Guidelines for Performance Management of Oil Sands Fluid Fine Tailings Deposits to Meet Closure Commitments

Canada's Oil Sands Innovation Alliance

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Preface

Introduction

The large volume of oil sands processed by extraction plants in Alberta's oil sands mines results in the largest tailings facilities in the world. Oil sands tailings are deposited in above-ground and in-pit tailings impoundments. Sound engineering and management principles are used in the design and operation of these facilities to minimize environmental impacts and to meet engineering and safety standards.

An increasing number of oil sands mines will result in numerous tailings disposal impoundments that will be progressively reclaimed and closed in the 21st century. This reclamation requirement is hampered by a unique feature of oil sands tailings – the slow sedimentation and consolidation of fine tailings that are initially deposited in tailings ponds. These fluid fine tailings (FFT) require intervention with accelerated dewatering technologies, to enable reclamation during the active mine life and within a reasonable time after the cessation of mining. To address public concerns over this issue, the predecessor to the Alberta Energy Regulator (AER) enacted Directive 074 in 2009 to focus industry attention on disposal of FFT within set timeframes.

Document Context and Development Timeline

In August 2012, the Government of Alberta issued the Lower Athabasca Regional Plan 2012–2022 (LARP), a land-use policy document for the region, which had been under development since Alberta's Land Use Framework was released in December 2008.

The LARP intends to encourage "timely and progressive reclamation" of industrial sites, and for mineable oil sands states that "…the Government of Alberta will establish a tailings management framework for mineable oil sands operations. The framework will provide guidance on managing tailings to provide assurance that fluid fine tailings will be reclaimed as quickly as possible, and that legacy (current) inventories will be reduced."

Following issuance of LARP, Alberta Environment and Sustainable Resource Development (AESRD) began a process of consultation with stakeholders and oil sands mine operators through the Canadian Association of Petroleum Producers (CAPP).

To support its policy review on these matters, CAPP requested technical support from the industry. To that end, Canada's Oil Sands Innovation Alliance (COSIA) developed the *Technical Guide for Fluid Fine Tailings Management*, released in August 2012. That document described the different types of tailings deposits that could be produced for integration in mine closure landforms, and how their performance and behaviour should be measured.

This document further defines the process to manage and report annual and five-year progress to regulators, for control of FFT volumes on each mine site, consistent with progressive reclamation and with the formation of tailings deposits to meet mine closure commitments.

Document Purpose

The purpose of this document is to provide oil sands mining operators with guidelines for creating FFT management plans, consistent with the intent of Directive 074 and other government policy and regulations. The purpose of FFT management plans is to facilitate closure of oil sands mines by accelerating the conversion of FFT into stable closure landscapes. It is based on the concept of reducing FFT over the life of the mine using best available, currently deployed tailings treatment technologies (BATEA), and technologies under development that are considered practical and workable in the oil sands industry. It is sensitive to, and can accommodate, future tailings dewatering technologies, and will be revised as necessary when they are developed. (Technologies to accelerate the dewatering of FFT are being improved across the industry and new technologies are constantly being assessed and developed to reduce cost and reclamation timeframes.) It is expected that oil sands operators will use technologies that are the most effective for their mining lease.

Reclamation of FFT is a uniquely Canadian issue, which is being addressed by the industry and by universities and research institutes across Canada. COSIA is facilitating this research through public technical conferences and facilitated discussions among industry participants.

This guideline adopts approaches from the following sources:

- Oil sands mining companies' policies, practices and procedures.
- Mining Association of Canada (MAC) documents Towards Sustainable Mining Guiding Principles (which includes environmental policies) and A Guide to the Management of Tailings Facilities.
- Canadian Dam Association (CDA) Dam Safety Guidelines.
- Other guidelines and standards.

This guideline is intended to help companies comply with government regulation and corporate policy, demonstrate due diligence, practice continual self-improvement, and protect employees, the environment, and the public (MAC 2011b). COSIA will provide it to CAPP for input to the ongoing LARP discussions with the Government of Alberta and stakeholders regarding a tailings management framework for mineable oil sands.

Acknowledgements

This document was prepared by a committee of independent industry experts under the sponsorship of the COSIA Tailings Environmental Priority Area. The document authors were:

1. John Sobkowicz (Committee Chair), P.Eng., Ph.D., Principal with Thurber Engineering Ltd., Past VP Technical, Canadian Geotechnical Society.
2. Alexander Hyndman, P.Eng., Principal Consultant, Magnus Limited.
3. Richard Dawson, P.Eng., Ph.D., Executive Vice-President and Principal, Geotechnical Practice, NorWest Corporation.
4. Bryan Watts, P.Eng., M.Sc., CEO, Klohn Crippen Berger Ltd., Past-President, Canadian Geotechnical Society.

It was reviewed by:

1. Representatives from the COSIA Tailings Environmental Priority Area.
2. Technical reviewers:
    a) Norbert Morgenstern, P.Eng., Ph.D., University of Alberta.
    b) Ross Eccles, B.Sc., M.Sc., Senior Principal, Environmental Management, Stantec.
    c) John Errington, Ph.D., John C Errington and Associates Ltd.
    d) Barry Hurndall P.Eng., C.Eng., MICE, Managing Director, BJH Engineering Ltd.
    e) Eddy Isaacs, Ph.D., FCAE, CEO, Alberta Innovates – Energy and Environmental Solutions.
    f) Bernard J. Roth BA (Hons), LLB, LLM, Partner, Dentons Canada LLP.
3. Regulatory reviewers:
    a) Jim Dilay, P.Eng., former AER (ERCB) Board member, reviewed this document for its practicality with regard to regulatory matters.
    b) Wayne Clifton, P.Eng., D.Sc., consultant to Saskatchewan Environment, Chair of the SK Environmental Code Development Committee and author of a report on results-based environmental regulation of the resource industry in Saskatchewan[1], reviewed this document for consistency with Canadian practice and recent regulatory reform trends.

The most recent version of this document and associated references are available through COSIA.

www.cosia.ca

[1] *Towards a Results-Based Regulatory System*. 2009. Report to the Saskatchewan Ministry of Environment. February 2009.

