Oil Sands
Wetland Reclamation
USER NEEDS ASSESSMENT

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for the Cumulative Environmental Management Association

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The region of interest to the Cumulative Environmental Management Association (CEMA) and its subgroups corresponds to the Regional Municipality of Wood Buffalo. This map also shows the area of surface mineable oil sands (shaded expanse north of Fort McMurray).
1 INTRODUCTION

The Cumulative Environmental Management Association (CEMA) intends to update the 2007 guidelines for wetland establishment in reclaimed oil sands in the Wood Buffalo Region of Alberta. In preparation for this project, CEMA commissioned West Hawk Associates Inc. to conduct a User Needs Assessment, or an overview of what industry and government wish to see in the document. West Hawk arranged interviews with numerous industry and government representatives in February and March of 2012. This document constitutes a synthesis of these views, and provides a set of recommendations based on the views of the participants. Minor edits were also made following comments provided in November 2012 by CEMA.

For the interviews — some conducted in group sessions, others individually — West Hawk devised general and open-ended questions. The interviewers used these questions more as a springboard for discussion rather than as a checklist. The interviewees generally took the initiative to steer the discussion toward the issues they most wished to see addressed in the next iteration of the guide. West Hawk recorded the interviews, and paraphrased transcripts are included in Appendix IX.

The document also provides a summary of the synthesis of reviewer comments produced in 2007 by CH2M HILL. The summary of the comments is organized according to Table 2-1: Synthesis of Recurring Comments, from the synthesis. It lists 15 issues identified by the reviewers, including how many reviewers discussed each one. The summary then provides selected extracts of commentary from the reviewers for each of the 15 themes.

As well, this report includes a summary of the 2007 guide, organized in a manner roughly similar to the guide itself, and conveys the key messages from the guide in an abbreviated format (Appendix I). Three tables from the guideline are also included as an appendix. Table 4.3 describes design guidance for marshes and shallow-water ponds. Table 4.4 describes fen reclamation and associated environmental conditions. Table 4.5 describes guidance for vegetated watercourses and riparian margins.

Overall, the results of the interviews suggest that the 2007 version of the guideline was inadequate for design purposes. In the next iteration, industry and government wish to see a document that focuses more on engineering and planning, and less on basic biology principles. They largely agree that it should be written by multiple authors, under the supervision of a managing editor, and subjected to peer review. It should be more visual, relying less on text and more on illustrations, charts, graphics, and flowcharts. It may not even need to be produced in print, as stakeholders prefer the portability of digital copies. This document explores these views in detail, and constitutes a source for CEMA to reference as it prepares to produce the next wetlands guidance document.
2 SUMMARY of Synthesis of Reviewer Comments on the Guideline for Wetland Establishment on Reclaimed Oil Sands Leases (CEMA 2007)

Fifteen reviewers of the 2007 Guideline supplied 100 comments, most of them detailed and specific (see Table 2-1, below). All four reviewers with design experience concluded the manual is not useful for design purposes. It is strong scientifically and provides a foundation for evolution of knowledge and research, but weak on engineering and applied scientific design. Some comments were contradictory. The interview participants largely agreed with these comments, particularly in the case of the first three.

2.1 Comment Themes

Table 2-1: Summary of comment themes and reviewer count

<table>
<thead>
<tr>
<th>Comment</th>
<th>No. of reviewers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerous changes needed regarding peat and wetland reclamation hydrology</td>
<td>9</td>
</tr>
<tr>
<td>The importance of surface hydrologic interconnectedness for design, function, and resilience is not sufficiently recognized</td>
<td>5</td>
</tr>
<tr>
<td>Provides a strong foundation for evolution of knowledge/research</td>
<td>5</td>
</tr>
<tr>
<td>Spontaneous/opportunistic revegetation can impair establishment of desired community structure</td>
<td>4</td>
</tr>
<tr>
<td>Monitoring should always be done with a view to making adjustments or refining design in the future</td>
<td>4</td>
</tr>
<tr>
<td>Need more information on long-term climate variability and potential effects</td>
<td>4</td>
</tr>
<tr>
<td>It is not feasible to make an accurate prediction of the equilibrium wetland to watershed ratio in the reclaimed landscape</td>
<td>4</td>
</tr>
<tr>
<td>I am not sure that I could build a wetland from the information provided</td>
<td>4</td>
</tr>
<tr>
<td>Inadequate discussion of the accumulative nature of salinity</td>
<td>4</td>
</tr>
<tr>
<td>Soil stability or materials is important</td>
<td>4</td>
</tr>
<tr>
<td>Does not take into account a successional view of wetland evolution</td>
<td>3</td>
</tr>
<tr>
<td>Sedimentation rates should be kept as low as possible to ensure long-term wetland survival</td>
<td>3</td>
</tr>
<tr>
<td>The Wetlands Manual is inadequate in the section on Adaptive Management</td>
<td>3</td>
</tr>
<tr>
<td>Issues with natural analogue wetlands</td>
<td>3</td>
</tr>
<tr>
<td>There is little attention given to the importance of hydrologic manipulations in newly constructed wetlands</td>
<td>3</td>
</tr>
</tbody>
</table>

2.2 Conflicting Comments

- Adaptive management approaches are recommended/not recommended (3 vs 1)
- Wetland reference sites/analogues are recommended/not recommended (3 vs 1)
- Restoration goals should be more specific/less specific (1 vs 1)
3 **RECOMMENDATIONS for the 2013 wetlands guide**

1. **Managing editors** should oversee the entire editorial process. They should help choose the authors, coordinate their work, organize and facilitate workshops, assist in selection of peer-reviewers, coordinate their work, and create a final copy-edited and designed document.

2. **Employ a multi-author approach**, with specific authors and reviewers for each chapter, which should address a relevant phase of wetland reclamation. Although this approach invites contrasts in flow, style and perspectives (and possibly in interpretation of data), this is still a preferred option for the breadth of experience and knowledge gained.

3. Create a document that reads as a **step-by-step guide**. Start at a high level with a more general chapter, and then move on to more specific design criteria and sections that provide direction on approaches to wetland reclamation and how to handle reclamation materials.

4. Include **more visual elements**, including flowcharts, illustrations and engineering drawings that break up the text. Check lists and hypothetical "to do" lists would be helpful.

5. Hold a **workshop** of industry wetland designers to prepare for the next guide. An initial workshop held before the writing begins could be largely driven by experienced reclamation specialists.

6. The **primary audience of the document will be a team of mine planners, engineers, wetland ecologists, and regulators**. The wider audience will be First Nations, NGOs and other stakeholders.

7. Incorporate relevant current/ongoing **research** that is available. A lot of new information has come to light that can be recognized and incorporated into the next wetland guide. Include all critical information in the main body of the document, not appendices (e.g., hydrology).

8. It should include a **timeline** for the various steps necessary for the successful construction of a wetland. Provide the number of years required for planning and selection of conceptual drainage patterns.

9. An **abstract** for the document could be posted on blogs and circulated; this will help make it a real-time, living document.

10. The guide should be **online** and designed so that at least periodic recompiling and updating are possible. Increasingly, professionals are turning to the Internet to find new information and historical material.
4 SYNTHESIS of interviewee feedback

For this project, West Hawk Associates conducted in-person interviews with representatives of five industry stakeholders and with Alberta Environment. Below are the key topics the participants identified as being desirable elements of the next wetland guide. A list of those participants can be found in Appendix VIII. Included are samples of views expressed by interviewees, paraphrased for clarity and brevity.

4.1 Overall impressions

Overall, the interviewees concurred on the need for the next wetland guide to be more prescriptive. It should lay out the steps, materials, and vegetation required for wetland construction. At the same time, some participants felt that the guide should include a broader, more holistic picture that supplies context and presents lessons learned from other industries and municipalities. One participant suggested the guide begin at a high level and then move toward more detailed sections for companies that are more advanced in their wetland reclamation efforts.

Sample view:

*The manual should set out the measures required to create the right conditions to establish a wetland, and should describe the conditions needed to create a trajectory toward a sustainable ecosystem.*

Government interviewees noted the need for the document to address high-level objectives for reclamation, particularly if the guide is to be tied to approvals. The review of closure plans – occurring in the summer and fall of 2012 – are expected to reveal significant gaps in wetland planning. Many plans are so far largely conceptual. The manual needs to give direction and provide long-term planning. Fens and bogs take thousands of years, while marshes, swamps, and shallow open water bodies should take much less time. For example, a reclaimed wetland likely won’t produce peat in the short term, but the conditions can be put in place for eventual peat production.

Sample view:

*It cannot just be about ecology; there needs to be an engineering perspective and a sound discussion of geology.*

Some participants recommended taking a landscape approach, focusing largely on connectivity. Wetlands cannot be thought of in isolation; they must be integrated into the greater landscape.
Sample view:

_No wetland exists in isolation. It should be balanced between recovering resources (while moving as little dirt as possible), on the one hand, and generating a self-sustaining boreal forest ecosystem on the other._

Participants also wish to see the guide as a “living document.” Along these lines, many interviewees expressed an interest in the document being largely or even primarily electronic. A hard copy could be printed on demand, but the document could be a web-based version suitable for an iPad or similar device.

Government interviewees stressed the need for the guide to be written on the assumption that companies will need to comply with it. The government required companies to comply with the 2007 version, which is the reason Suncor and Syncrude are constructing fens.

### 4.2 Impressions of the 2007 guide

Some interviewees felt the 2007 version provided solid background material that captures the state of knowledge of wetland reclamation at the time. But they broadly agreed that it was not useful as a wetland reclamation guide; it was too general and focused too heavily on ecological principles at the expense of guidance for engineers and, in particular, the actual processes needed for wetland reclamation.

Sample view:

> It’s too broad, too general, too rudimentary, though has lots of good background that captures the state of knowledge of wetland reclamation at the time it was produced. When it comes to actually designing a wetland, it provided only general things to consider.

“Too much science, not enough engineering” was a commonly expressed reaction, indicative of the sometimes-limited use that some operators made of the guide. Participants commonly tempered their criticisms by recognizing the limitations of the knowledge on wetlands reclamation available at the time. Suncor, however, was able to use the document’s background material and recommendations to develop its 2011 Closure Plan.

Interviewees felt that the 2007 guide lacked sufficient discussion of the connectivity between surface water and groundwater hydrology. For each wetland that is designed, a greater understanding of hydrology and water quality is required. While certain issues apply to all wetlands, each wetland will be unique and will require different ways of treating each issue. Participants indicated that the guide included technical and scientific information that was drawn from too many sources and yet based on evidence that was too narrow.
The information was presented in a way that suggested it was widely applicable, when in fact it drew on a small base of evidence.

Sample view:

_The 2007 guide is too vague on important design aspects. For example, it should specify the amount of precipitation a certain area gets and therefore what the wetland size should be. It would not be helpful for operators. For one thing, they won't read it all. The document should spell out the required steps in wetland design. It is not sufficiently definitive; you would have to read through it and deduce your own conclusions._

Sample view:

_If you give this document to mine planners, they won't find it useful. The document provided basic principles that planners need to consider. But the next guide should go further, providing a more definitive approach._

Government interviewees concurred that the 2007 version was largely conceptual, with very little hands-on or step-by-step information. For example, it discusses swamps, but without providing a clear definition or any useful information on relevant design approaches. The next version needs to be more precise, particularly as it will be linked to approval conditions (i.e., the closure plans should comply with the guide).

### 4.3 Audience

In discussions about the target audience, interviewees noted the need for the wetlands guide to appeal to a broad spectrum of readers. This issue was also a major topic among those involved in the preparation of CEMA’s 2012 End Pit Lakes Guidance Document. Industry representatives expressed a strong interest in seeing the document provide precise direction to operators and planners, yet at the same time offer a coherent overview for the broader stakeholder and even public communities.

Participants recommended that a priority audience be the team of mine planners, engineers, and wetlands ecologists responsible for creating the topography of the wetlands, along with the biologists who select the species to be planted and government regulators. But a broader, less technically fluent readership should not be excluded. Interviewees suggested that a high-level overview is just as critical as the technical details associated with wetland reclamation. Clearly, a balanced approach is required, perhaps one in which certain sections (such as the introduction, chapter summaries, and conclusion) are aimed at a high-level audience, and more precise sections on design and construction be written for a more specific audience.
Participants noted that managers, regulators, and third-party observers will also make use of the guide; their needs should be reflected in how its contents are organized. For example, one participant cautioned against assuming that managers, regulators, and other readers are familiar with the regulatory or geographical context of the Athabasca oil sands. Therefore, introductory sections or chapters should be included for such audiences.

In addition, because each oil sands lease-holder is involved with different stages of wetland reclamation, from the pre-mining feasibility study through to actual construction, the guide must satisfy a wide range of needs, from the general to the specific. Participants recommended breaking the document into several distinct chapters that make it easy for each user to find the material most applicable to their needs. One participant suggested creating two separate documents: one “how to” guide for engineers and planners and one construction summary for the general audience.

One participant noted that the 2007 guide contained little of use for his employer, a company which is still years away from actually reclaiming wetlands. But even if his duties did include wetlands work, he would have found the guide of little help in creating fens and bogs as other types of wetlands received most of the attention. Therefore, he recommended broadening the discussion to ensure all types of wetlands receive comparable treatment.

Sample view:

*Overall, the guidance document should be written for a broad audience. But it also needs precise direction for planners and operators in order to be useful. It must largely be written for engineers.*

### 4.4 Topics of chapters/sections

Many interviewees identified specific chapters or at least sections that they believe must be included in the next version in order to make it useful for their purposes. For example, hydrology was mentioned by all participants as essential, and not given suitable attention in the 2007 guide. The subject areas that the interviewees most want to see discussed are:

- **Hydrology**: A section is required that incorporates numerous changes regarding peat and wetland reclamation hydrology (since the 2007 guide was produced). Hydrological modelling should be included (e.g. the work of Jonathan Price should be considered). The document requires thorough coverage of geology, hydrogeology, and civil engineering.

- **Water quality/treatment**: Information is needed on how to modify wetlands for treatment functions. The science and engineering of wetlands treatment can involve specific issues (at least in the early stages) and should be
addressed in detail. Reclaimed wetlands may evolve into a more natural state, but in the beginning will require attention to treatment. Processed water may play a role for 30 years or even 100 years. Over time, treatment wetlands would be expected to revert to habitat wetlands.

- **Connectivity**: Landscape connectivity, which was lacking in the 2007 version, is a big-picture issue. Wetlands will not materialize, or certainly won’t succeed, unless they exist in a landscape setting that has appropriate connectivity to allow for the migration and colonization of wildlife and vegetation. Guidance is required on how to ensure suitable connectivity is created. Drainage patterns and associated issues need to be addressed.

- **Salinity**: The impact of salinity on wetlands will be a critical consideration. A chapter discussing occurrence, amount, and influences is necessary. Even with a clear understanding of hydrology, the influence of salinity will be just as essential to the prospect of a healthy, functional ecosystem.

- **Process-affected and construction materials**: This chapter should describe the materials to be used to build the wetland. For example, there should be a discussion of overburden dumps. The closure plans assume some settling of materials, which can be a significant factor in wetland design.

- **Re-vegetation**: The optimal re-vegetation strategies should be described. Access to suitable plant and seed material must be considered. As more companies take on wetland reclamation projects, demand will mount for available seed material. One interviewee recommended the use of natural endemic species, suggesting this approach should prove acceptable to all stakeholders. Others indicated that some non-native species may be necessary. This issue will require investigation for the next guide. The re-vegetation manual should be referenced for upland information. The species types and amount that would ideally populate the wetland in 50 to 60 years time should be identified, and a plan provided for how that objective will be realized.

- **Wetland types**: Some interviewees expressed a desire to see separate sections on reclamation of each type of wetland, such as fens, bogs, or marshes. Government interviewees expressed the desire to know what types of wetland each company intends to construct. For example, in its closure plan, Suncor indicates that many of its wetlands will be marshes and swamps. The wetland guide could be written in such a way as to lay out the advantages and disadvantages, and the tasks involved, in producing each type of wetland.

- **Reclamation team**: Interviewees noted the need for a section on the steps to forming a reclamation team within the company. Some referred to the
team described in Chapter 7 of the *End Pit Lakes Guidance Document* (CEMA 2012) as a template.

