GUIDELINES FOR LAKE DEVELOPMENT

AT COAL MINE OPERATIONS IN MOUNTAIN AND FOOTHILLS

OF THE NORTHERN EAST SLOPES

Prepared by the

End Pit Lake Working Group

February 2002

Copies of this document are available from:

Information Centre
Alberta Environment
Main Floor, Great West Life Building
9920 – 108 Street
Edmonton, Alberta
T5K 2M4
Telephone: Toll Free Dial 310-0000 and ask for (780) 422-2079

Copies of this document can be viewed at:

Alberta Environment Library
6th Floor, Great West Life Building
9920 – 108 Street
Edmonton, Alberta
T5K 2M4
Telephone: Toll Free Dial 310-0000 and ask for (780) 427-5870

This report may be cited as:

End Pit Lake Working Group, 2002. Guidelines for Lake Development at Coal Mine Operations in Mountain Foothills of the Northern East Slopes, Report # ESD/LM/00-1, Alberta Environment, Environmental Service. ISBN ________________.

EXECUTIVE SUMMARY

Coal mining is a temporary use of the land. Alberta provincial legislation requires that reclaimed coal mine sites support uses similar, but not necessarily identical, to pre-development conditions. End pit lakes are critical to the economic sustainability of coal mining operations in the northern east slopes of Alberta.

These guidelines present factors that should be considered during the design and development of end pit lakes. They also outline the provincial regulatory process required to obtain a reclamation certificate, and summarize applicable government legislation, guidelines and policies. A series of tables outlining physical, hydrological, chemical, and biological criteria are included.

The adaptive management process is suggested as a tool to provide a framework for end pit lake evaluation as our knowledge evolves. These guidelines are expected to change as knowledge and construction techniques develop.

1 INTRODUCTION TO THESE GUIDELINES

1.1 BACKGROUND

1.1.1 Definition of an End Pit Lake

In these guidelines, - *Guidelines for Lake Development at Coal Mine Operations in Mountain and Foothills of the Northern East Slopes* (GLDCMOM) - an "end pit lake" is defined as a water body greater than 2 metres in depth that has been created as a result of mining activities in an end pit or final mine cut. The end pit lake may be a land locked water body or it may have inlet and outlet channels. The definition includes for the shallow littoral zone around the lake. Water bodies less than 2 metres in depth are considered "wetlands" and are not addressed in these guidelines.

Mining is a temporary use of the land. Alberta provincial reclamation legislation requires that lands disturbed by mining be returned to an equivalent land capability. Reclaimed lands should be able to support uses similar, but not necessarily identical, to the pre-development situation. At most surface coal mine operations in the mountain foothills of the northern east slopes, mined-out pits are back-filled with overburden material from other pits. The area is then reclaimed to a terrestrial end land use. In those cases where a pit is not completely back-filled, the landscape is reclaimed as an "end pit lake". End pit lakes are critical to the economic sustainability of coal mining operations and afford the opportunity to provide landscape diversity and to create multiple end land uses.

1.1.2 Rationale for End Pit Lake Development

Natural lakes are important components of landscapes and are recognized as valuable resources with broad biotic and abiotic functions. They provide habitat for a variety of fish and wildlife species, protect and improve the quality of surface water and groundwater, and provide flood control. In addition, natural lakes provide economic and recreational values. End pit lakes may provide similar values.

Dry land reclamation of a final pit can be very costly. In some cases the cost is prohibitive, as rock material would have to be re-excavated and hauled back to fill the pit. In those instances, the development of a viable end pit lake may be an acceptable alternative reclamation technique.

At the time this document was published, four end pit lakes (Silkstone, Lovett, Lac Des Roches and Sterling lakes - see Appendix E) had been created in this region. Each successive lake was built using end pit lake design and construction knowledge gained from previous development experiences. In the future, it is anticipated that a number of additional end pit lakes will be created. Both industry and government recognize the need and opportunity to synthesize past experience and current knowledge in order to provide guidance on the development of future end pit lakes. These guidelines recognize Adaptive Management principles and stress the importance of their continued use.

This document is a reference guide to assist in the development of future end pit lakes in the mountain foothills of the northern east slopes. It assists operators by providing information to develop plans and applications for end pit lakes. It assists government staff in providing advice to operators and in reviewing plans and applications for end pit lakes. It assists the public by outlining the expectations and requirements for end pit lakes. It also recognizes that site specific conditions will be taken into account when applying the guidelines.

1.2 Establishment of the End Pit Lake Working Group

In 1999, the staff of Alberta Government and coal operators in the mountain foothills agreed to form an End Pit Lake Working Group to develop these guidelines. The Working Group arose from the following needs:

- End pit lakes are and will continue to be a component of the reclaimed landscape at coal mines in the northern east slopes region.

- Guidelines are needed to provide a technical and scientific framework within which to develop and assess individual end pit lakes[1].
- The Alberta Government, the coal mining industry and other stakeholders need to share information to further refine the methods and procedures for developing and assessing end pit lakes in reclaimed landscapes.

The End Pit Lake Working Group had representation from the coal industry and government (Appendix A). The group was co-chaired by industry and the Alberta government.

1.3 Intent and Purpose of these Guidelines

The purpose of this document is to assist government and industry in designing, managing, monitoring and evaluating end pit lakes. Details of design parameters relative to lake-use are provided as reference for measuring existing compliance with appropriate legislation. The implementation process associated with end pit lakes, in an end pit cut, is outlined for use by both regulators and industry. Each end pit lake application will be assessed on its merits and associated technical details.

Government and industry should review these guidelines, as new information becomes available. This will ensure the growth of knowledge surrounding end pit lake development as well as the continuation of the Adaptive Management process.

[1] These guidelines do not address the specific number, size, location and/or type of end pit lakes that are or may be approved for construction within drainage basins in a reclaimed landscape. Individual end pit lake approvals are considered through the government regulatory review process.

Stripping and stockpiling of overburden - Formation of Silkstone Lake

1.4 End Pit Lakes and Government Policy, Regulatory Framework and Planning Initiatives

Existing government policy, legislation and planning initiatives allow for the development of end pit lakes. Appendix B contains a brief discussion of relevant sections of the following government documents:

- **Policy Documents**

  A Coal Development Policy for Alberta (Provincial)
  A Policy for Resource Management of the Eastern Slopes (Provincial)
  Policy for the Management of Fish Habitat (Federal)

- **Legislation**

Environmental Protection and Enhancement Act (Provincial)
Water Act (Provincial)
Public Lands Act (Provincial)
Coal Conservation Act (Provincial)
Fisheries Act (Provincial)
Fisheries Act (Federal)
Navigable Waters Protection Act (Federal)

- **Guidelines and Planning Initiatives**

Coal Branch Sub-Regional Integrated Resource Plan (Provincial)
Surface Water Quality Guidelines (Provincial)
Alberta Coal Mining Wastewater Guidelines (Provincial)
A Fisheries Conservation Strategy for Alberta (Provincial)
Water Body Management Strategy System (Provincial)
A Fish Stocking Process for Alberta (Provincial)
A Decision Making Process for the Evaluation of Fish Introductions in Alberta (Provincial)
Canadian Environmental Quality Guidelines (Federal)
Habitat Conservation and Protection Guidelines (Federal)

As policies, legislation and planning initiatives are amended, these "*Guidelines for Lake Development at Coal Mine Operations in Mountain Foothills of the Northern East Slopes*" should be revised to reflect the changes. Section 3 of these guidelines outlines the regulatory process associated with end pit lake development. It identifies those regulatory bodies/government agencies associated with each phase of the implementation process.

1.5 Guiding Principles in Lake Development at Coal Mines

The End Pit Lake Working Group endorsed the following principles in preparation of these guidelines.

1.5.1 End Pit Lake Function

End pit lakes should provide quality aquatic habitat that will support an abundant and diverse lake ecosystem. The end pit lake ecosystem should complement and enhance the aquatic ecosystems that exist in the region. End pit lakes may also perform ancillary hydrological functions that augment local aquatic ecosystems such as flood buffering, water storage, and attenuation of ground and surface water movements.

1.5.2 End Pit Lake Values

End pit lakes are a legacy of mine development operations and may provide residual value upon completion of mining and reclamation of the pit. The End Pit Lake Working Group has agreed that in the mountain foothills of the northern east slopes, the primary value of end pit lakes will be as self-sustaining sports fisheries or healthy non-sport fish habitat. However, these guidelines recognize that end pit lakes with other end use objectives are acceptable providing they are consistent with the goal of returning equivalent land capability.

1.5.3 Sustainability

An end pit lake should ultimately sustain the biological and hydrological processes necessary for ecological function. Present experience from lakes constructed using draglines indicates an establishment period of approximately 10 to 15 years. Once established, the system should be free to evolve as a functioning diverse aquatic ecosystem that does not require future maintenance or management. The system should be set on a path of ecological succession and development into a healthy, biologically diverse ecosystem. Any lake systems created with inlet and outlet watercourses should be designed and constructed so that long-term maintenance and management is not required.

1.5.4 Planning

Lake reclamation should reflect a sound understanding of basic lake structure and function, the timeframes necessary to establish ecological succession and the link between mine pit configuration (i.e. "self-design") and subsequent end pit lake ecological succession. Hydrology, hydrogeology, water quality, substrate and habitat design requirements are key factors in end pit lake creation. Hydrology in particular is critical to sustainable lake development. Studies to determine the required hydrology, drainage, topography, water quality, soils and vegetation characteristics of healthy end pit lakes and their relationship to the surrounding landscape will be required.

1.5.5 Biological diversity and use of native species

End pit lake development should promote endemic biological diversity at the landscape, community and species levels and therefore requires a multi-disciplinary planning approach.

1.5.6 Practical methods

End pit lake development requires practical design and construction criteria. Criteria will evolve as new and improved technologies are established.

1.5.7 Adaptive Management:

Lake ecosystems are complex and dynamic. Our knowledge of how to construct and manage an end pit lake to produce a diverse, productive and self-sustaining lake ecosystem is evolving. In creating end pit lakes managers have to make decisions and implement plans. Adaptive Management is a tool that can be used in this process and incorporates six main steps: Design, Implementation, Monitoring, Evaluation and Adjustment.

The use of Adaptive Management as a tool in end pit lake implementation is strongly recommended. More information on the steps involved in adaptive management can be found in Appendix C.

1.5.8 Performance assessment and certification

The performance of end pit lakes should be monitored in order to determine whether a lake is meeting the goals and objectives agreed to at the time of issuance of the approval. These goals and objectives relate to the physical, chemical and biological characteristics of the lake as well as its intended use. The chemistry and biological community of the lake should be shown to be moving towards comparable natural lakes in the region. Examples of water quality samples are shown in Appendix D. Excluding considerations for significant adverse effects, end pit lakes created using the best techniques available at the time of their implementation should not be significantly altered based on new knowledge gained after the end pit lakes were established[2].

Fish catch at Lovett Lake

2 REGULATORY PROCESSES FOR END PIT LAKES

During all steps in the development of end pit lakes, actions and decisions must be consistent with existing government policy, legislation and planning initiatives. Formal regulatory approval under various pieces of legislation is essential at specific points during development.

[2] Some end pit lakes that are created (e.g. a deep truck/shovel lake) have no clear analogue in the region. Consequently, criteria for assessing the performance and success of end pit lakes should be specific, measurable and based on a clear understanding of the intended use of the end pit lake. End pit lake performance will be considered "successful" when the values for a particular characteristic fall within an agreed upon range of target values for that characteristic. Target values must be established or set out during the planning stage, before approval to construct is issued.

Under Provincial and Federal legislation it is essential that agreement on the proposed end use of the lake be attained between the proponent and regulatory agencies. That agreement, in the form of the approvals listed below, sets the framework upon which future end pit lake construction activities and certification criteria are considered. The proponent is accountable for construction of the end pit lake in accordance with the approved development plan and is responsible for all reclamation and monitoring activities from the cessation of mining to certification of the water body.

2.1 Provincial Legislation

2.1.1 Environmental Protection and Enhancement Act, (EPEA)

Under EPEA, reclamation must achieve the objective of equivalent land capability. The return of equivalent land capability means that the ability of land to support various uses after conservation and reclamation is similar to the ability that existed prior to an activity being conducted on the land, but that individual land uses will not necessarily be identical. (Conservation and Reclamation Regulations, Sections 1(e), (j) and (k), Alberta Regulations (115/93) with amendments up to and including Alberta Regulation 167/96).

Plans, provided to relevant government bodies at the initial mine planning stage, outline the proponent's proposal to reclaim final mine cuts to end pit lakes. Upon acceptance of the conceptual plans, the proponent provides additional design and construction information for each specific lake at the detailed approval stage. Once these detailed pit plans have been reviewed and approved by the government review agencies, an EPEA approval is issued which authorises development of the end pit lake. The licencing conditions of this approval often require the proponent to submit final and specific lake construction and monitoring information prior to the completion of reclamation.

2.1.2 Water Act

Approval of the detailed design and construction information under the *Water Act* is also required prior to construction of the end pit lake. Each proposed end pit lake must designate a primary end use. Designation of the end use at the detailed design/planning stage is a fundamental component of the planning process as various end uses will have different design and construction requirements. Final end pit lake use may change as a result of adaptive management.

2.1.3 Public Lands Act

No separate approval is required under the *Public Lands Act* for the establishment of an end pit lake. It forms part of the surface disposition (i.e. Mineral Surface Lease, MSL) issued for the mine. Public Lands will not cancel the surface disposition until a reclamation certificate is issued.

2.1.4 Reclamation Certificate

The final formal regulatory step in the end pit lake development process is reclamation certification. Reclamation certification is based on an assessment as to whether or not the end pit lake has been built pursuant to the proponent's end pit lake construction application and government approval conditions issued for the construction of the end pit lake.

The *Environmental Protection and Enhancement Act* is the primary piece of legislation involved in the certification of the end pit lake. The administration of approvals under the *Water Act* and surface dispositions under the *Public Lands Act* is closely tied to and co-ordinated with the reclamation certification process under *EPEA*. Within *EPEA*, general information requirements for a reclamation certificate application are outlined in Section 12 of the Conservation and Reclamation Regulation.

The fundamental principle of reclamation certification is compliance with the terms and conditions of the *EPEA, Water Act* and *Public Lands Act* approvals. The criteria for assessing reclamation certification are lake specific. Certification should recognise that the design and approval of the lake may have been undertaken several years previously and should be judged against those objectives/requirements, which were in effect at the time the approval was issued.

2.2 Federal Legislation

The Department of Fisheries and Ocean's (DFO) *'policy for the management of fish habitat'* promotes integrated management for fish habitat management and encourages research initiatives related to achieving a net gain in habitat through conservation, restoration and development of fish habitat in support of Canada's fisheries resources. Due to the government of Canada's position with respect uncertainty for long-term viability of end pit lakes, to provide healthy, productive fish habitat, DFO does not endorse these Guidelines. Users of GLDCMOM are encouraged to check with DFO to determine their current position on this matter.

3 KEY STEPS IN THE DEVELOPMENT OF END PIT LAKES

Section 2 addressed regulatory requirements and policies that direct and influence the development of end pit lakes in the mountain foothills of the northern east slopes. This section focuses on other factors, which should be considered, and describes a course of action for those charged with the responsibility of developing and evaluating an end pit lake.