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Acronyms and Initialisms

Though every effort has been made to minimize the use of acronyms/ initialisms in this document, the following are used because of their very common adoption and understanding in the industry:

3D ..... three-dimensional
AER ..... Alberta Energy Regulator
AESRD ..... Alberta Environment and Sustainable Resource Development
BATEA ..... Best Available Technology Economically Achievable
Ca ..... calcium
CAPP ..... Canadian Association of Petroleum Producers
$CaSO_4$ ..... calcium sulphate
CDA ..... Canadian Dam Association
CO_2 ..... carbon dioxide
COSIA ..... Canada's Oil Sands Innovation Alliance
CT ..... composite tailings
DDA ..... dedicated disposal area
ERCB ..... Energy Resources Conservation Board
FFT ..... fluid fine tailings
FOFW ..... fines over (fines + water) ratio
LARP ..... Lower Athabasca Regional Plan
MAC ..... Mining Association of Canada
MFT ..... mature fine tailings
NST ..... non-segregating tailings
OSTC ..... Oil Sands Tailings Consortium
SFR ..... sand-to-fines ratio
TFT ..... thin fine tailings
TT ..... thickened tailings
UOSTCS ..... Unified Oil Sands Tailings Classification System
WT ..... whole tailings

Definitions and Units

µm	microns or micrometres – one millionth of 1 m
ASTM	American Society for Testing and Materials
Bitumen content	Mass of bitumen divided by mass of (solids + bitumen + water) x 100%.
Behaviour of FFT	Measured response of the FFT in a tailings deposit over time.
Coagulation	The agglomeration of fine particles in a tailings slurry, usually by addition of a chemical agent that alters the electrical charge on those particles, thereby reducing inter-particle repulsive forces and allowing particle agglomeration to occur.
Dedicated disposal area (DDA)	As defined in AER Directive 074, "…An area dedicated…to the deposition of captured fines using a technology or suite of technologies…."
Fines content	Mass of fines divided by mass of (solids + bitumen + water) x 100%.
Fines, fine solids	Mineral solids with particle size equal to or less than 44 µm, (does not include bitumen).
Fines/(fines + water) ratio (FOFW)	Mass of fines divided by the (mass of fines + water) x 100%.
Flocculation	The "clustering" of fine particles in a tailings slurry into groups or "flocs", usually by addition of a chemical agent that binds to those particles, thereby tying them together. The process of physical bridging of particles, which relies primarily on the size (or molecular weight, which represents polymer chain length) of the flocculant molecule rather than charge neutralization.
Fluid fine tailings (FFT)	A liquid suspension of oil sands fine tailings or fines-dominated tailings in water, with a solids content greater than 2% but less than the solids content corresponding to the Liquid Limit.
g/L	Grams per litre (used for polymer solution concentration).
g/t	Grams per tonne of dry solids (used for polymer addition rates).
Geotechnical fines content	Mass of fines divided by mass of solids x 100%
Geotechnical water content	Mass of water divided by mass of solids x 100%
Gravel	Mineral solids with a particle size > 2 mm and < 60 mm
Liquid limit	The geotechnical water content defining the boundary between a liquid and a solid in soil mechanics. This state is defined by a standard laboratory test (ASTM D4318-10; modified for use in oil sands tailings containing bitumen). It can also be described in terms of an equivalent FOFW or solids content. This test results in an equivalent remoulded shear strength of 1 to 2 kPa
L	litre
m	metre
MFT	A subset of FFT with a SFR of less than 1 and a solids content greater than 30% (nominal).
Pa (or kPa)	Pascals (or kilopascals)
Performance of FFT	A comparison of FFT behaviour to that predicted in the FFT management plan.
Plastic limit	The geotechnical water content defining the boundary between a plastic (i.e., remouldable) solid and a brittle solid in soil mechanics. This state is defined by a standard laboratory test (ASTM D4318-10; modified for use in oil sands tailings containing bitumen). It can also be described in terms of an equivalent FOFW or solids content. This test results in equivalent remoulded shear strength of about 100 kPa.
Progressive reclamation	The reclamation of mine areas during the life of the mine, to the extent practical, to reduce post-closure liability.
Sand	Mineral solids (excluding gravel) with a particle size greater than 44 µm and less than 2 mm (does not include bitumen).
Sand-to-fines ratio (*SFR*)	The mass ratio of sand to fines, i.e., the mass of mineral solids with a particle size >44 µm divided by the mass of mineral solids with a particle size ≤44µm.

Definitions and Units (cont'd)

Shrinkage limit	The geotechnical water content defining the point at which a soil, on loss of moisture, will experience no further volume reduction. This state is defined by a standard laboratory test (ASTM D4943-08; modified for use in oil sands tailings containing bitumen).
Solids	Sand, clay and other solid particles contained in oil sands tailings (does not include bitumen).
Solids content	Mass of solids (including bitumen) divided by mass of (solids + bitumen + water) x 100%.
Subaerial deposition	Deposited above water with exposure to the atmosphere.
Subaqueous deposition	Deposited below the water surface.
Sustainable landscape	A mature, reclaimed landscape that is stable within the natural environment.
t/m^2-y	Tonnes (typically, of dry solids) per square metre per year.
Thin fine tails (TFT)	A subset of FFT with a SFR of less than 1 and a solids content less than 30% (nominal).
Void Ratio	Volume of voids divided by volume of solids.
Water content	Mass of water divided by mass of (solids + bitumen + water) x 100%.
Whole tailings	Tailings produced directly from the primary and secondary separation vessels in the extraction plant, containing sand, fines and water from the oil sands ore plus recycle water.

1 Introduction

1.1 Document Purpose

This document provides oil sands mining operators with guidelines for creating fluid fine tailings (FFT) management plans, consistent with the intent of evolving government policy and regulations. The purpose of FFT management plans is to facilitate closure of oil sands mines by accelerating FFT conversion into stable closure landscapes.

The oil sands industry has developed a number of innovative technologies to contend with the naturally slow sedimentation and consolidation of FFT. Research and development continue to improve and commercialize these technologies. Even so, establishing reclaimable tailings deposits takes years to decades to accomplish, and their efficacy takes years to validate. This unique aspect of oil sands tailings disposal includes site- and process-specific uncertainties. For these reasons, each oil sands operation requires a FFT management plan, in addition to a conventional waste and tailings disposal plan.

The FFT management plan must be achievable and progressively verifiable. The oil sands operator makes a commitment to:

- Manage FFT over the life of the mine to a volume profile consistent with the approved tailings management plan.
- Place FFT in permanent deposits, where they will progress, at an approved rate, to a reclaimable state and where their behaviour will be monitored.