- **Non-oil sands examples:** Some attention should be paid to non-oil sands experiences. This could be the topic of a chapter/section. For example, vast experience on peatlands exists in Quebec and New Brunswick (understanding that these areas are greatly influenced by the Maritime climate). Stormwater management ponds can also be referenced, as they can provide useful information. Although their applicability may be limited, they can be examined for ways to build – and not to build – functional wetlands. Natural wetlands should be monitored as a reference for oil sands wetlands.

Interviewees also expressed a need to see information on: nutrients, climate, and long-range issues, reclamation features/types, knowledge gaps, and biodiversity. Concepts and subjects identified as desirable, but not necessarily deserving of an entire chapter, include failure modes, natural analogues (pro and con), geology, ecology, successional wetland evolution, and wildlife.

As well, some participants noted the need to identify/define the concept of “functioning ecosystem” as it applies to wetlands in the oil sands. If a functioning ecosystem becomes the requirement for certification, then that definition is essential. A timeline toward certification needs to be established. As well, indicators need to be established or referenced in the guide. Government interviewees suggested that criteria indicators, which are currently in development, could be part of a stand-alone chapter or in appendices. As well, government interviewees recommended that a monitoring section or chapter be produced. This should be set up even before wetland reclamation occurs. At present, a pilot wetland-monitoring program is being established, and the guide should reference it.

### 4.5 Editorial Approach

The interviewees universally agreed on the need for the next edition of the guidance document to be overseen by managing editors, written by multiple authors with varying expertise, and peer-reviewed. This was the approach taken for the 2012 EPL Guidance Document, as a response to the recommendations of the CH2M HILL review of the *Guideline for Wetland Establishment on Reclaimed Oil Sands Leases* (CEMA 2007).

#### 4.5.1 Managing Editors

The participants were open to the concept of retaining managing editors for the guide. Their role would include: working with the client to interview and select the authors, helping authors establish topics/outline for their chapters, organizing and facilitating the workshops, ensuring the case studies are compiled,
facilitating review phases and the peer review, and generating the final edited and designed document. A science advisor could be retained to assist in these tasks, in a role that would provide expertise and ensure accuracy.

Sample view:

Editors are needed to oversee the work and pull the document together after the authors are finished. This approach worked well with the 2012 EPL guide. They should facilitate a process whereby authors can review and comment upon one another’s work. This can occur through e-mail exchanges of text, workshops, one-on-one meetings, or conference calls.

4.5.2 Multi-author

Several participants, including government representatives, expressed support for the use of a multi-author approach. While they acknowledged the potential for inconsistencies among the different authors, they felt the benefits of a variety of perspectives will outweigh the costs. One industry representative noted that although the flow and style may not be consistent, this is a more valuable approach by virtue of the breadth of experience and knowledge that would be captured.

Sample view:

Get authors together, consult on broader scope, each write individually and consult in an iterative process. This takes more time, but will withstand peer review better. One author can’t anticipate all issues to consider.

4.5.3 Workshops

Participants suggested organizing at least one workshop to bring together industry, government experts and academics and in order to stimulate the collaborative process that such an approach will entail. The authors should then write chapters individually but consult as needed. Although this process may be more time-consuming, it will result in a document with a better chance of withstanding peer review.

4.5.4 Case Studies

The document should call upon the use of case studies as an educational and best-practice tool. In 2007, few case studies were available. The case studies do not need to be exclusively from the oil sands. Neither do they all need to involve treatment and habitat. A case study on each major topic would be useful. Municipal treatment of wetlands, for example, should be addressed (as it relates to oil sands). The case studies should be chosen for their applicability to the oil sands, and should emphasize any research/monitoring results that the case study has produced. Some interviewees indicated that Suncor and Syncrude
have undertaken a degree of reclamation work already, and would be able to supply suitable information for case studies.

4.5.5 Peer Review

Participants recommended a peer-review process that would involve: compiling a list of experts in wetland reclamation (to the extent they can be identified) who were not involved in the authorship of the guide; working with the client to narrow down the list to a handful of individuals; asking them to perform a cold-eye review of the document, and; submitting comments for the authors’ consideration.

4.5.6 Design

In terms of the look and feel of the guide, interviewees were overwhelmingly in favour of less text and a more visually appealing document. Dense, uninterrupted text should be avoided. They expressed a desire to see graphs, tables, flow charts, case studies (or box stories) and generous use of illustrations. A table should be included that lists the key elements the guidance document is going to address. One industry participant even recommended the incorporation of GIS maps, engineering drawings, and satellite photos where appropriate or feasible.

Sample view:

*It would be very useful to have tables that tell you exactly what you need to plant in given conditions. It should specify what plant types have the greatest chance of success in various conditions.*

In order to make the document as reader-friendly as possible, interviewees suggested the use of such tools as checklists and hypothetical “to do” lists. Some tables and lists of this nature were included in the 2007 version; however, according to one interviewee, they were not organized in an especially useful manner.

One participant expressed a great desire to see a wide assortment of visual techniques. It was suggested that the approach valued by geologists and engineers tends not to be taught to biologists, who may take a more text-based approach to reports and manuals.

Sample view:

*The manual should be visual. The document should include flow charts and illustrations to show the concepts. Engineers are drawn to flow charts*
and illustrations over lengthy text. The more bulleted lists and flow charts, the better (so long as they are not too complex). The document should provide a visual chronology of what the landscape used to look like, and what is happening currently.

As well, participants were overwhelmingly supportive of the development of a timeline similar to Table 7-2 from the _End Pit Lakes Guidance Document_ (CEMA 2012), which offers a detailed timeline for all activities associated with the planning, design, construction and operation of an EPL.

### 4.5.7 Medium

The medium of distribution for the next guide received considerable attention during the interviews. Notably, the interviewees expressed great support for an electronic version. Some participants involved in the production of the _End Pit Lakes Guidance Document_ (CEMA 2012) expressed similar sentiments. Today, to stay on top of new information, engineers and policymakers increasingly look to the Internet to find new reports, studies, minutes from meetings, and the latest regulatory and regional planning changes. Many do the bulk of their work on desktops and laptops.

The advantages identified by interviewees for an electronic version included:

- The potentially significant costs associated with printing copies of a document that is expected to be several hundred pages in length;
- The short time period between publication and the arrival of new research that could render some sections obsolete;
- The increasing demand for online references that can be indexed and searched.

Sample view:

_The manual could be largely an e-version, or electronically/web based. Print materials could be reserved as an “on demand” requirement only. Lengthy hard copy text-based documents are no longer as desirable as an electronic-based manual that operators can log into and use as a reference, free to move from section to section at will._

The growing prevalence of e-readers (iPads and other tablets) means that an otherwise bulky and awkwardly bound document can be replaced by digital copies that are easily distributed and transported, even in the field. Internet connectivity may be limited in some oil sands locations (although this is a rapidly diminishing concern thanks to frequent telecommunications technology upgrades), but the portability of e-readers gives them an advantage. Several interviewees suggested some consideration be given to a wholly digital format for the guide.
Sample view:

The Internet has become a phenomenal source of up to date information, along with historical material. That’s going to be the best information medium to the audience for this document. These days, people look immediately at the latest regulatory or regional planning changes, and the latest research reports, to stay on top of things. So why not put this document into that sort of information flow?

### 4.5.8 Research

Since the production of the 2007 guide, researchers have acquired considerable knowledge on the science of wetland evolution. Almost every participant expressed a strong desire for the new guide to take advantage of this research.

For example, the work of Jan Ciborowski and CFRAW (Carbon dynamics, Food web structure, and Reclamation Strategies in Athabasca oil sands Wetlands) should be taken into account [http://web2.uwindsor.ca/cfraw]. Also, the producers of the next guide should examine the work of the Canadian Oil Sands Network for Research and Development (CONRAD) [http://canadianoilsandsnetwork.ca]. Both initiatives are producing relevant research on wetland ecology and the impact of the oil sands on wetlands. Interviewees pointed to the CONRAD symposium sessions on peat accumulation as potential sources of useful material.

Participants noted that there is a technology transfer document soon to be released that could provide a great deal of useful information. One participant noted that the CEMA wildlife task group is developing wildlife criteria that should be referenced for the wetland guide. It will have information of value to wetland reclamation and other initiatives.

Syncrude and Suncor, as the two most experienced operators, also possess information on bogs and fens. Several industry participants and government representatives recommended finding a way to bring various operators together to share and transfer technology and experience through the writing of the wetlands reclamation guide.

### 4.5.9 Reference wetlands/analogues

The interviews revealed a wide range of perspectives on the value of including a discussion of natural, or analogue, wetlands as references for the design and construction of reclamation projects. Some participants indicated that analogues were largely inapplicable to the wetlands that will be created following mining. They noted that there are significant differences between natural wetlands and oil sands wetlands. Natural wetlands have evolved over thousands of years, exhibit low salinity values and high tolerance to disturbance, and are not influenced by process-affected water and materials. Oil sands wetlands share none of these
traits. One participant observed that reclaimed landscapes may resemble boreal forest, but will not resemble what existed prior to mining. Another argued that even wetlands that develop in the wake of a forest fire are unsuitable analogues for wetlands created from scratch on a disturbed mine site.

By contrast, some participants suggested that comparing reclaimed wetlands with much older, off-site natural wetlands may be a useful exercise, as will be a comparison of early-stage reclaimed wetlands with specific natural wetlands that exhibit certain similarities.

Sample view:

*Planners shouldn’t put too much emphasis on natural analogues. Some description of natural processes will suffice. One thing to note is that natural wetlands won’t have the same level of salinity as constructed wetlands.*

Sample view:

*Reclaimed wetlands should be compared with water bodies that have similar water quality characteristics. They cannot be compared with wetlands that have been established for hundreds of years. Even comparing wetlands with areas that are redeveloping after a forest fire is tricky, since wetlands in the oil sands are being created from scratch.*

Sample view:

*The landscape that will result from oil sands reclamation activities may resemble boreal forest, but it won’t resemble what was naturally there historically. Moreover, it may not resemble the landscape 100 km north or south of the reclaimed area. Therefore, natural analogues will be of little use. The basic principles of ecology will apply, but that would be the extent of the similarities.*

### 4.5.10 Timelines

The participants had varying views on the appropriate timeline to include in the document (though all agreed that it would be beneficial for the guide to suggest a timeline). Some said that it should be made clear whether a given wetland is evolving with a “positive” trajectory within as few as 10 years. Others suggested that it will take many decades of close monitoring to ensure desired trajectories have been achieved. Government representatives expressed a desire to see a 100-year schedule similar to Table 7-2 of the *End Pit Lakes Guidance Document* (CEMA 2012), with one industry participant calling it an “excellent” model (see Appendix IX). The discrepancies could be the result of differing perspectives on what constitutes a desired trajectory, but it is clear that this is a subject that will require some discussion among the authors and editors of the next version of the guide.
Sample view:

*The timeframe could vary significantly – from as much as 30 years to 100 years – before a wetland can be considered to be on a positive trajectory.*

One interviewee noted the need to know the number of years required for detailed planning and selection of conceptual drainage patterns. How quickly the water quality of wetlands will improve and stabilize will depend on how much processed-affected water is influencing the wetland. For at least a decade, water-quality stabilization is likely to take priority over re-vegetation and biodiversity considerations. A timeline indicating what features to prioritize and when would be useful.

### 4.5.11 Adaptive management

The use of adaptive management for wetlands reclamation, and the inclusion of a section devoted to it, did not receive a unanimous endorsement of the interviewees. Some said that it should only receive a brief mention, thanks to the rapidly rising costs of making changes in a wetland’s evolution as time passes. Others expressed an interest in seeing the subject included, if only to ensure that the guide recognizes that “not everything will work out as planned.” For example, the development of a monoculture would have a wholly negative impact on plans to develop a viable ecosystem in the wetland, and at this point an adaptive management strategy could be essential. One suggested that examples of the successful use of the technique would be useful, while another argued that an adaptive management approach would have “tremendous value.”

Sample view:

*Wetlands are highly variable systems to begin with, so the benefits of constantly tweaking them are few.*

One participant strongly endorsed the use of adaptive management throughout the process, suggesting that it is one of the main principles of environmental science. Many adaptive management issues could arise that need to be addressed. For example, operators should anticipate the need to address issues caused by beavers. Similarly, when bulrushes and similar species penetrate drainage ditches, a plan is needed to address this occurrence. Adaptive management may also be useful in determining why a wetland may not be meeting design criteria and indicator objectives.

Sample view:

*Ecosystems are constantly changing. Wetlands will evolve in directions you don’t expect. There will be fires and dry years that operators cannot anticipate. Therefore, certain resilience needs to be built into a wetland reclamation plan.*
Although a consensus on this issue was elusive, it appears that some treatment of adaptive management will be welcomed, so long as it does not overshadow other issues that enjoy stronger and broader interest. Some of the disagreement could be the result of varying definitions of adaptive management, and varying views on its applicability to wetland construction. One industry participant embraced the concept as a method to avoid maintenance in the future, rather than seeing it as something that would prove difficult to implement.
5 SUMMARY

The 2007 wetland guide was considered moderately valuable for its contribution to the science of wetlands reclamation. But it was largely considered unusable as a “how to” guide by both the CH2M HILL review and the participants interviewed by West Hawk Associates. As a result, it has not been widely used by oil sands operators involved in wetland construction. However, interviewees pointed out that there have been significant advances in the industry’s understanding of how to build and manage wetlands since 2007.

In the research conducted for this document, interviewees were largely in agreement on how the next guideline should be prepared. They want to see a document that is heavier on engineering. They prefer a document that sets out steps for operators to follow. The production should be overseen by managing editors, while the content should be prepared by multiple authors with varying expertise. The document should be peer-reviewed, and professionally edited and designed.

In terms of the audience, the guideline should be geared to a professional audience of engineers, reclamation professionals and operators, though accessible in some parts to a larger audience as well. In the design component, participants want a document that is more visual than the previous version, incorporating wherever possible illustrations, tables, graphics, flowcharts, and checklists.

Most participants indicated that a conventional, hard-copy-only version of the guide will not satisfy many potential users. Electronic media continue to evolve rapidly, and it is difficult to anticipate the most convenient and popular formats, but many interviewees were explicit in their desire to see a digital version that takes advantage of electronic distribution and organization tools.

The participants also expressed a strong interest in seeing a timeline established for wetland reclamation. Notably, most interview participants were familiar with the recent work associated with the creation of the End Pit Lakes Guidance Document (CEMA 2012), preliminary drafts of which were circulating within the CEMA membership at the time of the interviews. They indicated an interest in seeing a timeline created that is similar to Table 7-2 of the EPL guide.

In 2013, CEMA intends to produce a new edition of the wetlands guide. This guide will be of great value to industry, as it may be required to ensure that their future closure plans conform to common standards. This assessment lays out the expressed user needs for the document – how it should be written, how it should look, who the audience should be and how the document should be published – as indicated by industry and government. It is intended to provide a basis for CEMA to move ahead toward the production of the next wetland guideline.
6 APPENDICES

6.1.1 Origins and Objectives

The guide is the second version of Guideline for Wetland Establishment on Reclaimed Oil Sands Leases. A third edition is expected to be produced in 2013. The second version was designed as a guide, rather than a handbook, in tandem with the CEMA forest vegetation reclamation guide and other relevant documents. It assumes that a) wetlands are critical to distributing and retaining water; b) their evolution over time is multifaceted; c) inter-disciplinary collaboration and coordination are necessary; d) stakeholder goodwill is essential if natural ecosystems are to be approximated; and e) best practices will evolve with ongoing research.

While considerable expertise in wetlands reclamation exists globally, little is known about the process in an oil sands context. Further research will be necessary, given that wetlands cover half of the affected landscapes and serve as wildlife habitat, hydrological and climatological regulators and stabilization factors, carbon storage banks, and recreational areas. They are also integral to local Aboriginal culture.

The surface mining and upgrading of oil sands generates:

- mining excavations that produce end pit lakes and process-affected tailings containing water, sand, silts, clays, soluble organic chemicals, ammonia, heavy metals and salts;
- the need to store non-recyclable materials;
- stockpiled, retrievable byproducts such as sulphur and coke;
- an increase in the volume of soils, overburden, and tailings by 20-25% over the pre-disturbance volume.

