

Canadian Natural Resources Limited

Application for Horizon Oil Sands Processing Plant and Mine Tailings Management Plan

December 18, 2017

Alberta Energy Regulator

Decision 20171218A: Canadian Natural Resources Limited; Application for Horizon Oil Sands Processing Plant and Mine Tailings Management Plan

December 18, 2017

Published by

Alberta Energy Regulator

Suite 1000, 250 – 5 Street SW

Calgary, Alberta

T2P 0R4

Telephone: 403-297-8311

Inquiries (toll free): 1-855-297-8311

Email: inquiries@ aer.ca

Website: www.aer.ca

Contents

Abbreviations iii

Executive Summary v

Decision..... 1

 Application 1

 Statements of Concern 2

Approval Discussion..... 3

 Introduction 3

 Stakeholder Engagement 4

 Decision 4

 AER Findings 4

Fluid Tailings Profiles and Project-Specific Thresholds 5

 Profile for Legacy (Equivalent) Fluid Tailings 5

 Profile for New Fluid Tailings 7

 Thresholds 10

Fluid Tailings Treatment Technology 12

 Technology Selection 12

 NST and MFT-Spiked NST Technology 13

 CO₂ Injection 15

 Selective Mining (MFTRMP)..... 15

 Water Capping 17

 Alternative to Water Capping 18

 NRU Tailings Management..... 19

 Capping Material Availability 20

 Storage 24

 Pilots, Prototypes, and Demonstrations 25

Ready to Reclaim Criteria..... 25

 Deposit Milestones 26

 Measurement and Averaging 27

 Subobjective 1: Solids Content..... 28

 Subobjective 1: Trajectory 30

 Deposit Settlement 31

 Subobjective 2 32

 Water Capping 34

 NRU Tailings..... 34

Environmental Effects and Implications 35

 Air..... 35

Surface Water and Groundwater	36
Tailings Water Release.....	37
Alternatives to Capping NST	37
Other Technical Issues	38
Future Deposits	38
TMP and EPEA Plan Alignment	38
Dam Decommissioning	40
Conclusion.....	40
Appendix 1 Approval	43
Appendix 2 Submissions and Deposit Milestones Timeline.....	59
Appendix 3 <i>EPEA</i> Tailings Research Report and End-Pit Lake Research and Development Report Letter	63
Appendix 4 <i>EPEA</i> Life of Mine Closure Plan, Mine Reclamation Plan, and Annual Reclamation Progress Tracking Report Letter	67
Appendix 5 Deposit Milestones	71
Appendix 6 Measurement System Plan Requirements Letter	75
Appendix 7 Decommissioning Plan for Dams	79
Appendix 8 Canadian Natural Site Map	83
Figure 1. Profile for legacy fluid tailings	6
Figure 2. Profile for new fluid tailings.....	8

Abbreviations

ACFN	Athabasca Chipewyan First Nation
AER	Alberta Energy Regulator
BML	Base Mine Lake
DDA	dedicated disposal areas
<i>EPEA</i>	<i>Environmental Protection and Enhancement Act</i>
EUB	Alberta Energy and Utilities Board
FMFN	Fort McKay First Nation
<i>ICAF</i>	<i>Integrated Compliance Assurance Framework</i>
MFT	mature fine tailings
MFTRMP	MFT reduction mine plan
NRU	naphtha recovery unit
NST	nonsegregating tailings
<i>OSCA</i>	<i>Oil Sands Conservation Act</i>
OSEC	Oil Sands Environmental Coalition
RTR	ready to reclaim
SCO	synthetic crude oil
SFR	sand fines ratio
SOC	statement of concern
<i>TMF</i>	<i>Tailings Management Framework for Mineable Athabasca Oil Sands</i>
TMP	tailings management plan

Executive Summary

The Alberta Energy Regulator (AER) approves Canadian Natural Resources Limited's (Canadian Natural's) application 1869003, subject to the approval terms and conditions in appendix 1.

Background

Fluid tailings management arising from oil sands mining falls squarely within the mandate of the AER, which is to ensure the safe, efficient, orderly, and environmentally responsible development of hydrocarbon resources over their entire life cycle. To be effective, the AER must regulate development in a way that reduces risk and ensures that Albertans reap the economic rewards of our energy resources. The Lower Athabasca Region is an area of major industrial development driving Alberta's and Canada's economy.

The AER applies a risk-based approach to regulating, where higher-risk activities receive the greatest attention. Given the nature and scale of fluid tailings generated by oil sands mine operations and the ongoing research and development of tailings treatment technology, fluid tailings management is one of Alberta's higher-risk industrial activities.

Tailings are a by-product of the process used to extract bitumen from mined oil sands and consist of water, silt, sand, clay, and residual bitumen. The regulation of tailings has been an ongoing and evolving issue in Alberta. In the last 10 years, tailings reduction technologies have quickly evolved. To accelerate tailings reduction, in 2009, the Energy Resources Conservation Board (which became the AER) released *Directive 074: Tailings Performance Criteria and Requirements for Oil Sands Mining Schemes*, introducing specific performance criteria for the reduction of fluid tailings and the formation of trafficable deposits.

To further manage and decrease liability and environmental risk resulting from the accumulation of fluid tailings on the landscape, the Government of Alberta issued the *Tailings Management Framework for the Mineable Athabasca Oil Sands (TMF)* in 2015. As part of the implementation of the TMF, the AER released *Directive 085: Fluid Tailings Management for Oil Sands Mining Projects*, which sets out the new requirements for fluid tailings management plans. *Directive 085* represents an evolution in how industry, the AER, and government will manage tailings. It addresses both existing fluid tailings and new fluid tailings growth.

Canadian Natural's Approvals

Canadian Natural's Horizon oil sands processing plant and mine received approval through a joint Alberta Energy and Utilities Board (EUB) and Government of Canada panel in 2004 (*EUB Decision 2004-005*). Canadian Natural commenced tailings treatment in 2015. This decision recognizes that Canadian Natural is in the initial phase of operating its tailings treatment technology (nonsegregating tailings [NST])

technology) and first tailings deposit (ETF/DDA1) and verifying its selective mining approach (called MFTRMP). The approval requires Canadian Natural to provide appropriate and timely information based on its continued technology and deposit performance evaluation, along with research and other information, to inform tailings management at the Horizon oil sands processing plant and mine.

The AER must ensure that it has the appropriate assurance Canadian Natural's fluid tailings management will meet TMF outcomes on time and the approvals conditions are clear and enforceable.

It is not sufficient to rely exclusively on outcomes-based approvals terms and conditions. This is acknowledged in *Directive 085*:

The AER will include conditions in approvals that are outcomes based, manage risk and uncertainties, support flexibility and adaptive management, and are enforceable. The AER will build on approval conditions, where they exist, with respect to research and monitoring programs. At a minimum, approval conditions will address

- project-specific thresholds for both new and legacy fluid tailings,
- fluid tailings deposit performance and milestones,
- mitigation measures and contingency plans, and
- monitoring and reporting requirements (see 4.1).

To that end, the AER has included research, monitoring, evaluation and reporting requirements to Canadian Natural's approval to provide information to verify the technology and deposit performance assumptions in order to ensure that Canadian Natural's performance is tracking to the objective and outcomes of the *TMF* and the requirements of *Directive 085*.

While the AER will apply a risk-based approach to each of the oil sands mines' tailings management plans, it should be noted that Canadian Natural's approval does not represent a precedent for other oil sands mine approvals. Each mine is unique; consequently, the AER must consider a variety of factors in every application review, including the mine plan and project bitumen production levels, lease geography and geology, mining and extraction processes, tailings treatment processes, age of mine and existing infrastructure. Furthermore, each oil sands mine operator will employ different technologies and different ways to achieve the outcomes of the *TMF* and *Directive 085*. Like policy, tailings technology will continue to evolve. Consequently, these approvals reflect current *project-specific considerations*. Finally, each oil sands mine is subject to site-specific factors that will change as oil sands mine operators research and innovate.

Another component of the *TMF* is enhanced transparency and the involvement of others in the review of tailings management plans. In light of this direction, the AER expanded involvement of others in the review of initial tailings management plan applications.

The AER enhanced participation by providing an opportunity for Canadian Natural and statement of concern (SOC) filers – including Oil Sands Environmental Coalition, Fort MacKay First Nation, Athabasca Chipewyan First Nation, and McMurray Métis Local 1935 – to provide feedback on circulated draft approval conditions. The concerns raised as part of the feedback on circulated draft approval conditions informed the AER’s decision.

A summary of the primary issues together with the regulatory decision in Canadian Natural’s approval is as follows:

Ongoing Stakeholder Engagement

As mentioned above, both the *TMF* and *Directive 085* highlight the importance of transparency and involvement of stakeholders in tailings management. Given this overarching principle, together with the concerns expressed by SOC filers, the approval requires Canadian Natural to engage with stakeholders and indigenous communities, which will include an annual forum and report to the AER.

Primary Tailings Treatment Technology Performance and Future Plans

Canadian Natural’s NST facility was commissioned in 2015 and all treated tailings are currently being placed in the external tailings facility (ETF/DDA1). Canadian Natural will begin placing NST into DDA2, in 2021.

While early NST data meets initial performance expectations, Canadian Natural requires additional time to improve and optimize the technology and demonstrate steady performance. Canadian Natural indicated that performance will be steady-state by 2023.

The AER notes that NST performance is dependent upon sand, which is also critical for capping to produce a reclaimable tailings deposit that can achieve terrestrial outcomes. SOC filers indicated that NST requires further evaluation to confirm performance expectations.

The approval requires Canadian Natural to provide a plan 1 year prior to the placement of fluid tailings or treated tailings in any of the deposits, other than ETF/DDA1, that demonstrates the tailings treatment technology will perform, the tailings deposit can be reclaimed as predicted, and approved profiles are achievable.

The approval requires Canadian Natural to provide a sand balance and capping research plan that will demonstrate that the tailings deposits can be reclaimed as predicted, in the time predicted. The results of the sand balance and capping research will inform the need for any alternative or supplemental tailings treatment technologies.

Since 2015, Canadian Natural has been conducting an approved pilot for selective mining (called MFTRMP) that is intended to reduce tailings generation. Canadian Natural requested continuation of this

MFTRMP pilot. Canadian Natural indicated that it will reduce about 11 per cent of the tailings produced through continuation of its MFTRMP.

While initial data demonstrates effectiveness in reducing tailings generation, the MFTRMP data is limited because the pilot has only been running since 2015.

SOC filers are supportive of selective mining, but indicate that more information is required to make a full assessment. The AER concurs. The approval authorizes the continuation of the pilot until September 30, 2022, along with continued reporting on the MFTRMP.

Aquatic Closure (Water Capping)

Canadian Natural states 177 Mm³ of untreated fluid tailings will be stored in two tailings deposits (DDA3 and DDA8-9) that will then be capped with water to create an aquatic closure outcome. The rest of Canadian Natural's tailings deposits will be terrestrial closure.

SOC filers raised concerns with the aquatic closure outcome and uncertainties with the proposed technology; as such, they want Canadian Natural to provide a feasible and timely terrestrial closure outcome. The AER shares those concerns. In addition, Government of Alberta policy is expected on water capping tailings and pit lakes (aquatic closure).

The approval prohibits the placement of water over treated or untreated tailings (i.e., water capping) and requires Canadian Natural to meet future policy on water-capped tailings and pit lakes. The AER recognizes that Canadian Natural is required to research pit lakes as part of its *EPEA* approval. The AER expects that Canadian Natural will adjust its *EPEA* pit lake research as required to resolve uncertainties and provide timely, site-specific, and adequate information for future regulatory decisions associated with water capping of DDA3 and DDA8-9, and is requiring Canadian Natural to address the site specificity of current research as part of its pit lake research reporting.

The approval also requires Canadian Natural to submit a plan providing an alternative treatment technology to water capping by September 30, 2025. This is 3 years before placement of tailings in the first deposit currently planned for aquatic closure (i.e., DDA3) and 30 years before the end of mine life. This is a critical milestone, as it will provide time to adjust Canadian Natural's tailings management plan (TMP) if water-capped tailings and pit lakes are not permissible.

Ready-to-Reclaim (RTR) Criteria

RTR criteria are used to track the performance of a tailings deposit towards its ability to be reclaimed as predicted and in the time predicted. Consequently, RTR criteria are critical to evaluate trends and performance management.

SOC filers raised concerns with the adequacy and specificity of Canadian Natural's proposed RTR criteria. The AER has similar concerns.

The approval requires Canadian Natural to propose modified and additional RTR criteria, and to achieve deposit-specific RTR criteria throughout the life of the mine.

Fluid Tailings Profile

Canadian Natural's profile for legacy (equivalent) fluid tailings meets the TMF's objective and is approved subject to the approval conditions. Canadian Natural's legacy fluid tailings must achieve RTR status by 2032.