These commitments must align with a large spectrum of operational and planning objectives, including the following typical mine closure objectives:

1. To eliminate long-term storage of FFT behind dams in the closure landscape.
2. To establish a stable closure landscape, with sustainable and diverse ecosystems, within a reasonable time after cessation of mining activities.
3. To develop a sustainable surface drainage including a functional lake system.
4. To facilitate progressive reclamation.
5. To optimize full lifecycle costs without compromising reclamation objectives.

In meeting these closure objectives FFT management plans should consider the information in the following documents:

- *De-Licensing of Oil Sands Tailings Dams* (Oil Sands Tailings Dam Committee 2012)
- End Pit Lakes Guidance Document (CEMA 2012)
- Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (CEMA 2010)
- Guideline for Wetland Establishment on Reclaimed Oil Sands Leases (CEMA 2007).

Reference should also be made to the technical information provided in the *Technical Guide for Fluid Fine Tailings Management* (OSTC/COSIA 2012), which sets out the types of tailings deposits produced by the different process methods and their critical performance factors, and on the *Oil Sands Tailings Measurement Protocol* (COSIA 2014a), which describes methods of measuring oil sands tailings behaviour.

As shown in Figure 1-1, these documents (together with others) comprise a comprehensive set of oil sands industry practices for tailings management, particularly FFT.

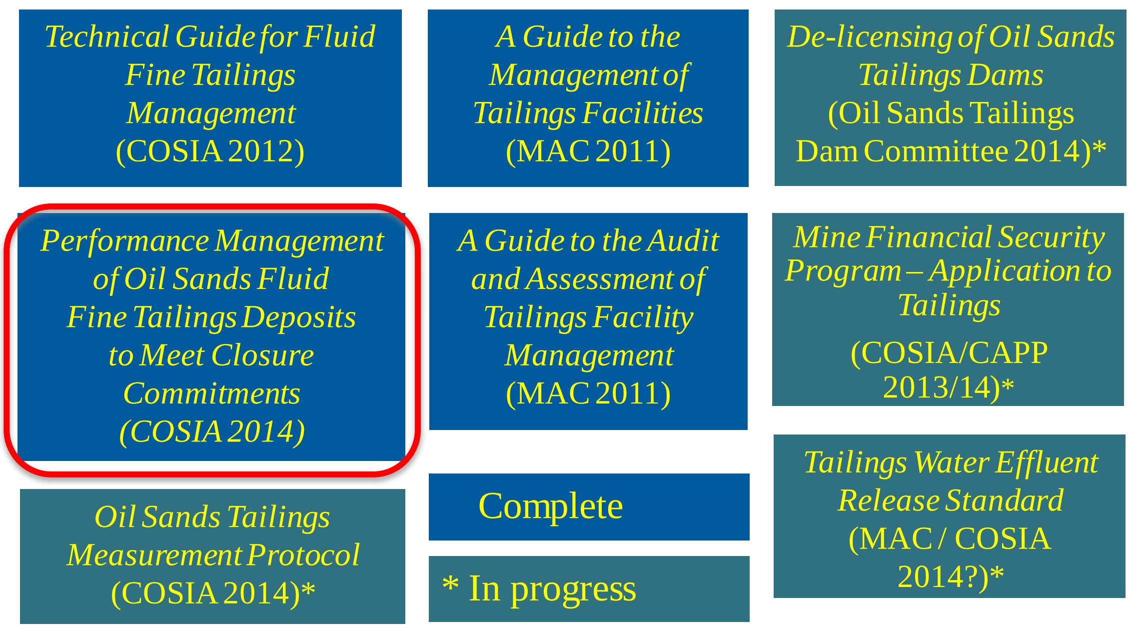


Figure 1-1 Oil Sands Industry Practices for Tailings Management

1.2 FFT Progress Toward Closure

A distinction is made in this document between two states or "conditions" of FFT as they progress toward closure:

- Condition 1 – FFT that are in their final position in the closure landscape, on a trajectory to being reclaimed (simply needing time, as defined by the closure plan), and needing no further processing. Eventually this material will dewater further, gain more strength and progress to a stable deposit.
- Condition 2 – FFT that need processing, re-processing, or other treatment measures, and may not be in their final position in the closure landscape or are not on a trajectory to being reclaimed. This is either material generated from normal tailings operations or "off-spec" material produced from some other secondary treatment process.

Examples of Condition 1 FFT are:

- CT that is on trajectory to being reclaimed
- Centrifuged FFT in a deep deposit in-pit, capped, and consolidating
- A stacked, multiple thin-lift deposit
- FFT at the bottom of a water-capped end-pit lake.

Examples of Condition 2 FFT are:

- FFT in an active tailings pond
- FFT produced by segregation of a tailings stream
- Low-SFR CT in a fluid state in a deposit, and not on trajectory to being reclaimed
- Off-spec FFT placed in a thin-lift deposit.

In some cases, a validation process will be needed to demonstrate that a deposit requires no further intervention and qualifies as Condition 1.

1.3 Tailings Performance Management

This section details the process for managing tailings performance. It is first important to establish the context for tailings management in general. The main business of an oil sands mine is to produce bitumen from the ore and in some cases, synthetic crude oil from the bitumen. To accomplish this, the mining company:

1. Characterizes the ore body on a specific lease, along with other overburden and interburden materials (that will be required for construction) and surface soils (that will be required for reclamation).
2. Develops a mine plan that recovers the ore and other materials in a timely manner, optimizes delivery of the ore to an extraction plant and accounts for storage of all mine waste materials.
3. Develops a water management plan that accounts for all water existing on or imported onto the lease, for use in the extraction process or for other plant needs. This plan addresses both water quantity and quality, and includes diversion, storage, treatment and return of water to various surface and groundwater sources.
4. Develops a management plan that accounts for all tailings produced in the extraction plant, and how this material is treated and/or placed in various tailings deposits.
5. Develops a closure and reclamation plan that describes how all mine structures will be transitioned into a closure landscape, how that landscape will be reclaimed, and how water and groundwater will flow on and through the lease (meeting the objectives described in Section 1.1).

Developing and carrying out these plans in an integrated and intimately aligned manner is critical. This alignment will allow each operator to have confidence about achieving mine closure goals. As technologies and opportunities evolve over time, so too will these various plans, but the commitment to the closure objectives and to the alignment of mine, water, tailings and closure plans will not change.