Reclamation must accommodate these elements and the resulting fundamental changes to the topography, geochemistry, and hydrology of the land. It must also follow the regulatory direction and legislative mandates in the Alberta Water Act and Alberta Environmental Protection and Enhancement Act (EPEA), among others, and in management strategies and regional plans. A fundamental objective of the EPEA is returning disturbed landscapes to “equivalent land capability,” which is defined as the ability of the land to support various land uses after reclamation that are similar but not necessarily identical to those that existed before mining.

The guide should be applied from inception to certification and closure. Intended audiences include mine closure planning teams, government regulators, resident Aboriginal communities, and other potential users of the reclaimed land.
6.1.2 Background

6.1.2.1 Environment

Hydrologists and geologists recognize the oil sands region as part of the boreal plain or the Western Canadian sedimentary basin. Foresters and ecologists know it as the central mixed-wood natural sub-region of the extensive northern boreal forest. Aboriginal peoples identify with the principal habitat of muskeg. The climate of the region is sub-humid, which means that precipitation is less than or equivalent to potential evapotranspiration. The bedrock is sedimentary and deep. The region has flat to gently rolling topography, and the water movement contrasts strongly with that of other regions of Canada, in that the influence of surface runoff is minimal; vertical movement dominates.

The Canadian Wetland Classification System describes the wetland forms currently and potentially attainable by reclamation initiatives: fens and bogs cover a significant area of boreal terrain (43% of the total landscape), compared with marshes (2%, also may be peat-forming in northern Alberta), shallow water wetlands (1%) and swamps (<1%). They are not static and will evolve through succession from one class to another.

Following mining, succession may occur in a much shorter period, because of elements introduced during or after construction. For instance, the compression of upland or wetland soils still settling after reclamation placement affects the morphology and depth of a wetland. Adaptive management can enhance succession and incorporate flexibility and diversity into reclamation.

Wetlands are a critical habitat for several indicator wildlife species, including woodland caribou (*Rangifer tarandus caribou*), wolves (*Canis lupis*), moose (*Alces alces*), muskrat (*Ondatra zibethicus*) and beaver (*Castor canadensis*), Canadian toads (*Bufo hemiophrys*), canvasback (*Aythya valisineria*), redhead (*A. americana*) and ring-necked (*A. collaris*) ducks and sea ducks such as bufflehead (*Bucephala albeola*) and common goldeneye (*B. clangula*). The moose is also a cultural keystone species, because of its significance to Aboriginal peoples.

6.1.2.2 Aboriginal use

People of the Fort McKay, Anzac, and Fort Chipewyan communities continue to use wetlands for subsistence hunting and trapping, for food and medicinal plant collection, and for spiritual well-being. Elders and others actively practicing a traditional lifestyle have a vast store of knowledge that could provide great insight when designing and reclaiming wetlands. In addition, the participation of local young people in building reclaimed wetlands may help strengthen cultural integrity.
Potential contaminant levels in plants and animals must be addressed before full access to the region can be granted. Research suggests that species collected from reclaimed wetlands on operating leases have negligible levels of metals. However, monitoring will need to occur routinely at each site to ensure the safety of food gathered through hunting and trapping.

6.1.2.3 Mining

Surface mining of oil sands began in 1967 and expanded greatly in the 2000s. Production, now exceeding one million barrels of crude oil per day, is occurring on over 250 km². The first two mines, Suncor’s Lease 86 and Syncrude Canada’s Mildred Lake lease, are proceeding with progressive closure of reclaimed landscapes. Wetlands reclamation experiments at these sites began in the early 1990s.

The topography of the mined landscape exhibits greater relief than the surrounding natural landscape, particularly where high sand or clay overburden deposits are formed. The increased gradients and increased volumes of waste deposits lead to interruptions or redirections of groundwater aquifers and will influence where wetlands can be created on reclaimed landscapes. Water movement through this altered environment may be dramatically different than it was pre-disturbance.

Overburden may be coarse-grained, fine-grained, non-saline, saline, or sodic. Saline and sodic leachates are a challenge for wetlands reclamation. Peat materials are valuable topsoil for reclamation.

The silts and clays from tailings streams delivered to settling basins eventually become mature fine tailings or soft (consolidated) tailings when dewatering is chemically accelerated. These materials may form bottom substrates for open-water wetlands or marshes. The sands that settle out around the edges of the settling basins may be used to control or direct groundwater flow in a reclaimed landscape. The process-affected water itself may influence wetland biochemistry.

6.1.2.4 Regulations

The four approaches used to direct the planning and evaluation of water management and landscape development are:


• Regional planning: Regional Sustainable Development Strategy for the Athabasca Oil Sands Area (and cumulative effects management), Oil Sands Consultation Group.

• Multi-stakeholder strategic planning: Oil Sands Mining End Land Use Committee, Athabasca Oil Sands Reclamation Advisory Committee, CEMA.

6.1.2.5 Reclamation Context

Wetland reclamation is the creation of wetlands on disturbed land where they did not formerly exist or where their previous form has been entirely lost. Wetland restoration is a process of restoring wetland function to a pre-disturbance state. Surface mining in the oil sands region leaves little to no remnants of wetlands to recover. The volume of information available on wetlands restoration is reasonably large, but much will have limited usefulness because of differences in the magnitude of disturbance (complete versus partial wetland removal) or in the environmental setting. The most relevant examples can be found in work on peat-forming wetlands and on marshes or shallow open-water wetlands.

6.1.3 Steps to reclamation

6.1.3.1 Landscape planning

Closure teams must coordinate with those planning adjacent upland and aquatic areas and embrace a holistic perspective. Among other questions, they must consider: desired uses and functions of the wetlands; how to ensure those uses and functions can be sustained, and; the proportion of the closure landscape needed to ensure landscape integrity.

The ability to achieve the five classes of wetlands varies. Marshes and ponds have been constructed on reclaimed oil sands, while fens, bogs and swamps have not, although CEMA and other agencies are conducting research. Each class has key limiting elements, such as elevation, surface water energy, soil permeability, and flora/fauna.

The importance of wetlands in the movement and retention of water on the natural boreal landscape cannot be overstated, as boreal plains forests persist in a near water deficit most years. Bogs and other perched wetland basins can contribute to groundwater recharge. Peat-forming wetlands hold water throughout the year (they may be as much as 95% water) and saturated fens can be an important source of storm runoff. Marshes and shallow waters may function in water storage, but can enhance water losses as well. The flood control capacity of wetlands has been overstated in the wetland-planning literature.

Water treatment must occur for finite periods in some reclaimed wetlands, which must still function as wildlife habitat. Treatment may be achieved for low-
molecular-weight organic acids through biodegradation to inert compounds. Although not all naphthenic acids degrade at the same rate, aging in wetlands reduces toxicity. Salts and other constituents that cannot be degraded must be treated by dilution.

Many of the species chosen by CEMA as indicators of sustainable ecosystems are habitat generalists and require good connectivity via extensive travel corridors. Others, such as the woodland caribou, are habitat specialists that require specific classes of wetland. The needs of each must be considered when choosing which wetlands to reclaim.

6.1.3.2 Hydrological and geological setting

“Perched” inland wetlands that are disconnected from groundwater discharge by an impermeable soil lens pose a threat to sustainability since climate change may dry up the landscape. However, there is value in creating some perched systems to function in flood control. The first edition of the guide assumed surface runoff would be the dominant contributor of water to wetlands; but this may not be the case in the oil sands region.

Research on natural analogues indicates that groundwater discharge to wetlands is a significant source of water, especially for those in low locations in coarse-grained soils, and for large fens. Wetlands with a groundwater connection exhibit moderated water-level changes during wet-dry climate cycles. This suggests that they would be more likely to persist over the long-term and through dryer periods. Process-affected water will seep from sand dykes, soft tailings, and mature fine tailings for an undetermined number of years. Water may be channeled through treatment wetlands associated with end pit lakes. But wetland plans must prepare for the eventual disappearance of this mining water source.

Research also suggests there may be benefits to incorporating layers of coarse- and fine-grained materials in the closure landscape to allow perched wetlands to persist. The marine origin of the Clearwater Formation creates challenges to the design of effective groundwater recharge and discharge regimes. Saline and sodic overburden is generally used for landform construction, but its effect on groundwater must be addressed during planning.

Vegetation on uplands and wetlands affects how much water is available to the ecosystem. Succession-induced changes to vegetation will require a shift in management focus over time from upland flood and erosion control to water retention and storage.

To date, planning has largely been conducted using a topographic model to define catchment boundaries; the first edition of this guide applied this modelling approach. However, research indicates that catchment boundaries are often defined by more complex interactions of climate, geology and vegetation. The desired watershed-to-wetlands ratio has varied since the first edition and it may not be practical to reach natural ratios. A greater number of moderate-sized (5-50
ha) wetlands with a high degree of connectivity may be the most practical option.

In the oil sands region, wetlands most often occur as complexes, with several classes in close proximity, making wetland complexes optimal for increased biodiversity of vegetation types, habitats and wildlife. Useful environmental parameters for each landscape setting include depth and location of aquifers, wind patterns, storm frequencies, sodicity and salinity profiles, water quality issues, and so on. Each setting comes with issues requiring resolution, such as how to maximize water storage, prevent sedimentation, and plan for succession; each case will involve specific decision sequences.

6.1.4 Building individual wetlands

The hydrology and geochemistry at the wetland scale is contingent on many interacting variables, as is the state of knowledge on wetland reclamation.

**Marshes** are wetlands dominated by reeds, rushes, and sedges rather than mosses or trees. They are periodically inundated, have a neutral to basic pH, and can persist in a wide range of hydrologic and nutrient regimes.

**Shallow open water wetlands** are often located as ponds within wetland complexes that are predominantly made up of other wetland classes. Ponds are distinguished from marshes by having at least 75% of total surface area in open water during the summer. The guide groups them together because in reclaimed landscapes, they tend to form wetland complexes. The acceleration of vegetation establishment (by seeding or planting) and invertebrate colonization (by inoculation) may be critical to the early success of habitat wetlands. The “build it and they will come” philosophy only works when the site is well-connected to healthy, remnant natural wetland complexes. Size, shape, depth, substrate type and depth, sedimentation, hydroperiod, and shoreline gradient are among the key design parameters.

The presence of fish, muskrat, and beaver in marshes and ponds can alter wetland dynamics. Boreal wetlands inhabited by brook stickleback (*Culaea inconstans*), for instance, have reduced biomass of grazing and predatory invertebrates. Muskrat can produce channels through marshes and affect the proportion of open water through grazing, while beavers influence the size, depth and organic makeup of wetlands.

**Fens** are peat-forming wetlands and the dominant wetland class in natural environments of the oil sands region. The water table is relatively stable and groundwater and near-surface flow are important for the maintenance of saturated conditions. Fens are dominated by mosses with less dense assemblages of sedges and shrubs.

**Bogs** are peat-forming; however, bog hydrology is driven solely by precipitation in a perched setting. The dominant vegetation is *Sphagnum* moss, which further acidifies the environment and is a poor heat conductor. It helps establish a micro-
environment unsuitable for most competing vascular plants.
To date, reclamation of fens or bogs in the oil sands has not been attempted.
Bogs require specific environmental conditions and represent a mature seral
state in peatland formation. Lessons learned from fen reclamation research in the
oil sands may be further applied to perched settings. Key design elements
include basin morphology, the nature of sediment and substrate, hydraulic
capacity, and water and peat chemistry.

**Swamps** are forested wetlands with 30% or more tree cover and a water table at
the soil surface. There have been no attempts thus far to reclaim swamps in the
oil sands; they are not considered a research priority because of their uncommon
status.

6.1.4.1 *Riparian margins and streams*

Riparian margins and riverine systems are not technically wetlands. But they
form critical links to uplands and between wetlands and lakes. The guide
discusses them briefly and provides limited guidance on their construction, as it
relates to wetland function. Discussion of littoral zones was left for future editions.
Considerations for connecting wetlands include shape, gradient/velocity,
sediment type, vegetation, and fish life.

6.1.4.2 *Construction phase*

Construction plans should consider: the timing of earthworks, particularly in low
elevation areas, to maximize activity when soils are dry or frozen; compaction
from movements of earth-moving equipment, which can be avoided by using
designed travel corridors; grading and contouring strategies to ensure precise
soil depth and wetland morphology; temporary control of hydrology to allow for
seasonal variation; substrate acquisition and placement to limit erosion, aeration,
and unintended migration; and vegetation establishment rates and how they are
affected by environmental and physical conditions.

6.1.5 *Monitoring and adaptive management*

While good pre-construction planning will reduce the need for adaptive
management changes later, minor reworking may occasionally be necessary
where unforeseen circumstances influence structural or functional integrity.
Aboriginal input may help by offering different valuation methods. Effective
monitoring includes: statistical validation to identify cause-effect relationships and
subsequent solutions to problems; comparisons with a variety of natural
analogues to serve as references; key primary and secondary structural and
functional variables that determine community composition, productivity, and
ecological function; timelines appropriate to each variable; well-communicated
data interpretation; and integrated planning through the entire monitoring team.

Among the potential problems to look for are unsustainable drying up of
wetlands, unmanageable floods and infilling, shoreline erosion, elevated salinity
and toxicity, and low biodiversity and habitat use. A general finding of field-scale trials is that robust wetland plant species will establish opportunistically in marsh and shallow water systems constructed with overburden, peat, soft tailings, and process-affected water. These compositional elements may be varied in placement and proportion to suit the target uses and functions of each wetland. But these lessons learned are tentative, because the data have not yet been subject to rigorous analysis, interpretation, and/or peer-review.

6.1.6 Restoration of altered wetlands

Unlike constructed wetlands on closure landscapes, altered wetlands persist throughout the mining process. Most altered wetlands will be peat-forming fens or bogs, marshes or a complex of transitions to several classes. The severity of impacts in altered wetlands will range greatly, but will likely follow a few common patterns. It is unlikely that the surface of the wetland will be directly affected, as in peat harvesting or other invasive earthworks. Rather, the impact will result from hydrological alterations, erosional forces, or chemical influxes. For example, where monitoring suggests that the water table is dropping by more than 20 cm in a fen for extended periods of time, mid-disturbance management is warranted. That may involve temporarily increasing the input or reducing the output of surface waters. Similarly, where marshes or open-water wetlands experience extreme changes in hydroperiod, temporary troubleshooting measures may be worthwhile.

The key differences in the restoration process involve the sequence of decisions and the magnitude of the changes required to restore wetland function. Monitoring must figure more prominently throughout the process. Key elements to consider include: hydrology; geology of upland soils; topographic setting; geochemistry of substrates and water; structural properties of substrates; vegetation; and aquatic animals.

6.1.7 Reclamation certification

The Alberta government requires that oil sands mine operators conserve and reclaim disturbed land to an equivalent land capability. It is probable that wetlands will be evaluated using a tiered approach, first determining the structural and functional integrity and values of each individual wetland, then considering them within the context of larger landscapes, perhaps as wetlands complexes, landform complexes, or as whole watersheds. In the absence of regulatory criteria, the 2007 guide posed three questions that could form the basis for a detailed development of reclamation evaluations:

1. Is the wetland viable/sustainable in the long term?
2. Does the wetland have structural and functional integrity?
3. Does the wetland have the capacity to support the intended functions?
6.1.8 Uncertainty

Significant local-scale and regional-scale variables exert unmeasured influences on reclamation. Regional-scale variability affects wetlands reclamation in ways that mine closure teams have little or no control over. It is important to identify their possible impacts, monitor their influence where possible, and develop strategies for minimizing the risks to wetlands reclamation. The dominant regional-scale uncertainties are:

1. **Climate change**: By 2040, the average air temperature in the region is predicted to increase by 2-3°C and the ratio of precipitation to potential evapotranspiration in the region is predicted to drop from 0.880 today to between 0.650 and 0.0775. It is unclear whether natural fens and bogs will persist in the oil sands region, and if so whether they will continue to accrue peat.

2. **Cumulative groundwater flow changes**: Particularly where wetlands reclamation efforts are bounded by new mining development, it will be difficult to trace the cumulative impacts and predict the magnitude and direction of groundwater flow on the reclaimed landscape. The best approach to addressing this source of uncertainty is a coordinated and intensive groundwater-monitoring program.