Figure 1 shows the logical progression of end pit lake development, where regulatory requirements need to be met and how to accommodate some Adaptive Management principles. Figure 1 identifies:

- Key steps which comprise the 'core process' of the development of an end pit lake from inception to the issuance of a reclamation certificate
- 'Process details' associated with each of the key steps in the 'core process'
- Key players involved in each step of the end pit lake development process
- Opportunities for input / involvement by public and stakeholders during the end pit lake development process

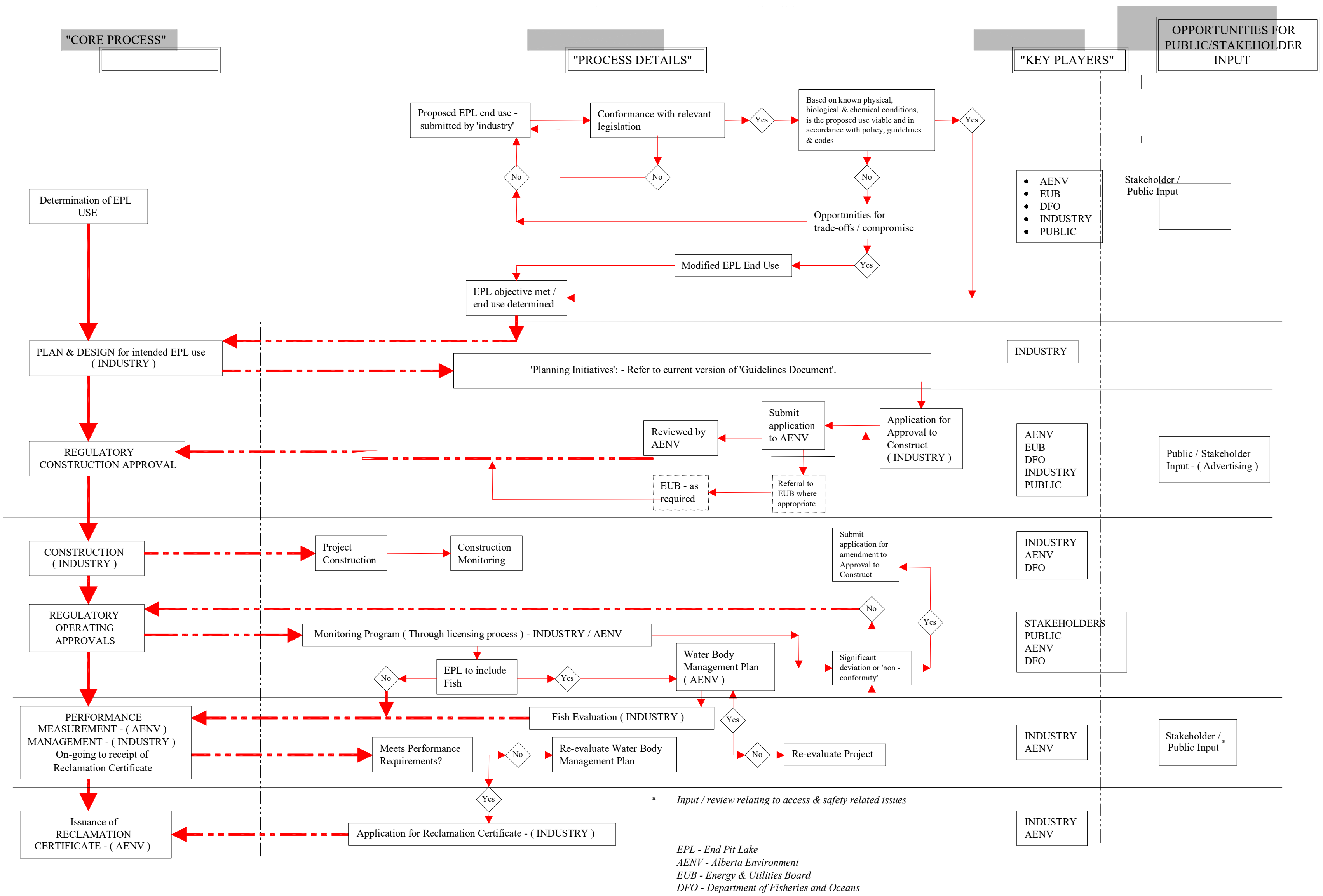
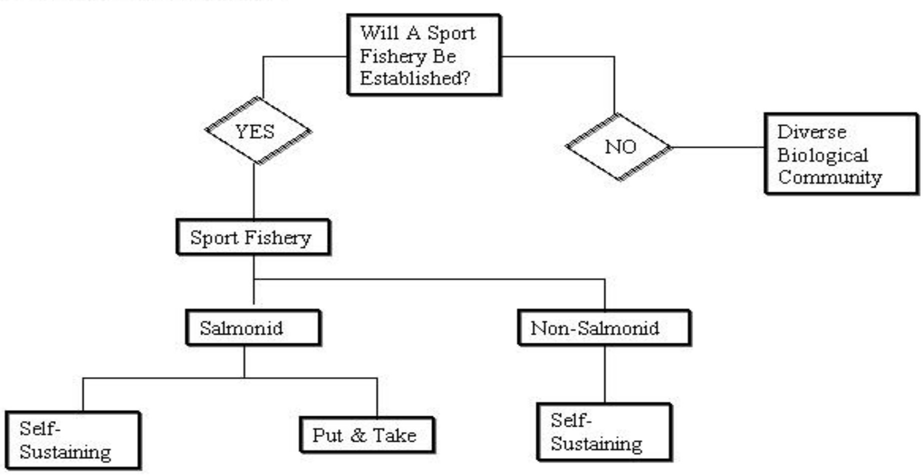

"CORE PROCESS"
"PROCESS DETAILS"
"KEY PLAYERS"
OPPORTUNITIES FOR PUBLIC/STAKEHOLDER INPUT
Proposed EPL end use - submitted by 'industry'
Conformance with relevant legislation
Yes
Based on known physical, biological & chemical conditions, is the proposed use viable and in accordance with policy, guidelines & codes
Yes
No
No
No
Determination of EPL USE
Opportunities for trade-offs / compromise
AENV
EUB
DFO
INDUSTRY
PUBLIC
Stakeholder / Public Input
Modified EPL End Use
Yes
EPL objective met / end use determined
PLAN & DESIGN for intended EPL use (INDUSTRY)
'Planning Initiatives': - Refer to current version of 'Guidelines Document'.
INDUSTRY
Reviewed by AENV
Submit application to AENV
Application for Approval to Construct (INDUSTRY)
REGULATORY CONSTRUCTION APPROVAL
EUB - as required
Referral to EUB where appropriate
AENV
EUB
DFO
INDUSTRY
PUBLIC
Public / Stakeholder Input - (Advertising)
CONSTRUCTION (INDUSTRY)
Project Construction
Construction Monitoring
Submit application for amendment to Approval to Construct
INDUSTRY
AENV
DFO
REGULATORY OPERATING APPROVALS
No
Yes
Monitoring Program (Through licensing process) - INDUSTRY / AENV
Water Body Management Plan (AENV)
Significant deviation or 'non - conformity'
STAKEHOLDERS
PUBLIC
AENV
DFO
No
EPL to include Fish
Yes
PERFORMANCE MEASUREMENT - (AENV) MANAGEMENT - (INDUSTRY) On-going to receipt of Reclamation Certificate
Fish Evaluation (INDUSTRY)
Yes
Meets Performance Requirements?
No
Re-evaluate Water Body Management Plan
No
Re-evaluate Project
INDUSTRY
AENV
Stakeholder / Public Input *
Yes
* Input / review relating to access & safety related issues
Issuance of RECLAMATION CERTIFICATE - (AENV)
Application for Reclamation Certificate - (INDUSTRY)
INDUSTRY
AENV
EPL - End Pit Lake
AENV - Alberta Environment
EUB - Energy & Utilities Board
DFO - Department of Fisheries and Oceans

Figure 1 is not meant to be the only method of achieving an approved and certified end pit lake. Rather, it outlines the fundamental implementation components, their inter-relationship and how the implementation components might be used to ensure critical steps in the process are not overlooked.

3.1 ASSESSMENT – Step 1 of the Adaptive Management Process

Step 1 of the Adaptive Management Process involves the determination of end pit lake use. End pit lakes in the mountain foothills of the northern east slopes may provide fisheries, waterfowl habitat and recreational activities. A primary objective of end pit lake development will be to provide a sport fishery. In cases where there was no fish habitat in the pre-development landscape, either a sustainable or a put and take sport fishery would be the primary objective. Unforeseen circumstances - (biological, physical, and chemical) - may preclude the ability to develop a lake capable of supporting a sustainable fish population. Provision is made in the lake development process to design end pit lakes with alternative end uses, as illustrated in the following figure.

Figure 2. End Pit Lake Use Options



3.1.1 Designing for End Pit Lakes as Sport Fisheries

Creating an end pit lake that supports a sport fishery end pit lake will, in most instances, require the highest level of planning and design effort. Consequently, the remaining portions of these guidelines focus on the design requirements for a self-sustaining native salmonid fishery. Since this option may be the most difficult to achieve because of it's complexity, key indicators relating to the planning, design, construction, monitoring and performance measurement criteria have been established using this as the base case. These criteria can be applied to alternative end-pit lake uses. If necessary, tables for alternate end pit uses may need to be developed.

The key indicators (or the measurable attributes) of a self-sustaining, salmonid end pit lake include hydrological, physical design, chemical, biological and public access/safety design factors (Table 1)

Table 1. Key Indicators - Self Sustaining Native Salmonid End Pit Lake

Design Factors	Key Indicators	
Hydrological	Water Balance	No inlet
		Inlet
	Inlet/outlet stability	
Physical	Shoreline erosion	
	Stability of head wall and other slopes	
	Sediment yield	
	Habitat effectiveness	
Chemical	Toxic substances	
	Overturn (mixing)	
	Water quality	
Biological	Biodiversity	
	Biomass/Productivity	
	Fish Production	
	Shoreline Development Index	
	% Littoral	
Access/Safety	Access	

These key indicators, together with their target values, provide the means for end pit lake design and performance measurement. Further details can be found in tables 2 through 6.

Tables 2 – 6 inclusive present suggested design factors for consideration in the development of end pit lakes.

3.2 DESIGN – Step 2 of the Adaptive Management Process

Step 2 of the Adaptive Management Process involves the design, construction, management and monitoring of end pit lakes.

The purpose of the planning and design phase is to produce a construction plan, a management plan and a monitoring program. These plans should be based on a synthesis of existing knowledge about the key indicators of the chosen option, which in this case is a self-sustaining native salmonid end pit lake. What features should a self-sustaining native salmonid end pit lake exhibit? What level of management control can be exerted over the key indicator? What are the maximum and minimum acceptable ranges of these features? Tables 2 through 6 were constructed using the Delphi approach, a reiterative approach aimed at encapsulating the best knowledge available from people experienced in the field at the time this document was prepared.

Table 2. Hydrological Design Factors - Self Sustaining Native Salmonid End Pit Lake

<table>
<tr><th rowspan="2">Design Factor
HYDROLOGICAL</th><th rowspan="2">Relative Importance</th><th rowspan="2">Degree of Control</th><th colspan="3">Parameter Ranges and Probability of Success[3]</th></tr>
<tr><th>High</th><th>Medium</th><th>Low</th></tr>
<tr><td>Sustainability (water balance)</td><td>High</td><td>Low</td><td>mean annual inflows > mean annual losses</td><td>Mean annual inflows = mean annual losses</td><td>mean annual inflows < mean annual losses</td></tr>
<tr><td colspan="3">Importance/Relevance
• to maintain end pit lakes a sufficient water supply and stable water levels are required
• the hydrology, water level and water budget should be carefully evaluated because reclamation efforts could be wasted if the water level does not develop as planned or if there are large variations in water level</td><td colspan="3">Design Considerations
• prediction of water supply and water level from surface water (runoff), meteorology (precipitation, evaporation) and groundwater (flow and levels)
• determine the area of the contributing watershed and the lake surface area
• mean annual outflows in the overall water balance if the lake has an outlet channel
• for lakes with an outlet maximize the size of the watershed if possible</td></tr>
<tr><td>Lake dynamics/function</td><td>High</td><td>Low</td><td>Very stable water level (<1 m annual variation)</td><td>Stable water level (1 to 2 m annual variation)</td><td>Unstable water level (> 2 m annual variation)</td></tr>
<tr><td colspan="3">Importance/Relevance
• important parameter as other variables can be derived from this data
• lakes fluctuate on both an annual cycle (e.g. in response to spring run-off, with subsequent draw down over the fall and winter), and over multiple years (in response to longer term climate trends such as droughts or wet periods)
• lakes provide storage capacity within the watershed that naturally leads to an attenuation of peak runoff events
• lake level fluctuation has an immediate bearing on the relative suitability of the lake to different flora and fauna
• annual fluctuations in lake level of 1 m are beneficial
• fluctuations in lake level affect % littoral zone</td><td colspan="3">Design Considerations
• the degree of fluctuation is highly correlated with the relative size of the watershed to the area of the lake (long term water balance)
• design or engineer a natural outlet to control or maintain water levels. Lake and channel features should be robust and maintenance-free. Engineered outlet control structures such as culverts, spillways, or weirs should be avoided whenever possible.
• lake response to storm peaks is dependent upon lake bathymetry (elevation/capacity relationship), outlet design and capacity (level, configuration, width, slope), and basin topography/relief (characterizes the shape of the inflow hydrograph)
• outlet supports fish movement in and out of the lake under low flows</td></tr>
<tr><td>Filling method/schedule</td><td>High</td><td>High</td><td>1 to 5 years</td><td>5 to 10 years</td><td>10 years +</td></tr>
<tr><td colspan="3">Importance/Relevance
• successful lake development requires a timely filling schedule</td><td colspan="3">Design Considerations
• contributing drainage area and mean surface runoff rates, groundwater flow,</td></tr>
</table>

[3] Probability that an end pit lake will support self-sustaining, native salmonids

Design Factor HYDROLOGICAL	**Relative Importance**	**Degree of Control**	**Parameter Ranges and Probability of Success[3]**		
			High	**Medium**	**Low**
• availability of water for filling depends on surface and groundwater sources and on the need to minimize impacts on other users or resources in the area or downstream of the lake, including fisheries resources			mean annual precipitation and evaporation, volume of lake • on-stream lakes that tie into existing streams, should consider maintenance of downstream flows as well as diversion into lake for filling • connection of lake inlets to existing streams after the lake is filled. • water from other sources to assist in lake filling, providing that effects on the water source are minimized or considered acceptable		
Watershed dynamics	**Low-medium**	**Low**	Not applicable		
Importance/relevance • major or cumulative land use changes within a watershed can impact rates of surface runoff in terms of peaks, timing and yields • if known future activities and anthropogenic effects are of a significant nature to the overall watershed, some allowance for these effects may be required			**Design Consideration** • upstream activities may effect water supply: watershed drainage area alteration or direct diversions; timber harvest or land clearing; cumulative effect of multiple end pit lakes; 'local area' industrial activities such as mining or oil and gas, and forestry		
Groundwater Dynamics	**Low-medium**	**Low-medium**	Variable		
Importance/Relevance • groundwater can be an important factor in lake filling • lakes can act as regional groundwater recharge sites			**Design Consideration** • maximum surface flow will assist in dilution of groundwater • groundwater movement/formation characteristics will determine the rate of groundwater flow into the lake and/or the rate that water flows out of the lake as groundwater recharge		

Table 3. Physical Design Factors - Self Sustaining Native Salmonid End Pit Lake

<table>
<tr><th rowspan="2">Design Factor
PHYSICAL</th><th rowspan="2">Relative Importance</th><th rowspan="2">Degree of Control</th><th colspan="3">Parameter Ranges and Probability of Success</th></tr>
<tr><th>High</th><th>Medium</th><th>Low</th></tr>
<tr><td>Lake geometry (size, volume, width, length, depth, (min, max, avg.), orientation, slopes, shoreline, bottom substrate)</td><td>High</td><td>Variable</td><td>< 25 m maximum depth</td><td>25 to 75 m maximum depth</td><td>> 75 m maximum depth</td></tr>
<tr><td colspan="3">Importance/Relevance
• lake geometry, in particular depth, is a key physical factor; deep lakes will tend to be colder and less productive than shallow lakes; in addition, they are more likely to stratify with the risk that low quality waters in the hypolimnion will turn over at some stage and adversely affect the lake; dragline lakes will tend to be shallower (< 30 metres deep on average) and easier to increase backfilling if needed; truck/shovel lakes will tend to be deeper(>70 m) and more difficult to backfill
• depth to volume or depth to surface area ratio should be considered. A 4 ha lake that is 25 m deep is not likely to mix (smaller fetch)</td><td colspan="3">Design Considerations
• evaluate opportunities to minimize lake depth or to provide shallow littoral zones that are isolated from the main, deeper part of the lake, for example, through underwater berms
• optimize design parameters in deep lakes so that they are consistent with the objective of equivalent land capability, and provide an acceptable end land use</td></tr>
<tr><td>Upland sediment yield</td><td>Low to Medium</td><td>High</td><td>> 90% vegetation cover</td><td>60 to 90% cover</td><td>< 60% vegetation cover</td></tr>
<tr><td colspan="3">Importance/Relevance
• erosion from upland areas surrounding the end pit lake could compromise lake development in terms of siltation and infilling of shallow areas, as well as negative effects on water quality, aquatic biota and productivity
• the type and extent of vegetation cover on the reclaimed upland landscape will affect the amount of erosion and resulting sedimentation in the lake</td><td colspan="3">Design Considerations
• establish vegetation cover in upland areas as soon as possible and prior to discharge of the lake
• provide for mitigation of excessive erosion arising from poor vegetation establishment or from gullies</td></tr>
<tr><td>Shoreline Stability/Erosion</td><td>High</td><td>High</td><td>> 90% stable shoreline</td><td>60 to 90% stable</td><td>< 60% stable shoreline</td></tr>
<tr><td colspan="3">Importance/Relevance
• excessive shoreline erosion will contribute to reduced water quality, siltation of shallow water habitats, and slope instability</td><td colspan="3">Design Considerations
• design sheltered bays
• use islands as breakwaters to protect shorelines
• use appropriate armouring or rip-rap on shoreline
• establish emergent vegetation and vegetation to the water’s edge</td></tr>
</table>

