca Oil Sands Region Final Report Draft 1.0 April 8, 2011. Prepared for the Cumulative Environmental Management Association, Fort McMurray, AB. CEMA Contract 2010-0025.

Kirk, D.A.; J. Schieck; and B. Eaton. 2009. Biodiversity review for the Guidelines to Reclamation to Forest Vegetation in the Alberta Oil Sands. Prepared for the Biodiversity and Wildlife Task Group of the Reclamation Working Group of the Cumulative Environmental Management Association. Final Version December 22, 2009. (CEMA Contract 2008-0031).

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Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐
Briefly explain: [12]		
Each polygon contributes to the mosaic.		
Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒
Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]		

Measure:	To be developed.
Method:	To be developed.
Threshold:	To be determined.

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

The BTG is developing guidance for implementing the reference condition approach as the experimental design model to monitor biodiversity in the reclaimed areas. The measures for evaluating landscape mosaic will be determined through the work of this project. Some proposed measures for landscape mosaic are:

- Diversity of vegetation types throughout the landform within a range that is natural for this landscape (i.e., consider pre-disturbance conditions as a reference)
- Fragmentation – targeting similar fragmentation and edge metrics as existed in the pre-disturbance or adjacent non-mined landscape.
- Connectivity – integrated landscape mosaic that resembles natural conditions and allows for movement of wildlife
- Hydrology linkages

The Reclamation Classification System Task Group is developing a classification system for the reclaimed areas to describe homogeneous reclamation units that are defined by hydrology, position on the landscape and biological response. The classification system will support closure planning and assist in mapping the reclamation areas which will facilitate a regional evaluation of the landscape mosaic in reclaimed areas among leases.

Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐

If yes, what is the condition number and corresponding EPEA approval? [17]

From Total-EP approval (N.B. – only the Total-EP approval was reviewed; other approvals may have different clauses):

6.2.1 The approval holder shall reclaim the land so that the reclaimed soils and landforms are capable of supporting self-sustaining, locally common boreal forest ecosystems, regardless of the end land use.

6.2.5 Using the pre-disturbance landscape as a reference for mine reclamation and closure planning, the approval holder shall return disturbed land to meet a reconciled distribution of pre-disturbance and proposed post-disturbance hectares of upland and wetland ecosites as presented and updated through approved Mine Reclamation Plans, Life of Mine Closure Plans, and approval amendment applications.

6.2.7 The Mine Reclamation Plan referred to in subsection 6.2.6 shall provide the detailed operational plan for development and reclamation for the next ten year period of operation of the plant. The plan shall:

(c) ensure that reclaimed features have natural appearances characteristic of the region;

6.2.8 The Mine Reclamation Plan referred to in subsection 6.2.6 shall address, at a minimum, the following:

(o) micro and meso topographic diversity;

6.2.11 The Life of Mine Closure Plan referred to in subsection 6.2.10 shall outline the most recent concepts for development and reclamation of the plant to the end of mine life. The plan shall:

(c) ensure that reclaimed features have natural appearances characteristic of the region;

6.2.12 The Life of Mine Closure Plan referred to in subsection 6.2.10 shall address, at a minimum, the following:

(l) fish and wildlife habitat as defined by validated habitat modeling (or other habitat assessment tools recommended by the Director) for key species consistent with pre-disturbance capabilities;

(m) watercourse and riparian design and development, including specific design for fish habitat;

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6.3.19 The Soil Placement Plan referred to in subsection 6.3.16 shall describe how salvaged materials will be used to achieve the reclamation objectives, and shall address at a minimum, the following, unless otherwise authorized in writing by the Director:

(a) the target ecosites, including spatial extent and location, as identified in the mine reclamation plan;

6.3.26 The Revegetation Plan referred to in subsection 6.3.25 shall comply with the Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region, 2009, as amended, and shall at a minimum:

(c) establish capability for long term biodiversity consistent with the Plan for Reclamation Biodiversity referred to in subsection 6.4.33;

6.3.30 The Forest Resource Plans referred to in subsection 6.3.29 shall include the following, unless otherwise authorized in writing by the Director:

(b) a description of how the pre-disturbance forest characteristics (including equivalent areas and types of ecosystems, forest stand structure, and forest growth and yield) will be reflected in the reclamation areas;

6.3.35 The Wetland Reclamation Plan referred to in subsection 6.3.34 shall comply with Guideline for Wetland Establishment on Reclaimed Oil Sands Leases, 2007, as amended, and shall include at a minimum, all of the following:

(c) identification of the location, wetland type, target ecosite, and amount of wetlands to be created on the reclaimed landscape;

(d) identification of the location, wetland type, target ecosite, and amount of wetlands that will remain undisturbed by mine development;

(h) a Wetland Revegetation Plan that shall include at a minimum, the following:

(vi) re-establishment of the capability for long term biodiversity consistent with the Plan for Reclamation Biodiversity referred to in subsection 6.4.33;

(l) performance measures to assess wetland reclamation success including measures of wetland sustainability (including water quality and quantity), ecological function, traditional use, and biodiversity

6.4.18 The Wetland Research Plan referred to in subsection 6.4.17 shall consider the objectives of the Wetland Reclamation Plan referred to in subsection 6.3.34 and shall include, at a minimum, the following:

(d) expected criteria and performance measures for reclaimed wetlands including measures of wetland sustainability (including water quality and quantity), ecological function, traditional use, and biodiversity;

(i) assessment of ecological function of wetland types and potential to maintain and enhance biodiversity;

6.4.24 The approval holder shall re-establish wildlife and fish habitat levels, at a minimum, similar to that which existed prior to disturbance, in proportions appropriate relative to the approved Life of Mine Closure Plan.

6.4.25 The approval holder shall demonstrate, through monitoring, progress in achieving the wildlife and fish habitat levels as outlined in subsection 6.4.24.

6.4.26 The approval holder shall re-establish a diversity of wildlife and fish habitats similar to those that existed prior to disturbance, in proportions appropriate relative to the approved Life of Mine Closure Plan.

6.4.27 The approval holder shall demonstrate, through monitoring, progress in achieving a diversity of wildlife and fish habitats as outlined in subsection 6.4.26.

6.4.33 The approval holder shall submit a Plan for Reclamation Biodiversity to the Director by December 31, 2014, unless otherwise authorized in writing by the Director.

6.4.34 The Plan for Reclamation Biodiversity referred to in subsection 6.4.33 shall include, at a minimum, all of the following unless otherwise authorized in writing by the Director:

(a) a determination of the technology required to establish best practices for development of biodiversity for a range of target ecosystems through reclamation;

(b) a determination of reclamation coversoil and subsoil composition and key vegetation species and their roles in supporting the return of biodiversity and native ecosystems in the reclaimed landscape;

(c) a plan and schedule to monitor and document the return of biodiversity in the reclaimed landscape; and

(d) a plan and schedule to evaluate and compare changes in biodiversity on reclaimed sites and in the region.

6.4.35 The approval holder shall implement the Plan for Reclamation Biodiversity referred to in subsection 6.4.33 as authorized in writing by the Director.

6.4.36 The approval holder shall participate in the regional Ecological Monitoring Committee for the Lower Athabasca, or any other

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	regional initiative that may be developed within CEMA or CONRAD, to monitor the long-term cumulative effects on biodiversity and wildlife in the region, to the satisfaction of the Director.
6.4.37	The approval holder shall participate in regional oil sand industry initiatives for establishing benchmark sites in ecosystems that are to be re-established on reclaimed sites on the oil sands leases to evaluate and monitor changes in biodiversity, to the satisfaction of the Director.

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Indicator 23: Species and Community Diversity

Group Name [1]	**Biodiversity Task Group (BTG)**	Submitted by [2]	*Names removed*	Date [3]	October 21, 2011
Objective [4]	Objective 1 – Reclaimed landscapes are established that support natural ecosystem functions. Objective 2 – Natural ecosystem functions are established on the reclaimed landscape. Objective 3 – Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses.	Criterion [5]	1.3 – The landscape and its landforms incorporate watershed features such as surface drainage, lakes and wetlands. 1.5 – Terrestrial and aquatic vegetation common to the boreal forest is established. 2.2 The reclaimed landforms have the necessary water quantity. 2.3 Nutrient cycling is established on the reclaimed landscape. 2.4 Ecosystem productivity is established on the reclaimed landscape. 2.5 – Reclaimed ecosystems display characteristics of resilience to natural disturbance and climatic variability. 3.1 – The reclaimed landscape provides for biodiversity.		

Describe the indicator being recommended. [6]

Species and community diversity is representative of the target.

Provide a brief statement on the value of the indicator. [7]

BTG adopted a hierarchical framework to evaluate biodiversity to address the spatial scale of measurement (see BTG mandate letter). The hierarchy includes the following levels: species, community, habitat, landscape and regional. The BTG is defining guidance for implementing the reference condition approach to monitor biodiversity within the hierarchical framework (CEMA Contract 2010-0025). Species and community is representative of the target addresses species and community level biodiversity and components of the approval conditions identified below.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (AENV 2010) – see Section 5

From Total-EP approval:

Mine Reclamation Plan
Life of Mine Closure Plan
Soil Placement Plan
Revegetation Plan
Forest Resource Plan
Wetland Reclamation Plan
Wetland Soil Salvage and Placement Plan
Wetland Revegetation Plan
Tailings Research and Development Report
Wetland Research Plan
Wetland Monitoring Program
Plan for Reclamation Biodiversity

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List references related to the recommended indicator (research paper, journal article etc.): [10]		
See References in Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (AENV 2010) Alberta Biodiversity Monitoring Institute (ABMI). 2009. ABMI's Habitat Pyramid: Definitions and Element Lists (20039), Version 2009-04-20. Alberta Biodiversity Monitoring Institute, Alberta, Canada. Report available at: abmi.ca [Date Cited]. Ciborowski, J.J.H.; M. Kang; D. Raab; S.E. Bayley; and A.L. Foote. 2011. Synthesis: Applying the Reference Condition Approach for Monitoring Reclamation Areas in the Athabasca Oil Sands Region Final Report Draft 1.0 April 8, 2011. Prepared for the Cumulative Environmental Management Association, Fort McMurray, AB. CEMA Contract 2010-0025. Kirk, D.A.; J. Schieck; and B. Eaton. 2009. Biodiversity review for the Guidelines to Reclamation to Forest Vegetation in the Alberta Oil Sands. Prepared for the Biodiversity and Wildlife Task Group of the Reclamation Working Group of the Cumulative Environmental Management Association. Final Version December 22, 2009. (CEMA Contract 2008-0031).		
Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐
Briefly explain: [12]		
The survey intensity level of each polygon will differ depending on the measure and the scale the measure represents (i.e., species, community).		
Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒
Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]		
Measure:	See Terrestrial Sub-group indicator recommendations for Plant Community Composition-Weeds; Plant Community Composition – Characteristic Species; and Plant Community Composition - diversity, richness, evenness, abundance. See Wildlife Task Group indicator recommendations of Populations and Ecological Role. Further measures to be developed.	
Method:	To be developed.	
Threshold:	To be determined.	
If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
The BTG is developing guidance for implementing the reference condition approach as the experimental design model to monitor biodiversity in the reclaimed areas. The measures for species and community diversity representative of the target will be determined through the work of this project. Some proposed measures for this measure are: • Topographic features (diversity) • Species diversity (composition for vegetation and for other organisms) • Structural diversity (includes vegetation structure and other features, like CWD) • Potential for diversity due to use of surface soils containing propagules, or proximity to a natural propagule source (important if expecting natural regeneration) The Reclamation Classification System Task Group is developing a classification system for the reclaimed areas to describe homogeneous reclamation units that are defined by hydrology, position on the landscape and biological response. The classification system will support closure planning and assist in mapping the reclamation areas which will facilitate evaluation of community diversity on the reclaimed landscape.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
From Total-EP approval: 6.2.2 The approval holder shall revegetate disturbed land to target the establishment of self-sustaining, locally common boreal forest ecosystems, integrated with the surrounding area, unless otherwise authorized in writing by the Director. 6.2.8 The Mine Reclamation Plan referred to in subsection 6.2.6 shall address, at a minimum, the following: (g) vegetation, with consideration of the target ecosite phases and forest productivity, including reference to spatial and temporal vegetation sourcing; (h) forest resources considering progressive establishment of upland vegetation communities and timber productivity consistent with pre-disturbance upland communities and consistent with the Revegetation Plan referred to in subsection 6.3.25;		

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6.2.12 The Life of Mine Closure Plan referred to in subsection 6.2.10 shall address, at a minimum, the following:
(f) vegetation, with consideration of the target ecosite phases and forest productivity, including reference to spatial and temporal vegetation sourcing;
(g) forest resources considering progressive establishment of upland vegetation communities and timber productivity consistent with pre-disturbance upland communities and consistent with the Revegetation Plan referred to in subsection 6.3.25;

6.3.19 The Soil Placement Plan referred to in subsection 6.3.16 shall describe how salvaged materials will be used to achieve the reclamation objectives, and shall address at a minimum, the following, unless otherwise authorized in writing by the Director:
(a) the target ecosites, including spatial extent and location, as identified in the mine reclamation plan;

6.3.20 The approval holder shall consider the following in developing the Soil Placement Plan referred to in subsection 6.3.16:
(g) matching pre-disturbance ecosite to targeted ecosite of reclaimed areas for the two categories of upland surface soil;

6.3.26 The Revegetation Plan referred to in subsection 6.3.25 shall comply with the Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region, 2009, as amended, and shall at a minimum:
(b) incorporate vegetation and vegetation communities that establish habitat for wildlife, including birds;

6.3.30 The Forest Resource Plans referred to in subsection 6.3.29 shall include the following, unless otherwise authorized in writing by the Director:
(b) a description of how the pre-disturbance forest characteristics (including equivalent areas and types of ecosystems, forest stand structure, and forest growth and yield) will be reflected in the reclamation areas;