Other sources of uncertainty include release of water from reclaimed materials that will occur for an undetermined period of time; nutrient and chemical loadings to wetlands from uplands composed of varying reclamation materials; nitrogen and phosphorus limitations to vegetation establishment; and how wildlife will use reclaimed wetlands. These local-scale sources of uncertainty may contribute to the environmental variability expected on reclaimed landscapes.

6.1.8.1 Research directions

Research priorities include: reclamation of peat-forming wetlands, including fens; incorporation of societal values into wetlands reclamation; hydrological mechanisms in wetlands reclamation; biological processes driving wetlands establishment; water treatment capacity of reclaimed wetlands, and; methods for monitoring efficacy of wetland ecosystem establishment. A number of studies into these issues are underway.
6.2 Appendix II: Table of Contents of the Guideline for Wetland Establishment on Reclaimed Oil Sands Leases (CEMA 2007)

Executive Summary
1.0 How to Use This Guideline
2.0 Guideline Objectives
   2.1 Founding Principles for the Guideline
   2.2 Guideline Origins
   2.3 Key Intent of Guideline
   2.4 Key User Groups and Stakeholders
3.0 Background
   3.1 Environmental Context and Wetlands Classification
   3.2 Aboriginal Use Context
   3.3 Oil Sands Mining Context
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   3.5 Reclamation Context
4.0 Steps to Creating Reclaimed Wetlands
   4.1 Landscape-scale Planning
      4.1.1 Potential uses and functions provided for by reclaimed wetlands
      4.1.2 Sustainable placement of reclaimed wetlands
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      4.1.4 Potential landscape settings for reclaimed wetlands
   4.2 Building Individual Wetlands
      4.2.1 Building marshes and open water wetlands
      4.2.2 Building fens and bogs
      4.2.3 Building swamps
      4.2.4 Building connectivity into wetland complexes using riparian margins and streams
      4.2.5 The construction phase in wetlands reclamation
   4.3 Monitoring, Maintaining and Modifying
      4.3.1 Monitoring methods
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      4.3.3 Monitoring wetlands on oil sands leases: Lesson learned so far
5.0 Restoration of Altered Wetlands
   5.1 Characterization of Altered Wetlands by Monitoring Trends
   5.2 Managing Impacts During the Period of Disturbance
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6.0 Reclamation Certification
7.0 Addressing Uncertainty with Targeted Research
   7.1 Hitting a Moving Target: Challenges for Reclamation
   7.2 Research Directions and Projected Knowledge Gains

References
Glossary
Table 4.3  Design guidance for constructing marshes and shallow water ponds on reclaimed landscapes.

<table>
<thead>
<tr>
<th>Key design element and parameter</th>
<th>Design guidance for marshes and shallow water ponds</th>
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<tbody>
<tr>
<td><strong>Basin morphology</strong></td>
<td></td>
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</table>
| Size                             | • Minimum sizes for waterfowl are 0.2 ha (within larger complex of wetlands) or 5 ha (isolated)\(^{120}\)  
• Minimum size for beaver is 1.3 km\(^2\) marsh\(^{121}\)  
• Volume of recharge is often directly proportional to surface area\(^{122}\)  
• Large surface areas increase evaporation and concentrate salt ions in treatment wetlands\(^{123}\) |
| Shape & forms                    | • Convoluted shorelines increase use by territorial species\(^{124}\)  
• Islands provide protected nesting areas for ducks\(^{124}\)  
• Shoreline complexity index >1.6 preferred by breeding waterfowl\(^{125}\)  
• Length:width of 10:1 increases water treatment efficiency\(^{126}\)  
• Long fetches may resuspend sediments (& sediment-bound contaminants), but aid volatilization of water-borne contaminants (like ammonia)\(^{122}\) |
| Depth                            | • 1.5 to 2 m for open water habitat, oxygenated water treatment, over-wintering by fish, muskrat & beaver\(^ {127}\)  
• <1.5 m for submergent vegetation (moose forage), microbes\(^ {128}\)  
• 0.1 to 0.5 m for emergent vegetation\(^ {128}\)  
• > 25 cm for diving ducks, 5 – 25 cm for dabbling ducks, < 18 cm for waders (shorebirds)\(^ {129}\)  
• Temporary weirs increase winter depths, HRT and allow for some water treatment processes to occur under ice\(^ {123}\)  
• Deep areas should be contiguous to prevent entrapment of fish or fur-bearers during water level fluctuations\(^ {127}\)  
• Deep water produces stronger piezometric gradients, which encourages groundwater recharge & discourages discharge\(^ {122}\) |
| Shoreline gradient               | • Slopes of 15:1 horizontal(H):vertical(V) or flatter\(^ {130}\)  
• Submerged slope of 0.5% optimal for emergent plants\(^ {131}\)  
• Low banks required for access to forage by moose & beaver (<1 m, <10\(^\circ\))\(^ {127}\)  
• High banks required for winter denning by muskrat & beaver (maximum 5H:1V, <2 m high)\(^ {127}\) |

\(^{120}\) Lokemoen 1973; Wiacek et al. 2002  
\(^{121}\) Allen 1982 cited in Wiacek et al. 2002  
\(^{122}\) Hayes et al. 2000; landscape position is a greater controlling factor of recharge (Appendix C1[Devito & Mendoza], section 4.1)  
\(^{123}\) Golder Associates 2006a; concentrations of ammonia, TP & TN may still increase under-ice (Devito and Dillon 1993)  
\(^{124}\) Appendix E (Lumbis et al.)  
\(^{125}\) Jalkotzy et al. 1990  
\(^{126}\) Kadlec and Knight 1996  
\(^{127}\) Wiacek et al. 2002; Axys 2003  
\(^{128}\) Appendix D (Cooper et al.); Golder Associates 2005a  
\(^{129}\) Appendix E (Lumbis et al.); Taft et al. 2002  
\(^{130}\) Kentula et al. 1992
<table>
<thead>
<tr>
<th>Key design element and parameter</th>
<th>Design guidance for marshes and shallow water ponds</th>
</tr>
</thead>
</table>
| Bottom gradient               | • <1% is optimal for flood control, with deeper channels<sup>132</sup>  
  • Irregular bottom provides frictional resistance for flood control or sediment retention & increases HRT<sup>133</sup> |
| Percent open water            | • <75% for marshes, >75% for shallow open water ponds  
  • 50% optimal for breeding waterfowl & ammonia degradation<sup>134</sup>  
  • <50% optimal for other wetland birds (rails, etc) |
| Inlets & outlets              | • Restrict outlet to increase HRT, control floods, or increase groundwater recharge (relative to ET)<sup>133</sup>  
  • Increase inlet width to disperse suspended sediments<sup>133</sup> |
| **Sediment & substrate**     |                                                  |
| Substrate type                | • Organic substrate can bind metals and enhance nitrogen cycling<sup>135</sup>  
  • A peat–mineral mix with 15 to 20% organic matter is optimal for root penetration and turbidity control<sup>136</sup>  
  • Muskrat require a firm substrate for house-building (soft tailings would not be appropriate)<sup>137</sup> |
| Substrate depth               | • Transplanting 6-7 cm organic soil from natural marsh enhances vegetation with native species<sup>138</sup>  
  • 20 cm substrate is optimal for root penetration at water depths < 45 cm<sup>139</sup> |
| Sediment type                 | • Fine-grained if marsh or pond is perched and isolated, or for water treatment wetlands  
  • Deep organic sediment (> 2 m) common in natural analogues<sup>140</sup>, increases total water holding capacity of wetland |
| Sedimentation rate            | • <0.25 cm·y<sup>-1</sup> to allow wetland seed emergence<sup>141</sup>  
  • High suspended sediment loads limit macrophyte, plankton & fish growth<sup>142</sup>; incorporate sediment trap above habitat marshes  
  • 0.16 mm·y<sup>-1</sup> is acceptable for habitat wetlands<sup>143</sup> |
| **Hydraulic capacity**        |                                                  |
| Retention time*               | • Several months for the labile (more toxic) fraction of naphthenic acids<sup>144</sup>  
  • Several years for the refractory fraction of naphthenic acids<sup>144</sup>  
  • ~4-6 weeks for ammonia<sup>145</sup>  
  • Temporary weirs may be used to increase HRT |

<sup>131</sup> Steiner and Freeman 1989  
<sup>132</sup> Appendix C1 (Devito & Mendoza); Mitsch and Gosselink 2000  
<sup>133</sup> Hayes et al. 2000  
<sup>134</sup> Golet 1976; Weller 1978; Bishay and Nix 1996  
<sup>135</sup> Zedler and Langis 1991  
<sup>136</sup> Stauffer and Brooks 1997; Luong 1999  
<sup>137</sup> Wiacek et al. 2002; Ursus 2003  
<sup>138</sup> Brown and Bedford 1997  
<sup>139</sup> Hammer 1989; Brown and Bedford 1997  
<sup>140</sup> Bayley 2003; Bayley and Mewhort 2004  
<sup>141</sup> Galinto and van der Valk 1986  
<sup>142</sup> Harris 2001  
<sup>143</sup> Golder Associates 1998  
<sup>144</sup> Scott et al. 2005; Golder Associates 2005a; M. MacKinnon, pers. comm.  
<sup>145</sup> Golder Associates 2005a
<table>
<thead>
<tr>
<th><strong>Key design element and parameter</strong></th>
<th><strong>Design guidance for marshes and shallow water ponds</strong></th>
</tr>
</thead>
</table>
| **Hydroperiod**                    | - Spring drawdown & re-flooding by 15 – 45 cm enhances waterfowl habitat\(^{146}\)  
- Germination of emergent plants requires species-specific water level fluctuations\(^ {147}\)  
- Stable water levels required for beaver (<1 m·y\(^{-1}\)) & muskrat\(^ {127}\) |
| **Loading rate**                   | - 2.5 to 5 cm·d\(^{-1}\) for water treatment\(^ {148}\) |
| **Water chemistry**                | **Nutrients**  
- Nitrogen is a limiting nutrient in boreal emergent-dominated marshes and natural saline marshes & fens\(^ {149}\)  
- Phosphorus may be the limiting nutrient in sub-saline reclaimed marshes\(^ {150}\)  
- Phosphorus availability increases with catchment area\(^ {151}\)  
- Adding phosphorus (<100 µg·L\(^{-1}\)) enhances initial water treatment rates\(^ {152}\), but may favour weedy vegetation\(^ {147}\)  
- Natural analogues contain 10-50 µg·L\(^{-1}\) N, 25-100 µg·L\(^{-1}\) P\(^ {153}\)  
- Anoxic conditions under ice may lead to build-up of N & P\(^ {154}\)  
- **Naphthenic acids**  
- Marshes can be associated with end-pit lakes to extend HRT  
- Larger wetland volumes (by increased depth not surface area) will increase HRT and extend potential for biodegradation\(^ {155}\)  
| **Salinity**                       | - Electrical conductivity >10 dS·cm\(^{-1}\) in soil & > 2 mS·cm\(^{-1}\) in water limits vegetation to saline-tolerant species; EC <3-4 dS·cm\(^{-1}\) in soil allows establishment of non-saline riparian vegetation\(^ {156}\)  
- Flow-through, restricted hydroperiod or limited AET required to prevent salt crust formation  
- Larger wetland surface area increases salt concentrations as a result of additional ET\(^{155}\)  
- Greater depth will ameliorate concentration of salts under the ice in winter (salt rejection)\(^ {155}\)  
| **Ammonia**                        | - Open water aeration and a healthy bacterial population promotes removal\(^ {145}\)  
- Under-ice concentrations may increase as dissolved oxygen decreases\(^ {154}\)  
| **Hydrocarbons**                   | - Largely substrate- and sediment-bound  
- Increase water depth to reduce flow & shear stresses, promote sedimentation and limit resuspension\(^ {157}\)  
- Increase frictional resistance with dense submergent vegetation and irregular bottom to limit suspension of particulate-bound |

\(^{146}\) Taft et al. 2002; Kaminski et al. 2006  
\(^{147}\) see Appendix D (Cooper et al.) for requirements of species in the oil sands region  
\(^{148}\) Mitsch and Gosselink 2000  
\(^{149}\) Bayley 2003; Trites and Bayley, unpublished data; may be true for *Sphagnum fuscum* moss in local bogs (Vitt et al. 2003b)  
\(^{150}\) Trites and Bayley, unpublished data  
\(^{151}\) Prepas and Trew 1983  
\(^{152}\) Reed 1990  
\(^{153}\) Bayley 2003  
\(^{154}\) Devito and Dillon 1993  
\(^{155}\) Golder Associates 2006a  
\(^{156}\) Purdy et al. 2005; Appendix D (Cooper et al.)
<table>
<thead>
<tr>
<th><strong>Key design element and parameter</strong></th>
<th><strong>Design guidance for marshes and shallow water ponds</strong></th>
</tr>
</thead>
</table>
| **Metals**                          | • Mo, B, Fe, Al, Cu, Zn present in soft tailings, possibly above water quality guidelines<sup>158</sup>  
• Maintain neutral - basic pH to limit mobilization of metals  
• Co, Cu, Mn, Ni, V, Zn are released quickly from coke; pre-rinsing coke with water and crushing it to reduce particle size before placement as substrate may reduce associated toxicity<sup>159</sup> |
| **Vegetation & phytoplankton**      | **Submergent**  
• Phytoplankton dominate ponds >1.5 m deep  
• Macrophytes dominate ponds < 1.5 m deep  
• >21 % cover preferred by breeding waterfowl as forage<sup>160</sup>  
• 30 mg·L<sup>-1</sup> NAs and 1000 µS·cm<sup>-1</sup> are thresholds above which phytoplankton community composition is altered (thereby changing the structure at the base of the aquatic food web)<sup>161</sup>  
• Macrophytes (pondweed) and floating plants (yellow pond lily roots) are high-quality summer foods for moose<sup>162</sup> |
|                                     | **Emergent**  
• Transplant densities are species-specific<sup>163</sup>  
• Water table depths for planting are species-specific and may vary from natural settings in process-affected soils<sup>163</sup>  
• Saline tolerant species are often not proximate to reclamation sites and will not self-seed; need to transplant in donor wetland soil (seed bank) or plant propagules from saline sources<sup>164</sup>  
• Cattail monocultures help retain nutrients<sup>165</sup>, but limit habitat  
• 30 – 90 % cover preferred by waterfowl for nesting & brood-rearing habitat<sup>166</sup>  
• Muskrat prefer reedgrass for house-building and cattail, rat root, burreed, bulrush and sedges for foraging<sup>166</sup>  
• A weed-free seed bank reduces competitive stress for plants<sup>164</sup> |
|                                     | **Riparian**  
• Aspen & willow <15 cm in diameter and close to water (<100 m) will enhance beaver habitat<sup>167</sup>  
• Willow, water birch and black spruce are tolerant of CT-associated salinity and sodium (EC 4440-7910 µS·cm<sup>-1</sup>)<sup>168</sup>  
• Canadian toad prefer >50% aspen cover<sup>160</sup> |

<sup>157</sup> Evans 1994; Hayes et al. 2000  
<sup>158</sup> Golder Associates 2005a; Mo=molybdenum, B=boron, Fe=iron, Al=aluminum, Cu=copper, Zn=zinc  
<sup>159</sup> Squires 2005; Co=cobalt, Mn=manganese, Ni=nickel, V=vanadium  
<sup>160</sup> Wiacek et al. 2002; toad requirements (riparian) may be a function of sandy hibernaculum soils  
<sup>161</sup> Hayes 2005  
<sup>162</sup> Wiacek et al. 2002; Garibaldi 2006b; pondweed (Potamogeton spp.), yellow pond lily (Nuphar variegatum; Aboriginal name = beaver pineapple)  
<sup>163</sup> see Appendix D (Cooper et al.) for recommended densities for a number of native species; Golder Associates 2005a  
<sup>164</sup> Appendix D (Cooper et al.); Purdy et al. 2005; Golder Associates 2005a  
<sup>165</sup> Cronk and Fennessy 2001; CEMA 2003  
<sup>166</sup> Wiacek et al. 2002; Garibaldi 2006b; reedgrass (Phragmites spp.), cattail (Typha latifolia), rat root (sweet flag, Acorus calamus), burreed (Sparganium spp.), bulrush (Scirpus spp.), sedges (Carex spp.)  
<sup>167</sup> Wiacek et al. 2002  
<sup>168</sup> Renault et al. 1998
### Key design element and parameter