Design Factor PHYSICAL	**Relative Importance**	**Degree of Control**	**Parameter Ranges and Probability of Success**		
			High	**Medium**	**Low**
Stratification/Mixing	**High**	**Low**	<10 m mean depth <20 m maximum depth	10 to 15 m mean depth, 20 to 23 m maximum depth	<4m, >15m mean depth; <8m, >30m maximum depth
Importance/Relevance • Summer stratification and fall mixing are important for healthy lake function • Infrequent mixing of strongly stratified lakes can release potentially toxic substances (e.g., some metals, dissolved solids [salts], H_2S) from the hypolimnion			**Design Considerations** • Lakes that are deep relative to their surface area will stratify most strongly and are most likely to mix poorly. • Area; dragline < 10 ha, truck-shovel > 10 ha (5 to 50 ha)		

Table 4. Chemical Design Factors - Self Sustaining Native Salmonid End Pit Lake

Design Factor CHEMICAL	Relative Importance	Degree of Control	Parameter Ranges and Probability of Success		
			High	**Medium**	**Low**
Water Quality (pH, alkalinity, dissolved oxygen, temperature, suspended solids, turbidity, TDS, major ions, nutrients, metals)	**High**	**Variable**	Close to median water quality values of natural water bodies in the region	Within the range of values for natural water bodies in the region	At the extreme, or outside of the range for natural water bodies in the region
Importance/Relevance • natural water bodies exhibit a wide variation in general water quality • end pit lakes with water quality that is within the general range of natural variation for the region have a higher chance of supporting a viable ecosystem than those outside of regional variation • acceptable water quality is essential in supporting aquatic life			**Design Considerations** • evaluate the anticipated water quality (surface and groundwater) to see if there are any water quality characteristics that may adversely affect aquatic biota and long term ecosystem function • examine possible measures to improve water quality for any parameters that may be of concern • maximize flow of surface water through lake		
Potential Toxic Substances	**High**	**Variable**	Meets water quality guidelines	Slightly exceeds guidelines	Significantly exceeds guidelines
Importance/Relevance • potentially toxic substances (e.g., some metals, salinty, H_2S) may seriously compromise the ability of an end pit lake to meet its intended objective of supporting fisheries • substances that accumulate (e.g., Se, Hg) in aquatic biota may have detrimental effect (e.g. on biota, food webs and human consumption of fish)			**Design Considerations** • end pit lakes should meet the *Surface Water Quality Guidelines for Use in Alberta* (AENV 1999 as amended) or other applicable guidelines for parameters not specifically addressed in Alberta's guidelines • if guidelines are exceeded further investigations to evaluate the source, fate and effect of a particular parameter are required • known geological sources (e.g. overburden) of toxic substances should be selectively handled to reduce the chances of them contacting lake water • toxic substances should not be placed in end pit lakes		

Table 5. Biological Design Factors - Self Sustaining Native Salmonid End Pit Lake

Design Factor BIOLOGICAL	Relative Importance	Degree of Control	Parameter Ranges and Probability of Success			
				High	**Medium**	**Low**
Littoral zone	**High**	**High (DL)†** **Low (TS)**	Area	20 to 40%	10 to 20%	< 10% > 40 %
			Maximum Littoral Depth ♣	<3 m		3 to 6 m
Importance/Relevance • the extent of the shallow area littoral zone is one of the most important factors for lake productivity and fisheries habitat • littoral zones are shallow, warm and highly productive; they provide food organisms and shelter for fish, as well as habitat diversity • need a balance between littoral and deep water areas because littoral zone sediments tend to release phosphorus at increased rates			**Design Considerations** • pit development and backfill sequencing can affect the amount of littoral zone and early consideration in the mine planning process may optimize the area occupied by this important habitat in end pit lakes • dragline lakes are more likely to meet optimum targets. Lakes that exceed optimum targets may become too eutrophic • truck/shovel lakes may not always be able to meet the optimum targets due to the cost of backfilling; however, early planning of benches may increase the extent of the littoral zone • underwater berms could isolate the littoral zone in lakes from the deeper, main body of the lake and allow the shallow isolated zone to heat up more quickly in summer			
Area/Depth –	**Medium**	**Medium -DL** **Low - TS**	10 to 15 metres mean depth		15 to 50 mean depth	<4m, >50 m mean depth
Importance/Relevance • mean depth influences trophic conditions, thermal dynamics, DO, stratification and nutrient distribution of the lake			**Design Considerations** • mean depths of >4m are beneficial to minimize winter kill from dissolved oxygen depletion • excessive depth may result in permanent stratification • Maximum depth of dragline lakes ≅25 m, truck-shovel ≅ 75 m			
Substrate in littoral zone	**High in TS**	**Medium**	**High** Boulder density in littoral zone **Low** **High** Fines in littoral zone **Low**			
Importance/Relevance • substrate characteristics (texture and composition) are important in providing a variety of habitats and in enhancing biodiversity. Substrate type and composition exhibit a considerable influence on macrophyte and benthic productivity and type of biota present • sediments are crucial in the release and chemical transformations of many elements; they can affect bioavailability of nutrients and elements			**Design Considerations** • the source and size of materials available for placement will maximize substrate diversity • placement of organic material in the shallow lake areas will enhance vegetation • large boulders placed in the littoral area will provide cover for fish and other biota particularly in large truck shovel lakes • inclusion of soil/fines in littoral zone			

Design Factor BIOLOGICAL	Relative Importance	Degree of Control	Parameter Ranges and Probability of Success		
			High	Medium	Low
• suitable spawning substrate or spawning structures is important			• variability in substrate of littoral zone		
Shoreline configuration	**Medium**	**Medium - DL** **Low -TS**	High sinuosity High variability in substrate size	Medium sinuosity Medium variability in substrate size	Regular circle Uniform substrate size
Importance/Relevance • providing a variety of shoreline habitats for wildlife will increase habitat and enhance biodiversity. • important for aesthetic consideration. • irregular shoreline will minimize wave action • irregular shorelines will reduce line of sight for wildlife and for recreation users			**Design Considerations** • irregular shorelines and reduced slopes provide a safe and stable feature and provide habitat for macrophytes • effective use of earth-moving equipment or backfilling can increase shoreline irregularity • maximize ratio of shoreline to surface area • integrated with littoral development		
Connectivity of lake to stream	**High**	**Medium to high**	Stable surface inlet and outlet	Ephemeral outlet only	No inlet/outlet
Importance/Relevance • some species require inlets or outlets to spawn • connectivity to surface waters that allow fish movement requires suitable construction • provide access and potential spawning habitats for fish • additional inflow to lakes will increase flushing rate and ability to maintain adequate long term water quality conditions			**Design Considerations** • supply suitable / effective spawning substrate for fish • provide access to and from the lake for all life stages depending on management objectives • construct stable and long-term channels and install natural structures • design connecting streams to have a broad flood-plain within which they can find a "natural" sinuous flowline		
Riparian	**High**	**Medium to low**	High diversity of well-established plants	Medium diversity of well-established plants	Poor establishment of vegetation
Importance/Relevance • increases habitat for aquatic and terrestrial organisms • wind/fetch effected by presence of trees along and close to shore • diversity of plants in the riparian area contributes to habitat diversity • overhanging vegetation at inlet/outlet provides habitat for fish and adult insects and thermal protection for fish			**Design Considerations** • strive for different vegetative communities along shoreline • recognize the extent of riparian development is slope dependent • put effort into developing riparian zone of inlet and outlet		

† DL – dragline, TS –Truck and Shovel

♣ Littoral zone is entirely dependent on water transparency, however, the *Atlas of Alberta Lakes* refers to a survey in which littoral zones ranged from 3.5 to 5 m in depth.

Table 6. Access and Safety Design Factors - Self Sustaining Native Salmonid End Pit Lake

Design Factor PUBLIC ACCESS/SAFETY	Relative Importance	Degree of Control	Parameter Ranges and Probability of Success		
			High	Medium	Low
Public access	**Medium**	**High**	Variable – depends on social values		
Importance/Relevance • good access to end pit lakes for public use is important in order to increase visibility of reclamation efforts and to increase public support of mining reclamation activities • development and management criteria should be consistent with regional recreational land uses, (i.e. trail systems, roads, signage) • if the end pit lake is attractive to users, access will occur			**Design Considerations** • environmentally friendly and safe access route. Level of access should be considered at the EIA stage and during any subsequent EPEA, *Public Lands Act*, or Water Act approvals for the lake. • there are two main types of access to consider: random and constructed (hiking, ATV and vehicular). Generally, road and recreational features will require a land disposition in favour of some proponent who will provide stewardship and maintain access. • the type of access and the number of users expected and projected over time • impacts and needs of parking lot and/or trail and maintenance • local and regional traffic - increased traffic to site • modifications to public road for access or parking • type of development at other lakes in the region • ensure that mine and pit design considers eventual access routes from known start points off existing public access		
Public facilities/lake use	**Medium**	**High**	Variable – depends on social values		
Importance/Relevance • the extent, need and type of public facilities should be determined from the type of lake development proposed and the expected amount of public use			**Design Considerations** • the area around end pit lakes should be returned to as near natural conditions as possible.		
Safety	**High**	**Low**	Variable – depends on social values		
Importance/Relevance • public safety around end pit lakes is extremely important • lake design should have due regard for public safety • the public should be well-informed of dangers or restricted from dangerous areas • access to steep walls by land or water should be restricted through lake design if possible • trail and road safety issues should be addressed in the design stage and			**Design Considerations** • factor of safety on highwall design, trail and road safety, presence of unusual dangers • use reclamation design to restrict access to highwalls from land and water. • special land use zones may require monitoring and enforcement. • slope stability and factor of safety on highwalls. • design of end pits should have due regard for public safety. • eliminate any unusual danger.		

Design Factor PUBLIC ACCESS/SAFETY	**Relative Importance**	**Degree of Control**	**Parameter Ranges and Probability of Success**		
			High	**Medium**	**Low**
implemented during construction			• measures taken to protect public (highwall design, fencing, signage)		

Table 7 summarizes the optimum design characteristics for self-sustaining native salmonid end pit lakes. These optimal conditions are not design requirements but rather provide an indication of desirable lake characteristics. (adapted from Luscar et al. (1994) and drawing on the information contained in Tables 2 through 6.)

Table 7. Optimum Lake Characteristics of Self Sustaining Native Salmonid End Pit Lake

Parameter	Optimal Condition
Water level	• Fluctuations up to 1 metre are beneficial
Area	• Increase surface area to volume ratio to promote productivity • Connectivity to adjacent lakes and the natural watershed is important.
Depth	• The deepest part of the lake should be in the range of 25 m for dragline lakes and 75 m for truck and shovel lakes. • Mean depth should be 10 to 15 5 metres
Bank slope	• Shore slopes should range from 2H:1V to 5H:1V
Shoreline	• Long and irregular shorelines provide habitat diversity for fish and wildlife and minimize erosion due to wave action.
Littoral zone	• 20% to 40% of the total lake area to maximize productivity, irregular surface to provide microsite diversity of habitat and shelter for fish
Bottom configuration	• Irregular bottom in the littoral zone is important for habitat diversity at depths less than 6 m
Substrate	• Variation in size and compaction to provide variable benthic habitat. • Organic soil and boulders in the littoral zone to promote vegetation establishment and growth • Suitable sized substrate for spawning in inlet and outlet channel.
Lake orientation	• Exposed and parallel to prevailing wind direction to promote mixing of the water column
Water quality	• Conform to the current Surface Water Quality Guidelines for Use in Alberta • Water quality should not pose limitations to aquatic organisms
Inlet/outlet channels	• Maintenance free inlet and outlet that provides spawning habitat • Vegetation or some other structure that provides overhead cover
Public access	• Access should be stable and safe
Safety	• No unusual dangers • Visible signage
Biological diversity	• Comparable biological diversity to other lakes in the region

3.2.1 Monitoring Plan

A monitoring plan must also be developed for each end pit lake. Using an Adaptive Management approach this would normally be done during the planning and design stage. The monitoring plan (e.g. methods, parameters and frequency of sampling) must be defined prior to lake implementation.

Table 8 provides a list of potential parameters to be considered for monitoring end pit lake development trends. The monitoring plan (i.e., sampling methods, locations and frequency) outlined for a specific end pit lake should consider the intended use of the lake, and whether similar end pit lakes have been constructed and assessed. As the knowledge base expands with respect to end pit lake development trends it is anticipated that the level of monitoring intensity may decrease[4].

Table 8. Potential monitoring parameters for Self-Sustaining Native Salmonid End Pit Lake

Water Quality	• Dissolved oxygen (DO) (seasonal and winter) • Temperature • Conductivity • Total dissolved solids (TDS) • Major ions (routine analysis) • pH • Alkalinity • Total Suspended Solids (TSS) • Turbidity • Nitrogen (nitrate + nitrite, ammonia, Kjeldahl) • Phosphorus (dissolved, total) • Chlorophyll a • Sulphides • Metals, metalloids • Organic compounds if warranted • Toxicity (acute, chronic) if warranted • Microbiological parameters if warranted
Hydrology	• Surface inflow determined through runoff yield in nearby streams to estimate surface inflow by prorating the drainage areas or determining total net inflow (sum of direct precipitation, evaporation, surface runoff, and groundwater) • Climate data • Outflow rate (surface water) that can be directly measured, or derived if lake levels and the outlet rating curve are available • Lake levels
Sediments	• Chemical analysis if warranted by water chemistry • Erosion rates from surrounding watershed

[4] Monitoring and assessing progress towards target values can be complicated by the inherent inability of an immature lake to exhibit functional equivalency to an older system (i.e. functions develop over long periods). This feature of lake evolution should be taken into account when designing the monitoring plan.

Biology	• Composition, abundance, diversity of: • Phytoplankton, zooplankton • Benthic invertebrates • Aquatic and shoreline vegetation • Fish • Population estimates, growth rates, and productivity of sport fish • Biological tissues
Physical	• Channel/shoreline stability and erosion

While the information contained in Tables 2 through 8 should form the basis of construction, management and monitoring plans, a key goal of the Adaptive Management process is to improve understanding of system behaviours. These charts must be continually refined as a result of new information gained during the monitoring phase. Thus, when a subsequent end pit lake is constructed, the planning stage should be based on updated information, not the current charts.

Tables 2 through 8 summarize the best existing knowledge relating to a self-sustaining native salmonid end pit lake. However, there are a number of practical considerations that can influence the construction, management and monitoring plans. In the mountain foothills of the northern east slopes, these considerations include watershed analysis, mining factors, downstream effects, and regional or cumulative effects.

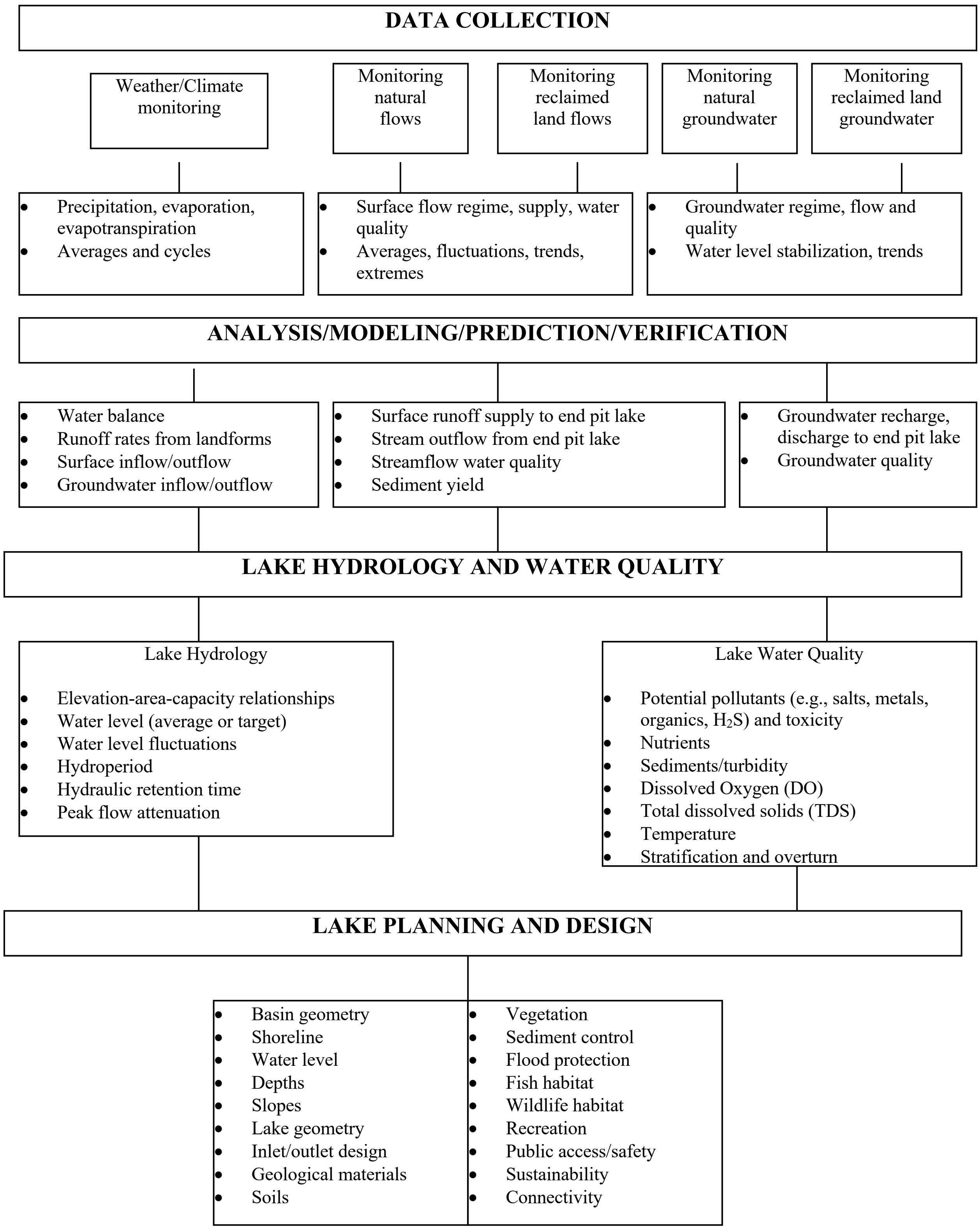
3.2.2 Watershed Analysis

The planning and design of end pit lakes requires predictions of the post mining hydrology and water quality conditions expected to be established in the end pit lakes on the reclaimed landscape. Both of these factors are key determinants in end pit lake development and performance.