The plan for production, treatment and placement of FFT is a subset of the integrated planning process described above. It is initiated by a forecast of FFT production, tied to bitumen production, and is driven by empirical relationships that vary somewhat from site to site.

Management of tailings performance is a part of responsible stewardship of FFT. The process is shown in Figure 1-2, and includes the following steps:

1. The desired closure landscape is defined in the mine closure plan. This includes landforms that contain all mine waste products: overburden, tailings (generally), and FFT (in particular), as well as a sustainable drainage system that will facilitate the return of process-affected water of acceptable quality to the environment.
2. Long- and short-term tailings plans are developed that define the tailings streams produced from the extraction plant and where they will be disposed.
3. A FFT management plan is produced that contains the specific details of the commitments outlined in Section 1.1, and details how and when the mine operator will achieve those commitments. This plan includes a discussion of the treatment technologies used to dewater the FFT and new treatment technologies in development.
4. The FFT management plan is executed, FFT behaviour is measured and FFT performance is assessed and reported to company senior management and regulatory authorities. Performance is also independently assessed (third-party review) on a five-year interval.
5. If the FFT behaviour is not consistent with the management plan, treatment technologies are improved or updated. In some cases, new treatment technologies might be developed and implemented. In either case, the objective is to bring the FFT behaviour into compliance with the mine operator’s commitments. As a natural consequence, the operator might update the FFT management plan but the operator’s closure commitments remain.

This document deals with Step 3 to Step 5 of the tailings performance management process.

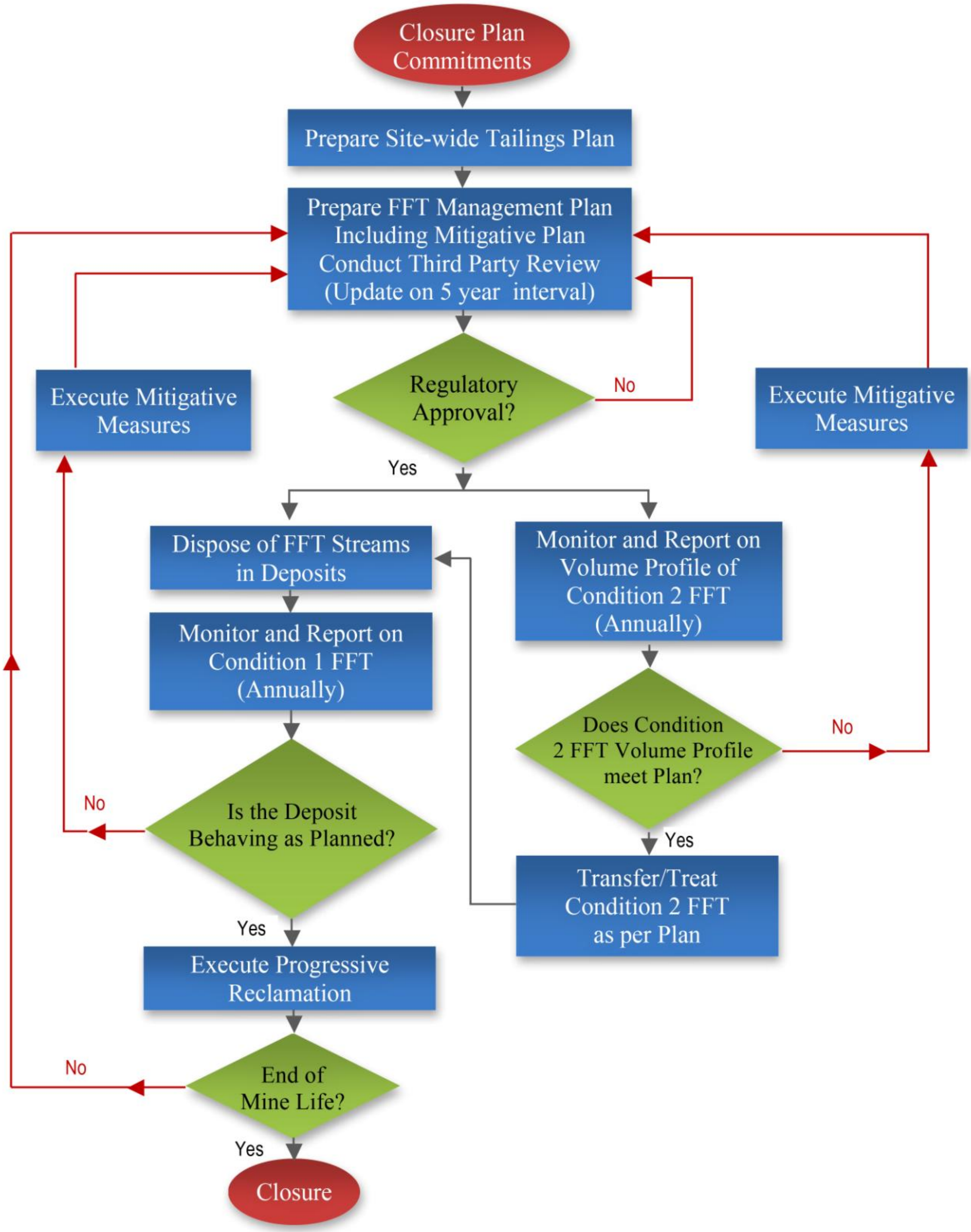
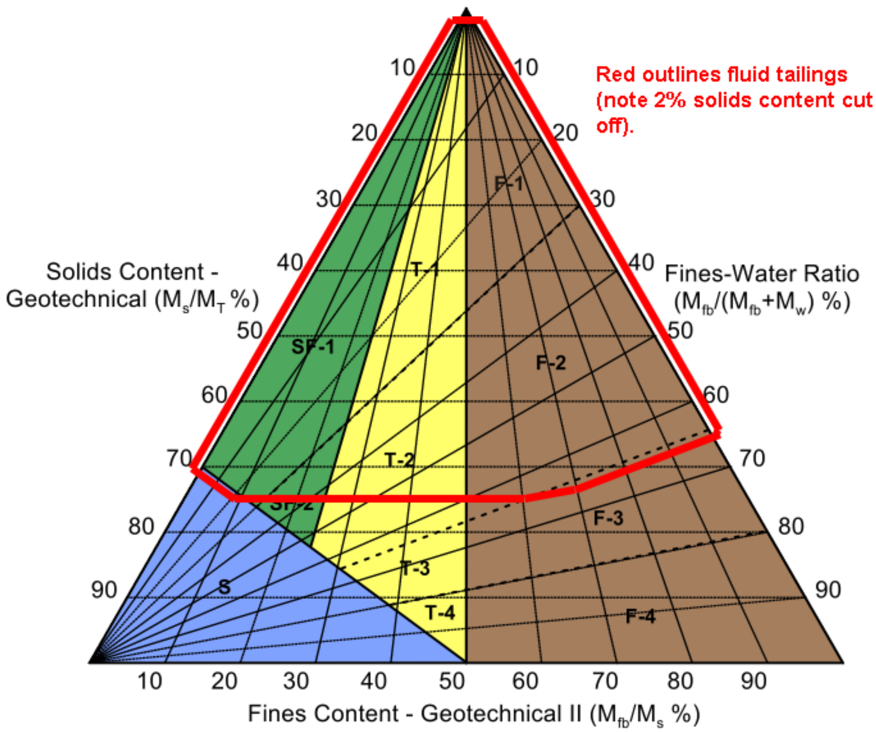