<table>
<thead>
<tr>
<th>Invertebrates</th>
<th>Design guidance for marshes and shallow water ponds</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Benthic &amp; Nektonic</strong></td>
<td>Submergent vegetation and channel edges increase snail densities&lt;sup&gt;169&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>• Habitat structural complexity (plants, submerged logs, detritus) are required to support invertebrate community diversity&lt;sup&gt;170&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>• Introduction of natural wetland sediments can be used to inoculate benthos; consider inoculation or stocking to establish poor dispersers&lt;sup&gt;171&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>• Presence of fish will alter zoobenthic community composition&lt;sup&gt;172&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>• Gatherer, predator, shredder &amp; piercer functional invertebrate groups are reduced where submergent vegetation is dominated by dissected leaves plants like milfoils&lt;sup&gt;173&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Planktonic</strong></td>
<td>1.1-9.0 mg L&lt;sup&gt;-1&lt;/sup&gt; naphthenic acids influences zooplankton community composition and may thereby alter food web structure (invertebrates and fish)&lt;sup&gt;174&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

**Other habitat for vertebrates**

<table>
<thead>
<tr>
<th>Fish</th>
<th>Spawning may occur in shoreline marshes among emergents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Suitable for introduction to phytoplankton-dominated ponds&lt;sup&gt;175&lt;/sup&gt;</td>
</tr>
<tr>
<td>Waterfowl</td>
<td>Spring staging requires shallow (&lt;0.5 m), open wetlands (often connected to lakes) with an early spring thaw&lt;sup&gt;176&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>• Breeding requires emergent vegetation with a significant vertical dimension and convoluted shorelines&lt;sup&gt;176&lt;/sup&gt;</td>
</tr>
<tr>
<td>Muskrat</td>
<td>Critical ice-water depth for winter survival is 75 cm under water&lt;sup&gt;177&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>• Optimal habitat contains 40-75% emergent vegetation cover and &gt;75% submergent vegetation cover&lt;sup&gt;178&lt;/sup&gt;</td>
</tr>
<tr>
<td>Canadian toad</td>
<td>Wetland should be within 50 m of hibernacula (burrows on south-facing 40˚ slopes, un-vegetated with loose sand)&lt;sup&gt;179&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

---

<sup>169</sup> Olson et al. 1998
<sup>170</sup> Hornung and Foote 2006; invertebrate biomass is positively related to the proportion volume of submergent plants
<sup>171</sup> Brady et al. 2002; inoculate once a submergent macrophyte community is established
<sup>172</sup> Gould 2000; Hornung and Foote 2006
<sup>173</sup> Hornung and Foote 2006; milfoil (*Myriophyllum* spp.)
<sup>174</sup> McCormick 2000
<sup>175</sup> Bayley 2003
<sup>176</sup> Appendix E (Lumbis et al.); Wiacek et al. 2002
<sup>177</sup> Ambrock and Allison 1972 cited in Wiacek et al. 2002
<sup>178</sup> Jalkotzy et al. 1990 cited in Wiacek et al. 2002
<sup>179</sup> Axys 2003
### 6.3.2 Table 4.4 Fen reclamation and associated environmental conditions

<table>
<thead>
<tr>
<th>Design element</th>
<th>State of knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basin morphology</strong></td>
<td>- Microtopographic heterogeneity in the form of hummocks, hollows and flats is important for water retention, soil temperature gradients, vegetation diversity, nutrient partitioning and microbial activity(^\text{188})</td>
</tr>
<tr>
<td><strong>Sediment &amp; substrate</strong></td>
<td>- Underlain by peat at least 50-100 cm deep, tapering shallower on upland slopes to allow for paludification - Must establish aerobic-anaerobic layers (acrotelm-catotelm), with living peat above decomposing peat - Fens have been established on mineral soils including in the boreal after the last glaciation(^\text{189})</td>
</tr>
<tr>
<td><strong>Hydraulic capacity</strong></td>
<td>- Water table must stay near the soil surface throughout seasons and vary by &lt;20 cm(^\text{190}), grade site to within 20 cm of mapped level of groundwater aquifer</td>
</tr>
<tr>
<td><strong>Water &amp; peat chemistry</strong></td>
<td>- Electrical conductivity maximum is 300-400 (\mu\text{S}\cdot\text{cm}^{-1}), pH range 4-8(^\text{192}) - Phosphate fertilizer application (2 g·m(^{-2})) prior to vegetation enhances establishment of vascular plants like sedges(^\text{193}) - Nitrogen from current oil sands air emissions (~4 kg·ha(^{-1})·y(^{-1}) for Steepbank) enhances Sphagnum moss growth, but growth inhibition occurs at higher N levels (~14 kg·ha(^{-1})·y(^{-1}))(^\text{194})</td>
</tr>
<tr>
<td><strong>Vegetation</strong></td>
<td>- Community assemblages, key indicator species are well known(^\text{195}) - Vascular sedges and possibly some mosses may be established by collecting peat substrate with diaspores from natural analogues in the spring; take top 10 cm, break up and spread(^\text{196}) - Straw mulch application (3000 kg·ha(^{-1})) may protect vegetation from fluctuating temperature and drying soil moisture regimes during establishment(^\text{197}) - Awned sedge, seaside arrow-grass and bulrush are salt-tolerant and may accumulate organic matter sufficiently to form peat(^\text{198}) - Indigenous knowledge of Sphagnum mosses may provide insight on local optimal growing conditions</td>
</tr>
</tbody>
</table>

\(^{188}\) Bruland and Richardson 2005  
\(^{189}\) Halsey et al. 1998; Amon et al. 2005  
\(^{190}\) Gignac et al. 1991; Zoltai et al. 1999  
\(^{191}\) Nicholson et al. 1996; Cobbaert et al. 2004; Whitehouse and Bayley 2005  
\(^{192}\) Vitt 2003; Whitehouse and Bayley 2005  
\(^{193}\) Rochefort et al. 2003; Cobbaert et al. 2004  
\(^{194}\) Vitt et al. 2003b; implies that *Sphagnum fuscum* in region may be nitrogen-limited  
\(^{195}\) Vitt and Slack 1975; Gignac and Vitt 1994; Vitt 1994; Vitt et al. 2003a; Whitehouse and Bayley 2005  
\(^{196}\) Cobbaert et al. 2004  
\(^{197}\) Price et al. 2003; Cobbaert et al. 2004  
\(^{198}\) S. Bayley and M Trites, preliminary results; awned sedge (*Carex atherodes*), seaside arrow-grass (*Triglochin maritima*), bulrush (*Scirpus paludosus*)
Table 4.5 Design guidance for vegetated watercourses and riparian margins to wetlands

<table>
<thead>
<tr>
<th>Key design element and parameter</th>
<th>Design guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Morphology</strong></td>
<td></td>
</tr>
</tbody>
</table>
| Shape                            | ▪ Two-level channels mimic many natural systems (narrow central channel – bank – wider outer channel – bank)  
  ▪ Beaver use streams >0.8 km long & <5 m wide<sup>200</sup> |
| Gradient & velocity              | ▪ Submerged slope range is 1.5H:1V (fine-grained sediment) to 4H:1V or flatter (coarse-grained sediment)<sup>201</sup>  
  ▪ Beaver use streams with low slope (<15%)<sup>200</sup>  
  ▪ Water velocity should be ≤10 m·min<sup>-1</sup> for muskrat<sup>202</sup>  
  ▪ Beaver dam streams with <10 % riffles<sup>203</sup> |
| **Sediment & substrate**        |                 |
| Sediment type                    | ▪ Zones of rock/cobble on steeper gradients intercept suspended sediments and provide micro-habitat  
  ▪ Peat-mineral mix must be protected from resuspension by gradual initial filling of channel and rapid vegetation growth  
  ▪ Beaver use streams with fine-grain, stable banks<sup>203</sup>  
  ▪ Shoreline banks with clay-loam soil (not peat) are suitable for muskrat burrows<sup>204</sup> |
| **Vegetation**                  |                 |
| Submerged                        | ▪ Rapid establishment of macrophytes and periphyton is necessary for erosion control; planting of propagules (plant plugs or rhizomes) is advised |
| Riparian                         | ▪ Moose browse species that are tolerant of moist soils include red osier dogwood (saline-tolerant), Saskatoon berry, choke-cherry and willow<sup>203</sup>  
  ▪ Beaver prefer aspen and willow<sup>203</sup> |
| **Habitat**                     |                 |
| Fish                             | ▪ Waterfalls may be constructed to prevent fish from reaching upstream sensitive wetlands |

<sup>200</sup> Bovar 1996; Wiacek et al. 2002  
<sup>201</sup> Golder 1998  
<sup>202</sup> Nadeau et al. 1995 cited in Axys 2003  
<sup>203</sup> Wiacek et al. 2002  
<sup>204</sup> Axys 2003
6.4 Appendix IV: Wetlands reclamation/source materials

(These lists are courtesy of BGC Engineering Inc.)

Partial List of Reclaimed Wetlands

- **Syncrude**
  - Peter Pond marsh
  - Bill’s Lake marsh
  - Golden Pond marsh
  - Beaver Creek Reservoir
  - S4 Wetland (Ephemeral, very small)
  - S4 Marsh
  - Sandhill Fen
  - U-Shaped Cell 28 fens
  - South Bison Pond marsh
  - SWSS Bench fens
  - S Pit Marsh
  - Cell 11 Experimental Marshes (EPL research area)

- **Suncor**
  - Wapisiw Lookout
  - Experimental Wetland marsh
  - Suncor Pilot Fen
  - CT Wetland Demonstration Pond
  - Crane Lake
  - Sandpit Wetland
  - The Experimental Trenches
  - Natural Wetland
  - Shipyard Lake
  - McLean Creek Wetlands
  - STP Wetlands

Material to draw upon

- CEMA wetland manual 1
- CEMA wetland manual 2
- Recent CEMA marsh work
- Wetland manuals from elsewhere in the world, especially the US
- Existing fen literature reviews BGC
- Dozens of theses/papers on oil sands wetland performance
- Existing hydrology model BGC or others
- Improvements to make based on Syncrude and Suncor work to date
6.5 Appendix V. McKenna Recommendations

As mentioned in the table below, future editions should work up some common design scenarios for oil sands wetland creations. More specific recommendations are provided in Table 3-1.

<table>
<thead>
<tr>
<th>Observation</th>
<th>Enhancement to future editions of the Wetlands Manual</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>The classification of five types of wetlands (marshes and shallow water wetlands, fens, bogs, swamps, riparian zones) is very useful.</td>
<td>Maintain this simple classification; continue to reinforce the need to fit the type of wetland to the specific reclamation situation.</td>
<td>This clear (if simplified) understanding of wetland classification is needed to allow all specialists in the design teams (as well as regulators and stakeholders) to understand wetland design, construction, and operation.</td>
</tr>
<tr>
<td>Manual focuses on background information and generalities for a general audience.</td>
<td>Provide more specific design information and case histories (especially oil sands specific). Choose several typical design scenarios and work these through to logical conclusion. Document these scenarios and use them to test assumptions and recommendations in the manual.</td>
<td>It is easier to write about the specifics than the generalities. The manual will continue to evolve to contain more specifics over time.</td>
</tr>
<tr>
<td>Every wetland design will be unique.</td>
<td>Provide more fundamental building blocks, including data on: percolation rates for upland areas, actual evapotranspiration rates, climate histories (as input to models and water balances), substrate saturated and unsaturated permeabilities and soil-water characteristic curves, vegetation planting schemes, watershed geometry (typical perimeter to area ratios), designs for influent and outflow structures for oil sands areas, typical reclamation equipment and unit costs.</td>
<td>Much of this data will need to be measured empirically.</td>
</tr>
<tr>
<td>There is limited (but important) influence of wetland designers on the substrates and geometries provided for reclamation.</td>
<td>The manual should recognize that designers are obliged to work with difficult conditions and materials, and that wetlands have to be created in some suboptimal areas. However, there are (sometimes limited) opportunities to influence some key aspects of the substrates and geometries—watershed sizes, meso-topography (hummock design for water table control), substrate stratigraphy, soft tailings consolidation rates, water chemistry.</td>
<td>It would appear that the manual suggests that wetlands should be put in the best locations, but likely more often than not, they will need to be located in the most difficult areas.</td>
</tr>
</tbody>
</table>
### TABLE 3-1
Dr. Gordon McKenna’s Recommendations for Potential Enhancements to Future Editions of the Wetlands Manual

<table>
<thead>
<tr>
<th>Observation</th>
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<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site selection / substrate design assumes one has full discretion on where to locate wetlands.</td>
<td>Provide some typical wetland setting scenarios – use closure plans to identify typical areas – a few scenarios will cover 80% of the situations – e.g. in discharge areas in low areas on tailings plateaus in sandcapped soft tailings, at the toes of tailings dam slopes on original ground, perhaps some perched wetlands.</td>
<td>It seems likely that most wetlands will be fed by tailings waters for decades or centuries.</td>
</tr>
<tr>
<td>There appears to be a presumption of significant control regarding the design and construction of wetlands.</td>
<td>Through the use of real scenarios and case histories, highlight that wetland construction is forced to deal with suboptimal substrates, geometries, water chemistries, climatic effects on operations, etc.</td>
<td>The present manual may be too optimistic in this regard. In particular, water level controls on wetland with modest substrate slopes may be impractical.</td>
</tr>
<tr>
<td>Many or most wetlands will be designed on tailings surfaces, often on tailings sandcapped soft tailings.</td>
<td>The manual should feature a special section on fens/bogs? And marshes for these landforms.</td>
<td>Trafficability is a major constraint to design and construction that should be featured.</td>
</tr>
<tr>
<td>Wetlands on tailings will generally see elevated salinities that will gradually lower over time.</td>
<td>Strategies for use of salt tolerant vegetation should be more central, along with advice regarding designing wetlands to self transition from moderate to low salinity over decades and centuries.</td>
<td>Perhaps no special design is needed if natural succession can be reasonably assumed to take care of this.</td>
</tr>
<tr>
<td>An important feature of the design is an operations, monitoring and surveillance manual for the wetland, similar to that provided for dams. The initial operation of the wetland can be crucial to its success.</td>
<td>Provide an example or outline of things that would be included (a table of contents perhaps).</td>
<td>See: Mining Association of Canada, 2001. Developing an operation, maintenance and surveillance manual for tailings and water management facilities. Mining Association of Canada, Ottawa.</td>
</tr>
<tr>
<td>There appears to be a presumption of too much ability to reconfigure or repair wetlands (Table 4.6).</td>
<td>Revise Table 4.6 to reflect what can be practical changed once the wetland is established. Establish a list of design features that can be controlled or changed during operation that improve performance with minimal disturbance.</td>
<td>Ambiguity whether adaptive management applies to repair of existing wetlands, design and construction of new wetlands, or both. Trafficability, redisturbance, and general morphology of the initial wetland preclude most changes after reclamation except in exceptional circumstances.</td>
</tr>
<tr>
<td>Headlands watercourses on tailings plateaus will be fen-like.</td>
<td>The manual should highlight that the watercourses on tailings beaches will generally be very low gradient, groundwater fed, and have poor trafficability and are more likely to be “fen-like” than presently anticipated in the manual.</td>
<td>A major finding of the Sandhill Fen design is that the areas between tailings sand hummocks will be fen like, and the collector areas will be a series of marshes and fens.</td>
</tr>
</tbody>
</table>
### TABLE 3-1
Dr. Gordon McKenna’s Recommendations for Potential Enhancements to Future Editions of the Wetlands Manual