Canadian Natural's profile for new fluid tailings meets the TMF's objective and is approved subject to the approval conditions. Canadian Natural's profile for new fluid tailings is dependent upon a number of assumptions and can be affected if tailings technology and deposit performance expectations are not being met and by changes to its mine plan.

At the end of mine life, Canadian Natural will have an accumulation of 177 Mm³ of new fluid tailings, which according to the AER's assessment represents more than five years of new fluid tailings production. This is not in alignment with *TMF* and *Directive 085* guidelines. The SOC filers raised concerns regarding the end of mine target of 177 Mm³. The AER shares those concerns. The approval requires Canadian Natural to provide a revised end of mine life target which is no greater than 5 years of fluid tailings production by September 30, 2025.

The approval requires Canadian Natural to confirm its ability to achieve the profiles when providing a plan one year prior to the placement of fluid tailings in any of the deposits other than ETF/DDA1.

Enhancements to Research

There are research requirements in the approval to manage risk and resolve uncertainties in Canadian Natural's TMP. Industry has significantly invested in research to resolve tailings issues; yet, key issues to ensure tailings can be managed to meet the *TMF*'s objective remain. Research to date has not solved all of the issues or addressed all of the risks. Given the state of the current information, research and monitoring is required to address uncertainties and risks that are unique to Canadian Natural's TMP. This information is critical to regulatory oversight of this TMP. Site-specific research is needed as a form of risk management to deal with unknowns on a timely basis.

20171218A

Canadian Natural Resources Limited

Application for Approval of Tailings Management Plan for Horizon Oil Sands Processing Plant and Mine

Application 1869003

Decision

[1] The Alberta Energy Regulator (AER) approves Canadian Natural's application 1869003 and issues *Oil Sands Conservation Act (OSCA)* Approval No. 9752E (appendix 1).

[2] In reaching its decision, the AER considered all relevant material constituting the record of Canadian Natural's application. The record consists of the application, which includes supplemental information requests and supplemental information filed by Canadian Natural; the SOCs filed by Oil Sands Environmental Coalition (OSEC), Fort MacKay First Nation (FMFN), Athabasca Chipewyan First Nation (ACFN), and McMurray Métis Local 1935; and the feedback on draft conditions of approval provided by Canadian Natural, OSEC, FMFN, and ACFN.

[3] References in this decision to specific parts of the record are intended to assist the reader in understanding the AER's reasoning on a particular matter and does not mean that the AER did not consider all relevant portions of the record with respect to the matter.

Application

[4] On September 29, 2016, Canadian Natural filed application 1869003 pursuant to section 13 of the *OSCA* for approval of the tailings management plan (TMP) for its Horizon oil sands processing plant and mine.

[5] Canadian Natural's Horizon oil sands processing plant and mine received approval through a joint Alberta Energy and Utilities Board (EUB) and Government of Canada panel in 2004 (*EUB Decision 2004-005*). The Horizon oil sands processing plant and mine are located about 70 kilometres north of Fort McMurray, Alberta, in the Regional Municipality of Wood Buffalo.

[6] Under application 1869003, Canadian Natural sought approval for its TMP for the period from the present until 2065.

[7] As part of its TMP, Canadian Natural sought approval for its MFTRMP for the period from the present until the end of mine life (2055). The MFTRMP is a selective mining approach that treats ore that

meets specific criteria as waste and does not process this ore. This reduces the fines content of the ore that is processed and thereby reduces the volume of fluid tailings produced.

[8] Canadian Natural sought approval to debottleneck the Horizon oil sands processing plant and mine to a capacity of 250,000 barrels per day (bpd) synthetic crude oil (SCO).

Statements of Concern

[9] The AER published a public notice of application for application 1869003 and received four SOCs:

- Oil Sands Environmental Coalition (SOC 30448)
- Fort McKay First Nation (SOC 30482)
- McMurray Métis Local 1935 (SOC 30483)
- Athabasca Chipewyan First Nation (SOC 30491)

[10] Canadian Natural submitted *Technical Review Responses to the Horizon Oil Sands Tailings Management Plan (TMP)* to the AER, Fort McKay First Nation, Fort McKay Métis, McMurray Métis Local 1935, ACFN, and Mikisew Cree First Nation, on February 10, 2017 which responded to the technical concerns raised in their SOCs or expressed by Mikisew Cree First Nation to Canadian Natural. On June 21, 2017, Canadian Natural also provided letters to each SOC filer that responded to the concerns and questions raised.

[11] On August 28, 2017, the AER notified the SOC filers and Canadian Natural that draft conditions of approval would be circulated for feedback to enhance involvement of others and inform a decision on the TMP. The AER decided to circulate the draft conditions of approval for feedback, rather than conduct a facilitated technical meeting with the SOC filers and Canadian Natural, based on a number of factors, including the issues and concerns raised by the SOC filers, the nature and magnitude of the changes proposed in the applications, the nature and extent of the information provided by the applicant, and the stage of operations (e.g., end of mine life schedule).

[12] The AER subsequently extended the deadline for comments on the draft approval conditions from September 11, 2017, to September 26, 2017. The AER received written feedback from Canadian Natural, OSEC, FMFN, and ACFN. McMurray Métis Local 1935 advised it was unable to provide written feedback due to capacity constraints.

[13] Upon receipt of the feedback, the AER reviewed the entire record, considered the SOCs and submissions by SOC filers and Canadian Natural, and made its decision on Canadian Natural's application.

[14] This decision report highlights the AER's consideration of the application.

Approval Discussion

Introduction

[15] The approach in the approvals granted by the AER is to reflect *TMF* outcomes and ensure appropriate information is captured in a timely manner to manage risk and make appropriate regulatory decisions in the course of Canadian Natural's operations. This approach – including research, monitoring, evaluation, and reporting requirements for Canadian Natural is acknowledged in *Directive 085* as necessary for fluid tailings regulatory oversight.

[16] The TMP was submitted as an application under *OSCA* and the decision on the application was made pursuant to that act. This decision report also makes reference to other existing approvals, in particular the *EPEA* approval issued to Canadian Natural in relation to this project. Further, various letters issued pursuant to these approvals, such as *EPEA*, that are related to the matters discussed in this report have been attached to this decision report.

[17] Generally, the approval conditions address:

- stakeholder engagement;
- project-specific thresholds for both new and legacy fluid tailings;
- tailings treatment technology and deposit performance and milestones, including
 - mitigation measures and
 - research, monitoring, evaluation, and reporting; and
- environmental effects and implications.

[18] The approval conditions will manage risk and uncertainties, support flexibility and adaptive management, and are enforceable. The AER has a full suite of enforcement and compliance tools available. The *AER's Integrated Compliance Assurance Framework (ICAF)* and Manual 013 are applicable. In addition, the management actions as set out in the *TMF* and *Directive 085* are new tools available to the AER. A common theme in *ICAF*, the *TMF*, and *Directive 085* is a flexible approach; namely, to allow for the discretion to choose the appropriate tool(s) to the specific circumstances to ensure the most effective compliance/enforcement outcome.

[19] Details of the main decisions are set out below.

[20] A summary of the timing for the various submissions in the approval are in appendix 2.

Stakeholder Engagement

[21] The *TMF* and *Directive 085* describe the importance of transparency, engagement, and enhancing the understanding of fluid tailings management.

Decision

[22] The approval requires Canadian Natural to engage with stakeholders and indigenous communities in respect of tailings management activities undertaken pursuant to the approval and report annually to the AER on the engagement undertaken by Canadian Natural.

[23] The AER is requiring an annual forum between stakeholders and indigenous communities and Canadian Natural.

AER Findings

[24] As part of their SOCs, Fort McKay First Nation raised the importance of engagement on future activities and reclamation planning and McMurray Métis Local 1935 identified that they require continue engagement on tailings management and reclamation planning.

[25] Further, a common theme expressed by OSEC and highlighted by the ACFN in the feedback on draft conditions included stakeholder engagement with respect to the required reporting and updates to TMPs. Additionally, OSEC requested that Canadian Natural conduct an annual forum with stakeholders.

[26] To increase transparency, information sharing, and involvement of others in tailings management, the AER has decided that Canadian Natural is required to engage stakeholders and indigenous communities in respect of tailings management activities undertaken pursuant to the approval. It is the AER's expectation that

- engagement efforts under the approval respecting tailings management will include the SOC filers on these applications;
- over the life cycle of Canadian Natural's mine operations, the stakeholders and indigenous communities who are engaged may change to reflect the issues and concerns of the day, and, as such, the AER expects Canadian Natural to conduct its engagement activities accordingly; and
- Canadian Natural's engagement will result from its research and ongoing operations and that engagement will be timely and meaningful.

[27] The AER has decided Canadian Natural is required to hold an annual forum with stakeholders and indigenous communities regarding tailings management activities undertaken pursuant to the approval to further support transparency, information sharing, and the involvement of others in tailings management. The AER is not specifying the format of the forum (e.g., workshop, meeting). The AER believes, based on Canadian Natural's engagement experience, that it is appropriate to leave the design

and scope of the event to Canadian Natural. However, it is the AER's expectation the annual forum will be tailored to what has occurred in the past year and what is upcoming. It can provide information to stakeholders, gather input from stakeholders, and plan on how engagement will occur for the upcoming year. In addition, it is expected the following annual forums may be more robust:

- in 2019 and 2020, as Canadian Natural will be commencing its second tailings deposit in 2020; and
- in 2024 and 2025, as these are the critical time frames for tailings management regulatory information, such as the provision of the revised end of mine life target for the profile for new fluid tailings, and the provision of the plan for management of DDA3 and DDA9.

[28] Canadian Natural is required to report to the AER on the details of its engagement efforts on an annual basis.

Fluid Tailings Profiles and Project-Specific Thresholds

[29] The *TMF*'s focus is to decrease overall fluid tailings volumes during and after mine operation. The *TMF* and *Directive 085* require that new and legacy fluid tailings must be treated and progressively reclaimed during the life of a project, with all fluid tailings RTR ten years after the end of mine life. The *TMF* and *Directive 085* also provide guidance that operators must consider in the development of their TMPs.

[30] The fluid tailings profile represents the volume of fluid tailings that are not RTR (e.g., do not meet RTR criteria). Both the legacy and new fluid tailings profiles are important tools by which the performance of an operator will be measured.

Profile for Legacy (Equivalent) Fluid Tailings

Context

[31] Legacy fluid tailings are fluid tailings that existed before January 1, 2015. All legacy fluid tailings must be RTR by end of mine life.

[32] It is not possible to physically distinguish between the treatment of legacy and new fluid tailings when legacy and new fluid tailings are placed in the same deposit. For these situations the *TMF* and *Directive 085* recognize the concept of legacy (equivalent) volumes. The operator may allocate the volume meeting RTR criteria to either its legacy (equivalent) volume inventory or its new fluid tailings volume inventory. A legacy (equivalent) volume is an accounting volume.

Decision

[33] Canadian Natural’s profile for legacy (equivalent) fluid tailings meets the *TMF*’s objective of the *TMF* and is approved subject to the approval conditions.

[34] Canadian Natural is required to achieve the profile for legacy (equivalent) fluid tailings as shown in figure 1. Canadian Natural’s legacy fluid tailings must achieve RTR status by 2032.

AER Findings

[35] Canadian Natural’s use of legacy (equivalent) fluid tailings volumes is appropriate given that ETF/DDA1, Canadian Natural’s existing tailings pond, contains new fluid tailings and all the legacy fluid tailings.

[36] Canadian Natural’s profile for legacy (equivalent) fluid tailings meets the *TMF*’s objective as a volume equivalent to 66.2 Mm³ in ETF/DDA1 would be treated and would achieve RTR status by 2032, 23 years before end of mine life.