An essential element of end pit lake development is the actual availability of water for the end pit lake. Water quality and quantity should support the intended use, including consideration of seasonal dynamics and lake behaviour (e.g., overturn). A lot of reclamation effort could be wasted if the end pit lake water quality or quantity does not develop as planned. The implications for existing fish habitat of water diversions undertaken to fill end pit lakes should also be considered.

Figure 3, adapted after Nelson et al. (1982), provides a framework for evaluating probable hydrology and water quality in lake planning and design. It is recognised that information for all components identified in Figure 3 may not be available at the time of end pit lake design and/or construction. However, best efforts to collect this information should be made. The more factors that are known at the time of planning, design and construction, the more likely the targets or goals for the end pit lake will be attained.

Figure 3. Framework for Evaluating Probable Hydrology and Water Quality (from Nelson et al. 1982)



3.2.3 Mining Factors

Mining excavation operations and other activities will predetermine certain lake characteristics. For example, the type of mining operation (dragline vs. truck shovel) governs basic end pit lake configuration.

Dragline mining results in the creation of end pit lakes that are long, narrow and relatively deep compared to their width. Usually one side of the pit has a steep sloping rock face that originally overlay the coal seam, while the other side is gently sloping. The depth to which the dragline can dig limits the maximum depth of a lake created by dragline operations. Generally following re-contouring operations, a dragline end pit lake will have a maximum depth of less than 30 m.

Truck and shovel operations usually result in the creation of larger, more angular and much deeper end pit lakes. With truck and shovel operations the sides of the pit are generally steeply sloping, with the angle of the slopes being dependent upon the mining geometry. These lakes can be more than 70 m in depth and have relatively steep sides that pose several challenges in terms of making them into productive lakes.

Mining factors that may affect end pit lake design are often difficult to control. For example, lake geometry (i.e., size and depth) and orientation is often pre-determined by the location of coal seams. The extent of pit backfilling and final lake configuration depends on the availability of backfill material and the cost of material handling as a component of mining costs. Lake-design characteristics may be enhanced by pre-planning backfill operations. These include lake depth, the size and extent of shallow and littoral zone areas that can be created.

3.2.4 Downstream Effects Factors

End pit lakes will influence downstream areas in terms of both hydrology and water quality. Depending on the nature and extent of the effect, the changes may be either positive or negative. Table 9 provides a brief overview of some of the potential effects. End pit lake planning and design need to consider, where appropriate, issues associated with potential downstream effects.

Table 9. Potential Downstream Effects Associated with End Pit Lakes

	Positive Effects	Negative Effects
Hydrology	• Flood peak attenuation • Enhanced low flows, especially during winter	• Reduced stream flow during filling • Reduced flows if outlet level is too high or does not provide for outflow for a wide range of lake levels • Reduced flushing of downstream reaches
Water Quality	• Reduced sediment loads (if shorelines are stable)	• Reduced water quality if lake water quality deteriorates • Possible connectivity to saline aquifer
Biological	• Export of food organisms (e.g., plankton) to downstream habitats • Increased water temperature that will increase downstream productivity	• Reduction / elimination of seasonal flows and associated cycling of nutrients and sediments, especially in lotic systems downstream of end pit lakes • Increased water temperature that adversely influences indigenous biota

3.2.5 Regional or Cumulative Effects Factors

The development of end pit lakes may raise regional or cumulative effects issues associated with:

- The number of end pit lakes created. The number of end pit lakes established at an individual mine, or in combination with other mines, may result in cumulative hydrological, water quality or biological effects concerns at the local or regional level.

- Interactions with other activities (e.g., pipeline developments, forestry) on the land base. Depending on the location, extent and timing of these activities, end pit lake development may have regional level effects on surface water hydrology and water quality.

Each end pit lake application must consider matters related to regional and cumulative effects. Alberta Environment and coal operators will need to consider the number and types of end pit lakes that are appropriate in terms of regional and cumulative effects factors. Further guidance on regional matters may be developed through water management plans under the *Water Act* or other mechanisms such as a regional sustainable development strategy.

3.2.6 Finalizing construction, management and monitoring plans

The construction, management and monitoring plans should be based on Tables 2 through 8. If it is necessary to modify some of the design principles outlined in the charts, the implications of these changes in terms of expected results should be documented. During implementation, it may be necessary to deviate from the original plans. Again, during the planning phase, it should be decided when and what types of deviations are acceptable, who can make the decisions and who needs to be informed about the decisions. All changes must be documented.

3.3 IMPLEMENTATION – Step 3 of the Adaptive Management Process

During the mining process, monitoring of baseline surface and groundwater quality and quantity should be carried out in the pit. Once mining has been completed, construction of the end pit lake can commence when the planning documents have been approved by appropriate government agencies. The construction plan should be followed as closely as possible.

3.4 MONITORING - Step 4 of the Adaptive Management Process

Monitoring includes identification and monitoring of the key end pit lake indicators. Once constructed, end pit lakes need to be monitored in order to characterize their status and to allow for trend evaluation to determine if end pit lake conditions are moving in the direction predicted/expected. For example, is the development of the end pit lake, as measured by particular parameters, occurring at the expected rate or does it appear to be falling short such that remedial or management measures may need to be considered? The parameters to be monitored, the monitoring methods, expected results and data collection and recording techniques are defined during the planning and design phase of the project.

3.5 EVALUATION – Step 5 of the Adaptive Management Process

Part 5 of the Adaptive Management Process includes an evaluation or performance assessment. This is undertaken to determine whether an end pit lake is meeting its intended objective as agreed to at the time the approval is issued. It is also undertaken to determine whether the path of biological and chemical maturation of the lake is clear and leading to a lake that meets the target criteria. Data collected during the monitoring phase are analyzed and actual results are compared to the expected values defined during the planning process. The Adaptive Management process includes an evaluation step to assess both positive and negative effects. Inferences should be drawn and recommendations should be made for future actions. All results must be documented and communicated to regulators so that the knowledge base relating to end pit lakes can expand. As experience is gained in the construction and performance of end pit lakes, the extent of required reports could be minimized and reduced to key performance indicators.

Tables 10 and 11 provide an initial framework for assessing the performance of end pit lakes with respect to fisheries use. The performance criteria are not presented as a prescriptive requirement, but rather as a guide for consideration. Each end pit lake will have its own specific needs. Through an Adaptive Management process, it is probable that the number of evaluation criteria will change over time.

Table 10. Potential Evaluation/Performance Assessment Criteria

Design Factors	Indicators		Parameters to be measured	Targets/Goals
Hydrological	Water Balance	Non-contributory (No outlet)	• Observed lake levels and range of fluctuation	• < 2 metres annual change in water level
		Contributory (Outlet)		• <1 metre annual change in water level
Physical	Shoreline erosion		• Shoreline surveys with permanent reference points	• Minimal erosion (a numerical target should be defined)
	Stability of head wall and other slopes		• Subsidence of littoral substrate • Wall failure onto littoral zone	• Maintenance of littoral zone
	Inlet/outlet stability		• Populations of local fish in the lake	• Stable • Accessible and used by fish for spawning • Maintenance free
	Sediment yield - erosion from surrounding land		• Total Suspended Solids	• Minimal erosion from surrounding land into water. • Meet *Surface Water Quality Guidelines* used in Alberta
Chemical	Toxic substances		• Water chemistry • Tissue concentrations in biota if warranted	• Surface Water quality guidelines for aquatic life used in Alberta. • Background comparison to other lakes in region
	Overturn (mixing)		• Summer stratification • Fall mixing	• Presence of annual summer stratification and fall turnover
	Water quality		• Water chemistry of groundwater leaving lake in discharge areas • Water chemistry in lake and discharge	• Meet Surface Water Quality Guidelines used in Alberta • Chemical end points fall within regional range

| Design Factors | Indicators | Parameters to be measured | Targets/Goals |

Design Factors	Indicators	Parameters to be measured	Targets/Goals
Biological	Biodiversity	• Phytoplankton • Zooplankton • Macrophytes • Benthic invertebrates • Fish (including non-game fish) • Shoreline vegetation	• Comparable to local lakes and / or regional fisheries management objectives
	Biomass/Productivity	• Phytoplankton • Zooplankton • Macrophytes • Benthic invertebrates	• Comparable to local lakes and / or regional fisheries management objectives
	Game Fish Production	• Annual Production	• Comparable to local lakes and / or regional fisheries management objectives • DL 3 to 5 kg/ha/yr[1] • T&S 1 to 1.5 kg/ha/yr.
	Fish habitat effectiveness	• Diversity of invertebrates. • Redds in inlets/outlets.	• Comparable to local lakes and / or regional fisheries management objectives
Access/safety	Public Access	• Random • Constructed (Motorized, ATV, Hiking)	• Stable and safe

[1]Data from Silkstone, Lovett & Lac Des Roches (Luscar et al. 1994)

Table 11. Design issues contributing to failure to reach targets/goals

Design Factors	Indicators		Likely Causes of Failure	Prevention (Initial Design)	Potential Management Actions
Hydrological	Water Balance	No outlet	• Ratio of watershed area to lake area too low		
		Outlet	• Outlet too restricted. Does not accommodate wide range of discharge	• Change outlet design • Reconfigure outlet channel	

Physical	Shoreline erosion		• Excessive wave action	• Protect littoral zones and shore through
				  • Armouring
				  • Vegetation and/or
				  • Offshore islands
					• Re-armouring
					• Enhanced shoreline vegetation

	Stability of high wall and other slopes		• Subsidence leading to wall failure	• Backfill under dry conditions • Re-slope (dozer or blasting)	• Reshape failed areas • Backfill failed areas
	Inlet/outlet stability		• Unanticipated natural event and/or poor design	• Design for stable, maintenance free structures and channels	• Allow natural processes to occur (healing and readjustment) • Reconstruction
	Sediment yield (erosion from surrounding land)		• Poor vegetation cover • Erosion of exposed clay • Gully erosion	• Erosion control • Stabilize slopes • Repair high erosion areas	• Stabilize slopes • Improve / enhance vegetation cover • Use of different life forms e.g., shrubs/forbs/grass)
Chemical	Toxic substances		• High chemical input rates (e.g., leaching of elements)	• Minimize levels of toxic substances through low hydraulic retention time (i.e., high flushing rate), being aware of potential down stream effects	• Management of surface waters around lakes • Lake management (e.g., defer fish establishment until water quality improves) • Warning signs for public

Design Factors	Indicators	Likely Causes of Failure	Prevention (Initial Design)	Potential Management Actions
Chemical	Overturn (mixing)	• Low area/depth ratio • Excessive shelter from wind • Excessive chemical stratification • Inadequate fetch	• Increase area/depth ratio • Plant low growing vegetation around lakes • Low slope around lake • Minimize inputs of surface water high in Total Dissolved Solids	• Manage surface waters around lake • Manage vegetation close to shore
	Water quality	• Leaching from rock spoil (e.g., metals) • High salt levels in groundwater • High salt levels in inflow water	• Maximize surface water input and flushing • Managing the source	• Capture maximum runoff to lakes • Minimize reliance on groundwater • Manage surface water around lakes
Biological	Biodiversity	• No initial inoculation • Deterioration of habitat	• Inoculate with aquatic biota from a suitable disease-free source • Provide appropriate habitat (e.g., littoral zone, macrophytes)	• Inoculate with aquatic biota from a suitable local disease-free source • Improve quality of deficient habitat components
	Biomass/Productivity	• Inadequate habitat components • Limited habitat (not enough) • Insufficient food base • Insufficient nutrient levels • Lack of access to lake by aquatic organisms	• Design suitable habitat • Optimise lake design to provide sufficient nutrient inputs/recycle and good habitat • Inoculate with aquatic organisms from a suitable disease-free source	• Manage inflow/runoff waters to enhance nutrient inputs • Inoculate with aquatic biota from a suitable disease-free source • Improve/enhance deficient habitat components
	Fish production	• Insufficient food base • Deteriorating water quality	• Introduce fish species appropriate to lake characteristics • Artificial intervention (e.g., aeration)	• Review biomass and productivity data of food base for species • Improve/enhance limiting habitat components

Design Factors	Indicators	Likely Causes of Failure	Prevention (Initial Design)	Potential Management Actions
	• Fish habitat effectiveness	• Inappropriate structures (e.g., outlets) • Inappropriate habitat components • Insufficient habitat	• Design for habitat requirements of target fish species • Model outlet performance for a wide variety of conditions • Due diligence in reclamation	• Improve / enhance the habitat components of concern
Access/Safety	Public Access	• Poor routing • Poor substrate for access route • Topographic limitations on route selection and on structures • Excessive use in non-designated areas	• Proper consideration of how people will get to lake • Proper route selection • Proper route preparation and construction	• Remove all fixtures and return land to natural state • Relocate route • Reconstruction • Post warning signs

3.6 ADJUSTMENT – Step 6 of the Adaptive Management Process

In order for the information gathered during end pit lake development to have long-term value, it should be put to use. The information gathered should be used to verify or update the tables and actions outlined in the 5 previous steps in the Adaptive Management cycle of this report. It is very rare that all forecasts and predictions made at the outset of a project are verified by the results achieved. The information collected during the Adaptive Management process should be used to improve the planning and outcomes of the next end pit lake.