6.3.35 The Wetland Reclamation Plan referred to in subsection 6.3.34 shall comply with Guideline for Wetland Establishment on Reclaimed Oil Sands Leases, 2007, as amended, and shall include at a minimum, all of the following:
(c) identification of the location, wetland type, target ecosite, and amount of wetlands to be created on the reclaimed landscape;
(d) identification of the location, wetland type, target ecosite, and amount of wetlands that will remain undisturbed by mine development;
(e) identification of opportunities to maximize wetland reclamation across the reclaimed landscape over the life of the mine;
(f) a Wetland Soil Salvage and Placement Plan that describes how salvaged materials will be used to achieve the reclamation objectives for wetland ecosystems outlined in the Life of Mine Closure Plan referred to in subsection 6.2.10, in a format consistent with subsections 3.6.29 and 6.3.19;
(h) a Wetland Revegetation Plan that shall include at a minimum, the following:
  (i) the target ecosite, as identified in the Mine Reclamation Plan referred to in subsection 6.2.6;
  (iii) incorporation of vegetation and vegetation communities that can provide habitat for wildlife, including birds;

6.4.10 The Tailings Research and Development Report referred to in subsection 6.4.8 shall address, at a minimum, all of the following:
(a) for terrestrial ecosystem research:
  (vii) identification of local native vegetation species suitable for re- establishment on terrestrial lands affected by tailings waters;
(b) for wetland ecosystem research:
  (vi) wetland revegetation including:
  (1) identification of local native wetland vegetation species suitable to inhabit the tailings wetlands;

6.4.18 The Wetland Research Plan referred to in subsection 6.4.17 shall consider the objectives of the Wetland Reclamation Plan referred to in subsection 6.3.34 and shall include, at a minimum, the following:
d) expected criteria and performance measures for reclaimed wetlands including measures of wetland sustainability (including water quality and quantity), ecological function, traditional use, and biodiversity;
(i) assessment of ecological function of wetland types and potential to maintain and enhance biodiversity;

6.4.20 The Wetland Monitoring Program referred to in subsection 6.4.20 shall include:
(a) a plan to monitor natural undisturbed wetlands for natural variability to serve as reference conditions for comparing against potentially impacted or reclaimed wetlands;

6.4.24 The approval holder shall re-establish wildlife and fish habitat levels, at a minimum, similar to that which existed prior to disturbance, in proportions appropriate relative to the approved Life of Mine Closure Plan.

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Indicator 24: Biodiversity Targets that Support Cultural, Spiritual, Medicinal and Ceremonial Purposes

Group Name [1]	**Biodiversity Task Group (BTG)**	Submitted by [2]	*Names removed*	Date [3]	October 21, 2011
Objective [4]	Objective 3: Reclaimed landscapes support an equivalent capability appropriate to the approved end land uses.	Criterion [5]	3.4 – The reclaimed landscape provides opportunities for traditional uses.		

Describe the indicator being recommended. [6]

Reclaimed areas achieve biodiversity targets that support cultural, spiritual, medicinal and ceremonial purposes as defined through stakeholder consultation outlined in the Life of Mine Closure Plan, Mine Reclamation Plan, Wetland Revegetation Plan, Revegetation Plan and Plan for Reclamation Biodiversity.

Provide a brief statement on the value of the indicator. [7]

This indicator is derived from:
(1) the revegetation planning guidance and end land-use planning options provided in Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (referred to subsequently as the Revegetion Manual; AENV 2010);
(2) the Sustainable Ecosystems Working Group goals and indicators for wildlife (see Table D.1 in the Revegetation Manual);
(3) the results of the biodiversity traditional knowledge study (CEMA Contracts 2008-0032 and 2010-0022); and
(4) the approval conditions identified below.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

See Section 2 and Table D.1 of the Revegetion Manual (AENV 2010) and the approval conditions identified below.

From Total-EP approval:

Mine Reclamation Plan
Life of Mine Closure Plan
Revegetation Plan
Wetland Reclamation Plan
Wetland Revegetation Plan
Wetland Research Plan
Plan for Reclamation Biodiversity

List references related to the recommended indicator (research paper, journal article etc.): [10]

Please refer to the Revegetation Manual, reports for CEMA Contracts 2008-0032 and 2010-0022, and EPEA approvals.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐

Briefly explain: [12]

The survey intensity level will vary depending on the site characteristics, area covered and targeted end land use.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Indigenous research methodologies for monitoring to assess reclamation areas based on traditional knowledge need to be developed.
Method:	To be developed.
Threshold:	No thresholds.

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

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The results of the Biodiversity Traditional Knowledge Study (CEMA Contracts 2008-0032 and 2010-0022) conducted by the Biodiversity Task Group conclude that indigenous research methodologies for assessing reclamation based on traditional knowledge need to be developed. The Biodiversity Task Group 5-year workplan includes budget to continue to develop indigenous research methodologies for assessing reclamation success and defining traditional knowledge indicators, and the Terrestrial Sub-group 5-year workplan includes budget to continue to develop guidance for reclamation planning based on traditional knowledge. These workplan items address the recommendations of the Phase II report forwarded to and reviewed by the CEMA Board.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
From the Total-EP approval: 6.2.1 The approval holder shall reclaim the land so that the reclaimed soils and landforms are capable of supporting self-sustaining, locally common boreal forest ecosystems, regardless of the end land use. 6.2.2 The approval holder shall revegetate disturbed land to target the establishment of self-sustaining, locally common boreal forest ecosystems, integrated with the surrounding area, unless otherwise authorized in writing by the Director. 6.2.5 Using the pre-disturbance landscape as a reference for mine reclamation and closure planning, the approval holder shall return disturbed land to meet a reconciled distribution of pre-disturbance and proposed post-disturbance hectares of upland and wetland ecosites as presented and updated through approved Mine Reclamation Plans, Life of Mine Closure Plans, and approval amendment applications. 6.2.8 The Mine Reclamation Plan referred to in subsection 6.2.6 shall address, at a minimum, the following: (l) land uses including traditional land use, recreation, commercial/industrial, miscellaneous, etc.; 6.2.12 The Life of Mine Closure Plan referred to in subsection 6.2.10 shall address, at a minimum, the following: (k) land uses including traditional land use, recreation, commercial/industrial, miscellaneous, etc.; 6.3.26 The Revegetation Plan referred to in subsection 6.3.25 shall comply with the Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region, 2009, as amended, and shall at a minimum: (a) incorporate vegetation and vegetation communities of traditional value characteristic of the locally common boreal forest ecosystems; 6.3.35 The Wetland Reclamation Plan referred to in subsection 6.3.34 shall comply with Guideline for Wetland Establishment on Reclaimed Oil Sands Leases, 2007, as amended, and shall include at a minimum, all of the following: (h) a Wetland Revegetation Plan that shall include at a minimum, the following: (ii) incorporation of vegetation and vegetation communities of traditional value that are characteristic of the locally common boreal forest; (l) performance measures to assess wetland reclamation success including measures of wetland sustainability (including water quality and quantity), ecological function, traditional use, and biodiversity 6.4.18 The Wetland Research Plan referred to in subsection 6.4.17 shall consider the objectives of the Wetland Reclamation Plan referred to in subsection 6.3.34 and shall include, at a minimum, the following: (d) expected criteria and performance measures for reclaimed wetlands including measures of wetland sustainability (including water quality and quantity), ecological function, traditional use, and biodiversity; 6.4.33 The approval holder shall submit a Plan for Reclamation Biodiversity to the Director by December 31, 2014, unless otherwise authorized in writing by the Director. 6.4.34 The Plan for Reclamation Biodiversity referred to in subsection 6.4.33 shall include, at a minimum, all of the following unless otherwise authorized in writing by the Director: (a) a determination of the technology required to establish best practices for development of biodiversity for a range of target ecosystems through reclamation; (b) a determination of reclamation coversoil and subsoil composition and key vegetation species and their roles in supporting the return of biodiversity and native ecosystems in the reclaimed landscape; (c) a plan and schedule to monitor and document the return of biodiversity in the reclaimed landscape; and (d) a plan and schedule to evaluate and compare changes in biodiversity on reclaimed sites and in the region. 6.4.35 The approval holder shall implement the Plan for Reclamation Biodiversity referred to in subsection 6.4.33 as authorized in writing by the Director. 6.4.37 The approval holder shall participate in regional oil sand industry initiatives for establishing benchmark sites in ecosystems that are to be re-established on reclaimed sites on the oil sands leases to evaluate and monitor changes in biodiversity, to the satisfaction of the Director.		

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Indicator 25: Geotechnical Design

Group Name [1]	**N/A**	Submitted by [2]	*Names removed*	Date [3]	May 23, 2012
Objective [4]	Objective 1: Reclaimed landscapes are established that support natural ecosystem functions	Criterion [5]	1.6 The landforms have geotechnical stability		

Describe the indicator being recommended. [6]

Landform design professional signoff by a geotechnical engineer and acceptance of the design by the Energy Resources Conservation Board (ERCB).

Provide a brief statement on the value of the indicator. [7]

In addition to geotechnical stability, it is important that elements of the Landscape Design Checklist (CEMA, May 2005), the mine approval conditions and Mine Closure Plans be considered in the landform design. Design elements such as natural appearance, integration, connectivity and water features need to be addressed early into the landform design. Once the ERCB accepts the design for approval, there is reluctance by the operator to change the design after construction (design changes may negatively impact geotechnical performance and incur significant cost). If these considerations are not incorporated into the landform design, it will be too late to accommodate them later in the mine life cycle.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

The Landscape Design Checklist (CEMA, May 2005) p.3 explains how the ERCB approvals, AESRD approvals, Mine Closure Plans and the Landscape Design Checklist are considered by the landscape design team for incorporation into the design process and the stages of regulatory approval.

The ERCB mandate is to approve landform designs.

List references related to the recommended indicator (research paper, journal article etc.): [10]

N/A

Does the indicator need to be measured in every polygon? [11]	**Yes** ☐	**No** ☒

Briefly explain: [12]

The indicator is applied at the landform scale, including integration with adjacent land.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☒	**No** ☐

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Landform geotechnical design.
Method:	Using the Landscape Design Checklist, a design team ensures the landform is integrated with the overall closure plan and adjusts the design (geometry, material placement, footprint, slope angles, morphology, reclamation material placement and revegetation) to accommodate operational, closure and reclamation goals.
Threshold:	ERCB approval of the landform design.

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

N/A

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Is the indicator aligned to an EPEA approval condition? [16]	Yes ☒	No ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		

6.2.11 The Life of Mine Closure Plan referred to in subsection 6.2.10 shall outline the most recent concepts for development and reclamation of the plant to the end of mine life. The plan shall:

(a) be consistent with the values and objectives in the Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan, Alberta Sustainable Resource Development, 2002, as amended;

(b) be consistent with any applicable approved regional plan under the Land Use Framework, Alberta Government, December 2008, as amended;

(c) ensure that reclaimed features have natural appearances characteristic of the region;

(d) be conceptual in nature and shall apply to the life of the plant and until closure;

(e) describe the utility of the landscape and its ability to meet the various end land use goals and objectives; and

(f) provide designs for individual landforms and for the lease landscape that will target specific end land uses.

6.2.12 The Life of Mine Closure Plan referred to in subsection 6.2.10 shall address, at a minimum, the following:

(a) integration of landforms, topography, vegetation, waterbodies, and watercourses with adjacent undisturbed areas within or adjacent to the plant, and mine areas adjacent to the plant;

(b) geotechnical stability;

(c) surface water hydrology;

(d) soil salvage, stockpile, and placement, with consideration of the target ecosites, and adaptive incorporation of any guidelines prepared or provided by the Director related to reclamation material handling;

(e) reclamation materials balance relative to life of mine closure reclamation requirements, indicating soil quality;

(f) vegetation, with consideration of the target ecosite phases and forest productivity, including reference to spatial and temporal vegetation sourcing;

(g) forest resources considering progressive establishment of upland vegetation communities and timber productivity consistent with pre-disturbance upland communities and consistent with the Revegetation Plan referred to in subsection 6.3.25;

(h) groundwater, hydrology and hydrogeology;

(i) wetlands;

(j) end pit lakes, including adaptive incorporation of any guidelines prepared or provided by the Director related to end pit lakes;

(k) land uses including traditional land use, recreation, commercial/industrial, miscellaneous, etc.;

(l) fish and wildlife habitat as defined by validated habitat modeling (or other habitat assessment tools recommended by the Director) for key species consistent with pre-disturbance capabilities;

(m) watercourse and riparian design and development, including specific design for fish habitat; and

(n) any other information as required in writing by the Director.

6.2.13 The approval holder shall implement the Life of Mine Closure Plan referred to in subsection 6.2.10, as authorized in writing by the Director

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Indicator 26: Geotechnical Stability

Group Name [1]	**N/A**	Submitted by [2]	*Names removed*	Date [3]	May 23, 2012
Objective [4]	Objective 1: Reclaimed landscapes are established that support natural ecosystem functions	Criterion [5]	1.6 The landforms have geotechnical stability		

Describe the indicator being recommended. [6]

Through assessment of the landform, a professional geotechnical engineer signs-off on its geotechnical performance. The operator submits the report to the ERCB who reviews and approves the assessment for acceptance.

Provide a brief statement on the value of the indicator. [7]

The assessment for geotechnical stability is important because the land reverts to the province of Alberta upon reclamation certification. The assessment and sign-off provide a level of certainty that the landform is stable and is in an appropriate condition suitable for the planned end land use. Assessment of geotechnical performance and acceptance of the assessment by the Energy Resources Conservation Board (ERCB) is a requirement prior to reclamation certification.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

ERCB Directive 073: Inspection and Compliance of Oil Sands Mining and Processing Plant Operations (December 2008), page 37:

4. Geotechnical Stability

a) Is the geotechnical performance of the structure satisfactory (within design expectations)?

b) Is there an adequate level of instrumentation monitoring for the structure?

c) Have there been any noticeable deformations in the fill or foundations?

e) Have there been any noticeable increases in piezometric levels within the fill or foundation?

f) Are there any noticeable features on the structure indicative of instability?

g) Have any abnormal features been observed (cracks, sinkholes, burrows, etc.)?

h) Are there any significant erosion gullies on the upstream or downstream slopes that could impact stability?

i) Are there or have there been any stabilization methods employed?