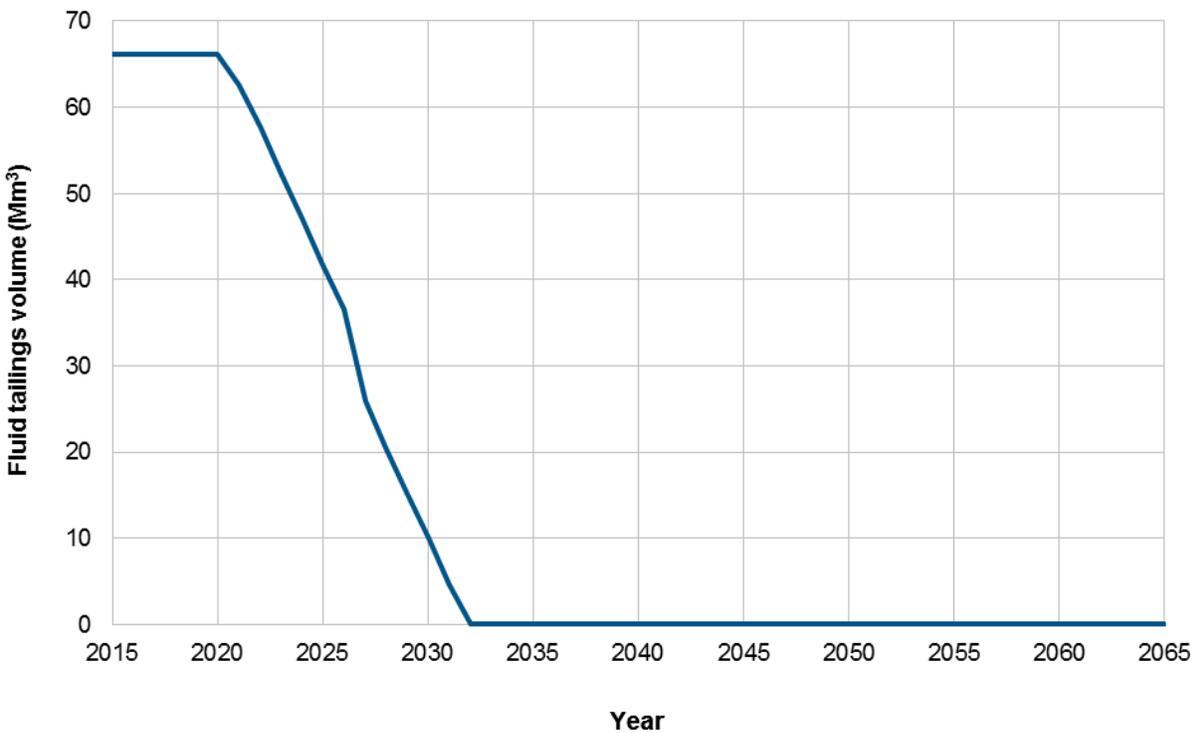


Figure 1. Profile for legacy fluid tailings

[37] Although Canadian Natural is not allocating the volume of fluid tailings in ETF/DDA1 meeting ready-to-reclaim (RTR) criteria to its legacy (equivalent) fluid tailings volume inventory until 2020, the AER finds this reasonable as Canadian Natural is still ramping-up its nonsegregating tailings (NST) technology, including MFT-spiked NST, and the profile for legacy (equivalent) fluid tailings is still achieving the *TMF*'s objective.

[38] Canadian Natural's profile for legacy (equivalent) fluid tailings may or may not be affected by resulting uncertainty in the performance of NST and MFT-spiked NST technology and deposits that will be understood during the ramp-up period for the technology implementation. *Directive 085* identifies the situations (e.g., increased risk of not meeting milestones) where the AER will consider a regulatory response (e.g., requiring implementation of an alternative solution), and when amendment applications are required.

[39] Canadian Natural's profile for legacy fluid tailings appears to begin in 2014 instead of 2015. Considering that there is no impact on achievement of the *TMF*'s objective due to this accounting, the AER is not modifying the profile to reflect different inventory in 2015.

Profile for New Fluid Tailings

Context

[40] New fluid tailings are fluid tailings that are produced after January 1, 2015. All new fluid tailings must be RTR by within ten years after the end of mine life.

Decision

[41] Canadian Natural's profile for new fluid tailings meets the *TMF*'s objective and is approved subject to the approval conditions. The approval conditions require Canadian Natural to provide a revised end of mine life target which is no greater than 5 years of fluid tailings production by September 30, 2025.

[42] Canadian Natural is required to achieve the profile for new fluid tailings as shown in figure 2.

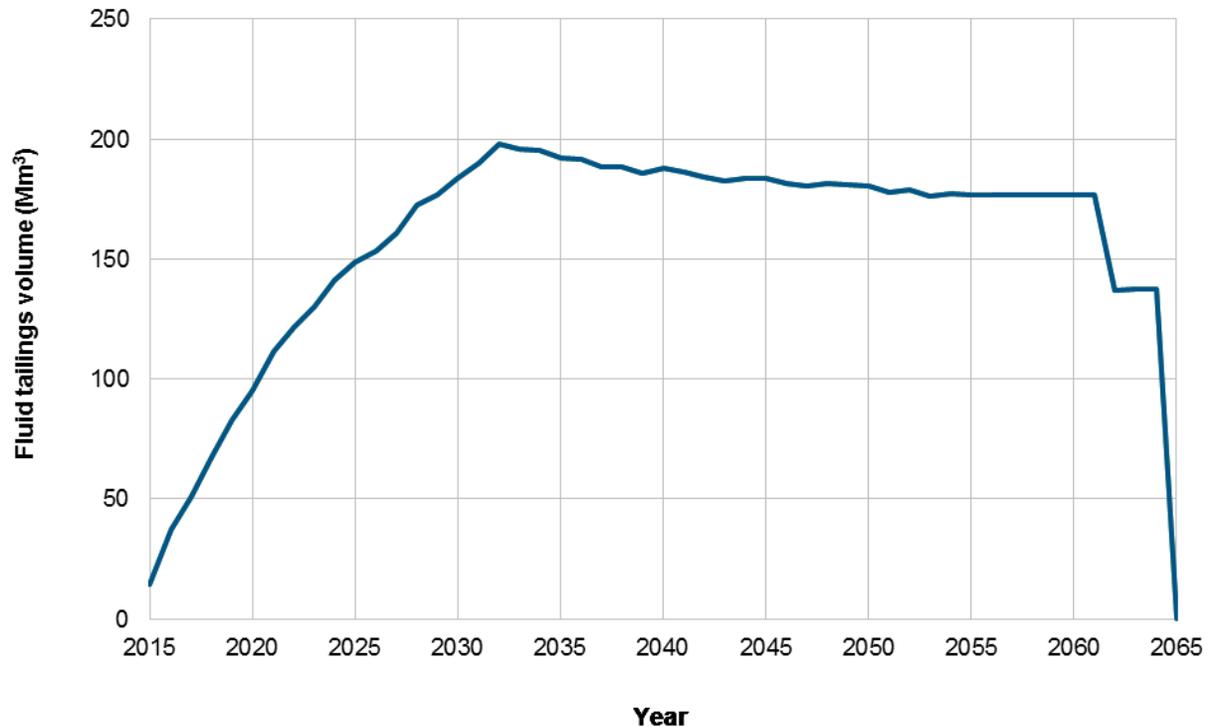


Figure 2. Profile for new fluid tailings

AER Findings

[43] Canadian Natural's profile for new fluid tailings meets the *TMF*'s objective as all new fluid tailings are proposed to achieve RTR status in 2065, ten years after the end of mine life. SOC filers, including McMurray Métis Local 1935, raised concerns that the proposal will allow Canadian Natural to increase fluid tailings volumes for too long (until 2032) and that the maximum volume of 198 Mm³ is too high, which would be inconsistent with the intent of the *TMF*.

[44] Canadian Natural meets *TMF* and *Directive 085* profile guidance in the following ways:

- In 2032 the volume of new fluid tailings will increase to a maximum of 198 Mm³, which is less than the maximum of ten years of full production stated in the *TMF*.
- After 2032, production of tailings is matched to tailings treatment capacity.

[45] Canadian Natural's profile for new fluid tailings is not in alignment with the following *TMF* and *Directive 085* profile guidance:

- The *TMF* states the end of mine life inventory, or target, is a volume of fluid tailings that can be managed to a ready-to-reclaim state within 10 years after end of mine life and is the equivalent of 5 years, or less, of fluid tailings volume accumulation.

- At the end of mine life, Canadian Natural will have an accumulation of 177 Mm³ of new fluid tailings, which, according to the AER's assessment, represents more than five years of new fluid tailings production.

[46] The SOC filers, including FMFN, raised concerns with Canadian Natural's proposition that, because it was contemplated in the 2013 TMP, the end of mine life target is 177 Mm³. Canadian Natural is required to provide a revised end of mine life target which is no greater than 5 years of fluid tailings production by September 30, 2025. This revision may or may not result in an updated profile for new fluid tailings and an amendment application under *Directive 085*.

[47] The AER also finds that there are uncertainties in Canadian Natural's assumptions that could affect Canadian Natural's profile for new fluid tailings. Canadian Natural's mine plan is based on approval of the MFTRMP for the life of the mine, and the MFTRMP is only authorized until September 30, 2022 (see *Fluid Tailings Treatment Technology* section).

- Canadian Natural's mine plan includes the Northeast Pit Extension, which is subject to a future application. Canadian Natural claimed that removal of the Northeast Pit Extension from its TMP would have no measurable effect on its fluid tailings profile, but Canadian Natural did not provide any evidence to support its claim. SOC filers raised concerns with the Northeast Pit Extension and these concerns can be raised in that future application process.
- Canadian Natural's experience with NST technology is relatively new, and performance expectations may not be met. *Directive 085* reporting requirements will also provide annual information on the tailings treatment technology and deposit performance.
- Canadian Natural's TMP relies on the use of two water-capped deposits and Canadian Natural's approval does not allow water capping. However, these technologies are subject to further assessment and future policy.

[48] These uncertainties could result in a situation where the AER may consider a future regulatory response or where an amendment application may be required.

[49] The AER finds that other assumptions that govern Canadian Natural's profile for new fluid tailings are reasonable because they are in alignment with *Directive 085* and reflect probable scenarios.

- bitumen production would increase to between 280 000 and 310 000 bpd by 2018 followed by relative stable production thereafter.
- the volume of fluid tailings in ETF/DDA1 meeting RTR criteria would be allocated to its legacy (equivalent) volume inventory, starting in 2020, and that this would take precedence over allocating volumes meeting RTR criteria to the new fluid tailings inventory.

[50] Canadian Natural's profile for new fluid tailings appears to begin in 2014 instead of 2015. Considering that there is no impact on achievement of the *TMF*'s objective due to this accounting, the AER is not modifying the profiles to reflect different inventory in 2015.

Thresholds

Context

[51] The volume of accumulated fluid tailings is identified as the primary indicator to be used in the *TMF* to manage and decrease liability and environmental risk resulting from the accumulation of fluid tailings on the landscape. Triggers and a limit (collectively referred to as "thresholds") will be set relative to the fluid tailings profiles, including the end of mine life target. The triggers and limit will ensure that fluid tailings are not accumulating beyond a volume and/or at a rate that precludes operators from meeting the *TMF*'s objective. These are tools to be used to manage risks associated with TMPs. Various additional management actions are required when thresholds are exceeded.

[52] Three project-specific thresholds are set based on an operator's fluid tailings profile in accordance with the *TMF* and *Directive 085*.

[53] The three thresholds are the profile deviation trigger, the total volume trigger, and the total volume limit:

- Profile deviation trigger:
 - Alerts regulators and operators when the volume of fluid tailings is growing 20 per cent faster than approved for the profile. Additional management action is required when the profile deviation trigger is exceeded.
 - This trigger is based on when the fluid tailings volume growth is 20 per cent higher than that in the approved profile.
 - The *TMF* states that the profile deviation trigger would consider a five-year rolling average to account for year-over-year variability. The profile deviation trigger applies to both profiles for legacy fluid tailings and new fluid tailings.
- Total volume trigger
 - Indicates that the volume of fluid tailings has exceeded its approved maximum accumulation and requires additional management action.
 - The *TMF* states that this trigger is based on 100 per cent of the greater of the maximum approved fluid tailings volume profile or the end of mine life target.

- The *TMF* indicates that the total volume trigger can be based on the greater of the maximum approved fluid tailings inventory volume or the end of mine life target. The total volume trigger applies to the profile for new fluid tailings.
- Total volume limit
 - A volume of fluid tailings that presents an unacceptable risk to the environment and potential long-term liability. Exceedance of this limit will compromise the ability of an operator to have all of their fluid tailings in an acceptable management state (i.e., RTR) by ten years after the end of mine life. Therefore, the most severe management responses are initiated.
 - The *TMF* states that this limit is based on 140 per cent of the greater of the maximum approved fluid tailings volume profile or the end of mine life target.
 - The *TMF* indicates that the total volume limit can be based on the greater of the maximum approved fluid tailings inventory volume or the end of mine life target. The total volume limit applies to the profile for new fluid tailings.

Decision

[54] The profile deviation trigger is based on a five-year rolling average of the annual profile deviation for the profiles for legacy and for new fluid tailings.

[55] The total volume trigger is set at 198 Mm³ for the profile for new fluid tailings.

[56] The total volume limit is set at 277 Mm³ for the profile for new fluid tailings.

AER Findings

[57] The *TMF* states the profile deviation trigger would consider a five-year rolling average to account for year-over-year variability. To allow for year-over-year variability, the AER set the profile deviation trigger for Canadian Natural as a five-year rolling average of the annual profile deviation. The profile deviation trigger is applicable to both the profiles for legacy fluid tailings and new fluid tailings.