Figure 1-2 Tailings Performance Management Process

2 Classification of Oil Sands FFT and Deposits

2.1 Tailings Classification

The *Oil Sands Tailings Measurement Protocol* (COSIA 2014a) introduces a method of classifying oil sands tailings, referred to as the Uniform Oil Sands Tailings Classification System (see Figure 2-1).



Primary Division		Secondary Division	Symbol	Name
Sand Tailings Sand void ratio ≤1.1		None	S	Sand
Fines-Dominated Tailings Sand void ratio >1.1	Sandy–Fine Tailings SFR ≥3 (geotechnical fines content ≤ 25%)	FOFW < static segregation boundary	SF-1	Sandy Fine Tailings – Zone 1
		Liquid limit > FOFW ≥ static segregation boundary	SF-2	Sandy Fine Tailings – Zone 2
	Transition Tailings 3 > SFR >1 (25% < geotechnical fines content <50%)	FOFW < static segregation boundary	T-1	Transition Tailings – Zone 1
		Liquid limit > FOFW ≥ static segregation boundary	T-2	Transition Tailings – Zone 2
		Plastic limit > FOFW ≥ liquid limit	T-3	Transition Tailings – Zone 3
		FOFW ≥ plastic limit	T-4	Transition Tailings – Zone 4
	Fine Tailings SFR ≤1 (geotechnical fines content ≥50%)	FOFW < static segregation boundary	F-1	Fine Tailings – Zone 1
		Liquid limit > FOFW ≥ static segregation boundary	F-2	Fine Tailings – Zone 2
		Plastic limit > FOFW ≥ liquid limit	F-3	Fine Tailings – Zone 3
		FOFW ≥ plastic limit	F-4	Fine Tailings – Zone 4

Figure 2-1 Unified Oil Sands Tailings Classification System

In this classification system, the symbols SF, T1, T2, F1 and F2 all designate FFT; the symbols T3, T4, F3 and F4 all designate solid tailings being managed in a tailings deposit. The location of the boundaries in Figure 2-1 is explained in the *Oil Sands Tailings Measurement Protocol* (COSIA 2014a).

2.2 Tailings Deposit Classification

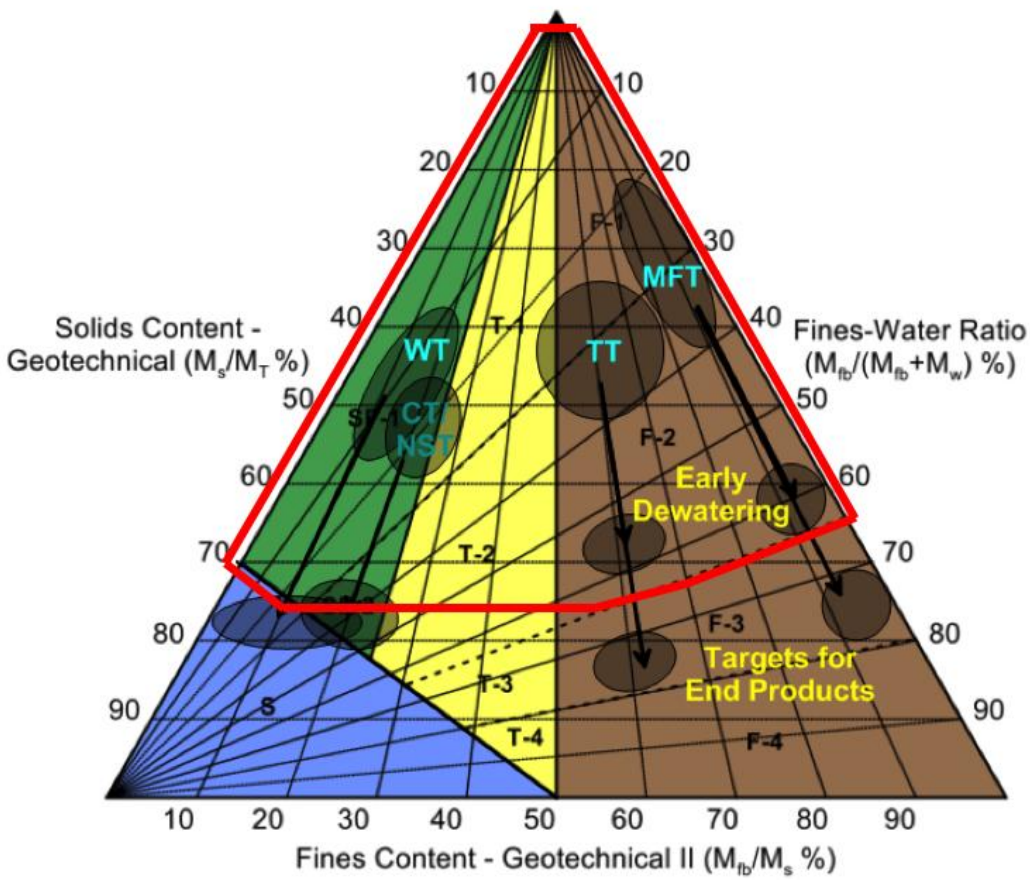
The *Technical Guide for Fluid Fine Tailings Management* (OSTC/COSIA 2012) provides a technical overview of current placement and management practices for the different types of oil sands tailings deposits, using best available technology. COSIA recognizes four main types of post-extraction, processed tailings deposits:

1. **Thin-Layered Fines-Dominated Deposits** (intended to contain F2 progressing to F3) – Thin-lift dewatering involves in-line injection of polymer to a FFT stream, and subsequent placement in thin lifts that allows initial dewatering and then the environmental effects of evaporation and freeze–thaw to complete the dewatering process. Deposit performance is closely linked with yearly climate variations.
2. **Deep Fines-Dominated Deposits** (intended to contain F2, progressing to F3) – Technologies that create deep fines-dominated (cohesive) deposits also involve the use of polymer flocculants. The FFT are first treated in some manner (in-line injection of flocculant, centrifuging or conventional thickener) and then are placed continuously in a deep containment area. From that point, dewatering occurs primarily by self-weight consolidation.
3. **Fines-Enriched Sand and Sandy Fines Deposits** (intended to contain SF2 progressing to S) – Technologies that produce composite tailings (CT) and non-segregating tailings (NST) create fines-enriched granular deposits by mixing sand and a coagulant with FFT. These deposits readily consolidate to form surfaces amenable for hydraulic sand capping. There are operational challenges to minimize segregation of the fines in high-energy depositional environments.
4. **Water-Capped Deposits** (could contain different types of FFT) – Water-capped deposits use mine-pit containment available at various stages of mine development and at the completion of the mine. This technology is a sequestering technology and accepts that the FFT will continue to slowly consolidate long after mine closure. An opportunity under evaluation with water-capping is to increase the density of the FFT before placement by in-line flocculation or process dewatering (e.g., centrifugation).

For completeness, this document includes two additional deposit types (see Table 3-1):

- Low-strength, fines-dominated deposits in cells constructed of overburden or other materials
- Deposits of transition material generally in the SFR range of 1.5 to 3 (T2 progressing to T3).

Figure 2-2 illustrates the degree of dewatering required to change FFT into a soil.



Note: Shaded areas on ternary plot have the meanings given in Figure 2-1 and in the *Technical Guide for Fluid Fine Tailings Measurement.*

Figure 2-2 Dewatering of Tailings Deposits

In Figure 2-2, the approximate initial conditions of whole tailings (WT), composite/non-segregating tailings (CT/NST), thickened tailings (TT) and other FFT are shown. Also shown are the nominal, target end-states for each product. In the case of TT and MFT, this is below the liquid limit line on the ternary plot (dashed line). Experience with F1- and F2-type FFT is that it is relatively easy to dewater to a FOFW ratio of about 55 to 60% (using some combination of flocculation, coagulation, centrifuging and/or drying), but the final stage of dewatering, to a FOFW ratio in excess of 70 to 75%, is more difficult.

3 Elements of a FFT Management Plan

3.1 Introduction

The FFT management plan contains the following elements (described in more detail in following sections):

- A general description of the amount of ore being mined and the FFT streams produced by the plant site (Section 3.2).
- A discussion of the predicted behaviour of the Condition 1 FFT (Section 3.3.1).
- A discussion of the volume profile of the Condition 2 FFT (Section 3.3.2).
- A comparison of predicted FFT behaviour with actual behaviour, i.e., FFT performance (the FFT performance report is discussed in Section 3.6).

3.2 General Information

All reports should contain general information about the ore and tailings production profiles on each lease. For the next reporting period (typically four years, tied to the mid-term mine and tailings plans), this would include:

- Ore to be processed in the extraction plant (mass), with a statement of average bitumen content and average fines content.
- A description of each tailings stream. For FFT, as a minimum, this should include:
  - Tailings classification (plotted on the UOSTCS diagram)
  - Rate of production (volume and mass).
- For each tailings disposal area, a description of:
  - Condition 1 tailings – location, geometry (area, depth) and timing
  - Condition 2 tailings – location, geometry, timing, plans for treatment and ultimate fate.

3.3 FFT Volume and Predicted Behaviour

In managing FFT, an operator must address two main factors:

1. Behaviour of Condition 1 FFT.
2. Volume profile of Condition 2 FFT.

In both these cases, the operator must predict volumes and rate of consolidation. These predictions must also include a range of likely values and an assessment of the uncertainty associated with that range.

3.3.1 Condition 1 FFT Predicted Behaviour

The operator will predict the behaviour over time of Condition 1 FFT in each DDA or other tailings deposit. This will include its progress toward reclamation and closure, and the end state that is consistent with the design of the closure landscape.

Table 3-1 shows the unique behaviour of each deposit type and the corresponding primary performance factors for measuring behaviour.

Table 3-1 Deposit Performance Factors

Deposit Type	Primary Performance Measures	Purpose
Thin-layered, fines-dominated (F2)	Strength	Indicate readiness for removal or next lift (if stacking).
Deep fines-dominated (F2)	Solids content, excess pore pressure dissipation and settlement of final surface.	Progress of consolidation and readiness for capping.
Fines-enriched sand and sandy fines (SF, S)	Sand/Fines Ratio (SFR) distribution, solids content, excess pore pressure dissipation and settlement of final surface.	Degree of segregation, liquefaction susceptibility and readiness for capping.
Water-capped end-pit deposits (F2)	Water quality in water cap and elevation of top of FFT zone.	Suitability of water cap to meet reclamation objectives; consolidation of FFT.
FFT contained in overburden dumps (F2)	Strength change with time and settlement of dump.	Demonstrate FFT meets dump design requirements; consolidation of FFT.
Deep, low-SFR FFT deposits (T2)	Solids content, excess pore pressure dissipation and settlement of final surface.	Progress of consolidation and readiness for capping.

3.3.2 Condition 2 FFT Predicted Volume Profile

The FFT management report will provide a predicted total volume profile for all Condition 2 FFT on the lease. FFT volumes are measured regularly to provide the basis for revised FFT volume projections and containment needs, and adjustments to the tailings plan.

The FFT predicted volume will be given in terms of its absolute amount with time, as well as volume per tonne of ore processed. The intent is to demonstrate that the volume trajectory is consistent with the progressive reclamation commitments underlying submitted plans, particularly closure plans, and to ensure that there are no trends in the trajectory that would trigger the need for additional containment.