List references related to the recommended indicator (research paper, journal article etc.): [10]

N/A

Does the indicator need to be measured in every polygon? [11]	**Yes** ☐	**No** ☒

Briefly explain: [12]

The indicator is assessed at a landform scale.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☒	**No** ☐

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Geotechnical stability.
Method:	Assessment by a professional geotechnical engineer.
Threshold:	Professional sign-off by a geotechnical engineer that the geotechnical performance of the landform is suitable and ERCB acceptance of the assessment.

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If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
N/A		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
From approval 228044-00-00 Total E&P Canada Ltd. Joslyn North Oil Sands Processing Plant and associated Mines: 6.2.12 The Life of Mine Closure Plan referred to in subsection 6.2.10 shall address, at a minimum, the following: (b) geotechnical stability; 6.3.1 The approval holder shall not bury snow, ice, or other material, which causes instability or unacceptable settlement in tailings sand and overburden disposal areas or mined out pits. 6.3.2 The approval holder shall recontour all final slopes no steeper than 3 horizontal to 1 vertical (18°), over the total height of any engineered structure, unless otherwise authorized in writing by the Director. 6.3.3 The approval holder shall construct all structures and slopes to be geotechnically stable with minimal erosion.		

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Indicator 27: Foliar Nutrients

Group Name [1]	**Terrestrial Sub-group**	Submitted by [2]	*Names removed*	Date [3]	April 18, 2012
Objective [4]	Objective 2: Natural ecosystem functions are established on the reclaimed landscape.	Criterion [5]	2.3 Nutrient cycling is established on the reclaimed landscape.		

Describe the indicator being recommended. [6]

Foliar nutrients

Provide a brief statement on the value of the indicator. [7]

Foliar analysis is a useful and convenient method for evaluating the nutrient status of forested sites. Foliar nutrient data provides information to assess nutrient cycling in forested sites. Foliar nutrients analysis can replace soils nutrient measurements once vegetation is established on a site. The data may inform a management response (i.e., need for fertilization) in some cases.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No** ☐

If yes, state the document and page number: [9]

Refer to Appendix B in the Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region 2nd Edition (AENV 2010) – foliar nutrients are defined as a soft indicator.

List references related to the recommended indicator (research paper, journal article etc.): [10]

Ballard, T.M. and R.E. Carter. 1986. Evaluating forest stand nutrient status. British Columbia Ministry of Forests, Victoria, B.C. Land Management Report No. 20.
Brockley, R. 2001. Foliar Sampling Guidelines and Nutrient Interpretative Criteria for Lodgepole Pine. British Columbia Ministry of Forests , Victoria, B.C., Ministry of Forests Research Program Extension Note 52.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐

Briefly explain: [12]

From Brockley (2001):
"Reliable interpretations of foliar analytical data depend on the assumption that the data represent the forest stand (or stratum) in question. Because substantial inter-tree [and intra-tree] variation exists in foliar nutrient levels, enough samples must be collected to ensure a suitable level of precision and confidence. An appropriate sampling strategy should account for this natural variation, and be reasonably simple and efficient."

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Standard foliar analytical packages generally analyze samples for the concentration of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), copper (Cu), zinc (Zn), iron (Fe), manganese (Mn), and boron (B). Total sulphur (S) may, or may not, be included in the standard package. Inorganic sulphate-S (SO_3) should also be completed.
Method:	As per Brockley (2001) above.
Threshold:	To be defined for reclamation areas.

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If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
Foliar nutrients have been analyzed on samples collected in plots in the TSG long-term plot network monitoring program. The effects of fertilization application on the nutrient status of reclaimed areas in the long-term plot network are unknown as the fertilization practices are not documented in the plot network database. Syncrude is currently conducting a nutrient status research project with Dr. Craig Farnden independently from CEMA.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
Foliar nutrients analysis provides information to support achievement of the following approval conditions: From Fort Hills approval: 6.1.6 The approval holder shall reclaim the land so that the reclaimed soils and landforms are capable of supporting a self-sustaining, locally co mmon boreal forest, regardless of the end land use. 6.1.7 The approval holder shall revegetate disturbed land to target the establishment of a self-sustaining, locally common boreal forest integrated with the surrounding area, unless otherwise authorized in writing by the Director. 6.1.22 The approval holder shall design all landforms to have self-sustaining and integrated surface drainage systems to convey surface runoff to adjacent watercourses, waterbodies, or wetlands.		

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Indicator 28: Resilience

Group Name [1]	**Terrestrial Sub-group**	Submitted by [2]	*Names removed*	Date [3]	April 18, 2012
Objective [4]	Objective 2: Natural ecosystem functions are established on the reclaimed landscape.	Criterion [5]	2.5 Reclaimed ecosystems display characteristics of resilience to natural disturbances and climatic variability.		

Describe the indicator being recommended. [6]

Ecological resilience is established

Provide a brief statement on the value of the indicator. [7]

Ecological resilience is established is defined as a soft indicator to document the management activities applied on reclaimed areas which support the concept of resilience. The documentation includes the activities and steps taken during reclamation to establish resilience for both upland and aquatic reclamation areas.

Resilience is defined as the capacity of an ecosystem to return to the precondition state following a perturbation, including maintaining its essential characteristics, taxonomic composition, structures, ecosystem functions, and process rates (Holling 1973). The resilience of reclaimed sites would be expected to follow the pattern of resilience observed in appropriate reference conditions. For reclaimed landscapes, resilience represents the sustainability of the reclaimed lands to natural disturbances and climatic variation. The resilience of an ecosystem to changing environmental conditions is determined by its biological and ecological resources, in particular (i) the diversity of species, including micro-organisms, (ii) the genetic variability within species (i.e., the diversity of genetic traits within populations of species), and (iii) the regional pool of species and ecosystems. For reclaimed sites, the geotechnical stability characteristics may also affect resilience. Resilience is also influenced by the size of ecosystems (generally, the larger and less fragmented, the better), and by the condition and character of the surrounding landscape (Thompson et al 2009).

The revegetation strategy, soils placement strategy and ongoing management activities would be documented to indicate how components of these strategies support establishing resilience.

As part of this indicator, a research and monitoring program is proposed to identify and define indicators of resilience for reclaimed landscapes. The indicators would assess whether or not the management activities applied to the reclaimed lands to support establishment of resilience are effective. These indicators could be developed into hard indicators for assessing resilience in the future depending on the research and monitoring program data.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☐	**No** ☒

If yes, state the document and page number: [9]

N/A

List references related to the recommended indicator (research paper, journal article etc.): [10]

Environmental Protection Authority. 2006. Guidance for the assessment of environmental factors (in accordance with the Environmental Protection Act 1986) Rehabilitation of Terrestrial Ecosystems No. 6. Western Australia.

Holling, C.S. 1973. Resilience and stability of ecosystems. Ann. Rev. Ecol. Syst. 4: 1-23.

Nichols, O.G., C. Grant and L.C. Bell. 2005. Developing ecological completion criteria to measure the success of forest and woodland establishment on rehabilitated mines in Australia. Presented at the 2005 National Meeting of the American Society of Mining and Reclamation, June 19-23, 2005. Published by ASMR, 3134 Montavesta Road, Lexington, KY.

Thompson, I., Mackey, B., McNulty, S., Mosseler, A. (2009). Forest Resilience, Biodiversity, and Climate Change. A synthesis of the biodiversity/resilience/stability relationship in forest ecosystems. Secretariat of the Convention on Biological Diversity, Montreal. Technical Series no. 43, 67 pages.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐

Briefly explain: [12]

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The management activities that contribute to the establishment of resilience will be identified and documented for each polygon.

As part of a research and monitoring program to develop hard indicators of resilience, all polygons or a subset of polygons may be monitored for specific parameters. Other jurisdictions have established long-term research programs to assess resilience. For example, in Australia, plant reproductive capacity (e.g. seed production) and resilience to disturbance events such as fire or insects have been addressed in long-term research programs (EPA 2006, Nichols et al 2005).

Plant species diversity, vegetation cover, presence of noxious or prohibited noxious weeds and forest health, invertebrate and vertebrate diversity also contribute to assessing resilience to disturbance and are addressed on other indicator recommendation forms.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	To further develop establish resilience and the documentation process describing the management activities supporting establishment of resilience, TSG proposes that resilience be defined and the management activities which support establishment of resilience be identified. These activities (i.e., Seed or planting stock derived from local provenance) would be summarized to define how the results address EPEA approval conditions and lead to the establishment of resilience. To further develop hard indicators to directly measure resilience of reclaimed landscapes, a long-term research and monitoring program is proposed for measures such as: • Regeneration from propagules. • Diversity of propagules. • Nutrient cycling. • Adequate stocking rates of tree species capable of regenerating after a wildfire or withstanding a burn or wildlife. • Adequate stocking rates of understorey species capable of withstanding a burn or wildlife. • Analysis of insect infestation patterns to determine whether reclamation areas are being selectively attacked in the region. • Range in hydroperiod of a reclaimed aquatic site. • Sustainability of reclaimed soil cover designs. • Rates (and types?) of erosion • Rates (and location?) of sedimentation
Method:	To be determined.
Threshold:	To be determined.

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

TSG proposes to develop a scope of work to articulate the concept of resilience and summarize how management activities contribute to the establishment of resilience. OSRIN has indicated that support to complete this work in 2012 could be available.

Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐

If yes, what is the condition number and corresponding EPEA approval? [17]

From Fort Hills approval:

6.1.6 The approval holder shall reclaim the land so that the reclaimed soils and landforms are capable of supporting a self-sustaining, locally common boreal forest, regardless of the end land use.

6.1.7 The approval holder shall revegetate disturbed land to target the establishment of a self-sustaining, locally common boreal forest integrated with the surrounding area, unless otherwise authorized in writing by the Director.

6.1.22 The approval holder shall design all landforms to have self-sustaining and integrated surface drainage systems to convey surface runoff to adjacent watercourses, waterbodies, or wetlands.

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Indicator 29: Functional Littoral Communities

Group Name [1]	**ASG**	Submitted by [2]	*Names removed*	Date [3]	March 19, 2012
Objective [4]	Obj. 2 - Natural ecosystem functions are established on the reclaimed landscape.	Criterion [5]	2.4 - Ecosystem productivity is established on the reclaimed landscape		

Describe the indicator being recommended. [6]

Littoral communities are productive, functional, and biodiverse.

Provide a brief statement on the value of the indicator. [7]

This indicator speaks to littoral zone functionality, as opposed to quantity (see Indicator 2 on % littoral area).

Why are littoral zones important?
The littoral zone contributes greatly to lake ecosystem diversity and performs many ecosystem services. Aquatic plants contribute to primary production and dissolved oxygen level; they stabilize sediments, maintain water clarity, increase esthetics and provide fish and wildlife with food, spawning or nesting habitat, foraging substrates, cover from sun and predators (Engel 1990, Klessig 1995, Anderson et al. 1999). Several species of fish, including some species common to northern environments, require aquatic vegetation directly for spawning whether for adherence of eggs, or the building of nests (e.g., northern pike, yellow perch and ninespine stickleback; Scott and Crossman 1973). The littoral zone fish fauna plays an important role in freshwater lake ecosystems (Northcote 1988). Abundance is typically greater than in other zones, and in many lakes, littoral species make up the bulk of the total fish community (Keast and Harker 1977, Werner et al. 1977). Littoral zone habitat and food resources are frequently important as prey to larger fish species (Lyons and Magnuson 1987). A naturally diverse fish prey base in the littoral zone, particularly the presence of large invertebrates, is critical for maintaining energy transfer to growing fish. An impoverished littoral benthic community can lead to stunting or a bioenergetic bottleneck – a failure to diet shift to larger-sized prey (Sherwood et al. 2002, Rasmussen et al. 2008). In general, littoral zones are 10 times more biodiverse and productive than the open-water zone (Rasmussen 2011).

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☐	**No** ☒

If yes, state the document and page number: [9]

N/A

List references related to the recommended indicator (research paper, journal article etc.): [10]

Bayley et al. 2008. An analysis of existing information on marsh vegetation in the regional municipality of wood buffalo. Report prepared for CEMA.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐

Briefly explain: [12]

For each polygon classified as littoral zone.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	TBD - For example, rooted aquatic plants and zoobenthos (primarily) are present from year to year. Species abundance and diversity are consistent with appropriate reference systems.
Method:	TBD
Threshold:	TBD
Stage:	Revegetation – Certification monitoring

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If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
This indicator is not fully developed since no thresholds have been established. A list of common wetland species in natural marshes according to the Alberta Wetland Inventory Classification system is available in Bayley et al. (2008) and could be used to establish thresholds (minimum # of plants per wetland; minimum % cover per species).		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
Supports conditions 6.4.9, 6.4.24, 6.4.26, and 6.4.34 of Approval no. 228044-00-00		

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Indicator 30: End Pit Lake Percent Littoral Area

Group Name [1]	**ASG**	Submitted by [2]	*Names removed*	Date [3]	May 18, 2012
Objective [4]	Obj. 2 - Natural ecosystem functions are established on the reclaimed landscape. Obj. 3 – Reclaimed landscapes support equivalent land capability appropriate to the approved end land uses.	Criterion [5]	2.4 - Ecosystem productivity is established on the reclaimed landscape 3.1 – The reclaimed landscape provides for biodiversity 3.3 – The reclaimed landscape provides for fish and wildlife habitat 3.5 – The reclaimed landscape provides opportunities for traditional use 3.6 – The reclaimed landscape provides opportunities for recreational use		

Describe the indicator being recommended. [6]

Suitable quantity of littoral zone to support EPL productivity, sustainability, biodiversity and end land uses.