[58] In accordance with the *TMF* and *Directive 085*, Canadian Natural's total volume trigger is 198 Mm³, which is 100 per cent of the greater of the maximum approved fluid tailings volume profile or the end of mine life target. Canadian Natural's total volume limit is 277Mm³, which is 140 per cent of the greater of the maximum approved fluid tailings volume profile or the end of mine life target.

[59] *Directive 085* identifies that changes to end of mine life or changes to the TMP that affect thresholds require application amendments.

[60] Canadian Natural shall not exceed these thresholds. If any threshold is exceeded, Canadian Natural is required to comply with the management response or action directed by the AER. Management responses and actions are set out in the *TMF* and *Directive 085*. The AER also has a full suite of

enforcement and compliance tools available. The AER's *ICAF* and *Manual 013* are applicable to the approval.

Fluid Tailings Treatment Technology

[61] The *TMF* stipulates that all fluid tailings must be treated with an accepted technology. The risks, benefits, and trade-offs associated with the proposed technology must be understood, have contingencies identified, and have risks mitigated.

Technology Selection

Context

[62] *Directive 085* requires operators to justify that selected technologies are the best available for the project. Canadian Natural proposed the use of NST technology, enhanced by MFT-spiked NST technology, CO₂ injection, selective mining, and water capping of untreated tailings.

Decision

[63] The use of NST technology, enhancements to NST technology (i.e., MFT-spiked NST technology and CO₂ injection), and selective mining are authorized, subject to the approval conditions.

[64] Specifically the approval prohibits the placing of any water, which includes industrial wastewater, above treated or untreated tailings for the purpose of creating an aquatic closure landscape.

[65] Decisions regarding individual technologies are in subsequent sections.

AER Findings

[66] Canadian Natural's approach to technology selection, which is to reduce fluid tailings volumes, either through treatment or avoidance, is reasonable because it aligns with the *TMF*'s objective (i.e., treatment of fluid tailings) and will proactively minimize and manage the total volume of fluid tailings at Canadian Natural's Horizon oil sands processing plant and mine.

[67] The AER is authorizing, subject to the approval conditions, the use of NST technology, the enhancements to NST technology (i.e., MFT-spiked NST technology and CO₂ injection), and selective mining (MFTRMP). Each will contribute to reduced fluid tailings volumes, provided the expected performance is achieved, and each will provide adequate treatment capacity to meet the *TMF*'s objective. The AER also considered the following:

- Canadian Natural considered selective mining (MFTRMP), composite tailings, NST and MFT-spiked NST technology, centrifuging MFT with stacking, in-line flocculation with accelerated dewatering, in-line flocculation with thin lift dewatering, and thickened tailings technologies for its tailings treatment.

- Canadian Natural selected NST technology as its primary treatment technology because, relative to the other technologies it considered, NST technology minimized the production of fluid tailings, reduced time to achieve progressive reclamation, and reduced water consumption. Canadian Natural indicated that NST technology's fluid tailings reduction would be improved through MFT-spiked NST and CO₂ injection.

[68] Canadian Natural's water capping of 177 Mm³ untreated fluid tailings is not authorized as the technology is subject to further assessment, research, and future policy.

NST and MFT-Spiked NST Technology

Context

[69] NST is created by removing water from tailings streams to a density that reduces the volume of tailings. NST technology combines thickener underflow and cyclone underflow to make a nonsegregating sand-and-fines mixture. MFT-spiked NST technology involves adding additional fluid tailings from tailings ponds to the NST mixture.

[70] Canadian Natural is currently placing NST in ETF/DDA1 and will commence placement of NST in DDA2, its second tailings deposit, in 2020.

Decision

[71] Canadian Natural is authorized for continued use of NST technology. As MFT-spiked NST technology is an optimization of NST technology, the AER also authorizes the use of MFT-spiked NST technology.

[72] In addition to annual monitoring and reporting on technology and deposit performance in accordance with *Directive 085* reporting requirements, Canadian Natural is also required to evaluate the technology and deposit performance at least one year before placing treated tailings in DDA2.

AER Findings

[73] The AER authorizes the continued use of NST technology to treat fluid tailings based on the following:

- Canadian Natural's use of NST technology as a tailings treatment technology for the Horizon oil sands processing plant and mine received approval through a joint EUB and Government of Canada panel in 2004 (*EUB Decision 2004-005*).
- Canadian Natural commissioned the technology in 2015 with NST being placed in ETF/DDA1 and provided NST technology and ETF/DDA1 deposit performance data that indicated that it should be able to achieve initial technology and deposit performance expectations.

[74] SOC filers raised concerns with the level of uncertainty with the performance of NST. The AER agrees there is some uncertainty in the performance of NST technology and ETF/DDA1 when Canadian Natural begins to place NST in DDA2, considering

- Canadian Natural stated that a seven-year ramp-up period (to 2023) was required for NST technology to meet its predicted performance 85 per cent of the time and prove technology and deposit performance.
- NST placement in DDA2 starts in 2020, 3 years before the end of the ramp-up period.

[75] Therefore, in addition to annual monitoring and reporting on technology and deposit performance in accordance with *Directive 085* reporting requirements, Canadian Natural is also required to evaluate the NST technology and deposit performance at least one year before placing tailings in DDA2. If the technology or ETF/DDA1 deposit data indicates inadequate performance, the AER will respond in accordance with *Directive 085*.

[76] The AER is concerned that Canadian Natural's NST technology and NST deposition plan may result in the segregation of NST or the creation of a softer deposit at the end of the deposition slope. Canadian Natural identified this possibility and associated mitigation measures. This segregation can result in more fluid tailings than expected, an increase in capping material requirements, a decrease in storage capacity, or an increase in the deposit consolidation time, all of which can affect Canadian Natural's ability to achieve its targeted ecosites. To understand if segregation of NST is occurring and if mitigation measures need to be implemented, the AER expects Canadian Natural to, as part of its annual fluid tailings management report required by *Directive 085*, identify any segregation of NST and provide data (e.g., sands to fine ratio) along the entire deposition slope.

[77] Canadian Natural's use of Flopam A-3331 in its thickener and the polymer Flopam A-3342 with its MFT-spiked NST technology is accepted. The AER acknowledges that the polymers used by Canadian Natural are similar to those previously used by Suncor at its Base Plant. The targeted terrestrial and wetland ecosites proposed by Canadian Natural are also similar to the previously proposed targeted terrestrial and wetland ecosites for Suncor. Canadian Natural provided results from Suncor's operation on the short-term effects of the polymers on water quality, tailings quality, and air emissions. The AER acknowledges that the polymers identified by Canadian Natural have been used in controlled circumstances without adverse effect. There are research requirements under Canadian Natural's *EPEA* approval that are expected to provide the necessary information about the long-term environmental and reclamation uncertainties and risks associated with the behaviour and effects of the polymers and the resulting treated tailings. Canadian Natural can and should also draw upon existing industry research.

[78] SOC filers requested further information about the identification and characterization of polymers used by Canadian Natural. The AER acknowledges that Canadian Natural may propose to change polymers in the future or that the manufacturer's formulas may change under the same product name. In

accordance with *EPEA*, Canadian Natural is required to notify the AER of any proposed change to the polymer or manufacturer modifications to the approved polymer formulas. Depending on the significance of the proposed change, additional authorizations or amendments may be required.

CO₂ Injection

Context

[79] CO₂ injection as an enhancement to NST technology has been a part of the Horizon oil sands processing plant and mine tailings management since 2004. Canadian Natural has been injecting CO₂ into its tailings since 2009. Canadian Natural stated that CO₂ injection was used to treat NST, whole tailings, and naphtha recovery unit (NRU) tailings.

[80] Canadian Natural indicated that the injected CO₂ enhances fines settlement, increases settled tailings' strength, decreases the potential for segregation, decreases the total suspended solids of process water stored in a tailings pond, and may reduce greenhouse gas emissions. ACFN's technical report indicated that the CO₂ treatment has been shown to work.

Decision

[81] Canadian Natural is authorized for continued use of CO₂ injection.

[82] Canadian Natural is required to continue to validate the benefits and provide information to the AER as part of its tailings research report required under its *EPEA* approval as set out in appendix 3.

AER Findings

[83] Canadian Natural provided data supporting its claims on the beneficial effects of CO₂ injection on water and tailings quality but indicated that information with respect to the sequestration of CO₂ and associated air emissions would not be available until 2018. As such, the claims by Canadian Natural respecting the benefits of CO₂ injection require further validation.

[84] Canadian Natural is required to continue to validate the benefits and provide information to the AER as part of its tailings research report required under its *EPEA* approval as set out in appendix 3. *Directive 085* reporting requirements will include annual information on use of CO₂ injection technology and its performance.

Selective Mining (MFTRMP)

Context

[85] Canadian Natural is piloting a selective mining approach (the MFTRMP pilot), which treats ore that meets specific criteria as waste and does not process this ore. By not processing this ore, Canadian Natural claims that fluid tailings generation is reduced.

[86] Under its MFTRMP pilot, authorized in 2015, Canadian Natural was granted a variance of the mining criteria in section 2 of *Directive 082*, permitting the sterilization of the bitumen resources to reduce production of fluid tailings. Canadian Natural stated that the variance would allow criteria selected to define ore properties within the mine plan to be refined as more information from the deposit is obtained and plant performance and economic circumstances evolve.

[87] The MFTRMP pilot criteria introduces a fines cut-off grade of 35 per cent by weight, a reduction in minimum bitumen cut-off grade from greater than 7 per cent to greater than 6 per cent by weight, and a reduction in minimum bench thickness from 3 metres to 2 metres.

Decision

[88] Canadian Natural is approved to extend its MFTRMP pilot until September 30, 2022. This includes a variance of section 2 *Directive 082* requirements and for recovery compliance to be calculated with the segregated resource excluded from the assessment.

[89] Canadian Natural is required to provide presentations, results in tabular format, model losses, and progress reports every six months, starting December 31, 2017.

AER Findings

[90] The fluid tailings projections provided by Canadian Natural provide positive results. During its previously approved pilot, Canadian Natural reported producing between 17 to 19 per cent less fluid tailings and using 17 to 19 per cent less water in 2015 and 2016. As part of its TMP, Canadian Natural claimed that the MFTRMP and change in criteria would result in a reduction of

- 255 million barrels of total recoverable bitumen,
- approximately 568 million tonnes in plant feed,
- 260 million tonnes of fines to be processed, and
- 141 Mm³ of fluid tailings generation (i.e., about 11 per cent of tailings produced).

[91] While Canadian Natural applied for approval of the MFTRMP from present until the end of mine life, the claims made are based on a theoretical model which will require time to validate as actual pilot results are only available since 2015.

[92] SOC filers are generally supportive of selective mining, but indicate that more information is required to make a full assessment. The AER concurs.

[93] The AER acknowledges that Canadian Natural has committed to conducting at least two pond surveys in 2018 and 2019, which will support its fluid tailings projections and MFTRMP claims. Given that Canadian Natural will perform two pond surveys in 2018 and 2019, a five-year extension of the MFTRMP pilot is expected to result in adequate data points for the AER to assess if Canadian Natural's

claims are valid. Therefore, Canadian Natural is approved to extend its MFTRMP, including for a variance of the requirements under section 2 of *Directive 082* until September 30, 2022, and for recovery compliance to be calculated with the segregated resource excluded from the assessment.

[94] The AER finds that Canadian Natural's proposed annual reporting frequency is inadequate to provide sufficient data points for the AER to assess if Canadian Natural's claims are valid. Further, annualized data may obscure the variability within Canadian Natural's results. Reporting every six months is expected to provide adequate data to assess if Canadian Natural's claims are valid and to understand the variability within the reported results. Canadian Natural is required to provide presentations, results in tabular format, model losses, and progress reports every six months, starting December 31, 2017.

[95] The AER expects that, if Canadian Natural's data demonstrates effectiveness in reducing tailings generation, Canadian Natural will submit an application to amend its approval by 2025, 1 year prior to the MFTRMP pilot expiration.

Water Capping

Context

[96] Water-capping technology involves the placement of water on top of untreated or treated tailings with an outcome of creating an aquatic closure ecosystem (i.e., pit lake or end-pit lake). Canadian Natural stated that 177 Mm³ of untreated fluid tailings would be stored in DDA3 and DDA8-9, which would be capped with water to create permanent end-pit lakes. Proposed placement of tailings in DDA3 commences in 2028 and placement of tailings in DDA8-9 commences in 2050. Water capping in both deposits is proposed in 2055.

[97] There are various uncertainties and risks associated with water-capping technology and the technology is subject to further assessment and research and to future policy.

Decision

[98] Canadian Natural is prohibited from placing any water, including industrial wastewater, above treated or untreated tailings for the purpose of creating an aquatic closure landscape.