4 GLOSSARY OF TERMS

Term	Definition
Adaptive Management	Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs (Forest Practices Branch 2001)
Anthropogenic	Involving the impact of man on nature; induced, caused or altered by the presence and activities of man as in water and air pollution. (NALMS)
Aquatic biota	Organisms which live in or frequent water. (adapted from OSWWG)
Aquatic ecosystem	The biological community and non-living environment functioning together as a system in water bodies. Aquatic habitat for interrelated and interacting communities, and populations of plants and animals. (OSWWG)
Aquatic vegetation	A term for plants adapted for a partially or completely submerged life (adapted from Lincoln et al. 1982)
Armouring	A facing layer (protective cover) or Riprap, consisting of very large stones placed to prevent erosion or the sloughing off of a structure or embankment. Also a layer of large stones, broken rocks or boulders, or pre-cast blocks placed in a random fashion on the upstream slope of an *Embankment Dam*, on a reservoir shore, or on the sides of a channel as protection against waves, ice action, and flowing water. The term armouring generally refers only to very large Riprap. (NALMS)
Back-filled	The action of refilling an excavation. (OSWWG)
Bathymetry	(1) The measurement of the depth contours in bodies of water (oceans, seas, ponds and lakes). (2) The measurement of water depth at various places in a body of water. Also the information derived from such measurements. (NALMS)

Benthic invertebrates	Aquatic animals without backbones that dwell on or in the bottom sediments of fresh or salt water. Examples are clams, crayfish and a wide variety of worms. (NALMS)
Benthos	All the plants and animals living on or closely associated with the bottom of a body of water (within or attached to the sediments of lakes, streams and oceans). Phytobenthos (benthic flora) includes macrophytes and bottom-dwelling algae. The zoobenthos (benthic fauna) includes a variety of invertebrate animals, particularly larval forms and mollusks. (NALMS).
Bioavailability	The amount of chemical which is actually available to the target tissues following exposure. (Powter 2000)
Biological community	All living things in a given environment. (NALMS).
Biological diversity	The number and kinds of organisms per unit area of volume; the composition of species in a given area at a given time. (NALMS).
Biomass	The weight of all living material in a unit area or volume at a given instant in time. It can be expressed at different biological levels (e.g. population, community). (OSWWG)
Biota	The plant (flora) and animal life (fauna) of a region or ecosystem, as in a stream or other body of water. (NALMS)
Delphi Approach	Used where empirical data are not available. It involves a survey of the opinion of technical experts in the field concerning specific issues. An iterative process involving the development of a consensus of the opinion of experts in the field. (Crance 1987)
Ecological endpoint	A term used in reference to Suter et al. (1994); loosely defined in Suter et al. (1994) as "assessment endpoints, which are explicit statements of the characteristics of the environment that are to be protected, and the measurement endpoints, which are quantitative summaries of a measurement or series of measurements related to effects on an assessment endpoint." (Suter et al. 1994)

Ecological function	1. The collective intraspecific and interspecific interactions of the biota, such as primary and secondary production and mutualistic relationships 2. The interactions between organisms and the physical environment, such as nutrient cycling, soil development, water budgeting and flammability (BioTech)
Ecological risk assessment	The application of a formal framework, analytical process or model to estimate the effects of human actions on a natural resource and to interpret the significance of those effects in light of the uncertainties identified in each component of the assessment process. Such analysis includes initial hazard identification; exposure and dose-response assessments, and risk characteristics. (NALMS)
Ecological succession	An orderly, directional and therefore predictable process of development that involves changes in species structure and community processes over time. It results from modification of the physical environment by the community and culminates in a stabilized ecosystem in which maximum biomass and symbiotic functions are maintained. (NALMS)
End Pit Lake	A water body greater than 2 metres deep that has been created as a result of an end pit cut; associated with mining activities (End Pit Lake Working Group)
Equivalent Land Capability	The ability of the land to support various land uses after conservation and reclamation is similar to the ability that existed prior to any activity being conducted on the land, but the individual land uses will not necessarily be identical. (AB Conservation and Reclamation Regulations)
Eutrophic (Lakes)	Lakes rich in nutrients and organic materials, therefore, highly productive for plant growth. These lakes are often shallow and seasonally deficient in oxygen in the *Hypolimnion*. (NALMS)
Fall turnover	The physical phenomena that may take place in a body of water during autumn. The sequence of events leading to fall turnover include: (1) the cooling of surface waters; (2) a density change in surface waters producing convection currents from top to bottom; (3) the circulation of

	the total water volume by wind action; and (4) eventual vertical temperature equality. Also referred to as Fall Overturn. Also see spring turnover. (NALMS)
Fetch	1) The distance travelled by waves in open water, from their point of origin to the point where they break. 2) The distance the wind blows over water or another homogeneous surface without appreciable change in direction. (NALMS)
Fish Stocking	It is the policy of the Alberta Government to maintain native fish populations in all water bodies where they occur. However, Alberta does raise fish in hatcheries and plants them in water bodies to re-establish fish where populations have collapsed, establish new populations in suitable lakes, provide trout fishing in areas where few other angling opportunities exist, and provide diversity in angling experiences where appropriate. (2000 Alberta Fish Stocking List).
Habitat	The natural environment or specific surroundings where a plant or animal naturally grows or lives. The surroundings include physical factors such as temperature, moisture, and light together with biological factors such as the presence of food or predator organisms. The term can be employed to define surroundings on almost any scale from marine habitat, which encompasses the oceans, to microhabitat in a hair follicle of the skin. (NALMS)
Habitat diversity	The number of different types of habitats within a given area (Dunster and Dunster 1996)
Habitat component	A single element (e.g., velocity, depth, cover) of the habitat or environment in which a fish or other aquatic species or population may live or occur (BioTech)
High wall	The unexcavated face of exposed overburden and mineral in a surface mine, or the face or bank on the hillside or a contour strip mining excavation. (Powter 2000)

Hydrology	The science of waters of the earth, their occurrence, distribution and circulation; their physical and chemical properties; their reaction with the environment including living beings. (NALMS)
Hypolimnion	The lowermost, non-circulating layer of cold water in a thermally stratified lake or reservoir that lies below the *thermocline*, remains perpetually cold and is usually deficient of oxygen. (NALMS)
Invertebrate	Animals lacking a dorsal column of vertebrae or a notochord (from OSWWG)
Land	terrestrial, semi-aquatic and aquatic landscapes when the term is used in the definition of "land capability" and "equivalent land capability". (End Pit Lake Working Group)
Lake ecosystem	The complex of living organisms and their environment that occur within a lake, linked by energy flows and material cycling. (adapted from OSWWG)
Lake turn over	1) The sinking of surface water and rise of bottom water in a lake that results in changes in temperature that commonly occur in spring and fall 2) One complete cycle of top to bottom mixing of previously stratified water masses. This phenomenon may occur in the spring or fall or after storms, and results in uniformity of chemical and physical properties of water at all depths. Also see *Spring Overturn* and *Fall Overturn*. (NALMS, *Overturn*)
Legislation	Laws enacted by the authority of a legislative body (Legislative Assembly of Alberta)
Lentic	Characterizing aquatic communities found in standing water. (NALMS)

Littoral Zone	The shallow area near the shore of a non-flowing body of water, or that portion of a body of fresh water extending from the shoreline lakeward to the limit of occupancy of rooted plants. (NALMS)
Lotic	(1) Of, relating to, or living in moving water. (2) Referring to a running water *Ecosystem* (streams and rivers). (NALMS)
Macrophyte	A member of the macroscopic plant life (larger than algae) especially of a body of water. (OSWWG)
Native salmonid	The trout family (Family Salmonidae). In the mountain foothills of the northern east slopes they are: bull trout, rainbow trout, Arctic grayling, mountain whitefish, pygmy whitefish, lake whitefish and lake trout. (adapted from Nelson and Paetz (1992))
Overturn	1) The sinking of surface water and rise of bottom water in a lake or ocean that results in changes in temperature that commonly occur in spring and fall 2) One complete cycle of top to bottom mixing of previously stratified water masses. This phenomenon may occur in the spring or fall, or after storms, and results in uniformity of chemical and physical properties of water at all depths. Also referred to as *Lake turnover*. Also see *Spring turnover* and *Fall turnover*. (NALMS)
Phytoplankton	Microscopic floating plants, mainly algae, which live suspended in bodies of water and that drift about because they cannot move by themselves or because they are too small or too weak to swim effectively against a current. (NALMS)
Productivity (water)	The physical yield expected from a unit of lake surface area assuming specific management practices and input levels. (adapted from Powter 2000)
Put-and-take fishery	A lake open to public fishing with only seasonal fish survival requiring the stocking of catchable-size fish annually; different from "put and

	grow" fisheries as that refers to year-round survival (adapted from A Decision-Making Process for the Evaluation of Fish Introductions in Alberta)
Reclamation	(i) the removal of equipment or buildings or other structures and appurtenances; (ii) repealed 1996 c17 s2; (iii) the decontamination of buildings or other structures or other appurtenances, or land or water; (iv) the stabilization, contouring, maintenance, conditioning or reconstruction of the surface of the land; (v) any other procedure, operation or requirement specified in the regulations **(EPEA)**
Recruitment	Refers specifically to the numbers of fish born that reached a specific stage of life (i.e. breeding age) (adapted from Dunster and Dunster 1996)
Redds	A type of fish spawning area associated with flowing water and clean gravel. Fishes that utilize this type of spawning area include trout, salmon, some minnows, etc. (NALMS)
Riparian area	Refers to terrain, vegetation or simply a position adjacent to or associated with a stream, flood plain, or standing water body. (Powter 2000)
Rip-rap	Broken rock, cobbles, or boulders placed on earth surfaces, such as the face of a dam, bank of a stream or lining drainage channels, for protection against the action of water. (Powter 1994)
Salmonid	A member of the trout family (Family Salmonidae) (Nelson and Paetz 1992)
Self-sustaining populations	A wildlife population of sufficiently large size to assure its continued existence within the area of concern without the introduction of other individuals from outside the area assuming that the desirable ecosystem conditions are maintained (Dunster and Dunster 1996)
Sport fish	Regionally defined; typically larger bodied fish caught for recreation. Native sport fish in the northern east slopes of Alberta include rainbow trout, northern pike, whitefish arctic grayling, bull trout and lake trout.

Spring turnover	A physical phenomena that may take place in a lake or similar body of water during early spring, most frequently in lakes located in temperate zones where the winter temperatures are low enough to result in freezing of the lake surface. The sequence of events leading to spring turnover include: (1) the melting of ice cover; (2) the warming of surface waters; (3) density changes in surface waters producing convection currents from top to bottom; (4) circulation of the water volume by wind action; and (5) vertical temperature equality. The overturn results in a uniformity of the physical and chemical properties of the entire water mass. Also referred to as Spring Overturn. Also see fall overturn. (NALMS)
Stratification	The arrangement of a body of water, such as a lake, into two or more horizontal layers of differing characteristics, such as temperature, density, etc. Also applies to other substances such as soil and snow. (NALMS).
Surface Inflow	Calculated inflow to lake based on flow in near by streams and prorating the drainage area of the lake. (adapted form Ponce 1989).
Sustainability	The process of managing biological resources (e.g., timber, fish) to ensure replacement by re-growth or reproduction of the part harvested before another harvest occurs. (Powter 2000)
Sustainable lake	A lake that can survive extreme events and natural cycles of change without being subjected to accelerated degradation or environmental impacts more severe than those of the natural environment. (adapted from Powter 2000)
TDS (Total Dissolved Solids)	All the solids (usually mineral salts) that are dissolved in water. Used to evaluate water quality. (NALMS)
Total Net Inflow	Sum of direct precipitation, evaporation, surface runoff, and ground water (M. Seneka, pers. comm.)
Trophic Level	1: the sequence of steps in a food chain or food pyramid *q.v.*, from producer to primary, secondary and tertiary consumer. 2.: The nutrient status of a body of fresh water; categories include eutrophic, mesotrophic, oligotrophic (Lincoln et al. 1982).

Viable ecosystem	Viable is defined as "that which is capable of exhibiting life" (Gray 1967). Ecosystem is defined as " a complex system of living organisms, together with their abiotic environment that function together to circulate nutrients and which creates biomass, a trophic structure in the living community, and a change in ecosystem function over time." (Dunster and Dunster 1996).
Water balance	(1) A measure of the amount of water entering and the amount of water leaving a system. Also referred to as *Hydrological Budget*. (2) The ratio between water assimilated into the body and that lost from the body; also, the condition of the body when this ratio approximates unity. (NALMS).
Watershed	All lands enclosed by a continuous hydrologic-surface drainage divide and lying up-slope from a lake or a specified point on a stream. (adapted from Powter 2000)
Wetlands	Land having a water table at, near, or above the land surface or which is saturated for long enough periods to promote wetland or aquatic processes as indicated by hydric soils, hydrophytic vegetation, and various kinds of biological activity that are adapted to the wet environment. Wetlands include peatlands and areas that are influenced by excess water but which, for climatic, edaphic or biotic reasons, produce little or no peat. Shallow open water, generally less than 2 m deep, is also included in wetlands. (Powter 2000)
Zooplankton	Animal life, usually microscopic, found floating or drifting in the water column of oceans or bodies of fresh water; forms the bulk of the primary consumer link in the aquatic food chain. Zooplankton form the link between primary producers (phytoplankton) and the higher trophic levels (e.g., fish, humans). (OSWWG)

2000 Alberta Fish Stocking List. Alberta Environment.
(http://www.gov.ab.ca/wnv/fw/fishing/2000Stocking/index.html) '

Alberta Conservation and Reclamation Regulations. #115/93. Alberta Government. Queens Printer. (http://www.qp.gov.ab.ca/display_regs.cfm)

BioTech Life Sciences Dictionary. (http://biotech.icmb.utexas.eud)

Crance, J.H. 1987. Habitat suitability index curves for paddlefish, developed by the Delphi technique. North American Journal of Fisheries Management. 48:1050-1053.

Dunster, J. and K. Dunster. 1996. Dictionary of natural resource management. UBC Press. Vancouver, British Columbia, Canada. 363 pp.

Gray, P. 1967. The dictionary of the Biological Sciences. Van Nostrand Reinhold Company. Toronto, Ontario, Canada. 602 pp.

Legislative Assembly of Alberta. 2001. http://www.assembly.ab.ca/visitor/parlterms.htm

Lincoln, P.F., G.A. Boxshall and P.F. Clark. 1982. A Dictionary of ecology, evolution and systematics. University Press. Cambridge, England. 289 pp.

OSWWG. Oil Sands Wetlands Working Group. 2000. Guideline for Wetland Establishment on Reclaimed Oil Sands Leases. Neil Chymko (Editor). Report # EDS/LM/00-1, Alberta Environment, Environmental Service. ISBN 0-7785-1041-7, Publication No T/517

NALMS. Lake and Water Word Glossary. http://nalms.org.glossary/glossary.htm

Nelson, J.S. and M.J. Paetz. 1992. The Fishes of Alberta. 2nd ed. The University of Alberta Press. Edmonton, Alberta, Canada. 437 pp.

Ponce, V.M. 1989. Engineering Hydrology: Principles and Practices. Prentice Hall, Englewood Cliffs, New Jersey.

Powter, C.B. (Compiler), 2000. Glossary of Reclamation and Remediation Terms Used in Alberta – 6th Edition. Alberta Environment, Environmental Sciences Division, Edmonton, Alberta. Report No. ESD/LM/00-3. 63 pp. ISBN 0-7785-3342-3.

Powter, C.B. 1994. Glossary of Reclamation Terms Used in Alberta - 4th Edition. Alberta Conservation and Reclamation Management Group Report No. RRTAC OF-1A.

Suter, G.W. et al. (1994). Approach and strategy for performing ecological risk assessment for the U.S. Department of Energy's Oak Ridge Reservation: 1994 revision. ES/ER/TM-33/R1, Oak Ridge National Laboratory, Oakridge Tennessee.

5 APPENDIX A

LIST OF REPRESENTATIVES OF THE END PIT LAKE WORKING GROUP

List of representatives on the end pit lake working group

Alberta Government
Tara Banks – AENV
Quinn Bottorff - AENV
Richard Casey - AENV
Neil Chymko – AENV
Dave Henderson – EUB
Ed Hoyes – AENV
Gene Leskiw – AENV
Rick Nutbrown – AENV
Derek Richmond – AENV
Heather Sinton – AENV
Darin Stepaniuk – AENV
George Sterling – ASRD
Paula Siwik – ASRD
Michael Seneka – AENV
Mel White – ASRD

Federal Government
Nadine Stiller – DFO

Industry
Andy Etmanski – Luscar Ltd.
Ernie Ferster – Luscar Ltd.
Fred Kuzmic – Luscar Ltd.
Dane McCoy – Luscar Ltd.
Bernd Martens – Grande Cache Coal Company
Al Watson – Luscar Ltd.
Alina Wolanski – Luscar Ltd.
Rick Ferster – Luscar Ltd.

6 APPENDIX B

Applicable Policy, Legislation and Planning Initiatives

Applicable Policy, Legislation and Planning Initiatives

INTRODUCTION

As noted in Section 2, end pit lakes may be a component of the reclaimed landscape. Their development must be consistent with existing government policy, legislation and planning initiatives. The following government documents are recognised as being applicable either to end pit lake planning and design, construction, management and/or assessment. Appendix C is provided to outline a brief discussion of the applicability of end pit lakes with the respective government documents. It is recognised that over time, as policies, legislation and planning initiatives are amended, revisions will have to be made to these guidelines.

- **Policy Documents**

  A Coal Development Policy for Alberta (Provincial)
  A Policy for the Resource Management of the East Slopes (Provincial)
  Policy for the Management of Fish Habitat (Federal)

- **Legislation**

  Environmental Protection and Enhancement Act (Provincial)
  Water Act (Provincial)
  Public Lands Act (Provincial)
  Coal Conservation Act (Provincial)
  Fisheries Act (Provincial)
  Fisheries Act (Federal)
  Navigable Waters Protection Act
- **Planning Initiatives**

  Coal Branch Integrated Resource Plan (Provincial)
  Surface Water Quality Guidelines (Provincial)
  Alberta Coal Mining Wastewater Guidelines (Provincial)
  A Fisheries Conservation Strategy for Alberta (Provincial)
  Water Body Management Strategy for Alberta (Provincial)
  A Fish Stocking Process for Alberta (Provincial)
  A Decision Making Process for the Evaluation of Fish Introductions in Alberta (Provincial)
  Canadian Environmental Quality Guidelines (Federal)
  Habitat Conservation and Protection Guidelines (Federal)

6.1 Policy Documents

A Coal Development Policy for Alberta (Provincial)

Overview. The Coal Policy[i] is designed to promote the benefits of coal development to the people of Alberta. Exploration and development are encouraged in a manner that is compatible with the environment. Development will be permitted only when the government is satisfied that it may proceed without irreparable harm to the environment and with satisfactory reclamation of any disturbed land.

The policy classifies provincial lands into four categories that determine the extent to which exploration and development of coal mining may be considered in a particular category. The Government developed the categories having regard to environmental sensitivity, alternate land uses, potential coal resources and the extent of existing infrastructure.