Provide a brief statement on the value of the indicator. [7]

Why are littoral zones important?
The littoral zone contributes greatly to lake ecosystem diversity and performs many ecosystem services. Aquatic plants contribute to primary production and dissolved oxygen level; they stabilize sediments, maintain water clarity, increase esthetics and provide fish and wildlife with food, spawning or nesting habitat, foraging substrates, cover from sun and predators (Engel 1990, Klessig 1995, Anderson et al. 1999). Several species of fish, including some species common to northern environments, require aquatic vegetation directly for spawning whether for adherence of eggs, or the building of nests (e.g., northern pike, yellow perch and ninespine stickleback; Scott and Crossman 1973). The littoral zone fish fauna plays an important role in freshwater lake ecosystems (Northcote 1988). Abundance is typically greater than in other zones, and in many lakes, littoral species make up the bulk of the total fish community (Keast and Harker 1977, Werner et al. 1977). Littoral zone habitat and food resources are frequently important as prey to larger fish species (Lyons and Magnuson 1987). A naturally diverse fish prey base in the littoral zone, particularly the presence of large invertebrates, is critical for maintaining energy transfer to growing fish. An impoverished littoral benthic community can lead to stunting or a bioenergetic bottleneck – a failure to diet shift to larger-sized prey. (Sherwood et al. 2002, Rasmussen et al. 2008). In general, littoral zones are 10 times more biodiverse and productive than the open-water zone (Rasmussen 2011).

The littoral zone is the near shore area where sunlight penetrates all the way to the sediment and allows aquatic plants to grow. Its lower boundary is also defined as the maximum depth of rooted plant colonization (see Atlas of Alberta Lakes). In terms of initial design, the littoral zone is often defined as an area shallower than 3 metres (e.g., compensation lakes in the region, End Pit Lake Working Group 2004 – for coal operators, 2012 draft EPL Guide).

What does the literature say?
The relationship between aquatic vegetation and other biota is complex. However, a number of studies show significant correlations between the occurrence of emergent and floating-leaf plant species and the biomass and size of fish (Radomski and Goeman 2000, Valley et al. 2004). Generally, conditions for large fish deteriorate when the percentage of a basin that is covered with aquatic vegetation falls below 10% or exceeds 40 to 60% (Valley at al. 2004). At low plant abundances, prey is scarce because of a lack of predator refuges. At high plant abundances, visual and swimming barriers created by dense vegetation reduce the ability of predators to capture fish prey. Low feeding rates or poor growth by predators commonly result. This range is consistent with the natural range in Alberta (Table 1).

What is common in natural lakes on the Boreal Plain?
Table 1: Minimum, maximum, and means from lakes on the Boreal Plain in Alberta for key features that are important in the design of pit lakes. Note that only lakes with maximum depths of 6 metres were chosen, which is consistent with pit lakes planned for the oil sands region of Alberta, as maximum depth may affect slopes and % littoral.

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Feature	Min	Mean	Max
Lake area (km^2) [1]	0.4	50	1160
Maximum depth (m) [1]	6.0	20	99
Slope from shoreline to max depth (%) [1]	0.07	1.9	5.7
Shoreline sinuosity [1,2]	1.1	2.2	4.4
Maximum depth of littoral zone (m) [3]	2.8	4.2	5.4
% surface area of lake as littoral zone [4]	10	28	48
% of lake perimeter where vegetation is present in the littoral zone [4]	5	61	100

Notes: [1] N = 65; data from Mitchell and Prepas (1990), Charette (2001) and Bennett (2005), [3] Ratio of the length of the shoreline to the length of the circumference of a circle of area equal to that of the lake. [3] N = 42; modelled depth of maximum plant colonization calculated according to Chambers & Prepas (1988), [4] N = 22; from Mitchell and Prepas (1990).

Consistency with other mines
Coal pit lakes (End Pit Lake Working Group 2004) and compensation lakes have been designed for 30% littoral, which is defined as < 3 metres. The Florida phosphate mining industry uses 20%.

This indicator is a milestone indicator.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	Yes ☐	No ☒

If yes, state the document and page number: [9]

It is in the draft 2012 EPL Guide, which has undergone extensive review by designers (AMEC & BGC), technical reviewers, global reviewers, and the EPLGTG.

List references related to the recommended indicator (research paper, journal article etc.): [10]

Radomski, P. and T.J. Goeman. 2001. Consequences of human lakeshore development on emergent and floating-leaf vegetation abundance. North Amarican Journal of Fisheries Management 21: 46-61.

Valley, R.D., T.K. Cross, and P. Radomski. 2004. The role of submersed aquatic vegetation as habitat for fish in Minnesota lakes, including the implications of non-native plant invasions and their management. Minnesota Department of Natural Resources, Special Publication 160: 1-25.

End Pit Lake Working Group, 2004. Guidelines for Lake Development at Coal Mine Operations in Mountain Foothills of the Northern East Slopes, Report # ESD/LM/00-1, Alberta Environment, Environmental Service.

Does the indicator need to be measured in every polygon? [11]	Yes ☒	No ☐

Briefly explain: [12]

The area of each littoral zone polygon would be measured and tallied.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	Yes ☒	No ☐

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	The lake area where sunlight penetrates all the way to the sediment.
Method:	Measure the lake area where light levels of 1% or more of surface values reach the sediment.
Threshold:	Measure the lake area where light levels of 1% or more of surface values reach the sediment.
Stage applied:	Certification monitoring

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If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
Supplemental - A minimum of 10% is being advanced as part of the EPL Guide, with 30% being recommended as "better". This is based on the literature, the ranges on the Boreal Plain, and best professional judgment from EPL Guide advisors. - Research done as part of the EPL Guide document has determined that regional lakes have littoral zone areas between 10 and 48%. - Coal pit lakes (End Pit Lake Working Group 2004) and compensation lakes have been designed for 30% littoral, which is defined as < 3 metres. The Florida phosphate mining industry uses 20%. - A minimum of 10% will allow wildlife and fish habitat levels similar to what exists in natural areas, with respect to littoral zone habitat.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
Supports the following: 6.3.35 The Wetland Reclamation Plan … shall include … identification of opportunities to maximize wetland reclamation across the reclaimed landscape over the life of the mine. 6.4.13 The End Pit Lake Research and Development Report … shall address… the role of wetlands and littoral zones in creating continuity between the reclaimed landscape and the EPL. 6.4.13 The End Pit Lake Research and Development Report … shall address… lake design features which optimize fisheries potential. 6.4.24 The approval holder shall re-establish wildlife and fish habitat levels, at a minimum, similar to that which existed prior to disturbance, in proportions appropriate relative to the approved Life of Mine Closure Plan. 6.4.26 The approval holder shall re-establish a diversity of wildlife and fish habitats similar to those that existed prior to disturbance, in proportions appropriate relative to the approved Life of Mine Closure Plans.		

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Indicator 31: End Pit Lake Littoral Slope

Group Name [1]	**ASG**	Submitted by [2]	*Names removed*	Date [3]	May 18, 2012
Objective [4]	Obj. 1 – Reclaimed landscapes are established that support natural ecosystem functions Obj. 2 - Natural ecosystem functions are established on the reclaimed landscape.	Criterion [5]	1.4 – Reclamation materials are placed appropriate to the landform 1.6 – The landforms have geotechnical stability 2.4 - Ecosystem productivity is established on the reclaimed landscape		

Describe the indicator being recommended. [6]

Suitable slope of littoral zone to support EPL productivity, sustainability, biodiversity and end land uses.

Provide a brief statement on the value of the indicator. [7]

Why are littoral zones important?
The littoral zone contributes greatly to lake ecosystem diversity and performs many ecosystem services. Aquatic plants contribute to primary production and dissolved oxygen level; they stabilize sediments, maintain water clarity, increase esthetics and provide fish and wildlife with food, spawning or nesting habitat, foraging substrates, cover from sun and predators (Engel 1990, Klessig 1995, Anderson et al. 1999). Several species of fish, including some species common to northern environments, require aquatic vegetation directly for spawning whether for adherence of eggs, or the building of nests (e.g., northern pike, yellow perch and ninespine stickleback; Scott and Crossman 1973). The littoral zone fish fauna plays an important role in freshwater lake ecosystems (Northcote 1988). Abundance is typically greater than in other zones, and in many lakes, littoral species make up the bulk of the total fish community (Keast and Harker 1977, Werner et al. 1977). Littoral zone habitat and food resources are frequently important as prey to larger fish species (Lyons and Magnuson 1987). A naturally diverse fish prey base in the littoral zone, particularly the presence of large invertebrates, is critical for maintaining energy transfer to growing fish. An impoverished littoral benthic community can lead to stunting or a bioenergetic bottleneck – a failure to diet shift to larger-sized prey (Sherwood et al. 2002, Rasmussen et al. 2008). In general, littoral zones are 10 times more biodiverse and productive than the open-water zone (Rasmussen 2011).

The littoral zone is the near shore area where sunlight penetrates all the way to the sediment and allows aquatic plants to grow. Its lower boundary is also defined as the maximum depth of rooted plant colonization (see Atlas of Alberta Lakes). In terms of initial design, the littoral zone is often defined as an area shallower than 3 metres (e.g., compensation lakes in the region, End Pit Lake Working Group 2004 – for coal operators, 2012 draft EPL Guide).

What does the literature say about slope?
Slope can be a major factor controlling the physical characteristics of the sediments by affecting sediment stability and the deposition of fine nutrient-rich materials. Variation in slope can also modulate wave action in the littoral. A gently sloped littoral allows the deposition of fine materials, while steep slopes are mainly areas of erosion and sediment transport. Also, gentle slopes reduce the probability of slumping, with slumping by gravity alone having been reported for underwater slopes as low as 0.5% (Prior and Suhayda 1979). In general, aquatic plant biomass decreases where the slope nearshore is steep. Slopes less than a threshold of 2.5% do not appear to cause adverse effects for plant biomass (Duarte and Kalff 1986). .

What is common in natural lakes on the Boreal Plain?

Table 1: Minimum, maximum, and means from lakes on the Boreal Plain in Alberta for key features that are important in the design of pit lakes. Note that only lakes with maximum depths of 6 metres were chosen, which is consistent with pit lakes planned for the oil sands region of Alberta, as maximum depth may affect slopes and % littoral.

Feature	**Min**	**Mean**	**Max**
Lake area (km^2) [1]	0.4	50	1160
Maximum depth (m) [1]	6.0	20	99
Slope from shoreline to max depth (%) [1]	0.07	1.9	5.7
Shoreline sinuosity [1,2]	1.1	2.2	4.4
Maximum depth of littoral zone (m) [3]	2.8	4.2	5.4
% surface area of lake as littoral zone [4]	10	28	48
% of lake perimeter where vegetation is present in the littoral zone [4]	5	61	100

Notes: [1] N = 65; data from Mitchell and Prepas (1990), Charette (2001) and Bennett (2005), [3] Ratio of the length of the shoreline to the length of the circumference of a circle of area equal to that of the lake. [3] N = 42; modelled depth of maximum plant colonization

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calculated according to Chambers & Prepas (1988), [4] N = 22; from Mitchell and Prepas (1990).

Consistency with other mines
The Coal Mine EPL Guide recommends a 5% slope. Most wetland reclamation guides recommend 5%.

Classed as a milestone indicator.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☐	**No** ☒
If yes, state the document and page number: [9]		
It is in the draft 2012 EPL Guide, which has undergone extensive review by designers (AMEC & BGC), technical reviewers, global reviewers, and the EPLGTG.		
List references related to the recommended indicator (research paper, journal article etc.): [10]		
Duarte, C.M. and J. Kalff. 1986. Littoral slope as a predictor of the maximum biomass of submerged macrophyte communities. Limnology & Oceanography 31: 1072-1080. End Pit Lake Working Group, 2004. Guidelines for Lake Development at Coal Mine Operations in Mountain Foothills of the Northern East Slopes, Report # ESD/LM/00-1, Alberta Environment, Environmental Service.		
Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐
Briefly explain: [12]		
Slope would be measured in every littoral polygon in the lake.		
Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☒	**No** ☐
Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]		

Measure:	Slope in polygons classified as littoral zones.
Method:	Slope (rise over run) in polygons classified as littoral zones. Measured from the shoreline to the distance perpendicular to the shoreline where light levels of 1% of surface values reach the sediment surface.
Threshold:	Maintained at ≤ 5%
Stage applied:	Design, re-grading, final certification

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

Supplemental:
- This threshold will ensure that the littoral zone will be sustainable over the long-term. That is, it will not be unduly affected by erosional forces.

Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		

Supports:

6.4.13 The End Pit Lake Research and Development Report … shall address… the role of wetlands and littoral zones in creating continuity between the reclaimed landscape and the EPL.

6.4.13 The End Pit Lake Research and Development Report … shall address… lake design features which optimize fisheries potential.

6.4.26 The approval holder shall re-establish a diversity of wildlife and fish habitats similar to those that existed prior to disturbance, in proportions appropriate relative to the approved Life of Mine Closure Plans.

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Indicator 32: End Pit Lake Littoral Zone Reclamation Materials

Group Name [1]	**ASG**	Submitted by [2]	*Names removed*	Date [3]	May 18, 2012
Objective [4]	Obj. 2 - Natural ecosystem functions are established on the reclaimed landscape.	Criterion [5]	2.4 - Ecosystem productivity is established on the reclaimed landscape		

Describe the indicator being recommended. [6]

Suitable substrate to support plant establishment, productivity and biomass in the littoral zone.

Provide a brief statement on the value of the indicator. [7]

Two factors are commonly related to substrate composition: low nutrient levels and little or no organic matter. The lack of adequate attention to soil conditions can result in the total failure of vegetation establishment in an ecological restoration project. Sediment acts as an anchoring substrate and a source of nutrients for rooted plants. Some bottom types are inhospitable. Coarser sediment (sand & gravel) is unfavorable for aquatic plant growth. Coarse-textured cobble may provide few rooting microsites and sand is nutrient-poor. Excessively soft and flocculent substrates do not provide anchorage and may be eroded easily whereas clay is a more stable substrate. Low nutrient and organic matter levels will result in poor plant growth and high rates of plant mortality. In general, relatively favourable benthic substrates are composed of a mixture of inorganic particulates and are rich in humified organic matter (Lacould and Freedman 2006).