[99] Canadian Natural is required to provide as part of its end-pit lake research and development report required under its *EPEA* approval the following, as set out in appendix 3:

- the applicability of Syncrude's Base Mine Lake (BML) research to Canadian Natural's TMP
- how Canadian Natural will address uncertainties and risks where BML research is not applicable

AER Findings

[100] SOC filers submitted that there was great uncertainty around the use of end-pit lakes and water-capping technology is yet unproven. ACFN and OSEC stated that the pilot end-pit lake project being studied by Canada's Oil Sands Innovation Alliance will not commence construction until 2017 and there are substantial research gaps. The AER agrees that water-capping technology is subject to further assessment, research and future policy, and therefore Canadian Natural is prohibited from placing any water, including industrial wastewater, above treated or untreated tailings for the purpose of creating an aquatic closure landscape.

[101] The AER expects that any research should be focused on addressing site-specific uncertainties and be implementable on site in a timely manner to ensure that the *TMF*'s objective is met, ensure that future reclamation timelines are not extended, and be able to assist with regulatory decision making.

[102] Canadian Natural stated it was participating with Syncrude in the study of BML and was supportive of other industry and government research. Canadian Natural has not provided the information necessary to evaluate whether the BML research will address its site-specific uncertainties and the AER is concerned that Canadian Natural will not have timely or adequate information available to inform future decisions on water capping of DDA3 and DDA8-9. Therefore, Canadian Natural is required to provide as part of its end-pit lake research and development report required under its *EPEA* approval the following, as set out in appendix 3:

- the applicability of BML research to Canadian Natural's circumstances
- how Canadian Natural will address uncertainties and risks where BML research is not applicable

Alternative to Water Capping

Context

[103] *Directive 085* requires that, where water-capped fluid tailings technology are used to generate the inventory forecast in the profiles provided in the TMP, an alternative technology option is provided, including timeframes for implementation. SOC filers raised concerns with the aquatic closure outcome and uncertainties with the proposed technology; as such, they want Canadian Natural to provide a feasible and timely terrestrial closure outcome. The AER shares those concerns.

Decision

[104] Canadian Natural is required to submit a plan by September 30, 2025, for the management of fluid tailings to be planned to be placed in DDA3 and DDA8-9 that ensures no water, including industrial wastewater, is placed above treated or untreated tailings for the purpose of creating an aquatic closure landscape.

AER Findings

[105] The AER acknowledges that while Canadian Natural did not commit to a specific alternative technology to water capping with timeframes for implementation, it did commit to assess alternative treatment technologies between Q2 2018 and Q2 2021 and indicated it will decide on an alternative treatment technology or technologies in 2025. The treatment technologies Canadian Natural plans to evaluate include enhanced NST technology, alternative fluid tailings treatment, NRU tailings treatment, and in-pit extraction process.

[106] To provide Canadian Natural with time to assess alternative treatment technology options, and to ensure the AER receives adequate information to inform decision making prior to placement of tailings in DDA3, Canadian Natural is required to submit a plan by September 30, 2025. The plan is to ensure no water, including industrial wastewater, is placed above treated or untreated tailings for the purpose of creating an aquatic closure landscape in DDA3 and DDA8-9. This date is three years before Canadian Natural plans to start depositing tailings into DDA3, and thirty years before end of mine life. This provides adequate time for any changes to tailings management if it is necessary and aligns with Canadian Natural's alternative treatment technology decision. The plan is also critical to Canadian Natural's profiles, as the use of water-capped fluid tailings technology was used to generate the inventory forecast in the profiles.

[107] In making this decision, the AER also recognized that Canadian Natural is focused on its NST technology ramp-up and MFTRMP progress until 2023 and 2022, respectively, which all contribute to reduced fluid tailings volumes.

[108] As noted by Canadian Natural, it will update the AER on its progress regarding alternative technologies under *Directive 085* reporting requirements.

NRU Tailings Management

Context

[109] In the froth treatment plant, naphtha is added to froth to help separate bitumen from water and solids. The water and solids (i.e., tailings) from the froth treatment plant are sent to the NRU to recover naphtha. Once the tailings are processed by the naphtha recovery unit, they are known as NRU tailings. NRU tailings are less than 10 per cent of overall tailings volumes at Canadian Natural's project and can pose higher environmental risks because they can contain residual naphtha, other hydrocarbons, sulphides, and other substances.

Decision

[110] Canadian Natural can place NRU tailings only in ETF/DDA1.

[111] Canadian Natural is required to update its plan to manage NRU tailings by September 30, 2021. This plan must include how research results (reported through Canadian Natural's *EPEA* approval) and the long-term reclamation outcomes in the *EPEA* life of mine closure plan have been incorporated.

AER Findings

[112] Because Canadian Natural is currently placing NRU tailings in ETF/DDA1 and does not have a long-term plan for its NRU tailings, Canadian Natural can place NRU tailings in only ETF/DDA1. The AER considered the following in making this determination:

- Canadian Natural plans to place NRU tailings in ETF/DDA1 until 2025;
- Canadian Natural initially intended to place NRU tailings in DDA3 starting in 2026;
- Canadian Natural acknowledged that placing untreated NRU tailings in DDA3 could be problematic for the future viability of an end-pit lake;
- Canadian Natural committed that untreated NRU tailings would not be placed into any DDA proposed to be capped with water (i.e., DDA3); and
- Canadian Natural did not propose an alternative deposit other than ETF/DDA1 until 2025 and DDA3 starting in 2026 for its NRU tailings as part of its TMP.

[113] Canadian Natural is required to update its plan to manage NRU tailings by September 30, 2021, which will include where NRU tailings will be placed and how NRU tailings will be treated, and must incorporate Canadian Natural's research results on the effect NRU tailings may have on the viability of pit lakes and end-pit lakes. The timing for submitting this plan is appropriate because Canadian Natural stated that it expected to make a decision on NRU tailings treatment technology and other alternative treatment technologies between Q2 2018 and Q2 2021.

[114] As noted by Canadian Natural, it will update the AER on its NRU tailings treatment technology status under *Directive 085* reporting requirements.

Capping Material Availability

Context

[115] Canadian Natural requires tailings sand for the following purposes:

- treating fluid tailings by NST and MFT-spiked NST technologies,
- landform contouring to facilitate the flushing of salts from the capping material and control expressed tailings pore water, and
- landform stability, including managing any settlement and controlling surface water.

Decision

[116] Canadian Natural is required to submit a capping research plan by December 31, 2020.

[117] Canadian Natural is required to explain how the results of capping research have been incorporated in to the plans submitted 1 year prior to placement of fluid tailings or treated tailings into each new deposit.

[118] Canadian Natural is also required to explain how the results of capping research have been incorporated into the plan for the management of fluid tailings planned to be placed in DDA3 and DDA8-9 that will be submitted by September 30, 2025.

[119] Canadian Natural is required to provide additional information in its *EPEA* life of mine closure, mine reclamation plans, and annual reclamation progress tracking report as set out in appendix 4.

AER Findings

[120] The AER is concerned that future reclamation activity may be compromised due to inadequate tailings sand availability. Canadian Natural did not provide the volume of tailings sand available or the volume of tailings sand required for achieving the profiles (e.g., for NST and MFT-spiked technology use) or for other capping purposes (e.g., rooting zone protection, landform contouring, maintaining water table depth). The availability of tailings sand may be underestimated for the following reasons

- There is limited information on the SFR of the ore beyond the immediate area of mining activity.
- Canadian Natural's experience with NST technology is relatively new, and performance expectations are uncertain.
- Industry's experience with capping similar deposits (i.e., composite or consolidated tailings deposits) indicates that additional capping material will be required to ensure landform contouring and stability.

[121] Canadian Natural stated that NST deposits will be covered with a minimum of 1 m capping material, as per its *EPEA* approval. For clarity, Canadian Natural's *EPEA* approval condition for 1 m of suitable capping material is for the purpose of protecting the rooting zone and does not consider other objectives of placing capping material, such as water table control and geotechnical stability.

[122] Further planning by Canadian Natural needs to occur to ensure that there is adequate tailings sand and capping material. As set out in appendix 4, pursuant to its *EPEA* approval, Canadian Natural is required to provide the following additional information:

- research results for capping objectives in addition to rooting zone protection for tailings deposits;
- material balances for sand and any other suitable capping materials to meet terrestrial and wetland outcomes, which shall include accounting for limited drilling data, tailings treatment technology performance demands, landform development and stability, settlement management, expressed

tailings pore water control, water table control, landform contouring, and the suitability of the capping material's chemical and physical properties;

- rationale for defining capping requirements for NST or NST with fine fluid tailings additions in the dedicated disposal areas, including additional information on the capping requirements for landform development and stability, settlement management, expressed tailings pore water control, water table control, and landform contouring to facilitate the flushing of salts from the capping material and control expressed tailings pore water.
- contingency plans for capping material shortages.

[123] It is also acknowledged that Canadian Natural agreed to provide more details in its *EPEA* life of mine closure plan to be submitted to the AER.

[124] Canadian Natural's capping requirements are subject to uncertainties because of the stage of development. Research will provide timely, site-specific, and adequate information to address uncertainties and inform future decision making with respect to how capping material shortages may affect alternative tailings treatment technology selection or needs. Canadian Natural can and should also draw upon existing industry research on capping.

[125] The AER acknowledges that Canadian Natural has provided some capping research information as part of its *EPEA* approval. However, Canadian Natural did not specify what uncertainties associated with the TMP that the research is planning to address, nor how the research would be timely, site-specific, and generate adequate information to support future decision making with respect to how capping material shortages may affect tailings treatment technology selection or future reclamation activity. Therefore, the AER requires Canadian Natural to submit a capping research plan by December 31, 2020.

[126] For this research plan, the AER expects Canadian Natural to use standard scientific methodology in the design of its research plans, and Canadian Natural is required to provide details that support its research, including the objective, the applicability of that objective in addressing the uncertainties and risks associated with Canadian Natural's TMP, and how the research is building upon existing knowledge.

[127] The AER expects that any research plans should be focused on addressing site-specific uncertainties and be implementable on site in a timely manner to ensure that the *TMF*'s objective is met, ensure that reclamation timelines are not extended, and assist with regulatory decision making. It is important to understand how Canadian Natural can incorporate the research results into its mining operations. In addition, Canadian Natural should consider the benefits of peer-reviewed research and publication to provide an appropriate level of assurance.

[128] All research plans should include the following:

- rationale for proposed monitoring plans that support research;
- a discussion how the selection of performance measures, criteria, and validation methods relate to implementation;
- the applicability and scalability of the research to full implementation;
- a discussion on impact to long-term reclamation outcomes and timing for the site; and
- the changes that would be necessary to the mine design and material requirements to enable long-term reclamation outcomes.

[129] The AER's review of Canadian Natural's research plans will be informed by the research expectations set out in this decision. If Canadian Natural's research plans do not accord with these expectations, the AER will re-evaluate the regulatory approach.

[130] Research results will be made publicly available through *Directive 085* annual reporting to the AER. Canadian Natural is required to explain how the results of capping research have been incorporated into the plans submitted one year prior to placement of fluid tailings or treated tailings into each new deposit and the plan for the management of fluid tailings to be placed in DDA3 and DDA8-9. The explanation must also include whether there are any impacts from the results of capping research to tailings treatment technology selection (e.g., inform the need for any alternative or supplemental tailings treatment technologies) or future reclamation activity.

[131] Canadian Natural is also required to continue to report on capping and stability as part of its tailings research report required under its *EPEA* approval as set out in appendix 3.

[132] Material balances for sand and other suitable capping materials submitted in Canadian Natural's *EPEA* life of mine closure plans and mine reclamation plans are forecasts that performance will need to be assessed against. Therefore, as set out in appendix 4, Canadian Natural is required to provide in its annual reclamation progress tracking report material balances for sand and any other suitable capping materials to meet terrestrial and wetland outcomes.

[133] In addition, it is important for Canadian Natural to consider the effects of hydraulic placement of sand because it may result in the following

- high salinity or other water quality issues due to the recycled water used in the process,
- NST and sand mixing,
- non-uniform thickness of sand cap, and
- erosion of the NST deposit.

[134] Canadian Natural is expected to consider these effects as it develops the capping research plan.

Storage

Context

[135] Site-wide fluid storage space is needed to adequately contain and manage fluid tailings, treated tailings, and water, including industrial wastewater. Where the volume of fluid tailings, treated tailings, and water, including industrial wastewater, exceeds the on-site storage capacity, there is the potential to compromise the tailings management, increase land disturbance, create additional storage facilities, and sterilize resource; delay progressive reclamation activities; and impact dam safety.