<table>
<thead>
<tr>
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<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 4.3.3 on lessons learned is extremely valuable.</td>
<td>Continue to collect lessons learned, both positive and negative. Note which adaptive management strategies are applicable to existing versus new wetlands.</td>
<td>Lessons learned can be a valuable and accessible communication tool.</td>
</tr>
<tr>
<td>Table 4.1 provides a good summary of wetland functions.</td>
<td>Look to grow these tables with time as more information and experience becomes available.</td>
<td></td>
</tr>
<tr>
<td>Table 4.4 Fen reclamation and associated environmental conditions is quite good.</td>
<td>Three types of monitoring should be recognized and formalized – operational monitoring (that needed to operate the wetland and indicate if repairs are needed), certification monitoring (monitoring needed to support a reclamation certification application), research monitoring (that needed to advance the science for future wetland development).</td>
<td>Guidelines for operational and certification monitoring should be minimized, operators can choose to build upon these programs to meet their own needs. Presumably the need for research monitoring for oil sands wetlands will diminish with time.</td>
</tr>
<tr>
<td>The longevity of liners for perched wetlands is a major design issue.</td>
<td>Guidance on the protection of liner deterioration from freeze-thaw and chemistry effects. Guidance on use of geosynthetics clay liners (GCL) for permanent reclamation.</td>
<td>If liners leak faster than the peats can form low-permeability catotelms, perched wetlands will tend to dry out.</td>
</tr>
<tr>
<td>Except in exceptional circumstances, peat in wetlands can likely only be placed in a single lift.</td>
<td>Operational placement of peat is a critical area that deserves more attention.</td>
<td>Trafficability of wetlands once the peat is placed typically precludes equipment access or significant modifications.</td>
</tr>
<tr>
<td>The need to supplement freshwater flow to young wetlands will be common.</td>
<td>Discuss this issue and provide guidance regarding quantities, dilution factors, and water management.</td>
<td>Can be a significant design feature (and cost).</td>
</tr>
<tr>
<td>Flowcharts / decision sequence diagrams provide little value.</td>
<td>Omit flowcharts except for those necessary.</td>
<td>Such figures are too simplistic, never followed, and can be better expressed in a paragraph or two.</td>
</tr>
<tr>
<td>Limited use of cross-sections.</td>
<td>Wetland catena is a useful concept for those designing the topography, soils, and revegetation of wetlands. Creation of a dozen typical annotated cross-sections for design would be extremely useful.</td>
<td>Some of the concepts are already included in the text. Need to ensure that proposed slopes and topography are practical and reclaimable.</td>
</tr>
<tr>
<td>Limited use of map views.</td>
<td>Scour the existing literature and adapt some of the explanatory maps for use in the oil sands.</td>
<td>Use to show typical layouts, terminology, and important design features.</td>
</tr>
</tbody>
</table>
### TABLE 3-1
Dr. Gordon McKenna’s Recommendations for Potential Enhancements to Future Editions of the Wetlands Manual

<table>
<thead>
<tr>
<th>Observation</th>
<th>Enhancement to future editions of the Wetlands Manual</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Some important construction issues are missed in the construction section.</td>
<td>The manual should be updated when more construction information has been catalogued. The construction will often be governed by operational activities and climate than some of the items listed in the document.</td>
<td>Participation by tailings operations specialists in the next edition is recommended.</td>
</tr>
<tr>
<td>Good reference list.</td>
<td>Highlight the key references for designers, focus on enlarging the section on case histories and manuals.</td>
<td></td>
</tr>
<tr>
<td>Reclamation certification criteria don’t seem to allow that success otherwise falls short of equivalent capacity. The manual sets wetlands very high expectations for all constructed wetlands – something that will likely not be achieved in all situations, and it may not be practical to fix all perceived deficiencies.</td>
<td>Recognize that there will be a variety of acceptable performance of reclaimed wetlands. The manual should include some discussion whether maintenance and operation must cease at some point prior to certification, and whether monitoring instruments need to be removed prior to certification.</td>
<td>Not all wetlands will fulfill their design goals, but will still be important components of the closure landscape. For example, a wetland that dries out can still be valuable habitat and provide other ecosystem values.</td>
</tr>
<tr>
<td>Virtually all constructed wetlands will be modified by beavers.</td>
<td>Design guidance on accommodating beaver activities is recommended.</td>
<td>Damming of outlets and raising water levels will have profound effects.</td>
</tr>
</tbody>
</table>

6.6 Appendix VI: EPL Guidance Document 2012 Table 7-2

Conceptual development and reclamation schedule for a typical oil sands mine.
6.7 Appendix VII: Questions for Stakeholders

1. What are your general comments on the 2007 wetland manual?

2. What are the document's shortcomings?

3. Does the 2007 manual appear to have been written for the right target audience?

4. Is the 2007 manual too broad, or too specific, for your purposes?

5. What elements did the 2007 manual contain that were least useful?

6. What design issues were not sufficiently addressed in the 2007 manual?

7. What information did you or would you find useful in support of preparing or evaluating a closure plan?

8. Has new science emerged that should be included in a revision of the manual?

9. How would like to see the next manual laid out (presentation of material)?

10. What improvements would you make to the manual overall?
6.8 Appendix VIII: Interviewees

Alberta Government
   Rod Hazewinkel
   Tanya Richens
   Gerry Haekel

CNRL
   Richard Kavanaugh
   Steve Tuttle
   Scott Johnson

Imperial Oil
   Rachel Noble Pattinson

Shell
   Renee Frenette
   Michelle Girts (Consultant, CH2M HILL)

Suncor
   Christine Daly

Total
   Andrews Takyi
   Brent Hartley
   Camille Piquet
6.9 Appendix IX: Interview Transcripts
June 6, 2012

WETLANDS USER NEEDS ASSESSMENT
2013 Wetlands Manual
INTERVIEW WITH Alberta Environment

Date:
March 2, 2012

Attended:
Rod Hazewinkel, Alberta Environment
Tanya Richens, Alberta Environment
Gerry Haekel, Alberta Sustainable Resource Development

Interviewers:
David Wylynko, West Hawk Associates
James Hrynshyn, West Hawk Associates

KEY THEMES

Design

The next wetland manual needs to be more prescriptive, and less general or conceptual. It should be more design-oriented. It should be a document that tells operators what they need to know. The 2007 version was too conceptual and not suitably precise. The manual should address high-level objectives for reclamation. If the manual is to be tied to approvals, high-level objectives are essential. The review of closure plans underway will reveal some significant gaps in wetland planning. Many plans so far are still largely conceptual. The manual needs to give direction, and to provide long-term planning. Wetlands take thousands of years to develop. For example, a reclaimed wetland certainly won’t be peat-producing in the short term, but the conditions can be put in place for eventual peat production. The manual needs to describe what companies need to plan for in terms of species. What number and types of species do we want in 60 years? Also, the issue of recruitment of soil stock must be addressed. Broadly, it should discuss the materials that will be available or needed for reclamation.

Key features

- Hydrology needs to be prominently featured and discussed. It should be at the front, not in the appendices. Only hydrologists will read an appendix on hydrology.

* Following the interviews, the ministries of Environment and Sustainable Resource Development were merged.
It needs to include guidance on features of reclamation efforts. For example, in its closure plan, Suncor indicated that its wetlands will be mostly swamps. What is the basis for this statement? Guidance is needed on the types of wetlands needed and in what ratio. If recognized swamp “classes” that exist in the boreal forest are what companies mean when they use that term, then this distinction should be clearly indicated.

The manual should be written on the assumption that the provincial government will require that company closure plans comply with it. The government required companies to comply with the 2007 version, which is why Suncor and Syncrude are building fens.

The manual should include knowledge gaps (possibly include an entire knowledge gaps section) and should clarify the role of the manual in approvals on reclamation.

The companies seem convinced they can build marshes. What about functional fens? What swamp classes can they build? The manual should address the level of capability and the knowledge gaps.

The manual needs to consider drainage issues. You must plan for it and know what vegetation is needed.

It should include a discussion of overburden dumps, with information on materials. The closure plans assume there will be a settling of materials. It is important to know about settlement, as that can be a significant factor in design.

Biodiversity and related issues should have a section in the guide.

Certification should be considered; a timeline is needed on when specific land will be reclaimed and certified.

Criteria indicators need to be established or referenced in the guide. There have been three indicators identified for wetland vegetation. Not all indicators are in place. Indicators could be a stand-alone chapter or in appendices.

Monitoring should have a section. A monitoring program needs to be set up before wetland reclamation even occurs. At present, a pilot wetland monitoring program is being established which the manual should reference.

Soil stability is important, and materials relevant to wetland reclamation should be characterized.
2007 wetlands guide

The 2007 guide had a lot of relevant information, but it wasn’t written for planners. It provided a good basis for describing different wetlands. The guide didn’t address hydrology sufficiently within the main document. It was relegated largely to appendices. Overall, the 2007 guide was remarkably conceptual. It had very little hands-on or step-by-step material. For example, the manual talks about swamps, but without a clear definition and with little information on design. The manual needs to be precise, as it had links to approval conditions, which say that closure plans should comply with the manual.

Approach/Format

The manual should take a multi-author approach. The benefit is that you can break out the table of contents and assign an expert to each area of their specialization. Editors are also needed to oversee the work and pull the document together afterward. This approach worked well with the EPL guide. As well, authors should have an opportunity to see, and comment upon, one another’s work. This can occur through exchanges of text, workshops, one-on-one meetings, or conference calls. Dense, uninterrupted text should be avoided. The document should consist largely of tables that display key elements. A table format and other supporting visuals would be useful. A table should be included that lists the key elements the guidance document is going to address. As well, the manual should definitely include case studies. There may not be a great many examples that are applicable to the oil sands. But examples from elsewhere can be useful. Ducks Unlimited can provide some.

Audience

The primary audience should be the companies/reclamation practitioners. The communications shouldn’t end with the release of the guidance document. Operators need to be encouraged to communicate with one another. Recommendations should be included in the document on ways this communication can occur on an ongoing basis.

Research issues

There is work on hydrology being integrated into the tech transfer that should be included in the manual. For example, it will discuss placement of materials. The tech transfer document should be referenced. Scientist/consultant Clara Qualizza may have already done 95% of that work.

Reference/analog wetlands

The manual should draw on the experiences of non-oil sands examples. For example, there is vast experience on peatlands in Quebec and New Brunswick (although this area is also uniquely influenced by the Maritime climate). Storm
water management ponds can also be referenced, as they can provide useful information. They can be examined for ways to build functional wetlands. For example, they can teach us about slopes and inundation tolerance. Natural wetlands should be monitored as a reference for oil sands wetlands.

**Recommendations for 2013 guide**

- The next wetland manual needs to be more prescriptive, and less general or conceptual.
- The manual should take a multi-author approach. The benefit is that you can break out the table of contents and assign an expert to each area of their specialization.
- Editors are also needed to oversee the work and pull the document together afterward.
- The document should consist largely of tables that display key elements. A table format and other supporting visuals would be useful. A table should be included that lists the key elements the guidance document is going to address.
- The manual should definitely include case studies, from the oil sands if possible but also elsewhere.
- The primary audience should be the companies/reclamation practitioners.
June 6, 2012

WETLANDS USER NEEDS ASSESSMENT
2013 Wetlands Manual
INTERVIEW WITH CNRL

Date:
March 14, 2012

Attended:
Richard Kavanaugh, CNRL
Steve Tuttle, CNRL
Scott Johnson, CNRL

Interviewers:
David Wylynko, West Hawk Associates
James Hrynshyn, West Hawk Associates

KEY THEMES

Design

To benefit CNRL, the guide needs to tell designers what to do. It would be very useful to have tables that tell you exactly what you need to plant in given conditions. It should specify what plant types have the greatest chance of success in various conditions.

Key features

• As there are many different types of wetlands, the guide would need to provide sections on each one (fens, marshes, etc.);

• The guide should discuss hydrology, the surface drawing system, and water quality. The guide should show how these three features are interdependent. It should include the operational systems needed.

• The guide should be current. To know if a wetland is working, you need to consider: is the vegetation robust and viable, and how does it look compared to natural wetlands? Does it look natural?

• The guide should be an instructive, “how to” document that says: if you want X, then do Y.

• The guide needs wetland indicators. Indicators are being established currently (for the fall of 2012). These indicators will play an important role in the wetland guide.
• The authors should be brought together in a workshop format at which they can consult one another on the broad scope of how to produce the document. They should then write each chapter individually but consult as needed. This takes more time, but it will result in a document that has a better chance of withstanding peer review. One author cannot possibly anticipate all the issues to consider.

• There may be considerable disagreement between authors. The resolution to this possibility is that principles should be consistent, while details will vary.

2007 wetlands guide

The 2007 guide includes a useful literature review. However, it is not particularly helpful in terms of constructing a wetland. It is descriptive, but not prescriptive. CNRL has not used the guide in any work to date. It does not provide the detailed information required for designing a biologically sustainable unit. Even some of the concepts in the guide are weak. Designing a manual for engineers will require providing precise information up front, such as the contour of drainage patterns. The 2007 manual is too vague on important design aspects. Trying to find important design direction in the 2007 manual is like looking for a needle in a haystack. For example, it should specify the amount of precipitation a certain area gets and therefore what the wetland size should be. The 2007 guide would not be helpful for operators. For one thing, they won’t want to read it all. Ideally, the document would spell out the required steps in wetland design. It does a great job of providing a summary of the literature on wetlands, but it isn’t useful for people who need to do the work in the field. It won’t be much use to people who lack a science background. The document is not sufficiently definitive; you would have to read through it and deduce your own conclusions.

Approach/Format

CNRL supports the use of a table for the wetlands manual like Table 7.2 of the 2012 EPL guide. Table 7.2 covers an approximate 100-year timeline. The establishment of a functional wetland will require a similar timeframe. The wetlands manual should also include a virtual walk through, or step-by-step example, of how to create wetlands from A to Z.

The manual should set out the measures required to create the right conditions to establish a wetland, and should describe the conditions needed to create the trajectory toward a sustainable ecosystem. The manual should prescribe measures for setting the wetland on the right course. For example, nature has a tendency to move in its own direction; if one aggressive species takes over, it may be nearly impossible to get back on a desired trajectory. The manual should prescribe ways to ensure this doesn’t occur. Water treatment and habitat issues should also be addressed.
Audience

Overall, the guidance document should be written for a broad audience. But it also needs precise direction for planners and operators in order to be useful. It must largely be written for engineers.

Timeframe

Some argue that a wetland will require two hundred years before one can deduce whether it is functioning successfully. In the view of CNRL, 10 years is sufficient to determine if the wetland is on a positive trajectory. Over a longer period, one will see whether the wetland is integrating well with the landscape.

Research issues

Much new information is available that should be incorporated into the next version. For example, there is the work of Jan Ciborowski to consider. The work of CFRAW (Carbon dynamics, Food web structure, and Reclamation Strategies in Athabasca oil sands Wetlands) should be taken into account. The authors should look at CONRAD symposiums (Canadian Oil Sands Network for Research and Development). For example, sessions on peat accumulation would be useful to review. As well, Syncrude and Suncor have information on bogs and fens, as they have started work on those forms. It would be a great help to CNRL to have the benefit of knowing what those companies did and how they approached this construction. There is a technology transfer document that is about to come out that could provide a lot of important information. CEMA should draw on that document for the new manual.

Reference/analog wetlands

Reclaimed wetlands, no matter how well designed, will be different from natural analogues in the salinity of the soils and water. It would be unsuitable to compare reclaimed wetlands to natural freshwater ones in terms of salinity. As well, conductivity will be very different in constructed wetlands versus natural analogues. Rather, reclaimed wetlands should be compared with water bodies that have similar water quality characteristics. They cannot be compared with wetlands that have been established for hundreds of years. In the oil sands, new systems will be created, whereas natural wetlands have taken millennia to evolve. Even comparing wetlands being created in the oil sands to an area that redevelops after a forest fire is unsuitable, since wetlands in the oil sands are being created from scratch.

Adaptive management

Adaptive management regarding wetlands is a challenge, since it is hard to modify vegetation after it has been planted. Moreover, nature tends to follow its own course. But if this section can provide examples of adaptive management
techniques that have succeeded elsewhere, that would be useful. It is important, over time, to be able to show that the wetland is on a trajectory to the development of a healthy ecosystem. The development of a monoculture, for example, represents a negative trajectory that will not lead to a successful wetland; biodiversity, for one, will be impeded by a monoculture, and biodiversity is a critical element of a vibrant wetland.