The literature does not yield a great amount of information with respect to optimal soil mixtures to support aquatic plant colonization and growth. Field trials would be useful to determine the optimal soil mix for plant colonization and resistance to wave action. In general, a good planting soil to the depth of the rooting zone has proven effective in wetland construction projects in western Canada (L. Ross, personal communication). The addition of organic matter (compost, peat) can result in higher nutrient and higher soil moisture levels, which can improve seed germination and seedling survival and growth rates (van der Valk et al. 2009). However, these amendments do not appear to be necessary for establishment (L. Ross, personal communication).

Classified as a milestone indicator.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☐	**No** ☒

If yes, state the document and page number: [9]

It is in the draft 2012 EPL Guide, which has undergone extensive review by designers (AMEC & BGC), technical reviewers, global reviewers, and the EPLGTG.

List references related to the recommended indicator (research paper, journal article etc.): [10]

Lacould, P. and B. Freedman. 2006. Environmental influences on aquatic plants in freshwater ecosystems. Environmental Revue 14: 89-136.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐

Briefly explain: [12]

Measured in each polygon classified as littoral zone.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	TBD – For example, depth, physical properties (e.g., texture), and chemical properties (e.g., nutrients) of reclamation material
Method:	TBD
Threshold:	TBD
Stage applied:	Soils placement

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If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
This is a milestone indicator. Lab/field trials could determine the optimal soil mix for plant colonization and resistance to wave action. The Republic Ore Mine in Michigan requires a minimum of 6 inches of high quality soil (A horizon). Ducks Unlimited uses a mix of A and B horizon.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
Section 6.3.6 to 6.3.24 deals with soil placement for upland ecosystems. There are no approval clauses that address soil placement in wetland features. However, placement will affect the following clauses, through proven relationships with plant reclamation success: 6.4.13 The End Pit Lake Research and Development Report … shall address… the role of wetlands and littoral zones in creating continuity between the reclaimed landscape and the EPL. 6.4.13 The End Pit Lake Research and Development Report … shall address… lake design features which optimize fisheries potential. 6.4.26 The approval holder shall re-establish a diversity of wildlife and fish habitats similar to those that existed prior to disturbance, in proportions appropriate relative to the approved Life of Mine Closure Plans.		

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Indicator 33: End Pit Lake Total Dissolved Solids

Group Name 1	ASG	Submitted by 2	Names removed	Date 3	May 18, 2012
Objective [4]	Obj. 2 - Natural ecosystem functions are established on the reclaimed landscape.	Criterion [5]	2.1 - The reclaimed landforms have the necessary water quality.		

Describe the indicator being recommended. [6]

The concentration of major ions in pit lake water is stable or declining.

Provide a brief statement on the value of the indicator. [7]

Major ions (Ca, Mg, Na, Cl, etc.) are important drivers for aquatic ecosystem structure in that freshwater aquatic biota, by definition, have a limited tolerance for elevated salt concentrations. They are also conservative. Provided that the target ecosystem is a freshwater ecosystem, it is critical that the ion budget is properly constrained and the water balance designed accordingly. Very high concentrations of salts can also influence lake mixing processes by their influence on water density. Provided that the objective is a lake that mixes thoroughly and frequently, lake design should target relatively low salt concentrations.

Classified as trend-based indicator.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☐	**No** ☒

If yes, state the document and page number: [9]

N/A

List references related to the recommended indicator (research paper, journal article etc.): [10]

EPL Guidance document (2012 draft).

Does the indicator need to be measured in every polygon? [11]	**Yes** ☐	**No** ☒

Briefly explain: [12]

In the context of water quality major ion concentrations need only be measured in surface water. However, salt loads to surface water associated with leaching of reclaimed landforms should be constrained.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☒	**No** ☐

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Total dissolved solids (TDS).
Method:	Surface water samples collected at least monthly for a period of at least 10 years in both the EPL and a suite of representative reference lakes. Measured with standard procedures insitu and in certified laboratory with field blanks and lab standards. EPL data to be corrected against significant trends in the reference dataset to account for the effects of climate variability. Trend analysis, as per standard methodologies, performed on the corrected EPL data to determine if there is significant change over time (at probability level of 0.05).
Threshold:	Slope of TDS concentration over time is zero or negative ($P \geq 0.05$).
Stage applied:	Certification monitoring.

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

N/A

Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐

If yes, what is the condition number and corresponding EPEA approval? [17]

6.4.13 The End Pit Lake Research and Development Report … shall address… lake design features which optimize water residence time with particular consideration of salinity.

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Indicator 34: End Pit Lake Water Column Mixing

Group Name [1]	**ASG**	Submitted by [2]	*Names removed*	Date [3]	May 18, 2012
Objective [4]	Natural ecosystem functions are established on the reclaimed landscape.	Criterion [5]	Ecosystem productivity is established on the reclaimed landscape		

Describe the indicator being recommended. [6]

Presence of annual summer stratification and fall turnover

Provide a brief statement on the value of the indicator. [7]

Meromictic lakes are relatively rare, although they are widely distributed throughout the world. A meromictic lake has layers of water that do not intermix on an annual basis. As a result, the deeper layer of water (termed "monimolimnion") receives little oxygen from the atmosphere and becomes depleted of oxygen. The upper stratum where mixing by wind occurs may behave like a typial lake and become seasonally stratified and/or mix completely. Meromictic conditions can last anywhere from one year to centuries. There is nothing inherently wrong with meromictic lakes – they are a state found naturally throughout the world. In general, they tend to have low productivity and few fish and they are often studied as ecological oddities. In the context of oil sands pit lakes, however, what is relevant is that meromixis would reduce one of the main functions of a pit lake during the "active treatment phase", that is, treatment efficiency (treatment function is drastically reduced under anoxic conditions). Low productivity in these types of systems may also be at odds with certain desired ecosystem functions, such as fish production.

Classified as a performance indicator.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☐	**No** ☒

If yes, state the document and page number: [9]

It is in the draft 2012 EPL Guide, which has undergone extensive review by designers (AMEC & BGC), technical reviewers, global reviewers, and the EPLGTG.

List references related to the recommended indicator (research paper, journal article etc.): [10]

EPL Guide (2012 draft).

End Pit Lake Working Group, 2004. Guidelines for Lake Development at Coal Mine Operations in Mountain Foothills of the Northern East Slopes, Report # ESD/LM/00-1, Alberta Environment, Environmental Service.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☐	**No** ☒

Briefly explain: [12]

Measurement would occur in deepest site of lake.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☒	**No** ☐

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Monimolimnion strata in lake.
Method:	Temperature and oxygen measurements at 1 metre depth increments monthly from June to October, at deepest point in lake.
Threshold:	Presence of layers of water that do not intermix on an annual basis, at any time, over a period of at least 10 consecutive years.
Stage applied:	Certification monitoring

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If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
Supplemental - All involved with the EPL Guide production agree that meromixis must be avoided - Meromictic lakes are not regionally-representative. They are quite rare. - This indicator is used as a performance indicator for coal pit lakes (End Pit Lake Working Group 2004) in Alberta.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
It supports the following clauses: 6.4.10 The Tailings Research and Development Report… shall address… lake design features which optimize natural biodegradation and detoxification rates for toxic parameters 6.4.10 The Tailings Research and Development Report… shall address… biodegradation, detoxification and dilution of parameters identified as substances of concern by the CEMA Surface Water Working Group.		

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Indicator 35: End Pit Lake Water Level Variability

Group Name [1]	**ASG**	Submitted by [2]	*Names removed*	Date [3]	May 18, 2012
Objective [4]	Obj. 2 - Natural ecosystem functions are established on the reclaimed landscape.	Criterion [5]	2.2 - The reclaimed landforms have the necessary water quantity. 2.4 – Ecosystem productivity will be established on the reclaimed landscape 2.5 – Reclaimed ecosystems display characteristics of resilience to natural disturbances and climatic variability		

Describe the indicator being recommended. [6]

Suitable water level variability to support plant establishment, productivity, and diversity in the littoral zone.

Provide a brief statement on the value of the indicator. [7]

What does the literature say?

Water level and its variation is one of the most important variables in EPL design and the main variable that leads to the success or failure of the littoral zone. Littoral zone productivity will be closely tied to the vegetation community. A number of early studies documented cyclical changes in the abundance and composition of vegetation and noted that the diversity and productivity of both wetland flora and fauna appeared to be driven by cyclic wet and dry periods in wetlands across North America (Weller and Spatcher 1965, Weller and Fredrickson 1974, Walker 1959, 1965). Hydroperiod leads to a unique vegetation composition but can limit or enhance species richness depending on the depth of the water, the duration of flooding, and the frequency of disturbance events.

The most visible effect of a prolonged increase in water levels (i.e., >1 yr) is the elimination first of annual species, followed by emergent perennial species (van der Valk 1994, van der Valk et al. 1994). Many researchers initially believed that wetland plants can survive deep flooding periods by extending shoot length above the water's surface. We now know that for most wetland plants this is not the case. Squires and van der Valk (1992) found that upper marsh species, such as sedges (*Carex* spp.) and whitetop (*Scolochloa festucacea*), were unable to adjust their shoot length to maintain sufficient shoot area above water if they were growing in water deeper than 20-cm. Lower marsh species, such as cattails (*Typha* spp.) and bulrushes (SCHOENOPLECTUS spp.), were able to adjust shoot length up to a water depth of 70-cm, however both aboveground and belowground biomass was greatly reduced in order for the plants to do this. When subjected to water levels beyond their upper flooding range many wetland species can be eliminated in just one growing season. van der Valk (2000) studied the concept of plants being able to migrate upslope when water depths approached their depth limit. He found that plants already growing under stressed conditions do not have the energy needed for cloning growth into locations with more optimal water depths. Another challenge he observed is that most of the adjacent, shallower areas were already occupied by other emergent plant communities. Flooding depths of 70-cm to 1-m can cause many species of emergent plants to die within one growing season. That said, fluctuation between wet and dry conditions is critical to the long-term productivity of most wetland systems. Creating conditions where water levels remain stable for multiple years in a row can result in dramatic community shifts in flora and fauna that even management interventions cannot reverse.

What is common in natural lakes on the Boreal Plain?
Natural lakes, for which there is data, on the Boreal Plain in Alberta do not vary more than a metre on an annual basis (See Table 1).

Table 1: Maximum annual water level change statistics for 28 lakes on the Alberta Boreal Plain.

Statistic	Maximum WL change over a year (m)
Mean	0.56 ± 0.09
Standard deviation	0.23
95th percentile	0.98

Note. Lakes included in summary statistics include those that had no control structures and had at least 8 years of data collected during spring, summer and fall.
Consistency with other mines
<1 metre annual change in water level has been used in the Alberta coal mining industry as a performance/evaluation target (End Pit Lake Working Group 2004).
Classified as a performance indicator.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☐	**No** ☒

If yes, state the document and page number: [9]

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It is in the draft 2012 EPL Guide, which has undergone extensive review by designers (AMEC & BGC), technical reviewers, global reviewers, and the EPLGTG.		
List references related to the recommended indicator (research paper, journal article etc.): [10]		
EPL guide (2012 draft). DeVito and Mendoza. 2008. Guideline for Wetland Establishment on Reclaimed Oil Sands Leases. Appendix C1 Cooper et al. 2008. Guideline for Wetland Establishment on Reclaimed Oil Sands Leases. Appendix D Native Plant Solutions. 2010. Minimum Ecological Management. Report prepared for the Aquatics Subgroup of CEMA. End Pit Lake Working Group. 2004. Guidelines for Lake Development at Coal Mine Operations in Mountain Foothills of the Northern East Slopes, Report # ESD/LM/00-1, Alberta Environment, Environmental Service.		
Does the indicator need to be measured in every polygon? [11]	**Yes** ☐	**No** ☒
Briefly explain: [12]		
Water levels need only be measured in one location in the lake.		
Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☒	**No** ☐
Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]		
Measure:	Lake levels and range of variation.	
Method:	Water level sensor. Levels collected daily during the open-water season over a period of at least 10 years.	
Threshold:	No greater than a 1 metre change in water level during any one year.	
Stage applied:	Certification monitoring	
If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator:[15]		
This threshold is consistent with that of the EPL Guide for Coal Mines, which is being used by that industry. Note that the effects of climate change (greater variability) must be considered. Thus, continuous verification of this threshold is necessary.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
Supports: Conditions 6.4.9, 6.4.24, 6.4.26, and 6.4.34 of Approval no. 228044-00-00		

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Indicator 36: Water Balance

Group Name [1]	**ASG**	Submitted by [2]	*Names removed*	Date [3]	May 18, 2012
Objective [4]	Obj. 1 - Reclaimed landscapes are established that support natural ecosystem function Obj. 2 – Natural ecosystem functions are established on the reclaimed landscape Obj. 3 – Reclaimed landscapes support an equivalent land capability appropriate to the approved end land uses.	Criterion [5]	1.3 The landscape and its landforms incorporate natural features such as surface drainage, lakes and wetlands 2.1 The reclaimed landforms have the necessary water quality 3.1 The reclaimed landscape provides for fish and fish habitat		

Describe the indicator being recommended. [6]

EPL water balance

Provide a brief statement on the value of the indicator. [7]

From draft EPL Guide (Objectives, In-lake processes, and Natural Lakes chapters):

"There is a substantial amount of evidence from proxy systems, such as experimental test sites and constructed wetlands that contain OSPW and were constructed for this purpose. Studies conducted at these sites have shown that toxicity of OSPW in these aquatic reclamation sites is dissipated relatively rapidly and water and substrate quality improvements provide the basis for biota colonization. Experience has demonstrated that the rate and effectiveness of degradation will be hastened if such systems are operated in as flow-through systems with recharge of fresh water, rather than as terminal lakes, where instead of dilution there will be a concentration effect."

Classified as a performance indicator.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☐	**No** ☒

If yes, state the document and page number: [9]

It is in the draft 2012 EPL Guide, which has undergone extensive review by designers (AMEC & BGC), technical reviewers, global reviewers, and the EPLGTG.