[136] Canadian Natural stated that it would meet its planned treated tailings, fluid tailings, and process water storage capacity requirements by constructing nine DDAs. Canadian Natural presented its planned storage capacity requirements and planned storage capacity availability for the years from 2014 to 2065. Canadian Natural will experience storage capacity constraints in the years 2020 (start-up of DDA2) and 2028 (start-up of DDA4).

Decision

[137] Canadian Natural is required to report annually on the available storage capacity of each tailings deposit or tailings pond that contains water or tailings and storage capacity and volume requirements for the next five years.

AER Findings

[138] The AER is concerned that the planning assumptions used by Canadian Natural underestimate its storage capacity requirements based on the following:

- Canadian Natural's experience with NST technology is relatively new, and performance expectations may not be met, which could result in increased tailings storage capacity needs.
- Lease boundary negotiations with Total E&P Canadian Limited are not complete and, without a lease boundary agreement, Canadian Natural would be required to revise its mine plan and reduce the storage capacity of DDA2 by about 100 Mm³. The storage capacity may also be reduced in DDA4.
- Assessment of storage capacity was based on the approval of the MFTRMP for the life of the mine, and the AER has authorized the MFTRMP only until September 30, 2022.

[139] To assure the AER that storage capacity is sufficient, Canadian Natural is required to report annually on the available storage capacity of each deposit or pond that contains water or tailings and storage capacity and volume requirements for the next five years.

[140] Pond surveys are important measurement tools to assess deposit performance and verify storage planning assumptions. The AER accepts that Canadian Natural agreed to conduct one additional pond survey of ETF/DDA1 in 2018 and 2019 to further its understanding of deposit performance and to validate storage planning assumptions. This is in addition to its measurement and reporting requirements under *Directive 085*. The AER expects that the pond surveys will measure mudline, pond bottom, solids content, and SFR and expects Canadian Natural to verify and update its storage planning assumptions as information on deposit performance is gathered.

Pilots, Prototypes, and Demonstrations

Context

[141] Innovation is a principle of the *TMF* and *Directive 085*. Canadian Natural proposed to investigate a number of alternative and supplemental technologies in addition to those dealing with water capping.

Decision

[142] Canadian Natural is required to notify the AER 6 months in advance of any proposed, on-site pilots, prototypes, or demonstrations. Canadian Natural may not construct or implement the proposed, on-site pilots, prototypes, or demonstrations unless a written authorization or approval amendment is granted.

AER Findings

[143] To facilitate innovation at the Horizon oil sands processing plant and mine, and to address administrative inconsistencies between the *OSCA* and *EPEA*, the AER has updated the requirements in Canadian Natural's *OSCA* approval to be consistent with the principles of the *TMF* and *Directive 085*, and the requirements under the *EPEA* approval.

[144] These requirements in Canadian Natural's approval are to ensure appropriate oversight and transparency. The AER continues to support and acknowledge the importance of technological innovation, understanding, and certainty around fluid tailings treatment options. As highlighted in *Directive 085*, the AER expects Canadian Natural to show commitment to innovation and continuous improvement, and share ongoing technology learning and development.

Ready to Reclaim Criteria

[145] As stated in the *TMF* and *Directive 085*, fluid tailings are considered RTR when they have been processed with an accepted technology, placed in their final landscape position, and meet performance criteria (i.e., RTR criteria).

[146] RTR criteria supports the objective of reclaiming oil sands mining projects to a self-sustaining locally common boreal forest ecosystem that is integrated with the surrounding area and consistent with the values and objectives identified in local, subregional, and regional plans.

[147] RTR criteria are used to track the performance of a tailings deposit towards its ability to be reclaimed as predicted and in the time predicted. Consequently, RTR criteria are critical to evaluate trends and performance management.

[148] There are two subobjectives that address different aspects of performance:

- Subobjective 1: The deposit's physical properties are on a trajectory to support future stages of activity.
- Subobjective 2: To minimize the effect the deposit has on the surrounding environment and ensure that it will not compromise the ability to reclaim to a locally common, diverse, and self-sustaining ecosystem.

[149] The *TMF* and *Directive 085* provide the flexibility for operators to develop RTR criteria that are suitable to the type of tailings, technology, deposit, and enable future reclamation activity. *Directive 085* provides guidance on RTR criteria and requires operators to include information that supports the assessment of RTR criteria.

[150] In accordance with *Directive 085*, where treated tailings are meeting their RTR criteria, they can be removed from the fluid tailings inventory because they are on a trajectory to meeting long-term reclamation outcomes. Treated tailings will require ongoing monitoring to confirm they are still on the RTR trajectory and meeting trajectory milestones. In circumstances where RTR criteria are no longer met or there is a deviation from the expected trajectory, Canadian Natural must identify the volume not meeting the RTR criteria and the degree of nonperformance.

[151] SOC filers raised concerns with the adequacy and specificity of Canadian Natural's proposed RTR criteria. The AER has similar concerns.

Deposit Milestones

Context

[152] *Directive 085* states that, at minimum, approval conditions will address fluid tailings deposit milestones. As part of *Directive 085*'s application requirements with respect to the issue of RTR, applicants were required to identify critical milestones for each deposit including deposit preparation, start of fluid tailings placement, capping, and start of future reclamation activities.

Decision

[153] Canadian Natural is required to meet the milestones set out in its application, figure 8.1.1-1 (appendix 5).

AER Findings

[154] It is appropriate to require Canadian Natural to meet the deposition, capping, and revegetation milestones set out in its application, figure 8.1.1-1 because those milestones are aligned with the requirements and expectations of *Directive 085* and enable future reclamation activity.

[155] It is recognized that Canadian Natural is in its initial phase of operating its tailings treatment technology which may result in modifications to these milestones in the future as operations continue.

Measurement and Averaging

Context

[156] Each treated tailings deposit will have approved indicators that must be measured to determine if the RTR criteria has been achieved. *Directive 085* requires operators to submit a measurement system plan six months from the date of an approved TMP.

Decision

[157] Details on RTR criteria measurement will be included in Canadian Natural's measurement system plan (appendix 6). The measurement system plan must include:

- definitions of parameters for fluid tailings and RTR criteria measurements;
- reference to standards and procedures used to measure fluid tailings and treated tailings and RTR criteria;
- an explanation of and justification for measurement procedures that are unique to Canadian Natural and its plan;
- evidence that the plan will address the measurement outcomes as per section 5 of *Directive 085*;
- an explanation of how each of the deposit's RTR criteria will be measured, calculated, and reported;
- a description of the deposit sampling, measurement, and survey program; and
- justification of how measurement, sampling, and spacing intervals will
 - show the variation of the deposit properties,
 - verify that the tailings deposit is achieving RTR criteria, and
 - identify if any material in the deposit is not achieving RTR criteria.

[158] Canadian Natural is required to measure the volume of treated tailings that meets the RTR criteria based on deposit sampling and cannot use annual average solids content for the entire deposit. Treated tailings can only be removed from the fluid tailings inventory if the RTR criteria are achieved.

AER Findings

[159] RTR criteria alone do not explain how Canadian Natural will determine the volumes of treated tailings that are no longer meeting RTR criteria and must be returned to the inventory. Canadian Natural did not propose how it would determine the volume of fluid tailings to be returned to the fluid tailings inventory where subobjective 1 or subobjective 2 RTR criteria were not met. As such, Canadian Natural's measurement system plan is required to describe how Canadian Natural will measure the volume of treated tailings that do not meet RTR criteria and that must be returned to the inventory.

[160] A key issue of the measurement system is the use of averaging or deposit sampling. Canadian Natural's proposed use of using an averaging process for solids content of a deposit as an RTR criterion does not provide sufficient information to identify variations in tailings characteristics across a deposit. The use of an average, in particular, limits the ability to assess risks and liabilities for underperforming treated tailings and the effect on a deposit's performance towards the targeted ecosites. A deposit may show excellent performance on average while a significant portion of the tailings deposit is underperforming and compromising the ability to reclaim. The averaging process obscures understanding of the deposit volumes that have been treated unsuccessfully or are failing to improve as expected. Therefore, Canadian Natural is required to measure the volume of fluid tailings and treated tailings that meets the RTR criteria based on deposit sampling and may not use an annual average for the entire deposit.

[161] The AER recognizes that sampling of a tailings deposit is challenging and that Canadian Natural may use some form of 3-D modelling or spatial statistics to determine the volume not meeting the performance criteria, and the degree of inadequate performance. The AER expects that the frequency and spatial extent of monitoring, and the statistical methods applied, will minimize the margin of error.

Subobjective 1: Solids Content

Context

[162] Subobjective 1 RTR criteria are related to the performance of the deposit's physical properties. RTR criteria are made up of indicators, measures, and criteria.

- **Indicator:** a measurable variable that is strongly correlated with the condition of a component that is tied to a specific objective or outcome. Measurement of indicators provides evidence that a certain condition exists or certain results have or have not been achieved.
- **Measure:** a qualitative or quantitative aspect of an indicator; a variable that can be measured (quantified) or described (qualitatively) and demonstrates either a trend in an indicator or whether a specific criterion was met.
- **Criteria:** a quantitative aspect of a measure (values) that demonstrates whether or not an objective is met or that risk of adverse effects is unacceptable or likely.

[163] Canadian Natural proposed to use the solids content of a deposit as a subobjective 1 RTR criterion measure. Solids content represents the percentage mass of solid material present in a sample.

[164] This section only discusses Canadian Natural's proposed use of solids content. The AER's findings on the associated criteria (e.g., 70 per cent solids content) are discussed in *Subobjective 1: Trajectory*.

Decision

[165] The AER finds that the use of solids content of a deposit is an acceptable subobjective 1 RTR criteria measure.

[166] Canadian Natural is required to provide monitoring data, including representative cross-sections, for the probable indicators identified by Canadian Natural and for clay type and content (percentage) as part of its reporting under *Directive 085*.

[167] Canadian Natural is required to propose by September 30, 2019, additional RTR criteria for ETF/DDA1 that incorporates the ETF/DDA1 deposit monitoring results.

[168] Canadian Natural's approval is conditioned to allow for improvements or additions to RTR criteria.

AER Findings

[169] RTR is a new concept and Canadian Natural's RTR criteria may not adequately track the performance of a treated tailings deposit as expected. Improvements to or additional RTR criteria will likely be required. The AER expects that research and monitoring results could inform and lead to modified or new RTR criteria. Canadian Natural's approval is conditioned to allow for improvements or additions to RTR criteria.

[170] For NST deposits (e.g., ETF/DDA1, DDA2, DDA4, DDA5, DDA6, and DDA7), solids content alone may not be sufficient to measure a deposit's performance or its ability to meet future stages of reclamation activity. Solids content can remain constant while other deposit measures, such as SFR and clay type and content, can vary. The variation of these latter measures may be equally critical in determining the performance of the deposit and its ability to enable future reclamation activity.

[171] Canadian Natural's experience with NST technology is relatively new. The AER expects Canadian Natural to improve and develop RTR criteria based on what it learns as it continues to implement NST technology. As identified by Canadian Natural other probable indicators that may be developed and used in the future to assess deposit performance, include pore water pressure, effective stress, SFR, and consolidation of NST deposit.

[172] Active monitoring of these probable indicators and of clay type and content is important to ensure understanding of the NST deposit performance and RTR criteria sensitivity. Canadian Natural is required to provide monitoring data, including representative cross-sections, for the probable indicators identified by Canadian Natural and for clay type and content (percentage) as part of its reporting under *Directive 085*, submitted by April 30 each year. Canadian Natural is also required to use these monitoring results and any other ETF/DDA1 deposit monitoring results to provide additional RTR criteria for ETF/DDA1 by September 30, 2019.

Subobjective 1: Trajectory

Context

[173] Subobjective 1 RTR criteria are related to the performance of the deposit's physical properties. *Directive 085* indicates that a trajectory or progression of RTR criteria over time may be necessary in order to successfully enable future reclamation activity.

Decision

[174] Canadian Natural is required to meet the following RTR criteria:

- the solids content of a deposit, based on deposit sampling, is 70 per cent within one year of treated fluid tailings placement and
- the solids content of a deposit, based on deposit sampling, is 81 per cent within five years of achieving 70 per cent solids content.

AER Findings

[175] Based on the performance data submitted by Canadian Natural, the AER believes that Canadian Natural's NST deposits (e.g., ETF/DDA1, DDA2, DDA4, DDA5, DDA6, and DDA7) should be able to achieve a solids content of 70 per cent within one year of treated fluid tailings placement. The AER accepts this as Canadian Natural's trajectory starting point.

[176] It is uncertain whether Canadian Natural will be able to hydraulically cap its NST deposits at 70 per cent solids, as it proposed, because it did not provide adequate evidence to support this claim. To address this uncertainty, the AER expects that Canadian Natural will determine whether it can hydraulically cap its NST deposits at 70 per cent solids as part of the capping research plan required by December 31, 2020.