Figure 3-1 shows an example of the production of Condition 2 FFT and its transition to Condition 1 FFT. The lower curve (yellow/red dashed line) on this figure would be used as the basis of a mine operator’s commitment to manage Condition 2 FFT to a maximum volume profile.

This example is based on the parameters in the figure and applies only to that specific case. The upper line shows the volume of FFT that would accumulate if there were no additional dewatering; the lower two lines show the volumes of Condition 1 and Condition 2 FFT that would accumulate if centrifugation was introduced in two stages in the life of the mine – Year 7 and Year 12.

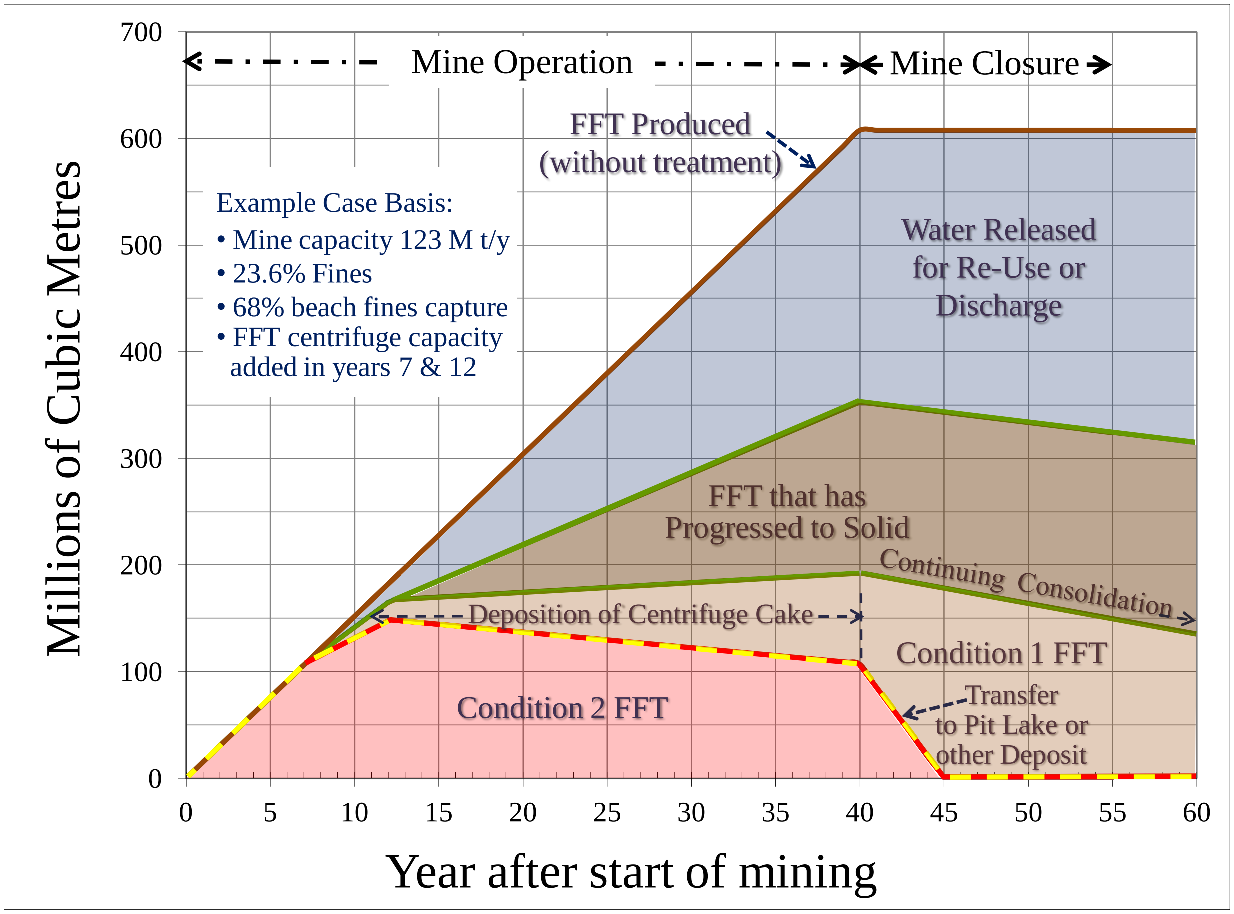


Figure 3-1 Schematic FFT Volume Profiles – (Illustrative Only)

The operator will also provide:

- A list of the temporary storage locations of all Condition 2 FFT, with their individual volumes
- For each temporary storage location, the planned type of additional treatment (to convert to a Condition 1 FFT), with its timing.

3.4 Alternative Solutions

An operator might, at its discretion, provide:

1. Similar information to that outlined in Section 3.2 and Section 3.3 for alternative FFT management plans considered, along with rationale for selecting the approach adopted in the operator's business plan.
2. Information on alternative tailings treatment technologies the operator is considering to improve its FFT management plan in the future. This might include the stage of development (innovative ideas, bench-scale research, piloting, prototyping, commercial-scale demonstration), expected benefits to be derived from the technology and the timeframe to bring to full-scale, commercial implementation.

3.5 Report on Containment Areas

The mine operator will report on actual versus plan for each containment area, for the items described in Section 3.2.

3.6 Report on FFT Behaviour and Performance

A mine operator will measure the volume of all FFT on its lease and the behaviour of treated deposits, in all areas described in Section 3.2 and Section 3.3. Reference will be made to the *Oil Sands Tailings Measurement Protocol* (COSIA 2014a) for information on measurement methods for FFT deposits. The operator will report FFT volumes and treated deposit behaviour annually.

The operator will compare the behaviour of each FFT deposit to that predicted in the FFT management plan, to establish its performance (acceptable or not). If tailings deposition proceeds according to approved plans, the tailings management report should be updated/ resubmitted every five years. If there is an out-of-compliance performance or significant changes to the basic FFT management plan, the plan should be updated and resubmitted more frequently, as needed. The oil sands industry is committed to maintaining alignment of its mine, water, tailings and closure plans; revisions in any of these plans that result in a revision of the FFT management plan should trigger submission of a revised tailings management report.