List references related to the recommended indicator (research paper, journal article etc.): [10]

EPL Guide (2012) – see above

Does the indicator need to be measured in every polygon? [11]	**Yes** ☐	**No** ☒

Briefly explain: [12]

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☒	**No** ☐

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Water balance
Method:	Standard methodology to determine lake water balance, measured over 10 years.
Threshold:	No surplus/outflow of water leaving the EPL (i.e., zero or negative water balance), on an annual basis, over a period of 10 years.
Stage applied:	Certification monitoring

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

Supplemental: In using this indicator, consideration must be given to regional climate effects (prolonged extreme droughts) as determined by comparison to relevant reference systems, although EPLs should be designed to be resistant to droughts as much as possible (see EPL Guide 2012).

Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐

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If yes, what is the condition number and corresponding EPEA approval? [17]
Supports the following clauses: 6.4.13 The End Pit Lake Research and Development Report… shall address… water residence time with particular consideration for salinity. 6.4.25 The approval holder shall re-establish wildlife and fish habitat levels, at a minimum, similar to that which existed prior to disturbance, in proportions appropriate relative to the approved Life of Mine Closure Plan. 6.4.26 The approval holder shall re-establish a diversity of wildlife and fish habitats similar to those that existed prior to disturbance, in proportions appropriate relative to the approved Life of Mine Closure Plans 6.4.28 The approval holder shall document wildlife and fish habitat utilization on the reclaimed land by monitoring wildlife and fish species typically associated with and naturally occurring in the wildlife and fish habitat types present.

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Indicator 37: End Pit Lake Bed Stability

Group Name [1]	**ASG**	Submitted by [2]	*Names removed*	Date [3]	May 18, 2012
Objective [4]	Obj. 2 - Natural ecosystem functions are established on the reclaimed landscape.	Criterion [5]	2.1 - The reclaimed landforms have the necessary water quality.		

Describe the indicator being recommended. [6]

Resuspension of fluid fine tails, where present, is minimized. Resistance to resuspension can be demonstrated under the expected range of kinetic mixing (e.g. 1 in 10 year wind event).

Provide a brief statement on the value of the indicator. [7]

Fluid fine tails have low resistance to resuspenson (shear strength) as deposited. They are susceptible to resuspension under moderate kinetic inputs (e.g. wind) that generate shear stress at the tailings/water interface, depending on water depth. The resuspension of tailings and the attendant disruption of biogeochemical gradients may generate ecologically damaging concentrations of tailings constituents in the free water zone and will retard consolidation of the tailings surface. Shear strength is expected to increase with time due to consolidation and biofilm development provided that the tailings-water interface is not disturbed excessively. Design considerations should account for shear stresses at the tailings water interface relative to the shear strength of the tailings.

Classified as a milestone indicator.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☐	**No** ☒

If yes, state the document and page number: [9]

It is in the draft 2012 EPL Guide, which has undergone extensive review by designers (AMEC & BGC), technical reviewers, global reviewers, and the EPLGTG.

List references related to the recommended indicator (research paper, journal article etc.): [10]

Lawrence, G.A., P.R.B. Ward and M.D. MacKinnon. 1991. Wind-wave-induced suspension of mine tailings in disposal ponds – a case study. Canadian Journal of Civil Engineering. 18: 1047-1053.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☐	**No** ☒

Briefly explain: [12]

Indicator needs to be measured only in polygons containing water capped fluid fine tails

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	For example: Shear strength of lutocline or tailings surface.
Method:	For example: Measurement at the lutocline or tailings surface of undisturbed tailings samples (e.g. using sediment cores, in-situ sampling devices, flumes, etc.) at multiple locations. Wind-wave induced shear stresses are modelled.
Threshold:	For example: Critical shear strength is less than projected shear stress at the tailings-water interface. The trajectory of shear strength, based on multiple measurements over time, must not approach the projected shear stress at the tailings-water interface induced by a 1 in 10 year wind event. Thresholds will be site specific and defined by numerical simulation or modelling.
Stage applied:	Certification monitoring

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

Standard methods for measurement of shear strength must be identified or developed and demonstrated.

Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☐	**No** ☒

If yes, what is the condition number and corresponding EPEA approval? [17]

N/A

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Indicator 38: Fen Organic Matter Accumulation

Group Name [1]	**ASG**	Submitted by [2]	*Names removed*	Date [3]	May 18 2012
Objective [4]	2. Natural ecosystem functions are established on the reclaimed landscape	Criterion [5]	2.4 Ecosystem production is established on the reclaimed landscape		

Describe the indicator being recommended. [6]

Net storage of organic matter in wetlands classified as peat-accumulating systems (bogs or fens).

Provide a brief statement on the value of the indicator. [7]

Establishing fen wetlands in the reclaimed landscape is an important step in achieving equivalent capability. Pilot fen programs are underway to evaluate program success. An important component of program success will be development of a peat-accumulating system (Daly et al 2011), although it may take as much as two decades to accomplish this long-term goal (Pers. comm. L. Rochefort).

Listed as trend-based indicator.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☐	**No** ☒

If yes, state the document and page number: [9]

List references related to the recommended indicator (research paper, journal article etc.): [10]

Daly, C., Price, J.S., Rochefort, L., Rezanezhad, F., Pouliot, R., and M.D. Graf. Consideration for building a fen peatland in a post-mined oil sands landcape. In: Reclaiming and restoring North American Boreal Ecosystems: Towards Responsible Mangement, Vitt, D. (ed.). Submitted to Cambridge University Press (March 2011).

Waddington, J.M., Rotenberg, P.A. and F.J. Warren. Peat CO2 production in a natural and cutover peatland: Implications for restoration. Earth and Environmental Science 54 (2) 115-130.

Trites and Bayley, 2009. Organic matter accumulation in western boreal saline wetlands: A comparison of undisturbed and oil sands wetlands. Ecological Engineering 35, 1734-1742.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐

Briefly explain: [12]

In each wetland classified as peat-accumulating

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	E.g., Organic matter accumulation
Method:	E.g., Calculate organic matter accumulation potential metrics that use annual production and decomposition rates. Decomposition rates are calculated with the litter bag technique and above and belowground production by clipping biomass from quadrats. Annual organic matter budgets can be calculated with OM = Σ (P-D), where P represents the sum of all biomass produced both aboveground and belowground within each zone (gm−2 year−1) and D represents the amount of material decomposed in 1 year (gm−2 year−1) based on the exponential decay rates specific to each plant tissue contributing to total biomass. See Trites and Bayley (2009) for more information.
Threshold:	Needs to be developed

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If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
This indicator is not fully developed since no threshold has been established. A range of OM accumulation in the Athabasca region could be compiled from literature (i.e. Bayley and Trites 2009). Without a thorough literature review, I am uncertain how much data is available to establish thresholds. At a minimum a literature review will be required for this work (~50k). At a maximum, more field work to determine OM accumulation rates in fens and potentially other wetland classes is required.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
Condition numbers 6.1.65 and 6.1.66 in EPEA approval number 94-02-00.		

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Indicator 39: Fen Water Quality

Group Name [1]	**ASG**	Submitted by [2]	*Names removed*	Date [3]	May 18, 2012
Objective [4]	Natural ecosystem functions are established on the reclaimed landscape	Criterion [5]	The reclaimed landforms have the necessary water quality		

Describe the indicator being recommended. [6]

Reclaimed fens should have water quality that is suitable for fen plant establishment.

Provide a brief statement on the value of the indicator. [7]

Establishing fen wetlands in the reclaimed landscape is an important step in achieving equivalent capability. Pilot fen programs are underway to evaluate program success. Suitable water quality for fen plant establishment and, hence, peat accumulation is critical for successful reclaimed fen wetland development (Daly et al 2011). Water quality parameters (pH, HCO2, Ca and conductivity) in reclaimed fens should fall within the range quantified within natural fens (poor to extreme-rich) in the region. Water quality thresholds presented here are for rich fens, which is the class of fens that is planned for the oil sands region.

Classified as a performance indicator.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☐	**No** ☒

If yes, state the document and page number: [9]

N/A

List references related to the recommended indicator (research paper, journal article etc.): [10]

Jacques Whitford AXYS, 2008. An analysis of existing information on peatland vegetation in the regional municipality of wood buffalo. Report prepared for CEMA.

Vitt, D.H. and W.L. Chee, 1990. The relationships of vegetation to surface water chemisty and peat chemistry in fens of Alberta, Canada. Plant Ecology 89 (2), 87-106.

Vitt, D.H., Achuff, P. and R.E. Andrus, 1975. The vegetation and chemical properties of pattenered fens in the Swan Hills, north central Alberta. Canadian Journal of Botany 53(23), 2776-2795.

Szumigalski, A.R. and S.E. Bayley, 1996. Decomposition along a bog to rich fen gradient in central Alberta, Canada. Canadian Journal of Botany 74 (4), 573-581.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐

Briefly explain: [12]

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☒	**No** ☐

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	pH, HCO2, specific conductivity (µS/cm2), Ca2+
Method:	All parameters are measured with standard procedures insitu (pH, conductivity) and in certified laboratory with field blanks and lab standards. For calculation of reduced conductivity, see Sjörs, H. 1950. On the relation between vegetation and electrolytes in north Swedish mire waters. Oikos, **2**(2): 241–258.
Threshold:	$5.5 < pH < 9.5$; $0 < HCO_3 < 550$ mg/L; $17.5 <$ reduced conductivity < 1234 µS/cm^2; $2 < Ca^{2+} < 150$ mg/L

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If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
Values recommended by personal communication from Dale Vitt and Line Rochefort (Oct 2011) and checked against field values from Jacques Whitford AXYS. 2008. An analysis of existing information on peatland vegetation in the Regional Municipality of Wood Buffalo: Phase 1 peatland data compilation and summarization. Prepared for the Wetlands and Aquatics Subgroup of CEMA.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
Condition numbers 6.1.65 and 6.1.66 in EPEA approval number 94-02-00.		

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Indicator 40: Wetland Traditional Ecological Plants

Group Name [1]	**ASG**	Submitted by [2]	*Names removed*	Date [3]	May 18 2012
Objective [4]	Reclaimed landscapes support an equivalent land capability appropriate to the approved end land use	Criterion [5]	The reclaimed landscape provides opportunities for traditional uses		

Describe the indicator being recommended. [6]

Traditional plants communities have been established in mine reclaimed wetlands.

Provide a brief statement on the value of the indicator. [7]

Numerous wetland plants are valued and used by Aboriginal people as part of their traditional way of life (i.e. cattail (*Typha latifolia*) Small bog cranberry (*Oxycoccus microcarpus),* Ratroot *(Acorus americanus),* Bog Cranberry *(Vaccinium vitis-idaea), and* Cloudberry *(Rubus chamemorus)) (*Wetlands Manual 2007; Kershaw and Pojar 1995). The scoping study part of the "Indigenous Ecological Classification of Wetlands" program identified that Aboriginals want reclamation efforts to focus on restoring the function and traditional values of wetlands rather than on wetland forms (O'Flaherty and Davidson-Hunt 2008), suggesting that traditional plant communities may be an important value to establish in reclaimed areas.

Classified as performance indicator.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☐	**No** ☒

If yes, state the document and page number: [9]

N/A

List references related to the recommended indicator (research paper, journal article etc.): [10]

Wetlands Manual, 2007. CEMA. pg. 16, appendix F.

Kershaw, J. and M. Pojar, 1995. Plant of the Western Boreal Forest and Aspend Parkland. Lone Pine Publishing and the Canadian Forest Service.

Jacques Whitford AXYS, 2008. An analysis of existing information on peatland vegetation in the regional municipality of wood buffalo. Report prepared for CEMA.

Wong, A., Greenway, C. and S. Bayley, 2008. An analysis of existing information on wetland vegetation in the oil sands region – marshes. Report prepared for CEMA.

O'Flaherty, M. and I. Davidson-Hunt, 2008. Scoping exercises for Indigenous ecological Classifcation of Wetland sin the Athabasca Oil Sands Region. Report 07-02 prepared for CEMA.

Does the indicator need to be measured in every polygon? [11]	**Yes** ☐	**No** ☒

Briefly explain: [12]

Would only apply to polygons designated for traditional value, in consultation with FN communities.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Traditional wetland plant community diversity
Method:	Cover and diversity of traditional wetland plant species and communities present
Threshold:	Undetermined

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If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
This indicator is not fully developed since diversity of culturally significant plants in wetlands of the Athabasca oil sands region is not well understood. Research should examine traditional wetland plant diversity within various wetland classes to determine plant community diversity in the region and help set targets for reclaimed areas. Work could use existing databases (i.e. Golder) and reports or papers (Wong et al. 2008; Jacques Whitford AXYS 2008). May take as little as $50k to compile the data and set thresholds.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
Approval No. 228044-00-00: 6.3.35 Wetland Revegetation Plan shall include at a minimum… incorporation of vegetation and vegetation communities of traditional value that are characteristic of the locally common boreal forest.		

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Indicator 41: Typical Fen Plants

Group Name [1]	**ASG**	Submitted by [2]	*Names removed*	Date [3]	May 18, 2012
Objective [4]	Reclaimed landscapes are established that support natural ecosystem function	Criterion [5]	Terrestrial and aquatic vegetation common to the boreal forest is established		

Describe the indicator being recommended. [6]

Typical fen plant species have been established

Provide a brief statement on the value of the indicator. [7]

Establishing fen wetlands in the reclaimed landscape is an important step in achieving equivalent capability. Pilot fen programs are underway to evaluate program success. An important component of program success will be establishment of appropriate fen plant species (Daly et al 2011). Reclaimed fens should have fen plant species that are typical of the region. Establishment of typical fen plant communities may be difficult at this time given the saline sodic conditions of many reclamation construction materials and the predominance of freshwater fens in the region; however, it is possibly that they may occur over the long-term. A realistic goal is the establishment of typical fen plant species in reclaimed fen wetlands.