[177] Canadian Natural's NST deposit trajectory's end point of 81 per cent solids content within 5 years after achieving 70 per cent solids content is also acceptable to the AER based on industry evidence which supports that reclamation activities can begin at this point. As subobjective 1 RTR criteria is meant to demonstrate progression of the deposit's physical properties towards enabling future reclamation

activity, Canadian Natural is also required to meet 81 per cent solids content as an RTR criterion. SOC filers supported the use of the 81 per cent as an RTR criterion.

[178] There are, however, uncertainties if Canadian Natural's NST deposits will achieve 81 per cent solids and enable future reclamation activity because Canadian Natural did not provide adequate site-specific evidence to support

- how long it would take to achieve 81 per cent solids content,
- the capping material requirements needed for its deposits to achieve 81 per cent solids content, or
- that a deposit solids content of 81 per cent would support the targeted ecosites.

Canadian Natural is expected to address these uncertainties as part of the capping research plan required by December 31, 2020.

Deposit Settlement

Context

[179] Deposit settlement could compromise a deposit's physical properties and the ability of a deposit to successfully enable future reclamation activity.

Decision

[180] Canadian Natural is required to provide a flux, settlement, and consolidation model that is representative of ETF/DDA1, including the downslope of the deposit by September 30, 2018.

[181] Canadian Natural is also required to provide such modelling as part of the updated deposit-specific plan one year prior to placement of fluid tailings or treated tailings in a specific deposit.

AER Findings

[182] As tailings settle, the majority of tailings pore water expressed seeps upward, and this upward flux or pore water could cause a rise in the water table or contaminate the soil cover. Canadian Natural's suggestion of deposit settlement as a possible RTR criterion is encouraged because the AER agrees that settlement will occur and pose a risk to a deposit's ability to enable future reclamation activity.

[183] While Canadian Natural predicted that settlement would occur in all deposits, it did not provide flux, settlement, or consolidation models for any of its deposits to demonstrate the expected degree and duration of settlement, and it noted that additional research on settlement after capping was required. To provide additional information to enhance the understanding of settlement and mitigate associated risks, such as insufficient availability of capping material and expression of pore water impacting the water table, Canadian Natural is required to provide a flux, settlement, and consolidation model for ETF/DDA1

by September 30, 2018. This information could be used in the future for improvements to or additional RTR criteria.

[184] In addition, Canadian Natural is required to include in its updates to deposit plans, a flux, settlement, and consolidation model that is representative of the tailing deposit in which placement of fluid or new tailings is planned within 1 year.

[185] The AER expects that the required capping research plan also address deposit settlement, including wetland implications. For example, while Canadian Natural indicated that wetlands would be designed and built into the closure landscape, it is important to understand how opportunistic wetlands will develop from the collection of water in low-lying areas or depressions that arise from differential settlement. This understanding is necessary to ensure that the RTR criteria align with the targeted final landforms and the targeted range of ecosites and that there will be no significant adverse effects such as erosion or water releases. Canadian Natural is also required to continue to report on wetlands as part of its tailings research report required under its *EPEA* approval as set out in appendix 3.

Subobjective 2

Context

[186] Subobjective 2 RTR criteria focus on circumstances where the operator may propose management strategies, design features, or mitigation measures for risks associated with the specific nature of the deposit or its surrounding environment that could impact reclamation—for example, design features that control specific water movement such as drainage control systems, or management of risks associated with deposit characteristics such as treated froth fluid fine tailings, acidification, specific additives, or gas formation.

[187] SOC filers raised concerns with management of water quality, such as salinity and salt movement within the plant rooting zone.

Decision

[188] Canadian Natural is required to meet the following subobjective 2 RTR criteria for DDA1/ETF, DDA2, DDA4, DDA5, DDA6, DDA7:

- groundwater is monitored as required by the *EPEA* approval, and
- the water table is maintained at a depth between 2 and 4 metres.

[189] Canadian Natural proposed subobjective 2 criteria for surface water, erosion, soil, and vegetation are not approved.

AER Findings

[190] Canadian Natural's groundwater monitoring program can provide early indicators of contaminant mobility from tailings deposits, which addresses risk to groundwater and the risk of seepage. The AER approves Canadian Natural's proposal to use its existing groundwater monitoring program as subobjective 2 criteria because this information can be used to ensure that the deposit's effects on the surrounding environment will not compromise the ability to reclaim to a locally common, diverse, and self-sustaining ecosystem. Canadian Natural is also required to ensure there is alignment between the groundwater monitoring program and RTR measurement system plan (appendix 6).

[191] Maintaining Canadian Natural's planned 2 to 4 m water table depth to mitigate risks to future reclamation activity is important. Canadian Natural's proposal that mounding of capping materials to incorporate a vertical relief of 1 to 4 m, as appropriate, in areas of high salinity to protect the rooting zone as a subobjective 2 RTR criterion is not accepted because it does not measure the success of this design feature. Rather, it is acknowledged that mounding of suitable capping materials is a design feature that will contribute to Canadian Natural's planned 2 to 4 m water table depth, preventing risks such as salt movement to the plant rooting zone and providing sufficient drainage. As such, Canadian Natural is required to maintain the water table depth between 2 and 4 m as a subobjective 2 criterion because it measures the success of this design feature in not compromising future reclamation activity.

[192] Because Canadian Natural is not capping until 2030 and must submit a capping research plan, it is acknowledged there is the possibility this subobjective 2 RTR criterion, maintaining a water table depth between 2 to 4 m, may be modified or added to. Further, through its capping research Canadian Natural may confirm the ability to maintain the water table depth with less capping materials in some areas.

[193] While Canadian Natural's proposal that subobjective 1 RTR criteria will also provide an indication of possible issues related to subobjective 2 RTR criteria, the AER is not approving its use as subobjective 2 RTR criteria because it is not unique and is already being measured as subobjective 1 RTR criteria.

[194] Canadian Natural's proposal of subobjective 2 RTR criteria for surface water, erosion, soil, and vegetation are not accepted because Canadian Natural proposed criteria focused on design features for future stages of reclamation (e.g., soil type and depth; wetland littoral zones) and measures of successful reclamation rather than addressing deposit risks or success of proposed design features that could affect reclamation but which could be managed before reclamation (e.g., tailings quality, capping, landform design, or surface water collection). The AER encourages Canadian Natural to continue measurement and monitoring of such indicators to enable future reclamation activities.

[195] Canadian Natural will continue to research risks associated with tailings and the achievement of ecosystems as part of its *EPEA* approval. Research results may modify or identify additional subobjective 2 RTR performance criteria.

Water Capping

Context

[196] RTR criteria for water-capped deposits are subject to further assessment, research, and future policy.

Decision

[197] The AER does not authorize any RTR criteria for water-capped deposits.

AER Findings

[198] Canadian Natural did not provide evidence in support of the following proposed RTR criteria for DDA3 and DDA8-9

- The deposits would achieve RTR status immediately after water capping was completed.
- The deposits would achieve RTR status when the water quality was adequate to establish a littoral zone.

[199] In addition, Canadian Natural is prohibited from placing any water, including industrial wastewater, above treated or untreated tailings for the purpose of creating an aquatic closure landscape.

NRU Tailings

Context

[200] NRU tailings are less than 10 per cent of overall tailings volumes, and, as previously stated in the decision, Canadian Natural can place NRU tailings only in ETF/DDA1 at this time.

Decision

[201] Canadian Natural is required to provide RTR criteria for NRU tailings before claiming these tailings volumes as RTR.

AER Findings

[202] Canadian Natural's proposal that 100 per cent of its NRU tailings volumes would be RTR in a year is not accepted because

- Although Canadian Natural indicated that NRU tailings in the beach reach 75 per cent solids content within a year, Canadian Natural did not propose this as RTR criteria for the 40 per cent of the NRU tailings captured in the beach.
- No RTR criteria are proposed for the 60 per cent of NRU tailings that is not captured in the beach.

[203] Canadian Natural is required to provide RTR criteria for NRU tailings before claiming these volumes as RTR because NRU tailings are a part of the tailings volumes that need to be managed under *Directive 085*.

Environmental Effects and Implications

[204] The *TMF*'s objective is to minimize fluid tailings accumulation, which may reduce environment effects such as seepage, occurrences of wildlife contact with tailings ponds, and the tailings footprint.

[205] However, efforts to minimize fluid tailings volumes may result in potential changes or trade-offs to other environmental risks and effects to air, land, and water. These changes or trade-offs must be identified and their short-term and long-term implications to environmental performance assessed. Applications will identify the nature, location, and magnitude of environmental effects and the understanding of their environmental and reclamation implications.

[206] For currently approved projects, the proposed TMP should be consistent with the previously predicted environmental outcomes or identify any inconsistencies. The existing and proposed monitoring plans will confirm that environmental performance is achieved.

[207] The TMPs must align with existing provincial and federal policies, legislation, regulations, strategies, frameworks, requirements, and stated desired outcomes for the region.

[208] TMPs, including mitigation measures and contingency plans, will minimize the risk of environmental effects over the life of a project.

[209] Based on Canadian Natural's TMP, there are no *EPEA* terms and conditions, including approval limits being amended.

[210] However, there are environmental effects and implications that the AER addresses below to provide and ensure clarity of the decision.

Air

Decision

[211] No *EPEA* approval air emission limits are being amended as a result of the TMP.

[212] Canadian Natural is authorized to increase production of SCO from about 232 000 bpd (37 000 m³/d) to about 250 000 bpd (40 000 m³/d).

AER Findings

[213] Canadian Natural requested approval to increase production of SCO from about 232 000 bpd (37 000 m³/d) to about 250 000 bpd (40 000 m³/d) as a result of debottlenecking its oil sands processing plant. No changes to its existing oil sands processing plant are required for this increase in production.

[214] The AER agrees with Canadian Natural's statements that its technical assessment confirms that its air emissions at 250 000 bpd of SCO would be within current *EPEA* air emission limits and were consistent with the emission rates used in the air dispersion modelling completed for the most recent *EPEA* renewal application. Canadian Natural provided the results of its technical assessment, which showed that emissions of NO_x, SO₂, and particulate matter (PM_{2.5}) were not expected to change. The AER is not amending any *EPEA* approval terms and conditions, including air emission limits, as a result of the TMP.

[215] The AER also recognizes that there is ongoing work with respect to *Recurrent Human Health Complaints Technical Information Synthesis Fort McKay Area* (September 2016), which may result in modified or new conditions related to odours and emissions being imposed on Canadian Natural in the future.

Surface Water and Groundwater

Decision

[216] There are no changes arising from the TMP that are expected to change previously assessed impacts to surface water or groundwater quality during the mine's operating phase.

AER Findings

[217] The AER finds that Canadian Natural's existing surface water and groundwater control measures manage the environmental risks and effects during the mine's operating phase. Canadian Natural must operate these measures in accordance with the terms and conditions of its *EPEA* approval. The AER expects that the duration of surface water and groundwater control measure operation will continue to be addressed in Canadian Natural's *EPEA* life of mine closure plan.

[218] Oil sands process water, tailings, and mine-affected water are intercepted and kept in a closed-circuit water system, and surface water drainage within the tailings deposit was designed to keep process-affected precipitation within the tailings area and within the closed-circuit water system.

[219] A network of groundwater wells were currently in place to manage oil sands process water that could seep into the groundwater from tailings deposits, and additional wells would be drilled to monitor groundwater flow and water chemistry. The AER acknowledges Canadian Natural's statement that if groundwater were affected by contact with water expressed from tailings, the groundwater would be

pumped back into the tailings deposit. The network of groundwater wells would be expanded as the mine area expanded.

[220] The AER finds that Canadian Natural's existing surface water and groundwater control measures manage the environmental risks and effects during the mine's operating phase.

Tailings Water Release

Decision

[221] Canadian Natural did not request approval to release water as part of its TMP. Water release is not authorized except under Canadian Natural's *EPEA* approval.

AER Findings

[222] Canadian Natural provided water quality modelling for all pit lakes and ponds. The water quality modelling indicated that all parameters of concern were predicted to meet guidelines or chronic effects benchmarks prior to any planned release to the environment. However, the Government of Alberta has not accepted the use of chronic effects benchmarks or other guidelines as water quality limits for discharge to the receiving environment. SOC filers raised concerns with possible future water release and requested that the decision needs to be able to implement future policy changes.

[223] At this time, Canadian Natural's water quality model assessment lacks the necessary detail to evaluate the uncertainties and risks concerning water quality, the viability of water-capped pit lakes, the effect of source water quality on the viability of water-capped pit lakes, and the ability of water-capped pit lakes to become self-sustaining boreal forest lake ecosystems.