Relation to end pit lake development. The concepts of protection of the environment, compatibility with other land uses, and land reclamation are key elements of the Coal Policy. The Alberta Government is committed to maintaining a balance between resource development and environmental protection. The policy recognises the importance of Alberta's environment and land resources. Only where coal development is judged to be in the public interest, and where full reclamation is assured, will the Alberta Government authorize developments that would cause land disturbance. The creation of end pit lakes as a component of the reclaimed landscape can be consistent with the broad intent of the Coal Policy providing the lakes are properly planned and meet reclamation requirements under provincial legislation.

Relation to these guidelines. These guidelines provide direction for creating lakes as part of the reclaimed landscape. The advice in these guidelines will help ensure that end pit lake creation meets the intent and objectives of the Coal Policy.

A Policy for the Resource Management of the East Slopes (Provincial)

Overview. Regional objectives for watershed management and fisheries as outlined in *A Policy for the Resource Management of the East Slopes* include:

1. management of headwaters in the region to maintain the recharge capabilities and protect critical fisheries habitat
2. protection of aquatic habitat
3. establishment of optimal in-stream flow for fish through modification of land/water use practices
4. recognition of sport fishing as the principal use of fishery resources in the eastern slopes
5. maintenance of naturally reproducing salmonid populations in the region and expansion of these fish resources into presently vacant and appropriate aquatic habitat
6. supplementation or enhancement of game fish stocks by stocking when natural reproduction does not occur or is limited.

Relation to end pit lake development. Protection and restoration of aquatic habitat, and the existence of naturally reproducing fish populations form part of the guiding principles of *A Policy for the Resource Management of the East Slopes*. The creation of end pit lakes as a component of the reclaimed landscape can be consistent with the broad intent of the East Slopes Policy providing the lakes are properly planned and meet reclamation requirements under provincial legislation.

Relation to these guidelines. These guidelines provide direction for creating lakes as part of the reclaimed landscape. The advice in these guidelines will help ensure that end pit lake creation meets the intent and objectives of *A Policy for the Resource Management of the East Slopes*.

6.2 Legislation

Environmental Protection and Enhancement Act[ii] (Provincial)

Overview. The *Environmental Protection and Enhancement Act* (EPEA) and its regulations provide a comprehensive set of legislation intended to protect the environment and achieve sustainable development.

Under its environmental assessment provisions, EPEA requires the proponent of a new coal mine or major expansion to prepare an Environmental Impact Assessment (EIA) report. The EIA report is filed as part of the application for a coal mine permit from the Alberta Energy and Utilities Board (EUB). The EIA report is used by the EUB in its evaluation of the social, economic and environmental effects of the proposal and its determination of whether the project is in the public interest. The EUB process sets the broad, conceptual framework for the project, including the conceptual reclamation plan. In this context, the EIA/EUB process considers matters related to the general nature of landscape types, including lakes, which will occur in the reclaimed landscape. Decision Reports issued through the EIA/EUB process may identify specific issues that must be addressed when detailed applications are submitted.

EPEA requires an operator to conserve and reclaim land disturbed or affected by an industrial activity such as a coal mine and to obtain a reclamation certificate. EPEA also requires the operator of a coal mine to apply for and obtain an approval for the opening up, operation and reclamation of a mine. Normally, this should be done on a pit-by-pit basis and should include a monitoring component. The EPEA application must include detailed operational plans for conservation and reclamation of the land affected by coal mine development, including the detailed plans for the establishment of lakes on the reclaimed landscape. A fundamental component of EPEA is the expectation for public consultation in the preparation of applications and the provision for public involvement in the review of these applications.

Under EPEA, the *Conservation and Reclamation Regulation*[iii] establishes the objective of reclamation as the return of equivalent land capability. The return of equivalent land capability means that the ability of land to support various land uses after conservation and reclamation is similar to the ability that existed prior to an activity being conducted on the land, but that individual land uses will not necessarily be identical. Land capability is the ability of land to support a given land use (e.g., agriculture, forestry, wildlife habitat, recreation, etc.) based on an evaluation of the physical, chemical and biological characteristics of the land, including landscape (topography, drainage, hydrology), soils and vegetation.

This objective of equivalent land capability provides for sustained levels of use at least equivalent to those that existed prior to development. The concept provides for flexibility such that individual land capabilities and land uses may change but overall land capability and land use will be equivalent to pre-disturbance conditions. Although reclaimed landscapes may differ from pre-disturbance conditions, they should normally be characteristic of the region. If they are not completely characteristic, they must be sustainable landscapes with viable biological communities that are acceptable to the government, project proponent, and stakeholders.

Relation to end pit lake development. EPEA and its regulations provide the regulatory framework for reclamation. End pit lake development will require an application for approval containing the information needed to evaluate the proposed lake. As stated previously, this is normally done on a pit-by-pit basis. Under EPEA, the expectation is that the public will be appropriately consulted in the preparation of reclamation plans for end pit lakes.

When development of the end pit lake is considered complete, the operator must obtain a reclamation certificate as specified under the *Conservation and Reclamation Regulation* in order to demonstrate that reclamation has been successful. Section 12 of the *Regulation* outlines the information required on the application form for a reclamation certificate. An inspector may issue a reclamation certificate subject to any terms and conditions the inspector considers appropriate.

Water Act[iv] (Provincial)

Overview. The *Water Act*, which was proclaimed in 1998 and came into effect on January 1, 1999, promotes and supports the conservation, management and wise use of water in Alberta. An important component of the Act is the protection and enhancement of aquatic habitat and the development of a planning framework to help guide future decision-making.

All water in Alberta is vested in the Crown. As such, activities involving the creation of end pit lakes or alteration of drainage patterns are subject to review and approval under the *Water Act* and its regulations. Approvals may be subject to guidelines established under regional water management plans developed pursuant to the Act. Approvals will also be subject to public review.

Relation to end pit lake development. The establishment of end pit lakes and associated habitat on reclaimed coal mine sites is consistent with the philosophy of the Act and the province's policies on water conservation and management. The applications and approvals required for the establishment of end pit lakes on reclaimed mine sites will be closely tied to approvals and reclamation certificates issued under the *Environmental Protection and Enhancement Act.*

Relation to these guidelines. These guidelines outline to government, coal operators and the public the legislative requirements under the *Water Act* and expectations with respect to end pit lake development. These guidelines assist operators in preparing applications for approvals under the *Water Act* and government staff in reviewing and approving applications.

Public Lands Act[v] (Provincial)

Overview. The *Public Lands Act* and its regulations were established to provide for the administration and management of public lands owned by the province of Alberta. Public land is managed, under a multiple use philosophy, for timber production, watershed, wildlife and fisheries, agriculture, mineral extraction, recreation and other uses.

Authority to use public land (enter and occupy) is granted through surface dispositions issued under provisions of the Act. A surface disposition is a land use contract that conveys certain rights and obligations to the holder for the use and restoration of the land. Examples are a Mineral Surface Lease (MSL) for coal mining and License of Occupation (LOC) for an access road.

Relation to end pit lake development. The end land use planning and establishment of end pit lakes on the reclaimed mine site under surface disposition is directly tied to the approval issued in respect of the *Environmental Protection and Enhancement Act (EPEA)*.

No separate approval is required under the *Public Lands Act* for the establishment of an end pit lake, it forms part of the surface disposition (i.e., MSL) issued for the mine. The surface disposition will not be cancelled until a reclamation certificate is issued and all other conditions are satisfactory.

At the end of the day, the lands will be returned to the province and they will become vacant public lands available for re-leasing or other public uses.

Relation to these guidelines. The End Pit Lake Development Guidelines outline to operators and the public the legislative requirements and planning and design considerations necessary to ensure that end pit lakes, forming part of the end land use plan, will result in the construction and reclamation of a self-sustaining, maintenance free water body. These guidelines will assist the operator in preparing the necessary reclamation or end land use plan required under EPEA that will form part of the surface disposition issued for carrying out the activity on public lands.

Coal Conservation Act (Provincial)

Overview. The purpose of the Coal Conservation Act is to ensure the safe, orderly, efficient and economic development of Alberta's coal resources. The Act applies to every coal mine and coal processing plant in Alberta, and to all coal produced and transported within the province. The Act provides provision for the Government to protect the environment in the development of Alberta's coal resources.

Relation to end pit lake development. In accordance with the Act, no person may develop a mine without first having obtained a Mine Permit and Mine License from the Alberta Energy and Utilities Board (EUB). The EUB will only grant a Mine Permit or Mine License when it is of the opinion that it is in the public interest to do so.

When an application is made to develop a mine, the submission must be accompanied by a plan to reclaim all lands that will be disturbed by the proposed development. Pursuant to the Act, the EUB may require the permit holder to obtain performance bonds to ensure that reclamation and abandonment is carried out in accordance with the conditions prescribed by the EUB in issuing the Mine Permit or Mine License. In the event that the holder of the Mine Permit and Mine License fails to comply with the prescribed conditions, the EUB is entitled to access the performance bonds to do whatever it considers necessary to complete the reclamation and abandonment work.

Relation to these guidelines. These guidelines outline to operators and the public the requirements and expectations with respect to reclamation. These guidelines will assist operators in preparing reclamation plans and will assist government staff in reviewing and approving applications.

Fisheries Act (Provincial)

Overview. The provincial Fisheries Act pertains primarily to issues surrounding commercial fish culture licensing and fees, purchase of fish from a commercial fisherman, sportfishing license fees and research and stocking licences.

Relation to end pit lake development. This Act does not directly relate to the development of end pit lakes but legislates protocols and procedures that must be followed before fish are stocked or collected for research purposes.

Relation to these guidelines. The Act outlines any fees or provincial provisions associated with fish research and stocking licences.

6.3 Planning Initiatives

The development of end pit lakes in reclaimed landscapes has potential regional implications. These relate primarily to possible cumulative effects that a number of end pit lakes, in combination with other activities on the land base, may have on surface hydrology (e.g., peak flows, low flows, flow pattern) and surface water quality (e.g., chemistry, metals, temperature). In addition, there are management implications to the Crown if large numbers of end pits are created and eventually turned over to the province.

Coal Branch Integrated Resource Plan[vi] (Provincial)

Overview. The Coal Branch Integrated Resource Plan (IRP) provides guidance on land and resource use on public lands in the region. The IRP establishes Resource Management Areas (RMA's) that guide resource and land use through the identification of management objectives and guidelines. Each RMA is identified on the basis of a common landscape, its current land use and its resource capability.

Relation to end pit lake development. The broad objectives and guidelines in the IRP should be considered during end pit lake planning to ensure consistency with the IRP and to see what opportunities exist to meet some of the objectives with respect to resources such as fisheries, wildlife, and recreation. Operators will need to identify the RMA that applies to their development area and then refer to the broad resource/land use objectives and guidelines that apply to the planning area.

Relation to these guidelines. The guidelines for end pit lake development provides direction to coal mine operators and government to create lakes in reclaimed landscapes that will be consistent with the intent of the IRP. The IRP document does not address decisions related to end land use planning, including uses to be provided by end pit lakes at a specific coal mine site. Land use issues for a proposed coal development are initially considered during the Environmental Impact Assessment (EIA) process and the decision-making process of the Alberta Energy and Utilities Board (EUB). These processes would consider the direction, objectives and guidelines in the IRP. Ultimately, Alberta Sustainable Resource Development and Alberta Environment through regulatory approvals, and land management mechanisms will make land use decisions.

Surface Water Quality Guidelines (Provincial)

Overview. Water quality guidelines and application of these guidelines are outlined in the " Surface Water Quality Guidelines for Use in Alberta "[vii]. This document supercedes all earlier compilations of water quality guidelines used in Alberta. These guidelines are compiled from new and previous Alberta guidelines, from the Canadian Council of Ministers of the Environment [viii]guidelines, and from the U.S. Environmental Protection Agency[ix] criteria. These guidelines are numerical concentrations or narrative statements recommended to support and maintain designated water uses namely the (1) protection of aquatic life, (2) agriculture and (3) recreation and aesthetics. Development and evaluation of water quality guidelines is an ongoing process and this Alberta Environment 1999 document will be revised periodically to incorporate new information and guidelines.

Relation to end pit lake development. Surface water quality guidelines for the protection of aquatic life are routinely used to evaluate monitoring data in assessments of ambient conditions and to identify the potential for adverse effects on aquatic biota in lakes and rivers throughout Alberta. If monitoring data do not exceed these guidelines, problems are unlikely. If these guidelines are exceeded, a detailed assessment might be required in order to determine the extent, cause, and potential adverse effects arising from the exceedance. Guidelines are sometimes exceeded due to natural causes, such as heavy run-off and extreme weather conditions.

Water quality guidelines for other designated uses, such as agriculture (irrigation and livestock waters), recreation and aesthetics and drinking water may also be used to evaluate these specific water uses if appropriate. Alberta has adopted the Canadian guidelines for drinking water quality.[x]

Relation to these guidelines. Surface water quality guidelines and other guidelines where applicable for the protection of aquatic life will be used to evaluate the potential of adverse effects in end pit lakes and the connected aquatic ecosystem. Other pertinent guidelines for evaluating adverse effects on aquatic biota include the Canadian sediment quality guidelines for the protection of aquatic life and Canadian tissue residue guidelines for the protection of wildlife consumers of aquatic biota.[xi]

Alberta Coal Mining Wastewater Guidelines (Provincial)

Overview. The Coal Mining Wastewater Guidelines is a general reference document for wastewater management at coal mining operations in the province. Alberta Environment's expectations are outlined for the collection, treatment and disposal of mine wastewater. Typical *Environmental Protection and Enhancement Act* approval requirements for mine wastewater release limits, monitoring, and reporting are discussed.

Relation to end pit lake development. The Coal Mining Wastewater Guidelines outline that an approval is required for the construction, operation, and reclamation of a coal mine in accordance with the Activities Designation Regulation (211/96) of EPEA. Applications must be prepared pursuant to the Approvals and Registrations Procedure Regulation (113/93 and 216/96) and submitted to Alberta Environment. These activities may also require approval in terms of the *Water Act* for the diversion and use of water, and for the placing of any structure in a water body, or watercourse.

These guidelines recognize that numerical limits regulating wastewater quality may need to vary from one mine to another due to differences in mine type and location (e.g. mountain mines versus prairie mines). Where an operator believes that certain guideline requirements are impractical or not applicable due to particular site-specific circumstances, the operator may request from the Director an exemption from those conditions in the course of applying for an approval. Adequate justification must be supplied to support an application for exemption.

Relation to these guidelines. The mine wastewater limits outlined in Section 4.2 (Table 1) of these guidelines remain in force until the disturbed land in the watershed is reclaimed as per the EPEA approved reclamation plan and a reclamation certificate is issued.

A Fisheries Conservation Strategy for Alberta[xii] (Provincial)

Overview. This strategy was developed to guide management of fisheries resources in a manner consistent with the *Fisheries Act*[xiii] of Canada and the Fish and Wildlife Policy for Alberta. The document's foundation is the Fisheries Management Division's mission statement "to sustain the abundance, distribution and diversity of fish at the carrying capacity of their habitats"[xiv]. The primary components of the strategy are habitat maintenance, fish conservation and fish-use allocation.

Relation to end pit lake development. Due consideration must be given to the seven guiding principles when developing end pit lakes[xv]. The principles are:

1. No net loss of the productive capacity of habitats; every effort should be made to avoid habitat losses. If habitat losses are unavoidable, they should be balanced with habitat replacement.
2. Fish populations are to be maintained by natural reproduction wherever possible; natural reproduction is the most biologically sound and cost-effective way of maintaining fish populations and fish production.
3. Biological diversity of the fish fauna is to be maintained, and the depletion or extirpation of species, populations and sub-populations or unique strains should be avoided.
4. Management of the fisheries will be based on fundamental ecological principles and factual information.
5. There should be public involvement and education in the fisheries management process.
6. The "user-pays philosophy" should augment the financing of the stewardship and management of fish resources.
7. Public access should be provided and maintained to waters producing publicly-owned fish

The aforementioned principles will assist in achieving the goals set out for each of the three primary goals listed below. The habitat maintenance and fish conservation goals are directly applicable to the pre-certification phase of end pit lake development. These goals are:

Goal 1: Habitat Maintenance Restore and maintain the natural productive capacity of fish habitat, and where possible and appropriate, increase the amount of productive fish habitat.[xvi]

Fish habitat is defined by the *Fisheries Act* as “spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes.[xvii]. Habitat in our context also includes instream flow needs, water quality, fish health and ecosystem integrity.

Goal 2: Fish Conservation Restore and maintain the abundance, distribution and diversity of fish through natural reproduction.[xviii]

Goal 3: Fish Use and Allocation

The strategy states that proponents of development should rehabilitate habitat they alter in order to restore or maintain productive capacity. In this instance, aquatic habitat created or altered during coal extraction should meet the habitat maintenance goal in order to achieve the natural reproduction component of the fish conservation goal.

Water Body Management Strategy System

Overview. The Water Body Management Strategy System outlines how to develop, approve and implement site-specific fisheries management strategies. The two main components of a water body management strategy are 1) the current fisheries management strategy and 2) a proposed management plan.