Critical Review of the 2007 manual

CNRL strongly agrees with the first three critiques of the CH2M HILL review of the 2007 guide, and generally with the rest:

2.1 Numerous changes needed regarding peat and wetland reclamation hydrology.

2.2 The importance of surface hydrologic interconnectedness for design, function, and resilience is not sufficiently recognized.

2.3 Wetlands manual provides a strong foundation for evolution of knowledge/research.

2.4 Spontaneous/opportunistic revegetation can impair establishment of desired community structure.

2.5 Monitoring should always be done with a view to understanding the processes sufficient for making adjustments or refining the design in the future.

2.6 Need more information on long-term climate variability and potential effects.

2.7 It is not feasible to make an accurate prediction of the equilibrium wetland to watershed ratio in the reclaimed landscape.

2.8 I am not sure that I could build a wetland from the information provided.

2.9 Inadequate discussion of the accumulative nature of salinity.

2.10 Soil stability of materials is important.

2.11 The Wetlands manual does not take into account a successional view of wetlands evolution.

2.12 Sedimentation rates should be kept as low as possible to ensure long-term wetland survival.
2.13 The Wetlands manual is inadequate in section on Adaptive Management.

2.14 Issues with natural analogue wetlands.

2.15 There is little attention given to the importance of hydrologic manipulations in newly constructed wetlands.

Recommendations for 2013 guide

- An initial workshop should be held to fully identify the needs of the new manual. The workshop could be largely driven by reclamation people who have been doing the work to date, such as Suncor staff.
- The document should be multi-authored, and should include a peer review.
- A team should be put together (like the one recommended in Chapter 7 of the EPL guide).
June 6, 2012

WETLANDS USER NEEDS ASSESSMENT
2013 Wetlands Manual
INTERVIEW WITH IMPERIAL OIL

Date:
February 27, 2012

Attended:
Rachel Noble Pattinson, Imperial Oil

Interviewers:
David Wylynko, West Hawk Associates
James Hrynyshyn, West Hawk Associates

KEY THEMES

Design

The guidance document needs to take an overall landscape perspective. No wetland exists in isolation. It should be balanced between recovering resources (while moving as little dirt as possible), on the one hand, and generating a self-sustaining boreal forest ecosystem on the other. Current practices suggest that recovering resources is the priority, while trying to find ways to rebuild the ecosystem. Mine closure plans work on a five-year cycle. The government requires that industry develop long-term plans. Wetlands cannot be considered in isolation; they must be thought of in terms of integrating them into the greater landscape.

The guidance document needs to take this broader, holistic approach. It should be aimed at mine planners and engineers, who should be involved very early in the reclamation process. The guide needs to be a step-by-step process. While each wetland is unique, there are some common elements. A planner should be able to read the guide and, for example, then be able to say "I need to talk to these people, get this information, and set out such-and-such time horizon."

Key features

• The guide should identify the range of specific design issues. Much more on design is needed (compared to 2007 version).

• The guide should be directed at mine planners (for example, provide information on resource and mineral disturbance and how these materials will affect wetland reclamation).
• The guide needs information on hydrology. There needs to be a lot of coverage of geology, hydrogeology, and civil engineering.

• It cannot just be about ecology; there needs to be an engineering perspective and a sound discussion of geology.

• At a fundamental level, mine planners need to know how to dig the holes to accommodate the needs of wetland ecosystems.

• As its primary objective, the document needs to discuss the building of wetlands for water treatment purposes.

• Environmental concerns – vegetation and wildlife – become the next issue.

• Beavers on the landscape are a major issue that needs to be addressed. In this regard, building resilience into the system is needed.

• A section needs to be devoted to operational wetlands (i.e. cleaning up affected water) during operations, and how to transform a process-affected wetland into a functioning ecosystem. Municipalities, for example, use wetlands for treatment.

• A section should be devoted to determining how to put a reclamation team together (see Chapter 7 of the EPL guide).

• The guide should lay out the most basic principles involved; don’t assume that planners will be experts on any given issue.

• If outside consultants/engineers are to be retained, set out the project management specifics for industry. Many people who undertake environmental projects are not trained in project management, and so there is a tendency not to apply engineering project control protocols.

• Include a discussion of the aquatic criteria of the wildlife task group in the manual.

2007 wetlands guide

The 2007 manual had a lot of focus on vegetation and wildlife, which is understandable given that the author is a biologist. The document needs more on hydrology, geology, hydrogeology, and civil engineering. If you give this document to mine planners, they won’t find it useful. The document provided basic principles that planners need to consider. But the next guide should go further, providing a step-by-step approach.
Approach/Format

In terms of the process, Imperial Oil supports a multi-author approach and a peer-review process. Workshops should be held to allow authors to communicate and share information. Each chapter should have a single primary author. Case studies would be useful. For example, Suncor and Syncrude have undertaken reclamation work from which case studies could be drawn.

The manual should be visual. The document should include flow charts and illustrations to show the concepts. Engineers are drawn to flow charts and illustrations over lengthy text. The more bulleted lists and flow charts the better (so long as they are not too complex). The document should provide a visual chronology of what the landscape used to look like, and what is happening currently. GIS and satellite photos would be beneficial. Engineering drawings should be drafted; the approach valued by geologists and engineers tends not to be taught to biologists, who may take a more text-based approach to reports and manuals. In fact, the manual could be largely an e-version, or electronic/web-based. Printed materials could be reserved as an “on demand” requirement only. Lengthy hard-copy, text-based documents are no longer as desirable as a digital manual that operators can log into and use as a reference, free to move from section to section at will. Each section should be highly visual.

Audience

The manual needs to appeal to a broad audience. There needs to be sections that address a variety of disciplines; geology and hydrogeology must be taken into account.

Timeframe

The timeframe spelled out in Table 7.2 of the EPL guide would be useful as a prototype. This approach should be mimicked for wetlands reclamation. That table sets out a 100-year time horizon and the stages of steps required within that period.

Research issues

The CEMA wildlife task group is developing wildlife criteria. That information could be used in the wetlands manual, as well as by other design teams. But it doesn’t need to be a central focus of the wetlands manual. Other research conducted since 2007 needs to be considered, such as the marsh tech transfer work. As well, the CFRAW project (Carbon dynamics, Food web structure, and Reclamation strategies in Athabasca oil sands Wetland) and a good deal of other science have advanced our understanding of wetlands reclamation by leaps and bounds since 2007. This material should all be incorporated.
Reference/analog wetlands

The landscape that will result from oil sands reclamation activities may resemble boreal forest, but it won’t resemble what was naturally there historically. Moreover, it may not resemble the landscape 100 km north or south of the reclaimed area. Therefore, natural analogues may be of little use. The basic principles of ecology will apply, but that would be the extent of the similarities.

It will always be difficult to determine that a piece of landscape is a “functioning ecosystem” that can be certified. If we have reclaimed an area and it is functioning similarly to a municipal treatment wetland, is that good enough? This issue should be addressed in the manual. If we need to duplicate a particular natural wetland 200 km west of our location, we may never succeed in producing a wetland that could be certified.

Natural lakes are more tolerant of dramatic events because they are not replete with process-affected and disturbed landscape elements. CFRAW research will prove very useful to this discussion, as opposed to making comparisons to natural analogues. The question is: is your wetland going in the proper trajectory? Many planners are familiar with this science only on a cursory level, so the manual needs to include details on how to derive a wetland with a high probability of becoming a functional ecosystem.

There are lessons to be learned from non-oil sands wetlands. But we shouldn’t belabour the point. There is a lot of wetland compensation work occurring in the US. But there is so much available information that researchers/manual authors need to be careful not to inundate us with too much material.

Adaptive management

Adaptive management has tremendous value. It is one of the main principles of environmental science. Ecosystems are constantly changing. Wetlands will evolve in directions you don’t expect. There will be fires and dry years that operators cannot anticipate. Therefore, a certain resilience needs to be built into a wetland reclamation plan. What if a beaver builds a dam upriver in your drainage? Should we let the beaver go about his business of geoengineering? That is a natural process. How will it affect our plan? Similarly, we see bulrushes and other endemic species going into our drainage ditches, even though they are not part of our plan. Do we rip them out and plant what we want? These are adaptive management issues, and need to be addressed in the manual.

Critical review of the 2007 manual

Imperial Oil concurs that the first three themes prioritized in the CH2M HILL critique of the 2007 manual are valid:
2.1 Numerous changes needed regarding peat and wetland reclamation hydrology.

2.2 The importance of surface hydrologic interconnectedness for design, function, and resilience is not sufficiently recognized.

2.3 Wetlands manual provides a strong foundation for evolution of knowledge/research.

The first two are similar: surface and subsurface hydrology are critical. The 2007 manual was too plant- and soil-focused, whereas hydrology needs to have greater emphasis. The fourth theme is also valid:

2.4 Spontaneous/opportunistic revegetation can impair establishment of desired community structure.

To a lesser extent, Imperial Oil agrees with the balance of the CH2M HILL critiques:

2.5 Monitoring should always be done with a view to understanding the processes sufficient for making adjustments or refining the design in the future.

2.6 Need more information on long-term climate variability and potential effects.

2.7 It is not feasible to make an accurate prediction of the equilibrium wetland to watershed ratio in the reclaimed landscape.

2.8 I am not sure that I could build a wetland from the information provided.

2.9 Inadequate discussion of the accumulative nature of salinity.

2.10 Soil stability of materials is important.

2.11 The Wetlands manual does not take into account a successional view of wetlands evolution.

2.12 Sedimentation rates should be kept as low as possible to ensure long-term wetland survival.

2.13 The Wetlands manual is inadequate in section on Adaptive Management.

2.14 Issues with natural analogue wetlands
2.15 There is little attention given to the importance of hydrologic manipulations in newly constructed wetlands.

Recommendations for 2013 guide

- The guidance document needs to take an overall landscape perspective.
- It should be aimed at mine planners and engineers, who should be involved very early in the reclamation process.
- The guide needs to be a step-by-step process.
- Imperial Oil supports a multi-author approach and a peer-review process.
- Workshops should be held to allow authors to communicate and share information.
- Each chapter should have a single primary author.
- Case studies would be useful.
- The manual should be visual. The document should include flow charts and illustrations to show the concepts.
- The manual needs to appeal to a broad audience. There needs to be sections that address a variety of disciplines.
June 6, 2012

WETLANDS USER NEEDS ASSESSMENT
2013 Wetlands Manual
INTERVIEW WITH SHELL

Date:
March 1, 2012

Attended:
Renee Frenette, Shell
Michelle Girts, Consultant with CH2M HILL

Interviewers:
David Wylynko, West Hawk Associates
James Hrynyshyn, West Hawk Associates

KEY THEMES

Design

The next wetland manual will need to provide a strong basis of background material for those new to reclamation, as did the 2007 guide. But it should do more than that. It should provide precise direction on the approach to wetland reclamation, and how to handle reclamation materials and when to take the various steps necessary for successful construction of a wetland. It should include a discussion of reclamation of altered wetlands, and how these wetlands will be integrated into the larger landscape. An abstract should be created of the manual, which could be posted on blogs and circulated. It needs to be a real-time, living document.

Key features

- The manual should describe construction standards for each stage of the project (e.g. layering of materials underneath the wetlands).

- It should answer precise questions such as: How do you treat uplands? There is a good understanding of the biology, but not enough about what people need to do. What equipment should be used? What materials? At what stage?

- A thorough treatment of hydrology (a chapter possibly) is essential. Hydrology is the very first thing the authors should consider, along with a discussion of regional groundwater patterns.
• The guide should be divided by chapters, and should include at a minimum sections on: construction, hydrology, summaries of specific species, and reclamation materials.

• The authors must assume an audience with a general knowledge. It would therefore be prudent to present the material in specific sections: one on design, one on planning, one on monitoring, and so on.

• Water treatment requires its own chapter. The science and engineering of wetlands treatment, which can have very specific issues (at least in the early stages) should be addressed. Reclaimed wetlands may evolve into a more natural state later, but in the beginning will require attention to treatment. Processed water may play a role for 30 or even 100 years. Over time, treatment wetlands will revert to habitat wetlands.

• An important area to focus on (and which was lacking from the 2007 guide) is landscape connectivity. This is a “big picture” issue. Wetlands will not materialize, or certainly won’t succeed, unless they exist in a suitable landscape setting that has appropriate connectivity that allows for the migration of wildlife and vegetation. Guidance is required on how to ensure suitable connectivity exists or is created in wetland construction.

• Access to suitable plant and seed material must be considered. Where is it going to come from? As more companies take on wetland reclamation projects, demand will mount for available seed material.

• The guide should have a broad range of parameters and schedules. For example, it should not include criteria that set out specific proportions of invertebrates.

**2007 wetlands guide**

The 2007 guide was a useful starting point for stakeholders, in terms of providing a wealth of significant background material. It was a solid document for what was known at the time. Any future guide will need to also serve this function to be useful to people new to the reclamation process. However, the 2007 document was not written for a broad audience. It included technical and scientific information that was, at once, drawn from too many sources and yet based on evidence that was too narrow. The information was presented in a way that suggested it was widely applicable when in fact it drew on a small base of evidence.

You could not construct a wetland using the 2007 guide. It had too much science, and not enough engineering. For example, the materials available for wetland reclamation need to be characterized. It failed to describe how wetland reclamation would be integrated into the larger landscape. The document provided too much theoretical discussion rather than presenting a hands-on
discussion on reclamation materials and handling specifics. The latter approach would have been more useful. The document included some discussion of hydrology in the appendices. What was missing was a thorough treatment of hydrology. The document included flow charts that are useful for introductory level instruction.

Approach/Format

The document should be drafted by different authors from varying areas of expertise. Although the flow and style may not be consistent, this is a more valuable approach by virtue of the breadth of experience and knowledge that would be captured.

In today’s age, with the speed of modern communications, new information comes available regularly. In response to the cyber-age, the wetland guide needs to be as current as possible. It cannot be an on-the-shelf publication.

The guide should be online. Increasingly, professionals are turning to the Internet to find new information and historical material. To be most accessible to the target (and wider) audience, the guide should be online in an accessible format.¹ Today, to stay on top of new information, engineers and policy-makers increasingly look to the Internet to find new reports, studies, minutes from meetings, and to find the latest regulatory and regional planning changes. Many professionals associate the great bulk of their work with their desktops or laptops. As connectivity is an issue in the field, gearing the document to wireless devices would be less useful.

The guide should include more flow charts and illustrations than were included in the 2007 version. Checklists and hypothetical to-do lists would be helpful. The ones in the 2007 version were not organized in a helpful manner. Visuals and summary text should be prioritized over reams of text.

The guide should include case studies. In 2007, not many case studies were available. The case studies do not need to be universally from the oil sands. They don’t need to all involve treatment and habitat; a case study on each of the major topics relevant to wetland reclamation would be useful. Municipal treatment of wetlands, for example, should be addressed (as far as it relates to oil sands). The case studies should be linked to their applicability and any research/monitoring results that they have produced.

Table 7-2 from the EPL guide represents an excellent approach that should be replicated for the wetland guide. If progressive reclamation can be exhibited early on in the process, industry will be able to demonstrate to government that 100 years of monitoring may not be needed. It would also be helpful if a costing could be provided of long-term wetland reclamation.

¹ An HTML version of each chapter, including text and all graphics, would make the guide optimally accessible – WHA.
Audience

The document needs to be written for a broader audience than the 2007 guide. When writing for global companies, the authors cannot assume that the readership will have very much understanding of local regulatory and geographical context. The document needs to address issues at a very specific level.

Timeframe

Wetland reclamation should occur in a timely fashion relative to the mining schedule. Consideration for wetland construction should be given right from the beginning, even before mining begins. It could easily take 100 years for the reclaimed wetland to evolve to an acceptable state. The timeframe could vary significantly – from as much as 30 years to 100 years – before a wetland can be considered to be on a positive trajectory. Along the way, operators need to ensure that the right factors are being brought to bear on the wetland. For example, is a proper adjacent riparian area developing? At some point, we should be able to conclude that the probability is high for the wetland to stay on a desired trajectory. But this assessment should occur on a watershed-by-watershed basis, not a wetland-by-wetland basis.

Research issues

Research exists that could prove beneficial and should be integrated into the next manual. For example, studies have been done on salinity and tolerant species.