Classified as a performance indicator.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☐	**No** ☒

If yes, state the document and page number: [9]

N/A

List references related to the recommended indicator (research paper, journal article etc.): [10]

Kershaw, J. and M. Pojar, 1995. Plant of the Western Boreal Forest and Aspend Parkland. Lone Pine Publishing and the Canadian Forest Service.

Jacques Whitford AXYS, 2008. An analysis of existing information on peatland vegetation in the regional municipality of wood buffalo. Report prepared for CEMA.

Daly, C., Price, J.S., Rochefort, L., Rezanezhad, F., Pouliot, R., and M.D. Graf. Consideration for building a fen peatland in a post-mined oil sands landcape. In: Reclaiming and restoring North American Boreal Ecosystems: Towards Responsible Mangement, Vitt, D. (ed.). Submitted to Cambridge University Press (March 2011).

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No** ☐

Briefly explain: [12]

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☐	**No** ☒

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Presence of fen plants (tree, shrub, forb/graminoid and bryophyte) in wetlands designated as reclaimed fens
Method:	Fen plant cover and species richness in wetlands designated as reclaimed fens
Threshold:	Needs to be developed (i.e. Common fen plants =>2 sp.)

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If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]		
This indicator is not fully developed since no threshold has been established. A list of common fen species in natural fens according to the Alberta Wetland Inventory Classification system is available in Jacques Whitford AXYS (2008) and could be used to establish thresholds (minimum # of fen plants per wetland; minimum % cover per species). Work should be less than $50k.		
Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [17]		
Condition numbers 6.1.65 and 6.1.66 in EPEA approval number 94-02-00.		

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Indicator 42: Wetland Hydroperiod

Group Name [1]	**ASG**	Submitted by [2]	*Names removed*	Date [3]	May 18 2012
Objective 4	Obj. 2 - Natural ecosystem functions are established on the reclaimed landscape.	Criterion 5	2.2 - The reclaimed landforms have the necessary water quantity. 2.5 – Reclaimed ecosystems display characteristics of resilience to natural disturbances and climatic variability		

Describe the indicator being recommended. [6]

Each wetland is characterized by the presence of water at a level, frequency and duration (hydroperiod) sufficient to support wetland vegetation characteristic of the boreal forest and wetland types specified in the closure plan.

Provide a brief statement on the value of the indicator. [7]

The hydroperiod defines the rise and fall of a littoral zone's surface and subsurface water and the speed with which these processes occur. Littoral zone productivity will be closely tied to the vegetation community. In fact, water table depth is the most commonly cited factor controlling vegetation establishment in wetlands. A number of early studies documented cyclical changes in the abundance and composition of vegetation and noted that the diversity and productivity of both wetland flora and fauna appeared to be driven by cyclic wet and dry periods in wetlands across North America (Weller and Spatcher 1965, Weller and Fredrickson 1974, Walker 1959, 1965). Hydroperiod leads to a unique vegetation composition but can limit or enhance species richness depending on the depth of the water, the duration of flooding, and the frequency of disturbance events.

Classified as a performance indicator.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☒	**No**

If yes, state the document and page number: [9]

DeVito and Mendoza. 2008. Guideline for Wetland Establishment on Reclaimed Oil Sands Leases. Appendix C1

List references related to the recommended indicator (research paper, journal article etc.): [10]

DeVito and Mendoza. 2008. Guideline for Wetland Establishment on Reclaimed Oil Sands Leases. Appendix C1

Cooper et al. 2008. Guideline for Wetland Establishment on Reclaimed Oil Sands Leases. Appendix D

Native Plant Solutions. 2010. Minimum Ecological Management. Report prepared for the Aquatics Subgroup of CEMA.

K. DeVito, personal communication (January 2012).

Does the indicator need to be measured in every polygon? [11]	**Yes** ☒	**No**

Briefly explain: [12]

For each wetland, which is defined as a polygon.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [13]	**Yes** ☒	**No**

Briefly describe the existing or proposed measure, method and threshold for the indicator: [14]

Measure:	Hydroperiod
Method:	According to Mitsch and Gosselink. 2000. Wetlands. John Wiley and Sons. Measured in both natural reference and test wetlands during the same period of time. Minimum monitoring period of time of 10 years to account for range of variability and allow statistical comparisons.
Threshold:	Within the range occurring in the natural reference wetlands of the wetland type in question.
Stage applied:	Certification monitoring

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [15]

Is the indicator aligned to an EPEA approval condition? [16]	**Yes** ☒	**No** ☐

If yes, what is the condition number and corresponding EPEA approval? [17]

Condition number 6.3.35 of approval no. 228044-00-00.

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Indicator 43: Marsh Wet Meadow Plant Index of Biotic Integrity

Group Name [1]	**ASG**	Submitted by [2]	*Names removed*	Date [3]	May 18, 2012
Objective [4]	2. Natural ecosystem functions are established on the reclaimed landscape	Criterion [5]	2.4 Ecosystem production is established on the reclaimed landscape		

Describe the Indicator being recommended. [6]

Wet meadow zone plant IBI. Combination of indicators 1 through 4 for rapid synoptic assessment (every 1-2 years). Combination of indicators 1 through 5 for comprehensive assessment (every 3-5 years).

1. Robel pole height
2. Wet meadow zone width
3. % of total richness of exotic species
4. % of total richness of halophytes
5. Mean C value

Provide a brief statement on the value of the indicator. [7]

1. Robel pole height estimates productivity and is correlated to biomass
2. Important indicator of gradual transition to upland. Gentler slopes facilitate wet organic substrate for wet meadow plants
3. Quadrat-level measurement indicating disturbed habitat
4. Quadrat-level measurement where higher salinity supports salinity-tolerant species but not natural freshwater species
5. Estimates the plant community's tolerance to stress and the floristic quality of a site. Requires botanical identification
6. Estimates biological condition of shallow open-water wetlands. Surrogate for other biota (e.g. songbirds).

Classified as a performance indicator, but can also be used as a trend-based indicator.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☐	**No** ☒

If yes, state the document and page number: [9]

N/A

List references related to the recommended indicator (research paper, journal article etc.): [10]

Forrest, A.S., 2010. Created stormwater wetlands as wetland compensation and a floristic quality approach to wetland condition assesssment in central Alberta. Biological Sciences, University of Alberta, M.Sc., pp. 102-109.

Rabb and Bayley. 2012. A vegetation-based index of biotic integrity to assess marsh reclamation success in the Alberta oil sands, Canada. Ecological Indicators 15: 43-51

Rooney, R.C., Bayley, S.E., 2011. Development and testing of an index of biotic integrity based on submersed and floating vegetation and its application to assess reclamation wetlands in Alberta's oil sands area, Canada. Environ. Monit. Assess. 184, 749-761.

Wilson, M.J., Bayley, S.E., 2012. Use of single versus multiple biotic communities as indicators of biological integrity in northern prairie wetlands. Ecol. Indic. 20, 187-195. 10.1016/j.ecolind.2012.02.009

Does the indicator need to be measured in every polygon? [11]	**Yes** ☐	**No** ☒

Briefly explain: [12]

In the wet meadow zone of each marsh. This indicator may not be appropriate to evaluate older sites since wet meadow zones were not specifically designed.

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Is the indicator fully developed? (has a defined Measure, Method and Threshold) [10]	**Yes** ☒	**No** ☐
Briefly describe the existing or proposed measure, method and threshold for the indicator: [11]		
Measure:	1. Robel pole height has a negative relationship to stress 2. Wet meadow zone width has a negative relationship to stress 3. Relative richness of exotic species has a positive relationship to stress 4. Relative richness of halophytes has a positive relationship to stress 5. Mean C value has a negative relationship to stress 6. IBI score has a negative relationship to environmental stress	
Method:	Materials. Measuring tape, Robel pole, and quadrat. Estimated cost of materials = $40. In brief, a random point is chosen and the site is divided into thirds. Transects are positioned perpendicular to the shoreline. At each transect, the width of the wet meadow zone is measured with a measuring tape. Two quadrats are spaced 5 paces apart. A 150 cm tall Robel pole is placed in the center of each quadrat. The height at which the pole is visible is estimated from 4 m away (parallel to the shoreline). In each quadrat, each plant species is identified in the comprehensive assessment. In the rapid synoptic assessment, omit species identification. Richness of exotic and halophyte species (listed in table A4) are expressed relative to the total richness. Every plant herbaceous plant species in the Boreal region has a C value assigned to it as listed in Forrest (2010). In comprehensive assessment (every 3-5 years), calculate mean C-value of species found in site. Use Appendix 1 and Table A6 to standardize metrics and get IBI score.	
Threshold:	A site monitored over time with an IBI score consistently higher than 173 is acceptable for certification of reclamation sites. If the Robel height is < 33 cm, then the site is in high stress and likely in poor condition. If Robel height is ≥ 33 cm and the mean C value is < 4.2, then the site is likely intermediately stressed. Sites in this category fall into two subcategories, sites with wet meadow zone width < 10 m (higher stress) and sites with wet meadow zone width ≥ 10 m (lower stress). If Robel height is ≥ 33 cm and the mean C value is ≥ 4.2, then the site is likely in low stress and healthy.	
Stage applied:	Certification monitoring	
If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [12]		
The indicators are well developed and scientifically justified. We suggest the rapid synoptic IBI be performed to monitor wetlands every 1-2 years and the more comprehensive version be performed every 3-5 years. These indicators have been published in a peer-reviewed scientific journal (Raab and Bayley 2012). A few metrics were adjusted after additional data was collected in 2009. The new IBI was tested and validated on an independent suite of sites. Similar IBIs are in wide use in other jurisdictions. Thresholds for individual metrics and the IBI were determined using regression tree analysis, a scientifically justifiable approach. However, we recommend that a manual to assist consultants to easily use the indicators be written. That might cost $5,000-20,000, depending on how detailed it is, how much explanation of each of the parameters in the Appendix below is required and how much explanation of the approach is needed.		
Is the indicator aligned to an EPEA approval condition? [13]	**Yes** ☒	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [14]		
Condition number 6.3.35 of approval no. 228044-00-00.		

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Indicator 44: Marsh Open Water Plant Index of Biotic Integrity

Group Name [1]	**ASG**	Submitted by [2]	*Names removed*	Date [3]	Apr 18, 2012
Objective [4]	2. Natural ecosystem functions are established on the reclaimed landscape	Criterion [5]	2.4 Ecosystem production is established on the reclaimed landscape		

Describe the Indicator being recommended. [6]

Open-water zone plant IBI (Combination of indicators 1 through 5)

1. Richness of free-floating and floating-leaf vegetation
2. % of total cover by alkali-tolerant species
3. % of total cover by floating-leaf species
4. % of total cover by *Ceratophyllum demersum*
5. % of total richness constituted by *Potamogeton* spp.

Provide a brief statement on the value of the indicator. [7]

1. Healthier wetlands have a greater diversity of floating-leaf species, which provide habitat for macroinvertebrates and amphibians
2. Alkaline tailings water and cation-rich sediment favors an altered alkali-tolerant plant community that differs from natural wetlands
3. Less cover of floating-leaf spp. at disturbed sites indicates lower productivity, possibly due to lower nutrient levels.
4. Nutrient-rich reference wetlands are often characterized by *C. demersum*
5. Nutrient-poor tailings pond sites are often characterized by *Potamogeton* spp. Dominance
6. Estimates biological condition of shallow open-water wetlands

Classified as a performance indicator, but can also be used as a trend-based indicator.

Is the indicator presently in use within approved guideline documents or Mine Reclamation Plans? [8]	**Yes** ☐	**No** ☒

If yes, state the document and page number: [9]

N/A

List references related to the recommended indicator (research paper, journal article etc.): [10]

Forrest, A.S., 2010. Created stormwater wetlands as wetland compensation and a floristic quality approach to wetland condition assesssment in central Alberta. Biological Sciences, University of Alberta, M.Sc., pp. 102-109.

Raab, D.J., Bayley, S.E., 2012. Reclamation of wetland habitat in the Alberta oil sands: Generating assessment targets using boreal marsh vegetation communities. Ecol. Indic. 15, 43-51.

Rooney and Bayley. 2011. Development and testing of an index of biotic integrity based on submersed and floating vegetation and its application to assess reclamation wetlands in Alberta's oil sands area, Canada. Environ. Monit. Assess.

Wilson, M.J., Bayley, S.E., 2012. Use of single versus multiple biotic communities as indicators of biological integrity in northern prairie wetlands. Ecol. Indic. 20, 187-195. 10.1016/j.ecolind.2012.02.009

Does the indicator need to be measured in every polygon? [11]	**Yes** ☐	**No** ☒

Briefly explain: [12]

In the open zone of a marsh wetland.

Is the indicator fully developed? (has a defined Measure, Method and Threshold) [10]	**Yes** ☒	**No** ☐

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Briefly describe the existing or proposed measure, method and threshold for the indicator: [11]	
Measure:	1. The number of free-floating and floating-leafed species has a negative relationship to environmental stress 2. The relative cover of alkali-tolerant species has a positive relationship to stress 3. The relative cover of floating-leaf species has a negative relationship to stress 4. The relative cover of *C. demersum* has a negative relationship to stress 5. The % of total richness of *Potamogeton* spp. has a positive relationship to stress 6. IBI score has a negative relationship to environmental stress
Method:	Materials: Paddle boat, paddle, anchor, and rake. In brief, 10 transects are made across the open-water zone. Along each transect a 1 m^2 quadrat is estimated. Vegetation is raked up within each quadrat and each species is identified. Relative abundances of species are estimated as the percentage of total vegetation on the rake. An average of the 10 quadrats is used to estimate species richness and relative abundances per site. Metrics can then be computed using the Appendices. Relative abundances are summed to calculate metrics based on relative abundance. Species counts are used to calculate richness metrics. Use Appendix 1 and Table A2 to standardize metrics and get IBI score.
Threshold:	If the % of total cover by *C. demersum* is >= 27%, then the site has low stress and is similar to reference sites. Less than 27% of total cover by *C. demersum* and less than 12.5% of total cover of alkali-tolerant species indicates moderate stress. Greater than 12.5% alkali-tolerant species signifies high stress. If the % of total richness constituted by *Potamogeton* spp. is >= 33%, the site is very highly stressed. Other 2 metrics do not have discernible thresholds. See Table A3 for flowchart of thresholds. A site monitored over time with an IBI score consistently higher than 200 is acceptable for certification of reclamation sites.