A Fisheries management strategy outlines the "existing fisheries management actions that maintain a defined fishery (ies)." It should outline all regulations, habitat protection and improvement actions, and public information sessions used to achieve the desired objectives for that water body. The specific form and content of a fisheries management strategy is outlined in this document.

The proposed management plan examines the future of a specific water body, and outlines the steps required to implement a new fisheries management strategy. A proposed management plan is required if the current fisheries management strategy cannot maintain the resource, if public expectations are not being met, to maximize production, or to address issues in fish conservation and allocation.

Relation to end pit lake development. The information required to develop both a fisheries management strategy and a proposed management plan is outlined in the water body management strategy system. Much of this information should be collected when monitoring the end pit lakes after introducing fish.

Relation to these guidelines. Specific, measurable objectives and goals should be established for an end pit lake so that a fisheries management strategy can be developed prior to stocking (see "Regional Fisheries Management Plans" below). If the initial goals and objectives change or cannot be met, a proposed management plan must be developed for the lake.

Regional Fisheries Management Plans (Provincial)

Overview. Regional fisheries management plans identify priorities concerning fish stocks, habitat, stocking and public use. The fisheries management plan for the northern east slopes region, while currently in development, is guided by various government policies/strategies. *A Policy for Resource Management of the East Slopes*, *A Fish Conservation Strategy for Alberta,* and the *Coal Branch Integrated Resource Plan* are particularly important with regard to end pit lake development.

Relation to end pit lake development. Fish stocking decisions are guided by *A Fish Stocking Process for Alberta*[xix] and *A Decision-Making Process for the Evaluation of Fish Introductions in Alberta*[xx]. The management principles involved are:

1. maintain fish populations through natural reproduction wherever possible
2. prevent the introduction of undesirable fish species
3. prevent the spread of fish diseases and fish parasites
4. maintain genetic composition of natural fish stocks
5. avoid negative impacts to existing fish populations and sensitive ecosystems
6. prevent the depletion or extirpation of any fish species
7. match proposed fish species and its biological needs to the habitat and environmental conditions of the water body and to the well-being of the resident fish community
8. indicate a demand and need to support a fish introduction
9. public consultation: resolve potential problems concerning resource use, lake use and environmental impacts through management planning prior to approving fish introductions

Before introducing fish into an end pit lake, Alberta Sustainable Resource Development fisheries staff must complete a water body management strategy and risk analysis. These documents will incorporate the lake objectives and all monitoring data collected by the mine to date. The management strategy should also spell out where the fish to be stocked will come from. The process associated with stocking fish is different depending on the source (hatchery vs. transplanted wild fish).

End pit lakes requiring hatchery stock should be incorporated into the region's 5-year planning cycle. An end pit lake displaying adequate biological development can be added to the schedule, then assessed again the summer before it is scheduled for stocking. If end pit lake development is inadequate (i.e., poor forage base, low biodiversity), the fish will be re-assigned to another lake in the region.

After stocking hatchery fish, the province requires an evaluation of stocking success. The mine carries out the evaluation as part of their monitoring program. The evaluation must reflect end pit lake objectives. For example, a put and take fishery end pit lake might only need to demonstrate fish growth and production while a lake slated to support a self-sustaining fish population would require evidence of sufficient recruitment, fish growth and production. If an end pit lake is not meeting its objectives with respect to fish, its objectives will be reassessed and the future of that end pit lake discussed. End pit lakes to receive continued stocking of hatchery fish (put and take fishery) will be assigned a priority as outlined in the document "*Fish Stocking Process for Alberta*" and stocked accordingly.

In situations involving fish not currently in the culture system (i.e., bull trout, lake trout, arctic grayling), fish must be removed from a disease free watershed that can tolerate the removal. This action must be done with the approval of area fisheries managers and stocking success evaluated as outlined above. This type of stocking is not sustainable, therefore, if self-sustaining populations are not established, modifications must be made to the lake, or the objectives of the lake re-evaluated. It is not possible to maintain a put and take fishery with fish outside the culture system.

Federal Legislation, Policy and Guidelines – Overview

This standard text is intended to for use in guideline documents. This text briefly introduces the *Fisheries Act*, the *Habitat Policy*, the role of Habitat Management in protecting fish habitat, the habitat protection provisions of the *Fisheries Act* and CEAA.

The *Fisheries Act* is federal legislation established to manage and protect Canada's fisheries and their supporting habitats. It applies to all Canadian waters and the exclusive economic zone and continental shelf of Canada. The *Fisheries Act* applies in all Provinces and Territories and affects both the Provincial and Federal Crown.

The federal department, Fisheries and Oceans Canada (DFO), is responsible to Parliament for administering the provisions of the *Fisheries Act* designed to protect fish habitat.

Section 35(1) of the *Fisheries Act* frequently applies to projects undertaken in or near water. This section prohibits the unauthorized "harmful alteration, disruption or destruction of fish habitat" (HADD). DFO defines HADD as:

"... any change in fish habitat that reduces its capacity to support one or more life processes of fish".

Any HADD that occurs, as a result of a work or undertaking is a violation of s. 35(1) of the *Fisheries Act* unless authorized by the Minister of Fisheries and Oceans under s. 35(2) or by regulation.

To comply with the *Fisheries Act* the project must either avoid HADD <u>or</u> the resulting HADD must be authorized.

Measures that may be used to avoid HADD of fish habitat include relocating or redesigning the project. Other measures that avoid adverse effects to fish habitat should be included in the planning, design, construction and operation phases of the project.

An Authorization may be issued when HADD cannot be avoided in keeping with the *no net loss* guiding principle outlined in DFO's *Policy for the Management of Fish Habitat* (1986). Authorizations are generally issued when the HADD can be compensated. Authorizations may be denied in cases where adequate compensation is not possible, where the habitat losses are unacceptable or for other reasons (e.g., habitats that are essential or critical for the survival of a fish species).

6.4 Other Sections of the **Fisheries Act**

Other sections of the *Fisheries Act* protect fish and fish habitat from the effects of human activities. These include:

- s.20(1): Requirement for safe passage of fish around an obstruction using fish-ways or canals;
- s.21(4): Provision of fish stops or diverters at obstructions;
- s.22(1): Provision of sufficient flow over obstructions;
- s.22(2): Provision for free upstream and downstream movement of fish during construction of an obstruction;
- s.22(3): Provision of sufficient water downstream of an obstruction for the safety of fish and flooding of spawning grounds;
- s.26. Main channel not to be obstructed;
- s.29. Nets, weirs etc. not to obstruct passage;
- s.30(1): Requirement for fish guards and screens at water intakes, ditches, channels or canals;
- s.32. Prohibition of the unauthorized destruction of fish by means other than fishing;

- s.36(1): Prohibition of throwing overboard certain substances;
- s.36(3): Prohibition of the discharge of deleterious substances in waters frequented by fish, unless otherwise authorized by regulation;

- s. 36(5): Governor in Council may make regulations for authorizing certain deposits;
- s.37(1): Requirement to provide plans specifications or undertake studies at the request of the Minister of Fisheries and Oceans;
- s.37(2): Requirement to implement modification or mitigation measures if ordered by the Minister of Fisheries and Oceans;

Canadian Environmental Assessment Act

Subsection 35(2) of the *Fisheries Act* is listed in the *Canadian Environmental Assessment Act* (CEAA) *Law List Regulations*. This means that for most works and undertakings, an environmental assessment (EA) pursuant to CEAA must be completed before a *Fisheries Act* Authorization can be issued. If the EA is favourable, an Authorization may be issued. Other sections of the *Fisheries Act* that trigger CEAA are s. 22(1), 22(2), 22(3), s. 32, s. 36(5) and s. 37(2).

Additional Information

Additional information may be obtained from:

Fisheries and Oceans Canada
Habitat Management and Environmental Science
200 Kent Street
Ottawa, Ontario
K1A OE6

or from your nearest DFO Region Office.

Pacific Region
Suite 400, 555 West Hastings Street
Vancouver, B.C. V6B 5G3
(604) 666-0384

Central and Arctic Region
501 University Crescent
Winnipeg, MB R3T 2N6
(204) 983-5000

Canadian Environmental Quality Guidelines (Federal)

Overview. The Canadain Council of Ministers of the Environment (CCME 1999) promotes the protection of freshwater environments from anthropogenic stressors jointly with the federal government, the Provinces and Territories. The CCME publishes (among other guidelines) *the Water Quality Guidelines for the Protection of Aquatic Life* and the *Sediment Quality Guidelines for the Protection of Aquatic Life* that are compiled into one document titled the *Canadian Environmental Quality Guidelines*. Some important factors to consider relating to these guidelines are:

- CCME proposes nationally consistent environmental standards and objectives so as to achieve a high level of environmental quality across the country.
- Guidelines are numerical limits or narrative statements based on the most current, scientifically defensible, toxicological data available for the parameter of interest.

- CCME does not impose its recommendations on its members and has no authority to implement or enforce legislation. The legislative authority for implementation lies primarily with each Provincial or Territorial jurisdiction, with the exception of Federal lands.
- CCME does not duplicate the efforts of other agencies. Items on the CCME agenda must be national and intergovernmental in nature, and of interest to a significant portion of CCME jurisdictions.

Relation to end pit lake development. Federal agencies such as Environment Canada and the Department of Fisheries and Oceans use CCME environmental quality guidelines including water quality and sediment quality guidelines to evaluate monitoring data in assessments of ambient conditions and to identify the potential for adverse effects on aquatic biota in aquatic ecosystems in Alberta. However, it is important to note that CCME guidelines do not exist for all substances that may cause a deleterious effect to fish. Furthermore, as stated in the *Environmental Quality Guidelines*:

For waters of superior quality or those supporting important biological resources, the CCME non-degradation policy states that the degradation of the existing water quality should always be avoided. The natural background concentrations of parameters and their range should also be taken into account in the design of monitoring programs and the interpretation of the resulting data.

Relation to the guidelines. Pertinent Canadian environmental quality guidelines including water quality and sediment quality guidelines for the protection of aquatic life will be used by Federal agencies and Alberta Environment in evaluating the potential of adverse effects on aquatic biota in end pit lakes. More detail on the uses of federal guidelines by Alberta Environment is provided in the section entitled *Surface Water Quality Guidelines* (Provincial) above.

7 APPENDIX C

ADAPTIVE MANAGEMENT

Adaptive Management

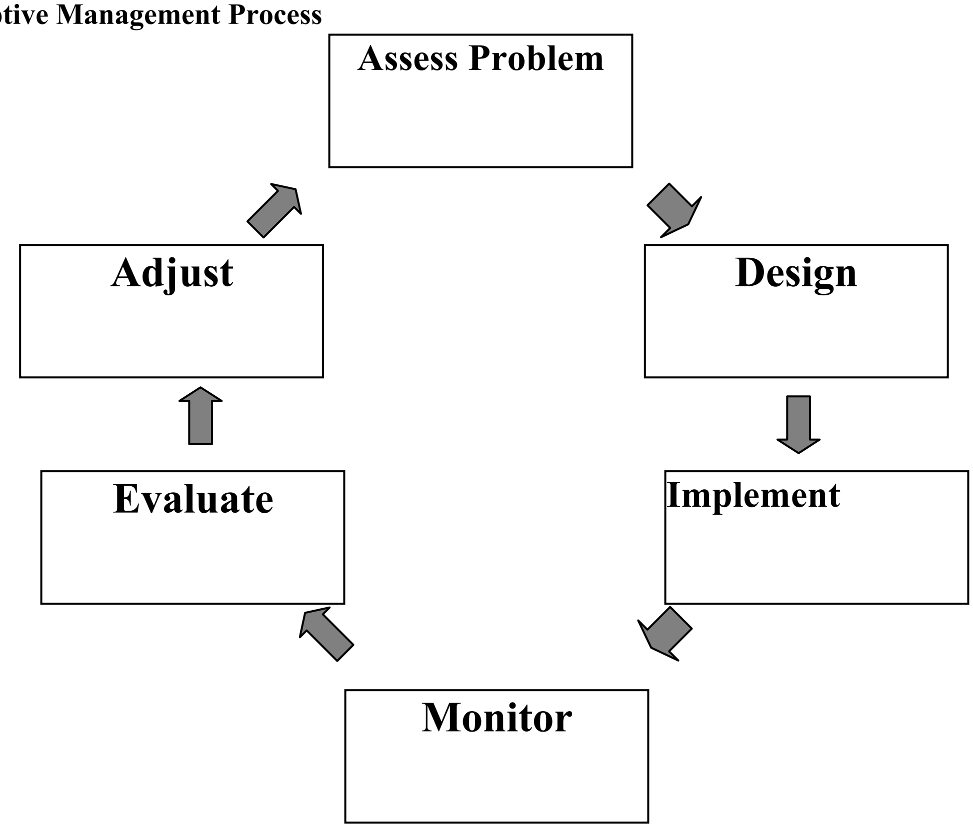
First developed in the 1970's by C.S. Holling[xxi] and co-workers at the University of British Columbia and the International Institute for Applied Systems Analysis, Adaptive Management is a process for continually improving management policies and practices by learning from the outcomes of operational programs. It is 'learning while doing'. By learning from the process of creating self-sustaining end pit lakes and documenting that learning, guidelines for end pit lake development can be continuously improved as our knowledge base grows.

Adaptive Management consists of quasi-experiments in the field that probe the responses of the ecosystem[xxii].

Adaptive Management is more rigorous than 'trial and error' (problem oriented observation aimed at solving or mitigating particular problems) and 'experience" (anecdotal observations). It is less rigorous than 'laboratory experimentation' which uses controlled replicated observation to infer cause and enable prediction.

The six main steps in Adaptive Management are shown below:

Figure 1. Adaptive Management Process



1. Problem assessment. During problem assessment, the scope of the problem is defined, existing knowledge about the problem is synthesized and the potential outcomes of alternative management actions are explored. Explicit forecasts about outcomes are made in order to assess which actions are most likely to meet management objectives. Key gaps in understanding should be identified and research/monitoring programs established to gain insight into them.
2. Design. This involves designing a construction management plan and monitoring program that will provide reliable feedback about the effectiveness of the chosen construction actions. Ideally, the plan should also be designed to yield information that will fill in the key gaps in understanding identified in the problem assessment phase.
3. Implementation. During this step, the end pit lake is constructed.
4. Monitoring. Indicators or parameters are monitored to determine how effective actions are in meeting management objectives and to test the hypothesised relationships that formed the basis for the forecasts.
5. Evaluation. Compares the actual outcomes to forecasts and interprets the reasons underlying any differences.
6. Adjustment. Practices, objectives and the models used to make forecasts are adjusted to reflect new understanding. Understanding gained in each of these steps may lead to reassessment of the problem, new questions, and new options to try next time.

8 APPENDIX D

RAINBOW TROUT SPAWNING HABITAT REQUIREMENTS

Rainbow Trout spawning habitat requirements

Introduction

Of all the different habitats required by rainbow trout (RNTR), spawning habitat has proven one of the most difficult to create/enhance (Hartman and Miles 2001). Hence, papers were included in this section if they mentioned specific rainbow trout spawning habitat requirements (or lack thereof) associated with lakes. As it is likely that the endemic strain of Alberta rainbow trout will be stocked in northeast slopes end pit lakes, stream spawning requirements of RNTR in this region are included. The emphasis of this section is on local research/reports and is a starting point, not an exhaustive search. **Also note that many of the physical parameters (i.e., gravel size and water depth) vary with fish size.**

Rainbow trout in the McLeod watershed – Alberta.

Schwartz, T. and J.H Allen. 1999. Fisheries Investigations at Lac Des Roches and West Jarvis Creek in 1998. Pisces Environmental Consulting Services Ltd.

- excavated RNTR redds in 4 sites on West Jarvis Creek; eggs in 2 sites buried 10 to 15 cm below the surface of finer gravel

Sterling, G. 1986. An evaluation of spawning habitat and fry escapement of rainbow trout (*Salmo gairdneri* Richardson) before logging in the Tri-Creek watershed of west-central Alberta. Research report #9. Alberta Environment. Edmonton, Alberta. 74 p.

- focused on Wampus and Deerlick creeks from 1969 to 1977
- majority of males matured at age 3 and females at 4
- egg pits were generally less than 0.3 m^2
- egg depth was generally less than 12 cm and depended on particle size; smaller the particles, deeper the eggs
- 75% of spawning substrate less than 25.4 mm in diameter; none > 76 mm
- mean fecundity of 293 ± 16; egg numbers and fork length highly correlated
- water velocities and depths at spawning sites were 32.3 ± 1.2 cm/sec and 14.5 ± 0.7 cm respectively
- cites Anders (1974) who calculated that spawning gravel of rainbow trout in tri creeks would begin to move at 0.566 m^3/s
- on average, 33% fry escaped from spawning gravel
- fry survival density dependent (negative correlation)

Sterling, G. 1990. Population dynamics of rainbow trout (*Oncorhynchus mykiss*) in the Tri-Creeks experimental watershed of west-central Alberta; a postlogging evaluation. Research report #10. Alberta Environment. Edmonton, Alberta. 68 p.