Reference/analog wetlands

It won’t be possible for wetland reclamation in the oil sands to replicate natural wetlands. It will take thousands of years to generate wetlands that are comparable to natural analogues. As well, topographic differences between natural wetlands and oils sands reclaimed wetlands dictate that connectivity will likely take on quite a different context. Therefore, natural wetlands, again, won’t represent a viable reference. It is useful to see what the results are of certain natural impacts on natural wetlands, but it won’t be a useful comparison in terms of a one-to-one comparison with a reclaimed wetland for permit release or compliance purposes.
Adaptive management

Adaptive management for wetlands need not be extensive. If a wetland project is successful initially, it will require less and less attention over time. Meanwhile, over time, human intervention will become increasingly expensive. Therefore, any adaptive management planning needs to be set out from the beginning, rather than spread out over 100 years. Wetlands are highly variable systems to begin with, so the benefits to constantly tweaking them are few.

Critical review of the 2007 manual

Shell is in agreement with the first three themes identified in the review of the 2007 manual conducted by CH2M HILL. These are:

2.1 Numerous changes are needed regarding peat and wetland reclamation hydrology.

2.2 The importance of surface hydrologic interconnectedness for design, function, and resilience is not sufficiently recognized.

2.3 Wetlands manual provides a strong foundation for evolution of knowledge/research.

Shell commented also on some other themes identified in the critique:

2.4 Regarding spontaneous/opportunistic revegetation impairing the establishment of desired community structure, Shell noted that opportunistic species are likely to die off as other species emerge.

2.5 Regarding monitoring on an ongoing basis, Shell suggested that the issue isn’t merely to refine the design and to practice adaptive management, but to ensure the design is initially sound and to monitor to confirm how the wetland is developing along the succession path.

2.6 On climate variability, Shell indicated that variability over time must be accounted for in the wetland plan. Over a 200-year period, the size of the wetland may vary substantially.

2.7 Shell concurred that it is not feasible to make an accurate prediction of the equilibrium wetland to watershed ratio in the reclaimed landscape.

2.8 Shell agreed that one could not build a wetland from the 2007 guide.

2.9 A discussion of salinity should be included and made part of the section on vegetation.

Recommendations for 2013 guide

- The manual should provide precise direction on the approach to wetland reclamation, and how to handle reclamation materials.
- It should include a timeline on when to take the various steps necessary for successful construction of a wetland.
• An abstract should be created of the manual, which could be posted on blogs and circulated.
• The document should be drafted by different authors from varying areas of expertise. Although the flow and style may not be consistent, this is a more valuable approach by virtue of the breadth of experience and knowledge that would be captured.
• The guide should be online and designed so that at least periodic recompiling and updating are possible. Increasingly, professionals are turning to the Internet to find new information and historical material.
• The guide should include more flow charts and illustrations than were included in the 2007 version. Checklists and hypothetical to-do lists would be helpful.
• The guide should include case studies. The case studies do not need to be universally from the oil sands. A case study on each of the major topics relevant to wetland reclamation would be useful.
• The document needs to be written for a broader audience than the 2007 guide. When writing for global companies, the authors cannot assume that the readership will have much understanding of local regulatory and geographical context.
June 6, 2012

WETLANDS USER NEEDS ASSESSMENT
2013 Wetlands Manual
INTERVIEW WITH SUNCOR

Date:
February 22, 2012

Attended:
Christine Daly, Suncor

Interviewers:
David Wylynko, West Hawk Associates
James Hrynyshyn, West Hawk Associates

KEY THEMES

Design

The manual needs to provide precise instructions on how to address given challenges. For example, if you are building X in a given area, the manual should provide the relevant slope gradient. Even if a hard and fast number isn’t available, a range of values would be useful.

Key features

• A section on salinity is critical. A chapter on salinity should include information on occurrence, amount, influences, and so on.

• A section is required on the use of process-affected materials to build wetlands.

• Information is needed on how to modify wetlands for treatment functions (Suncor recently completed a mine closure plan that includes descriptions of wetlands with treatment capacity).

• Information is required on optimal revegetation strategies and riparian areas, as well as the impact of climate change and other long-term issues.

• Identify optimal plant species per wetland type and optimal revegetation treatments (i.e. natural colonization, greenhouse seedlings, etc). Incorporate natural succession into the planning process.

• Hydrological modelling should be included (i.e. Jonathan Price).
• Provide information on how to re-vegetate wetlands. For example, Ducks Unlimited will have information on planting.

• Include planning for wildlife habitat in the wetlands manual.

• How are riparian areas factored in? What are the influences of riparian areas on wetlands?

• Include information from Table 4.1 of the 2007 guide, which has good material.

2007 wetlands manual

The 2007 manual had a lot of solid background material that captured the state of knowledge of wetland reclamation at the time it was produced. The document did raise some points that Suncor reclamation staff might not have otherwise considered. It did provide somewhat of a checklist of issues.

But overall, the 2007 manual was too broad, too general, and too rudimentary. It really only can serve as background. When it comes to actually designing a wetland, the document only suggested in general terms the topics to consider. For example, it touched on the vegetation you need to incorporate. It provided details on what to consider when designing a marsh, but it was not ordered in a step-by-step way. Suncor would prefer a document that sets out the steps of reclamation. The next guide needs to be something that tells operators to do “this” and then do “that.” You cannot pick up the 2007 manual and follow the instructions on what depth you need for a given situation, or what plants to use for building a treatment wetland.

A much more specific document is required. Suncor is working on a fen reclamation project. The company has attempted to make use of the 2007 wetlands manual wherever possible. The 2007 document included a lengthy appendix on hydrology which was very challenging to read. The subject is critical and should be given a chapter within the main body of the document, but made more readable and more accessible to a wider audience.

As a closure plan document, the 2007 manual was of little utility. Suncor only used the Wetlands Manual for background material and recommendations during development of its 2011 Closure Plan. The information in the 2007 document on wetland-land proportion seems at odds with what is now known from Ducks Unlimited data.

Approach/Format

Foremost, critical information should be in the main body of the document, rather than in appendices. The information must be presented in a format that is more useable by reclamation planners, designers, and the operations teams.
constructing the reclaimed landscapes. Flowcharts would be useful, and illustrations that break up the text and make the document easier to read.

**Audience**

It was unclear who the intended audience was for the 2007 manual. It would definitely not have been the engineers involved in designing a wetland. The target audience needs to be described at the beginning of the wetlands manual and a consensus reached on the target audience. The engineers involved in the design should be the primary target audience. It is important to ensure the guide accounts for stakeholder needs.

**Timeframe**

Table 7.2 from the *End Pit Lakes Guidance Document* (CEMA 2012) is an excellent template that should be applied to developing a wetlands timetable. The wetlands manual should be a step-by-step guide built around tables like Table 7.2 with links to other tables with more detailed information. These tables should specify exactly what to do, and when to do it. This will get all the scientists, engineers, and team members on the same wavelength.

**Research issues**

The guidance document should incorporate much of the current/ongoing research that is available. Monitoring indicators should be addressed, and research into water quality issues being conducted through CFRAW (Carbon dynamics, Food web structure, and Reclamation strategies in Athabasca oil sands Wetlands). The document should also account for marsh tech transfer work.

**Reference/analog wetlands**

The value of reference sites has been a subject of considerable debate. One side argues that since wetland construction is at such an early stage, it will be decades before these systems will be mature enough to compare to natural conditions in this region. Instead, reclaimed wetlands should be compared to opportunistic wetlands that develop naturally on or near operator sites in natural depressions and that are of similar age and design. Others contend that comparing reclaimed wetlands with much older, off-site natural wetlands is a good idea. Both viewpoints are valid. Suncor is of the view that in the early stages, reclaimed wetlands should be compared to wetlands of comparable conditions. CFRAW compared wetlands constructed with tailings to opportunistic wetlands, which is an appropriate comparison.
Adaptive management

Adaptive management means designing in a way that minimal maintenance will be required in the long term. It requires planners to be flexible and open to adapting to new circumstances. It would be useful to include a section focused on the fact that not everything will work out as planned.

Critical review of the 2007 manual

Suncor concurs with much of the critique of the 2007 guide, particularly the first three:

2.1 Numerous changes are needed regarding peat and wetland reclamation hydrology.

2.2 The importance of surface hydrologic interconnectedness for design, function, and resilience is not sufficiently recognized.

2.3 Wetlands manual provides a strong foundation for evolution of knowledge/research.

In addition, Suncor agrees with the following comments from the critique:

2.6 Need more information on long-term climate variability and effects.

2.8 One could not build a wetland from the 2007 manual.

2.9 The 2007 guide has an inadequate discussion of salinity.

2.11 The manual does not take into account a successional view of wetland evolution.

Recommendations for 2013 guide

• Create a document that reads as a step-by-step guide to reclamation.
• Hold a workshop of industry designers to prepare for the next manual.
• Include more pictures and tables and graphics.
• Critical information should be in the main body of the document, rather than in appendices. The information must be presented in a much more accessible way than it was in the 2007 version. Flowcharts would be useful, and illustrations that break up the text and make the document easier to read.
• The engineers involved in the design should be the primary target audience. It is important to ensure the guide accounts for stakeholder needs.
• The guidance document should incorporate much of the current/ongoing research that is available.
June 6, 2012

WETLANDS USER NEEDS ASSESSMENT
2013 Wetlands Manual
INTERVIEW WITH TOTAL

Date:
March 1, 2012

Attended:
Andrews Takyi, Total
Brent Hartley, Total
Camille Piquet, Total

Interviewers:
David Wylynko, West Hawk Associates
James Hrynyshyn, West Hawk Associates

KEY THEMES

Design

To be of benefit to Total, the guide needs to provide high level general details, showing the initial steps and overall general approach to wetland reclamation. Suncor, by contrast, probably needs something with more complex detail than that provided in the 2007 guide. Perhaps the most useful document would be one that starts at a high level to guide us, and moves toward more detailed sections for companies that are further along. This way all audiences are covered.

Key features

• It cannot be assumed that all wetlands will evolve the same way. The guide needs a chapter on hydrology and one on water quality, salinity and nutrients. These elements will determine how the wetland will evolve.

• The next guide needs a thorough discussion of water treatment and biodiversity functions. Although biodiversity is addressed in the 2007 guide, more is needed on treatment. The impact of water quality on biodiversity also needs to be addressed (and vice-versa). For example, will biodiversity take care of water quality issues or could the result be that lots of diversity occurs but poor water quality also results? Could one limit the other?

• Connectivity is a key concern. The guide needs to address and link between hydrology and groundwater/surface water.
• Salinity, and its impact on wetlands, will be a critical consideration. Even where hydrology is understood, emphasis needs to be placed on understanding the influence of salinity.

• Failure modes/natural stressors are important and must be addressed.

• If planners use all natural endemic species, that should prove acceptable to most stakeholders. Constructed wetlands should be managed for natural species to the extent possible. But some non-native species may be necessary. For the first few decades, the key function is water treatment. Then after the wetland has stabilized, biodiversity becomes the next concern.

2007 wetlands guide

Total is at a very general stage of design. Therefore, the company has not had occasion to incorporate the concepts of the 2007 wetlands guide. This doesn’t mean the document isn’t useful, but rather that its level of detail is not yet of use to Total. The company is still at an early stage of building bogs and other wetland-related constructs. The 2007 guide lacked sufficient discussion of the connectivity between surface water and groundwater quality. For each wetland that is designed, a greater understanding of hydrology and water quality is required. While certain issues apply to all wetlands, each wetland will be unique and will require different ways of treating each issue.

Approach/Format

The document should take a multi-author approach, with specific authors and peer reviewers for each chapter. The chapters should each address a relevant phase of the work required to create a wetland. But each phase should be interconnected. You cannot consider one without thinking about others. It would be a good idea to include decision flow charts. The tables in the 2007 guide are useful; a range of possible values can be used as a starting point. The manual should also link to other manuals on related topics. For example, the revegetation manual should be referenced for upland information.

Audience

The document was not written with Total in mind, but rather for those companies (such as Suncor) with more mature mines. Even then, the 2007 guide was light on direction specific to the creation of certain wetland types, such as fens and bogs.

Timeframe

It is probably not necessary to produce a guide that begins planning from 10 years prior to the commencement of mining. That sort of timeline may work better
for End Pit Lakes, which are a lot deeper. There is more flexibility in designing and building wetlands, and their construction can be adapted as the project progresses. However, it is important to know the total number of years required for detailed planning and selection of conceptual drainage patterns. In the case of wetlands, it should take 10 years for water quality to improve and stabilize. Certification time is harder to determine. That will depend on how much oil sands processed water is influencing the wetland. For the first decade, biodiversity cannot be your highest priority. First, water quality needs to be stabilized. Table 7-2 of the *End Pit Lakes Guidance Document* (CEMA 2012), prepared by Aaron Sellick, is a useful tool that could be used as a prototype for creating a similar table for the next wetland manual.

**Research issues**

A lot of new information has come to light that can be recognized and incorporated into the next wetlands manual. A lot of this new research is just coming out. The work of CFRAW (Carbon dynamics, Food web structure, and Reclamation strategies in Athabasca oil sands Wetlands) is important in this regard. Industry has done some research on non-fen and bog-related wetlands. There is some new work specific to fen creation, but data on that work are only emerging. If the objective is creation of a bog, more specific information is required on how to do that.

**Reference/analog wetlands**

Understanding what is occurring in the natural environment is critical to understanding how to establish the right goals for reclaimed wetlands. Certainly, attempting to create an identical situation to a natural environment right away is not feasible. But over the course of geological time, that is the objective to pursue. Planners shouldn’t, therefore, put too much emphasis on natural analogues. Some description of natural processes will suffice. One thing to note is that natural wetlands won’t have the same level of salinity as constructed wetlands.

**Adaptive management**

Total incorporates adaptive management techniques already as an ongoing practice. The company is always tweaking plans and looking for “better ways to build a mousetrap.” If other companies express an interest in seeing an entire chapter of the manual on adaptive management, then that is fine but it isn’t a high priority for Total.
Critical review of the 2007 manual

Total agrees with the reviewer comments of the 2007 manual. In particular, Total concurs with Comments 2.1 and 2.2. Total also agrees with, but feels less strongly, about the subsequent 13 comments:

2.1 Numerous changes needed regarding peat and wetland reclamation hydrology.

2.2 The importance of surface hydrologic interconnectedness for design, function, and resilience is not sufficiently recognized.

2.3 Wetlands manual provides a strong foundation for evolution of knowledge/research.

2.4 Spontaneous/opportunistic revegetation can impair establishment of desired community structure.

2.5 Monitoring should always be done with a view to understanding the processes sufficient for making adjustments or refining the design in the future.

2.6 Need more information on long-term climate variability and potential effects.

2.7 It is not feasible to make an accurate prediction of the equilibrium wetland to watershed ratio in the reclaimed landscape.

2.8 I am not sure that I could build a wetland from the information provided.

2.9 Inadequate discussion of the accumulative nature of salinity.

2.10 Soil stability of materials is important.

2.11 The Wetlands manual does not take into account a successional view of wetlands evolution.

2.12 Sedimentation rates should be kept as low as possible to ensure long-term wetland survival.

2.13 The Wetlands manual is inadequate in section on Adaptive Management.

2.14 Issues with natural analogue wetlands.

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2.15 There is little attention given to the importance of hydrologic manipulations in newly constructed wetlands.

Recommendations for 2013 guide

- Don’t be especially prescriptive. Total will be using the guidelines but also coming up with the specifics within the company itself. Total does not wish to be told to make wetlands in a particularly prescribed way.
- Start at a high level with a more general chapter, and then develop pieces with more specific design criteria so that the needs of all audiences are addressed.
- The guide needs a chapter on hydrology and one on water quality, salinity and nutrients.
- The next guide needs a thorough discussion of water treatment and biodiversity functions.
- Provide the total number of years required for detailed planning and selection of conceptual drainage patterns.
- The document should take a multi-author approach, with specific authors and peer reviewers for each chapter. The chapters should each address a relevant phase of the work required to create a wetland.
- A lot of new information has come to light that can be recognized and incorporated into the next wetlands manual.
- Don’t put too much emphasis on natural analogues. Some description of natural processes will suffice.