If the indicator is **not** fully developed, describe the effort and estimated direct cost required to fully develop the indicator: [12]
The indicators are well developed and scientifically justified. This IBI has been validated on an independent suite of sites. We suggest that the open water community be assessed every year to monitor and track the health of reclamation sites. These indicators have been published in a peer-reviewed scientific journal (Rooney and Bayley 2011). Similar IBIs are in wide use in other jurisdictions. Thresholds for individual metrics and the IBI were determined using regression tree analysis, a scientifically justifiable approach. However, we recommend that a manual to assist consultants to easily use the indicators be written. That might cost $5,000-20,000, depending on how detailed it is, how much explanation of each of the parameters in the Appendix below is required and how much explanation of the approach is needed.

Is the indicator aligned to an EPEA approval condition? [13]	**Yes** ☐	**No** ☐
If yes, what is the condition number and corresponding EPEA approval? [14]		

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APPENDIX 6 - EXTERNAL REVIEW INSTRUCTIONS

EXTERNAL REVIEW INSTRUCTIONS

This document outlines the review instructions and timelines for external review of the *Concepts for Use of the Criteria and Indicators Framework for Oil Sands Mine Certification (DRAFT)*.

Purpose

The external review of the *Concepts for Use of the Criteria and Indicators Framework for Oil Sands Mine Certification (DRAFT)* is designed to critique the proposed system and process flow for reasonableness and soundness towards performing the designed purpose, which is to support decisions determining successful reclamation and the readiness of a site for reclamation certification. The external review is a review of the framework management system and concepts and *not* a technical review of the specific criteria and indicators. However, if reviewers note issues or gaps in the criteria or indicators, they may provide comment.

Regulatory Context

It is important for the reviewers to have an understanding of the regulatory environment that the framework must be compatible with. In support of this, Appendix 1 includes a general summary of the Alberta regulatory system.

Procedure

1. In addition to these instructions, reviewers will be provided with the following background document:
   - *A Framework for Reclamation Certification Criteria and Indicators for Mineable Oil Sands*. This is the December 2009 report, outlining the criteria and indicator framework recommended by CEMA and accepted by the Alberta Government. This report led to the present work.

2. Reviewers will be provided with the following documents and support for conducting the review:
   - *Concepts for Use of the Criteria and Indicators Framework for Oil Sands Mine Certification (DRAFT)*. This is the document for review.
   - *Reviewer Comments Template*. This is a Word template for the recording and submission of the reviewer's comments (example shown in Table 1).
   - Support**.** Théo Charette, RWG Program Technical Manager will contact each reviewer throughout the process to answer any questions, track progress and manage the review submission timelines.

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Table 10: Example of Reviewer Comments Template

Reviewer Comments	
Reviewer:	
Page/Par/Line	*Reviewer Comment*

3. Reviewers are to submit their completed *Reviewer Comment Template* to theo.charette@cppenv.ca.
4. Upon receipt, reviewer comments will be summarized into the *Review Comment Summary and Author Response* (example shown in Table 2) and provided to the author for comment. Note that reviewer comments will be provided to the author as anonymous.

Table 11: Example of The External Review Comment Summary and Author Response

Review Comment Summary and Author Response				
Page/Par/Line	*Reviewer*	*Reviewer Comment*	*Author Comment*	*RWG Decision*

5. The author will provide comments in response to the reviewer feedback, agreeing, disagreeing or providing an alternate response.
6. The *External Review Comment Summary and Author Response* will then be submitted to the Reclamation Working Group for its review and decisions on how outstanding matters will be addressed in the final draft report.

Timelines

Activity	Date
Confirmation of reviewers.	March 1, 2012
Distribute background documents to reviewers.	March 30, 2012
Distribute the Concepts for Use of the Criteria and Indicators Framework for Oil Sands Mine Certification (DRAFT) report and final instructions to the reviewers.	June 11, 2012
Reviewers submit their comments.	July 6, 2012
All review comments are compiled into the summary template and provided to the author for comment.	July 31, 2012
Author's comments are submitted.	August 10, 2012
RWG decisions based on comments.	September 28, 2012

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Appendix – Alberta's Regulatory Environment

Following is a general summary of the Alberta regulatory process under the *Environmental Protection and Enhancement Act* (EPEA) with respect to requirements and activities supporting and leading up to reclamation certification. This summary is not intended to be a comprehensive representation of all requirements and processes. It is intended to establish the high level context for the reviewer to understand how the *Concepts for Use of the Criteria and Indicators Framework for Oil Sands Mine Certification (DRAFT)* is directly or indirectly aligned to regulatory requirements and existing procedures related to reclamation certification.

Activities Designation Regulation

- The construction, operation or reclamation of a mine is a designated activity under Schedule 1 Division 3 of the Activities Designation Regulation, requiring EPEA approval.

Environmental Protection and Enhancement Act

- EPEA requires an operator to reclaim specified land and obtain a reclamation certificate.
- A reclamation certificate may be issued on the entire area (the approved mine footprint) or only a part of the specified land. It can be assumed that the oil sands mines will be reclaimed progressively with reclamation certificate applications submitted on numerous parcels of land over the life of the mine. This supports the concept of progressive reclamation and the gradual relief of operator reclamation liability.
- EPEA requires specified land to be reclaimed in accordance with the terms and conditions of the mine approval, the terms and conditions of any environmental protection order regarding reclamation, the directions of an inspector or the Director, and the requirements of the Act.
- An inspector may issue a reclamation certificate if satisfied that the reclamation work has been completed in accordance with the requirements of the above bullet.
- Application for reclamation certificates are made by the operator to the Director or inspector in the form and manner provided for in the regulations (see Conservation and Reclamation Regulation below).
- An inspector shall, when required to do so by the regulations, conduct a reclamation inquiry (Author's note: a reclamation inquiry is a site visit by the inspector, which may include members of a technical review team, to observe that site conditions are reflective to those described in the reclamation certificate application).
- An inspector may issue a reclamation certificate subject to any terms and conditions the inspector considers appropriate.

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Conservation and Reclamation Regulation

- "Equivalent land capability" means that the ability of the land to support various land uses after conservation and reclamation is similar to the ability that existed prior to an activity being conducted on the land, but that the individual land uses will not necessarily be identical.
- "Land capability" means the ability of land to support a given land use, based on an evaluation of the physical, chemical and biological characteristics of the land, including topography, drainage, hydrology, soils and vegetation.
- "Specified land" means the land that is being or has been used or held for in connection with the construction, operation or reclamation of a mine (Author's note: other activities are included but not listed here).
- The objective of reclamation of specified land is to return the specified land to an equivalent land capability.
- The Director may establish standards, criteria and guidelines for reclamation of specified land and may release information documents respecting those standards, criteria and guidelines.
- Operators must reclaim specified land in accordance with the applicable standards, criteria and guidelines established by the Director (Author's note: it can be assumed the framework will be a document approved by the Director).
- An application for a reclamation certificate must contain the following information:
    - a map, with references to legal boundaries, showing the land for which the certificate is being requested and the adjacent land use,
    - particulars and characteristics of the reclaimed land, including topography, drainage, soils, vegetation and land capability,
    - documentation of reclamation procedures,
    - documentation of the history of the surface disturbance,
    - documentation of and justification for any surface improvements to be left on the reclaimed land and written acceptance of the improvements by the owners of the land (Author's note: the vast majority of oil sands mine tenure is on public land. There are a few parcels of freehold land owned by operators. Generally if improvements are to be left on public land, and agreed to by the government, the land on which the improvements occupy are covered by a form of tenure under the Public Lands Act such as a miscellaneous lease or a license of occupation. Outstanding reclamation under those forms of tenure is required under the Public Lands Act).
    - a declaration the operator has complied with:
        - all terms and conditions of any applicable approval, code of practice, environmental protection order or enforcement order,
        - the directions of an inspector or the Director,
        - any applicable standards, criteria or guidelines established by the Director.
    - a description of any substance or contamination on the land as a result of operator activity, the nature and extend of any adverse effect caused by the presence of the substance and particulars of any remedial measures taken in respect of the substance (Author's note: under provincial legislation, the operator continues to be liable for any contamination on the land caused by the operator, even after a reclamation certificate has been issued. This differs from reclamation liability - see below).
- Where an inspector is of the opinion that specified land has not been reclaimed in accordance with the Act and regulation the inspector may:
    - provide further direction respecting reclamation,
    - specify an additional waiting period to allow for further evaluation,
    - issue an environmental protection order regarding reclamation, and/or
    - refuse to issue a reclamation certificate

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- The reclamation certificate, upon issuance, relieves the operator from all future reclamation liability on the specified land. From the date of issuance of a reclamation certificate, the provincial government inherits any outstanding reclamation liability on the certified land.

EPEA Mine Approval

- Part 6 of the EPEA mine approval details the reclamation requirements for the mine.
- The approvals are renewed at 10-year intervals.
- Most conditions in a mine approval are common among the oil sands mines, however since renewals are staggered, as conditions are updated, not all mines will have the exact reclamation conditions.
- The mine approval in some cases will establish standards that must be met, for example minimum cover soil placement depths.
- The mine approval specifies the reclamation plans and the content of each plan that must be completed and submitted by the operator for approval.

EPEA Reclamation Plan Requirements

The following plans are submitted by the operator for approval (based on the Total Joslyn North Oil Sands Processing Plant and Associated Mines). This is not a comprehensive list or description of the plans, the intent is to identify the main reclamation planning documents and information leading to certification:

- Life of Mine Closure Plan
  - outlines the most recent concepts for development and reclamation of the plant to the end of mine life, and
  - is expected to be consistent with any approved regional land use plans,
- Mine Reclamation Plan
  - ensure that reclaimed features have natural appearances characteristic of the region,
  - details the procedures that will be used to ensure reclamation to an equivalent land capability,
  - illustrates integration with the Life of Mine Closure Plan, and
  - is updated every three years and re-submitted for approval.

- Soil Placement Plan
  - is submitted in October of each year, and
  - describes how salvaged materials will be used to achieve the reclamation objectives.
- Revegetation Plan
  - describes the upland vegetation communities to be established.
- Forest Resource Plan
  - defines strategies to mitigate impacts of the annual allowable cut by the mine development.
- Wetland Reclamation Plan
  - outlines the types and schedule for construction of wetlands on the reclaimed landscape.

- Plan for Reclamation Biodiversity
  - identify technology needed to establish a range of identified target ecosytems,
  - coversoil and subsoil composition and key vegetation species,
  - plans to monitor the return of biodiversity on the reclaimed landscape, and
  - evaluation and comparisons of changes in biodiversity on the reclaimed landscape.

EPEA Reporting Requirements

- Annual Report

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- annual reclamation progress tracking,
- an as-built plan (including maps) of all terrestrial and wetland reclamation of the previous year,
- any deviations from the soil salvage plan,
- any deviations from the soil placement plan,
- on a year-to-year and cumulative basis, a summary of the amount of land cleared, disturbed, reclaimed, and certified, including the upcoming year target,
- a summary of reclamation material salvage and placement practices for terrestrial and wetland reclamation,
- the results of the surveys conducted after reclamation material placement,
- a summary of revegetation activities, including but not limited to, targeted ecosites consistent the Life of Mine Closure Plan,
- progress and deviation in development of landform and topography consistent with the Life of Mine Closure Plan,
- a description of how landforms and topography at lease boundaries are or will be integrated with adjacent lease holders,
- a review and assessment of the landscape, reclamation and revegetation performance monitoring data, and
- a compilation of conservation and reclamation inspections of the previous year.

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APPENDIX 7 - ADDITIONAL INDICATORS SUGGESTED DURING THE PROJECT

1. **Sulfate and H_2S**. Sulfate is diminishing both in MFT (if present) and in the water column. Slope is significantly negative. Accumulation of H_2S in water and under ice has negative trend and does not contribute to winterkill or depleted DO after 10 years. Other RSC are not creating odours and are on a downward trend.

2. **Heavy metals**. All regulated heavy metals and metalloids, including vanadium, are on a significant downward trajectory. The levels just below regulated threshold do not contribute synergistically to chronic toxicity.

3. **Chronic toxicity** for fish and invertebrates is on a downward trajectory and not present at certification. Acute toxicity is assumed not to exist.

4. **Sediment toxicity** is non-existent in the upper layers populated by benthic organisms. Initially it should be decreasing, but it may be expected to be a very slow process for EPLs with MFT due to SOD and generally anaerobic conditions with the abundance of hydrocarbons.

5. **Interlayer toxicity including detritus.** Over time it is expected that in-lake decaying organic material and material from runoff and natural inflow will create a layer rich in organics. Those organics may have ability to adsorb (partition) COPC from water column as well as from PAW percolating from the bottom or from straight diffusion from the sediment. Levels of COPCs should be low enough to support healthy ecosystem that does not negatively influence the food chain.

6. **DO in water column** in general is high enough to support winter or summer survival**.** With time it is improving with positive slopes for concentrations. Lake fertilization, if applied, does not create algal blooms or otherwise contributes to toxicity.

7. **Presence and toxicity of diluent**. The presence of diluent as a fermentable material that contributes to bubbling and bed instability is negligible. Bacteria will start fermenting diluent and produce bubbling gasses (methane and CO2) only when both nitrate and sulfate are depleted, which may take years. Subsequent fermentation of residual diluent and light bitumen fractions may take decades and extend remediation/reclamation of EPL-s beyond acceptable level (10-20 years). Low risk approach for MFT capped lakes, if they are allowed, is to prevent mixing of Froth Tails (FTT) with FFT, thus depleting EPL solids from material that will be consumed by bacteria and archaea.

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