Following is a suggested table of contents for a FFT management plan:

1. General Information (see Section 3.2)
2. Production Profile (see Section 3.2)
3. Predicted Behaviour (see Section 3.3)
4. Measured Behaviour (described above)
5. Performance Assessment (described above)
6. Mitigation Plan (if required)

3.7 Independent Performance Assessment

The operator will arrange for an independent (third-party) assessment of Condition 1 FFT and Condition 2 FFT performance ([actual–predicted] behaviour; Table 3-1 and Figure 3-1) against the FFT management plan, at least every five years, using the procedures outlined in *A Guide to the Audit and Assessment of Tailings Facility Management* (MAC 2011b). In particular, the qualifications of the assessment team, as outlined in this *Guide*, are critical in assessing the key performance aspects related to these unique FFT deposits. It is also vital that the audit/assessment process confirm company senior management commitment.

3.8 End of Performance Assessment

Once deposit objectives have been achieved and observation of the deposit behaviour is no longer required, monitoring activity will revert to the normal effort of assessing the progression of surface reclamation until certification readiness has been attained.

4 Stewardship to FFT Management Plan

4.1 Compliance

The Condition 2 FFT volume accumulation or the Condition 1 FFT deposit behaviour could be in or out of compliance with the FFT management plan. Compliance is defined as:

- A volume of Condition 2 FFT that is less than or within the range of the committed maximum volume profile (see Figure 4-1 for an example).
- In each tailings deposit, the actual behaviour of Condition 1 FFT that is within the range or is better than the predicted behaviour.

Important in the assessment of FFT volume compliance are both the absolute value and the trend of the FFT behaviour. As indicated in Figure 4-1, actual accumulation of Condition 2 FFT should remain less than the committed volume profile, in which case it is in compliance, or it could be trending outside the committed volume profile, in which case it is, or might in the future be, out of compliance. The slope of the trend line is important as it conveys the urgency with which mitigation measures need to be implemented.

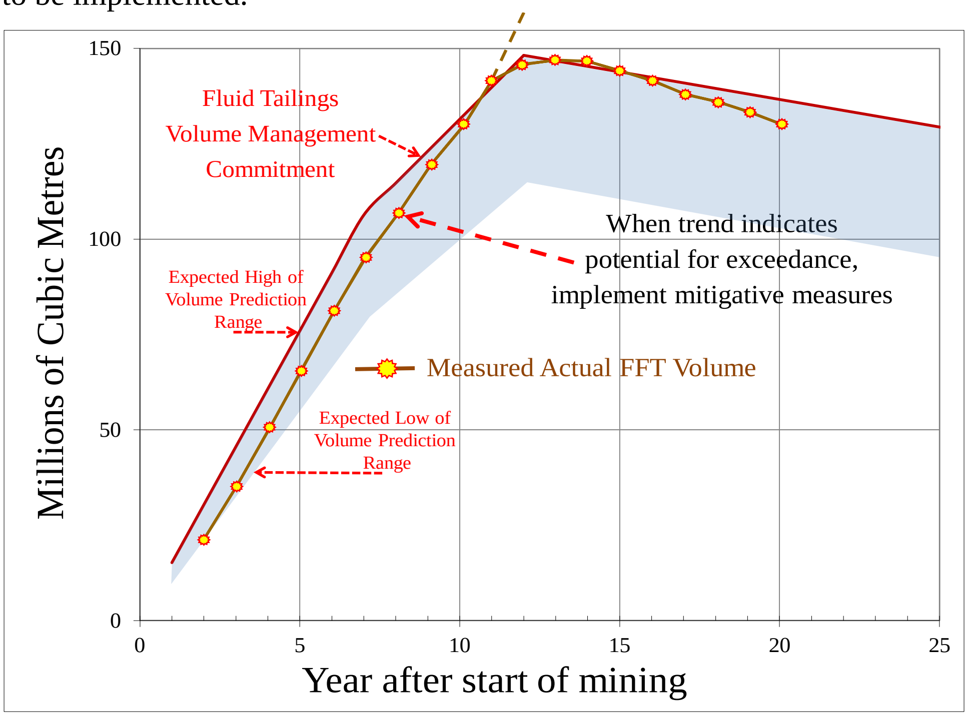


Figure 4-1 FFT Volume Compliance – Mitigation Measures (Illustrative)

In Figure 4-1, the first 25 years of the volume commitment profile from Figure 3-1 are expanded to illustrate the situation where the accumulating FFT volume could become non-compliant with the committed FFT volume profile. In the initial years, the measured volumes remain within the commitment maximum profile, but with a small margin.

After Year 8, it becomes clear that without additional action, the committed maximum volume will be exceeded. This triggers the need for contingency action and highlights several important facets of FFT management:

- The maximum volume profile commitment should be set with a high probability of attainment, taking into account what can practically be accomplished if available contingency measures are implemented, as required.
- When measured FFT volumes are close to the commitment maximum profile, increased diligence is warranted.
- Contingency implementation needs to occur based on the trend toward exceedance, so that exceedance is avoided.

4.2 Adaptive Management and Contingency Actions

The approach recommended in this document anticipates that undesirable changes can occur in FFT behaviour and adopts an adaptive management process to deal with these changes. Five-year progress reports will reflect all changes in production, resource assessment and evaluation of FFT behaviour and process performance.

As part of the adaptive management process, the operator will define contingency actions to deal with possible out-of-compliance FFT behaviour in its initial FFT management plan, will implement these actions, if necessary, and will update them as required and/or as new technologies become available.

Contingency actions available to an operator in the event of non-compliance include:

- Increase the capacity of technologies or actions that perform well.
- Implement concrete and practical measures to improve the efficiency and effectiveness of current operations.
- Adopt alternative current technology that improves performance.
- Develop and implement new technology to improve performance (which has a lead time and so might not in all cases be a practical contingency action).

Contingency plans need to be practical and economically viable. They also need to be identified and pre-engineered, so that they can be implemented in time to meet FFT management and closure plan commitments (keeping in mind that where capital implementation is involved, it could take two years or more to complete a pre-engineered solution). Operators must identify how the Condition 2 material will be changed to Condition 1 material, on a deposit-by-deposit basis.

The mitigation plan should contain:

- Technology to be used, and a description of its robustness and practicality
- Time required to implement that technology, which must be consistent with the closure plan and schedule
- Assessment of the likelihood of success of the contingency plan
- Impacts on the Condition 2 volume profile.

In some cases, the operator could elect to have contingency plans audited to establish robustness and likelihood of success (using the process described in Section 3.7).

5 References

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