- studied population densities, age, growth, mortality and recruitment in Wampus, Deerlick and Eunice creeks from 1970 to 1985 inclusive
- flood events had a major impact on population dynamics
- sex ratio: for combined age classes, sex ratio was 0.92 females for each male
- egg content of females correlated to fork length
- mortality : trout fry and age 9 fish had instantaneous mortality rates of 0.1124 and 0.1029 respectively
- mortality declined until age 3 then increased until life expectancy
- eggs had a 0.0061 chance of surviving to age 4
- recruitment ranged from 147 to 3564 fry/0.10 ha depending on the stream and year
- most male RNTR's in the region mate by age 3-4 while females mate at 4-5; females can be as small as 90 mm when mature

Sterling, G. 1992. Fry emergence survival of rainbow trout, *Oncorhynchus mykiss* (Walbaum), following timber harvest in two foothill streams of west-central Alberta. M.Sc. thesis. University of Alberta, Edmonton, Alberta. 116 p.

- focused on Wampus and Deerlick creek from 1973 to 1985
- spawning; generally in the first 10 days of June following 104 to 122 degree days after ice out
- spawning occurred in pool/riffle transition areas
- spawning sites had mean velocities of 31.1 ±0.8 cm s^{-1}; depths 14.3 ± 0.5 cm
- mean substrate size in spawning areas of 9.9 ± 0.5 cm and less than 12.1 % fines (<0.841 mm)
- water yield in Wampus exceeding a critical flow of 0.731 m^3 s^{-1} during incubation accounted for significant mortality
- increase of fines (<2.0 mm), of which the clays and silt component was dominant (<0.62 mm), was associated with increased mortalities
- cites Reiser and Bjornn (1979) who say <25% fines acceptable

Rainbow Trout in Streams - Alberta

Monenco Consultants Limited. 1983. Rainbow trout spawning habitat measurement study for Alberta Environment. Calgary, AB. 44 p.

- did not document redd success, only habitat parameters
- Threepoint Creek – turbid; low redd density; mean depth 0.57 ft ±0.18 (17.4 ± 5.5 cm); velocity 1.33 ±0.39ft/sec (0.41 ± 0.12 m/s); gravel 0.25 to 1.3 inches (6.35 to 34 mm) in diameter
- Ware Creek – depth 0.67 ft ±0.23 (20.42 ±7.0 cm); velocity 1.72±0.47 ft/sec (0.52 ±0.14 m/s); gravel 0.25 – 1.3 inches in diameter
- Pekisko Creek – depth 0.8 ft ±0.24 (24.4 ± 7.3 cm); velocity 2.03±0.53 ft/sec (0.62±0.16 m/s); gravel 0.25-1.3 inches in diameter
- Sullivan Creek – low redd density; depth 0.74 ft ±0.22 (22.6 ±6.7 cm); velocity 1.66±0.46 ft/sec (0.51+-0.14 m/s); no gravel measurements documented

Rainbow Trout in Lakes – British Columbia

Lindsey C.C., T.G. Northcote and G.F. Hartman. 1959. Homing of rainbow trout to inlet and outlet spawning streams at Loon Lake, British Columbia. J. Fish. Res. Board Can. 16 (5): 695 – 719

- traps set up at the inlet and outlet of Loon lake during spawning season from 1953 to 1956
- outlet fry: emerge between late May and early Aug; some migrate into lake others stay in outlet overwinter
- inlet fry: emerge between late June and late Sept. and almost all move into the lake during their first summer
- inlet output exceeds that of outlet
- adults mix throughout the lake though they show some preference for spawning in natal areas

Hartman, G.F. 1969. Reproductive biology of the Gerrard stock rainbow trout. p. 53-67. IN: TG. Northcote (ed.) Symposium o salmon and trout in streams. H.R. MacMillan lectures in fisheries, Institute of Fisheries, University of British Columbia. 388p.

- Kootney Lake drainage rainbow trout are large fish; 3.5 to 12 kg
- fish move into section below Trout lake outlet (Lardeau River) to spawn
- : George asked me some quesitons on these numbers that the paper could not answer so I just took this line out
- water velocities were stable during spawning; between 50 to 90 cm/sec
- clean water; little to no silt

- includes a table which describes some other large sized RNTR spawning habitats; info was primarily given as general info, not precise or detailed; some of the table info is below:

Lake	Lake area (km^2)	Approx. weight of fish (kg)	Approx. stream dimensions in m.	spawning area in lake outlet
Kootenaey	435	3.5 - 12	width - 30 - 45 depth - 0.5 - 2.0	Yes
Shushwap	324	1.5 - 10 (3.5 ave.)	width - 20 - 25 depth - 0.3 - 1.0	Yes
Slocan Pool	32	1.5 - 3 (6 max)	width - 45 - 90 depth - 1.0 - 2.0	Yes
Quesnel	259	3.5 - 12	unknown	Yes
Arrow	380	2 - 4.5	width - 10 - 15 depth - 0.6 - 1.5	No
Okanagan	352	1.5 - 9 (4.5 ave.)	width - 20 - 25 depth - 0.3 - 1.0	No
Stuart	360	fish 7 kg recorded	width - 10 - 15 depth - 0.6 - 1.0	Possibly
Pend d'Oreille	Ca 325	5.5 - 7 (or more)	width - 2.5 - 10 depth - 0.3 - 0.6 (range of several streams)	No

(adapted from Hartman, 1969)

Rainbow Trout Lakes - other studies

Penlington, B.P. 1983. Lake-shore spawning of rainbow trout at Lake Rotoma, New Zealand. N.Z. J of Mar. Fresh. Res. 17: 349-355.

- In-lake spawning areas in Lake Rotoma were monitored from 1976 to 1979
- Spawning observed in water depths from 10 to 150 cm
- Redds varied in size from 5 to 20 m^2
- Spawning site selection did not seem to be related to groundwater upwellings
- Substrate in spawning areas was primarily gravel; non-spawning areas were sand
- 26.8 % of the gravel on the spawning beds was between 19 to 75 mm
- temp and O_2 did not differ significantly between spawning and non-spawning sites
- fry in fry trap suffered 68% mortality
- hypothesize that water movement (i.e. wave action) likely important in lakes

NOTE: fish size was not given but based on the size of spawning gravel used, they are likely quite large

Kelso, J.R.M. and Kwain W.H. 1984. The post-spawning movement and diel activity of rainbow trout, *Salmo gairdneri*, as determined by ultrasonic tracking in Batchawana Bay, Lake Superior, Ontario. Can. Field Nat. 98(3): 320-330.

- tracked 33 fish over 3 years in Batchawana Bay using radio transmitters

- researchers only tracked fish when they were in the lake; did not track spawning stream
- fish ranged from 34.2 cm to 68.8 cm fork length
- males would occasionally enter the spawning stream more than once
- greatest activity in lake occurred between 6 and 9 am
- less active in afternoon/evenings
- most fish remained within 150 m of shore and in water < 3 m in depth (30 to 40% of the time); otherwise most often in 10 m strata
- fish followed the shore line when travelling

Additional papers that may be of use

Allon, S.P. 1970. Physical factors influencing trout density in a small stream. Colorado State University, Ph.D.Thesis.

- Relates physical parameters to trout density.

Allen, J.H. 1981. An evaluation of the aquatic resources of three streams in the Edson area. Prepared for NOVA, Calgary, AB. Pisces Environmental Consulting Services, Red Deer AB. 78 p.

- Assessed three streams to determine the route of least possible environmental damage
- Documented fish, and benthic communities, water quality and physical habitat characteristics in stream sections in June, July, August and September.

Kelso, B.W., and T.G. Northcote. 1981. Current response of young rainbow trout from inlet and outlet spawning stocks of a British Columbia lake

- exposed fry from both inlet and outlet stocks to current
- suggests differences that could have implications for spawning success of stocked fish

Beauchamp, D.A., E.R. Byron and W.A. Wurtsbaugh. 1994. Summer habitat use by littoral-zone fishes in Lake Tahoe and the effects of shoreline structures. Nor. Am. J. Fish. Manage. 14: 385-394.

- documented the substrate in the littoral zone and the fish associated with each type
- littoral zone defined as 0 to 18 m in depth but 50% of littoral zone is < 2 m in depth
- used boat and diver observation
- highest densities of all littoral zone fish found near boulder and cobble-boulder substrates; adult RNTR generally found in this habitat type
- RNTR found primarily at < 10 m in depth in complex habitats

Wang, L., K. Zimmer, P. Diedrich and S. Williams. 1996. The two-story rainbow trout fishery and its effect on the zooplankton community in a Minnesota lake. J. Freshwater Ecol. 11(1) : 67-79.

- evaluated location and predation of stocked RNTR
- rainbow trout found in strata <21 ºC and > 5 mg/L oxygen
- RNTR moved into shallower water (3.5 to 7 m) along the shoreline at night then in the open water thermocline during day
- dominant food organisms were *D. pulex* and Chironomidae

Dalacoste M., P. Baran, J.M. Lascaux, N. Abad, and J.P. Besson. 1997. Bilan des introductions de salmonides dans les lacs et russeaux d'altitude des hautes-Pyrenees. Bull. Fr. Peche Piscic. 344/345: 2.5-219.

- article looked at the consequence of salmonid introductions (6 species) into upper Pyrenees lakes
- all lakes were 1500 m + elevation; open water season ranges from 5 months to 6 weeks
- salmonids were introduced into lakes from 1906 to 1992; 477 introduction events in total
- 81% of introduction events resulted in fish that survived and grew
- 9% of introduction events resulted in naturally reproducing populations
- the native species (brown trout) naturalized (reproduced) in the greatest number of sites
- the lack of appropriate tributary (inlet/outlet) was the reason many of the species, including RNTR, did not naturalize

Post, J.R., E.A. Parkinson and N.T. Johnston. 1998. Spatial and temporal variation in risk to piscivory of age-0 rainbow trout: patterns and population level consequences. Trans. Am. Fish. Soc. 127: 932-942.

- evaluated the risk of predation on age-0 RNTR from pisciverous adult trout
- surface pelagic and littoral zone habitats are the lowest risk for age-0 RNTR during the day

Hartman, G., and M. Miles. 2001. Assessment of techniques for Rainbow Trout transplanting and habitat management in British Columbia. Can. Man. Rep. Fish. Aquat. Sci. IN PRESS

- investigated the effectiveness of compensation measures used to (re) create RNTR habitat
- few of the projects involving constructed/enhancing spawning habitat have been successful (<50%)

- discusses studies that found RNTR to use gravel of 0.2 to 45 cm diameter depending on fish size; typically use gravel of 0.4 to 10 cm diameter
- fines (< 2 mm) should not make up more than 5% of spawning site
- gravel must be permeable to allow interstitial flow but stream bed must also be stable
- water depth and velocity increases with fish size
- velocity ranges from 30 to 90 cm/s but 75 to 90 cm/s is high for RNTR <35 cm long
- depth ranges from 75 to 80 cm
- pH of 6.0 to 9.0
- heavy metal toxicity varies with O_2 conc., pH and water hardness
- < 25 mg/L suspended sediment
- this document includes a lot of detail around what led to the success/failure of certain projects and should be read so as to avoid repeating mistakes

9 APPENDIX E

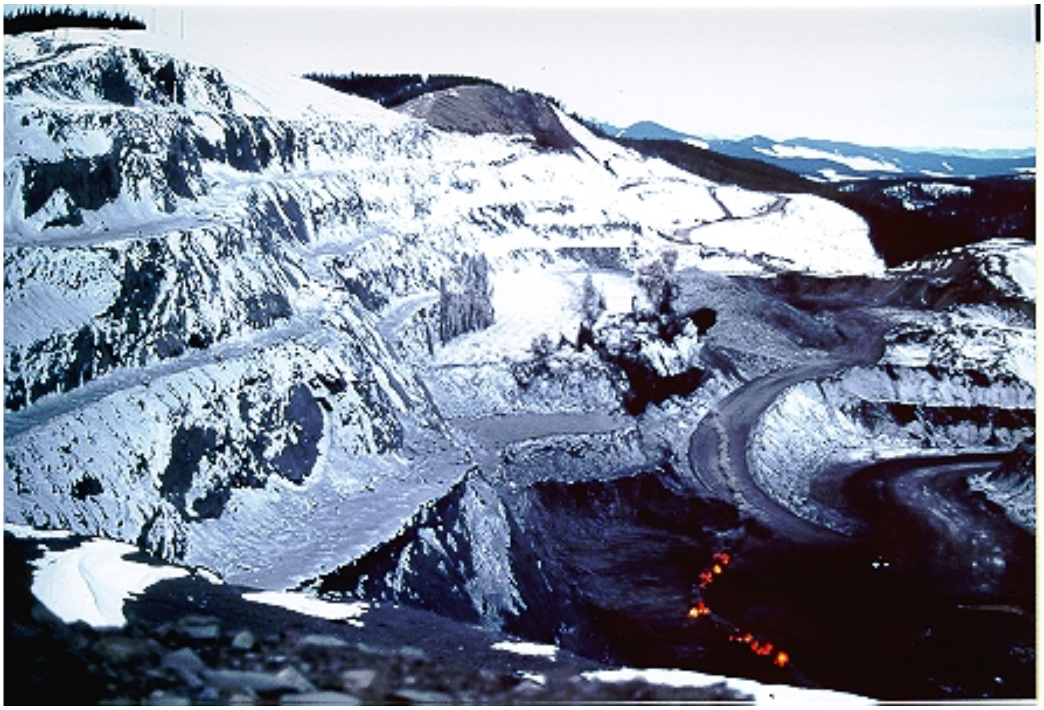
EXAMPLES OF END PIT LAKE DEVELOPMENT

Mine Excavation - Coal Valley - 1984

End pit lake formed - Coal Valley - 1986

New vegetation & tree growth - Coal Valley - 1990

Lovett Lake - well-established vegetation & shoreline



Lac Des Roches - Benched excavation

Lac Des Roches - Commencement of fill of end pit lake

Lac Des Roches - Lake filling and water turbidity reduced. No shoreline vegetation established at this time.

Lac Des Roches - Establishment of shoreline vegetation & littoral zone.

Early filling of Silkstone end pit lake. - Note steep talus slopes and lack of vegetation.

Silkstone end pit lake - Established vegetation and littoral zone

Construction of outlet to Silkstone end pit lake

Functioning outlet channel from Lac Des Roches

[i] Alberta. (1976). ***Coal Policy.***

[ii] Alberta. (19??). ***Environmental Protection and Enhancement Act., c. E-13.2.***

[iii] Alberta. (1993) ***Conservation and Reclamation Regulation***. Alberta Regulation 115/93.

[iv] Alberta. (1999). ***Water Act, RSA. c-W-3.5.***

[v] Alberta. (19??). ***Public Lands Act. c. P-30.***

[vi] Alberta Forestry, Lands and Wildlife. (1990). ***Coal Branch Integrated Resource Plan***.

[vii] Alberta Environment. (1999). ***Surface Water Quality Guidelines for Use in Alberta***. 20 p. (This report is available at http://www.gov.ab.ca/env/water/reports).

[viii] CCME. (1999). ***Canadian Environmental Quality Guidelines***. Canadian Council of Ministers of the Environment. Environment Canada. Hull, Quebec; 8 chapters.

[ix] US-EPA. (1999). ***National Recommended Water Quality Criteria - Correction***. Office of Water 4305, United States Environmental Protection Agency. EPA 822-Z-99-001. 25 p.

[x] Health Canada. 1996. Guidelines for Canadian Drinking Water. 6th ed. #96-EHD-196. 90 p.

[xi] CCME (1999) ***Canadian Environmental Quality Guidelines***. Canadian Council of Ministers of the Environment. Environment Canada. Hull, Quebec; 8 chapters.

[xii] Alberta Environment. (1998). ***A Fish Conservation Strategy for Alberta***. Edmonton: Natural Resources Services, Fisheries and Wildlife Management Division. Publication No. I/698. 19 p.

[xiii] Canada. (1998). ***Fisheries Act***. ***R.S., c. F-14.***

[xiv] Alberta Environment. (1998). ***A Fish Conservation Strategy for Alberta,*** p. 3.

[xv] Ibid. p. 14-18.

[xvi] Ibid. p. 5

[xvii] Canada. (1998). ***Fisheries Act***. ***R.S., c. F-14, s.34(1).***

[xviii] Alberta (1998). ***A Fish Conservation Strategy for Alberta***, p. 8.

[xix] Alberta. (1995). ***A Fish Stocking Process for Alberta***.

[xx] Alberta. (1993). ***A Decision Making Process for the Evaluation of Fish Introductions in Alberta***.

References

[xxi] Holling, C.S. ed. (1978). ***Adaptive Environmental Assessment and Management***. New York: John Wiley & Sons.

[xxii] Lee, Kai N. (1999). ***Appraising Adaptive Management***. Conservation Ecology 3(2):3. [online] http://www.conseecol.org/vol3/iss2/art3.