[224] The AER acknowledges that Canadian Natural is required to continue to research pit lakes and the risks to and uncertainties about water quality as part of its *EPEA* approval. The AER also acknowledges that Canadian Natural committed to including further modelling in its *EPEA* life of mine closure plan.

Alternatives to Capping NST

Decision

[225] NST revegetation, use of coarse NST as capping material, and placing coke on top of NST to form a trafficable surface have not been previously approved and is not approved as part of Canadian Natural's TMP.

AER Findings

[226] Canadian Natural stated that it was planning to do research to evaluate the possibility of reclaiming NST deposits directly, rather than using capping material. In addition to reclaiming NST directly, Canadian Natural stated that it would research the following options:

- using coarse NST as capping material above NST deposits and
- placing coke on top of NST to form a trafficable surface.

[227] SOC filers requested that they be involved in vegetation decisions made by Canadian Natural and expressed concern regarding the placement of coke above tailings.

[228] Reclaiming NST directly, using coarse NST as capping material, and placing coke on top of NST to form a trafficable surface are significant changes from current practice. Canadian Natural did not provide an assessment of the environmental effects and implications of this change, such as soil and vegetation quality and surface water quality and drainage, and Canadian Natural should seek guidance on AER expectations and requirements as it moves forward with this research.

Other Technical Issues

[229] This section contains technical issues that do not fit into the previous sections.

Future Deposits

[230] The AER acknowledges that, for projects in the early stages of operations such as this project, certain information is not available. As such, it is acknowledged that the TMP provides limited information on DDAs 2, 3, 4, 5, 6, 7, and 8-9.

[231] As such, the AER prohibits Canadian Natural from placing fluid tailings and treated fluid tailings in DDAs 2, 3, 4, 5, 6, 7, and 8-9 until Canadian Natural has provided additional information to the AER one year prior to placement. The additional information includes addressing the requirements of *Directive 085*, including RTR criteria; confirming the ability to achieve the profiles; evaluating performance of similar deposits; incorporating research results, reported through Canadian Natural's *EPEA* approval; incorporating the long-term reclamation outcomes in the *EPEA* life of mine closure plan; and mitigating uncertainties. These plans cannot be implemented by Canadian Natural until the AER permits such implementation.

TMP and EPEA Plan Alignment

[232] *Directive 085* requires that TMPs demonstrate alignment with existing approvals and plans, including the *EPEA* life of mine closure plan. Where alignment does not occur, the applicant must identify the inconsistencies and describe how alignment will be achieved.

[233] Canadian Natural's TMP is not aligned with its *EPEA* life of mine closure plan because of the following:

- The TMP includes one large pit lake in the north pit, whereas, Canadian Natural's *EPEA* life of mine closure plan proposed two small pit lakes. Canadian Natural did not provide information to evaluate the significance of the change in the DDA8-9 lake configuration and the AER is concerned that the lake configuration and size may not be sustainable.
- The TMP proposes a significant increase in postreclamation drier ecosites on tailings sand substrate or cap that may not support forest capability and commercial forestry potential. Further, Canadian Natural appears focused on achieving a commercial forestry, whereas the outcome of the TMF is to achieve a self-sustaining, locally common, boreal forest ecosystem.
- Canadian Natural indicated that the treatment wetlands would be planted with species tolerant to one group of substances (e.g., salt-tolerant boreal wetland species). The presence of salt and other substances and potential for increased land area dedicated to treatment wetlands with salt-tolerant boreal wetland species may impact the ability to achieve targeted ecosites and long-term reclamation outcomes. Canadian Natural did not assess the spatial extent of wetlands that would be used as treatment wetlands or the potential implications to the distribution of wetland types presented in previous closure submissions.

[234] As set out in appendix 4, Canadian Natural is required, as part of its revised *EPEA* life of mine closure plan submitted for review, to

- evaluate the significance of the change in DDA8-9 lake configuration and end-pit lake (EPL) 1 and EPL2 sustainability;
- provide an ecosite area summary table that includes an acceptable distribution of reclaimed wetland types and ecosite phases that supports a range of land uses, including commercial forest, biodiversity, wildlife habitat, and traditional use;
- provide a map showing the spatial extent and distribution of wetlands, including reclaimed and treatment wetlands; and
- demonstrate alignment or how alignment will be achieved with the TMP.

[235] Depending on the content of revised *EPEA* life of mine closure plan, Canadian Natural may require authorizations or amendments to its approvals. The AER is not authorizing changes to Canadian Natural's *EPEA* life of mine closure plan as part of this decision. The SOC filers raised concerns with the type of vegetation, viability and quality of wetlands, and sustainability of closure ecosystems, which are all matters to be addressed by Canadian Natural's *EPEA* life of mine closure plan.

[236] Canadian Natural is also required to continue to report on terrestrial and wetland ecosystem research as part of its tailings research report required under its *EPEA* approval as set out in appendix 3.

Dam Decommissioning

[237] SOC filers raised concerns regarding dam and dyke integrity and the lack of applicable plans. Canadian Natural stated that Dyke 10, which supports ETF/DDA1, would be the first dam structure to be decommissioned. The AER is concerned that Dyke 10 will not be able to be decommissioned when ETF/DDA1 will still contain treated fluid tailings, even if those tailings have achieved RTR status. Once a cap is placed, it will likely be technically challenging and costly to remove treated fluid tailings if the removal of treated fluid tailings is necessary to decommission the dam.

[238] In accordance with requirements of the *Water Act*, Canadian Natural is required to submit a plan for decommissioning of Dyke 10 one year prior to commencing of capping of the ETF/DDA1 (appendix 7).

[239] Future DDAs may also include dams that will need to be decommissioned. Canadian Natural is required to submit a plan for decommissioning dams one year before capping DDAs (appendix 7).

[240] The AER recognizes that future work with respect to dam decommissioning may result in modified or new conditions or requirements related to the plans for decommissioning of dams and the timelines associated with the plans.

Conclusion

[241] Canadian Natural's oil sands processing plant and mine received approval in 2004. Canadian Natural commenced its tailings treatment technology in 2015 and is operating its first tailings deposit, and has an end of mine life of 2055. The AER must have the appropriate assurances that Canadian Natural's fluid tailings will meet the *TMF*'s objective and outcomes, recognizing that there is time for Canadian Natural to operate, learn, and adjust. Therefore, Canadian Natural must submit appropriate and timely information. This approval reflects a risk-based approach tailored to project-specific considerations. The AER has added research, monitoring, evaluation, and reporting requirements and expectations to meet the requirements of the *TMF* and *Directive 085*.

[242] The approval also requires Canadian Natural to propose an alternative technology or technologies for DDA3 and DDA8-9 by 2025. This should provide sufficient time to adjust Canadian Natural's TMP if water-capped tailings and pit lakes are restricted by government policy or research and monitoring results.

[243] In alignment with the enhanced transparency and increased role of stakeholders introduced by the *TMF* and *Directive 085*, the AER expanded the involvement of stakeholders in the review of Canadian Natural's TMP by circulating the draft approval and providing opportunities for engagement on the issues. That transparency continues through the approval conditions.

[244] The approval takes a balanced approach to the continued involvement of stakeholders. The approval requires Canadian Natural to engage with stakeholders and indigenous communities about tailings management, including holding an annual forum and annually reporting on their engagement efforts to the AER. The approval also provides Canadian Natural with the flexibility in who it engages with and how it undertakes its engagement activities.

Dated in Calgary, Alberta, on December 18, 2017.

Alberta Energy Regulator

<original signed by>

Paul Ferenowicz
Senior Advisor
Alberta Energy Regulator

Appendix 1 Approval

<p>MADE at the City of Calgary, in the Province of Alberta, on</p> <p><original dated></p>	<p><original signed></p> <p>ALBERTA ENERGY REGULATOR</p>
--	--

IN THE MATTER of a scheme of Canadian Natural Resources Limited (hereinafter called “the Operator”) for the recovery of oil sands and production of oil sands products from the Athabasca Wabiskaw-McMurray Oil Sands Deposit in the Athabasca Oil Sands Area, as outlined in Appendix A to this approval.

WHEREAS the Operator has applied to the Alberta Energy Regulator (hereinafter called “the AER”) to amend the approval for its commercial scheme under the *Oil Sands Conservation Act* in respect of the Operator's Tailings Management Plan, including the MFTRMP and increase in production of synthetic crude oil to 250 000 barrels per day; and

WHEREAS the AER is confining substantive changes in this Scheme Approval No. 9752E (hereinafter called “the Scheme Approval”) to those arising from the Operator's Tailings Management Plan, MFTRMP, and increased production;

WHEREAS the AER deems it administratively desirable to consolidate the Scheme Approval and all previously issued amendments to the Scheme Approval granted under the *Oil Sands Conservation Act*.

THEREFORE, pursuant to the *Oil Sands Conservation Act*, chapter O-7 of the Revised Statutes of Alberta, 2000, the AER orders as follows:

1. (a) The commercial scheme applied for by the Operator for the recovery of oil sands and production of oil sands products, from the area shown on the attachment marked Appendix A to this Approval, as such commercial scheme is described in
 - (i) Applications No. 1273313, 1424963, 1615181, 1626022, 1686878, 1755011, 1853536, 1865138, 1844736, 1862178, and 1869003

is approved subject to the *Oil Sands Conservation Act*, the *Oil Sands Conservation Rules*, and the terms and the conditions set out in this approval.
 - (b) Subclause (a) does not preclude alterations in design or equipment provided the AER is satisfied the alterations are compatible with the outline of the commercial scheme, meet the operating criteria in the Scheme Approval, are made for the better operation of the commercial scheme, and do not result in unacceptable adverse impacts.
2. At least five years prior to mining at the southeast lease boundary but no later than June 30, 2017, the Operator shall submit to the AER for its review and approval a report on the southeast area lease boundary containing a comprehensive evaluation of the lease boundary geology and reserves, geotechnical conditions, alternative mining scenarios and impacts, and associated costs, in accordance with Section 3 of *Directive 082, Operating Criteria: Resource Recovery Requirements for Oil Sands Mine and Processing Plant Operations*.

3. At least five years prior to mining at the final pit wall but no later than December 31, 2018, the Operator shall submit to the AER for its review and approval a report evaluating the mineable oil sands ore quality and non-recoverable quantity in the east final pit wall area adjacent to the Athabasca River, and a detailed geotechnical stability evaluation of the final east pit wall location.
4. At least five years prior to mining beyond the currently approved 12:1 TV:BIP contour, the Operator shall submit to the AER for its review and approval a detailed mine plan in relation to the 13:1 TV:BIP area.
5. At least six months prior to beginning mine depressurization activities, the Operator shall submit to the AER for its review and approval a monitoring plan to detect basal aquifer pressure changes at the lease boundary with Total E&P Canada Ltd.
6. On or before February 28 of each year following start-up of mine depressurization activities, or such other date as the AER may stipulate, the Operator shall submit to the AER a report on the results of the basal aquifer monitoring program at the lease boundary with Total E&P Canada Ltd.
7. Within one year following the date of this Approval, the Operator shall satisfy the AER on the need, or otherwise, to monitor the effects of depressurization and injection activities along the northern and western boundary of mining activities.
8. The Operator's variance of *Directive 082: Operating Criteria: Resource Recovery for Oil Sands Mine and Processing Plant Operations*, as amended, as outlined in the MFTRMP program,
 - (a) is approved until September 30, 2022; and
 - (b) recovery compliance will be calculated with the segregated resource excluded from the assessment.
9. The Operator shall provide presentations to the AER outlining the performance and operations of the MFTRMP program, every six months or as otherwise specified in writing by the AER, starting on or before December 31, 2017.
10. The Operator shall submit progress reports to the AER on the MFTRMP program every six months or as otherwise specified in writing by the AER starting December 31, 2017.
11. The Operator shall submit MFTRMP program results tables to the AER including material mined, bitumen grade, in situ and recoverable bitumen, fines content and total fines, and bitumen gains and losses every six months or as otherwise specified in writing by the AER, starting on or before December 31, 2017.
12. The Operator shall submit model losses to the AER including surveyed wireframes, ore tonnage, modeled grade, and field grade every six months or as otherwise specified in writing by the AER starting on or before December 31, 2017.
13. On an annual average basis, the Operator shall limit diluent losses to tailings and the scheme to not more than 4.0 volumes per 1000 volumes of bitumen production, unless it can satisfy the AER that a limit of 4.3 volumes per 1000 volumes of bitumen production is appropriate.
14. The Operator shall not discharge any untreated froth treatment tailings to the tailings area.
15. Every five years commencing February 28, 2010, or such other date as the AER may stipulate, the Operator shall submit to the AER a report on the feasibility of coke use and sales potential.
16. Within one year following the date of this Approval, the Operator shall satisfy the AER on the need, or otherwise, to monitor for potential effects of injection activities on the depressurization needs of other developments in the regional study area.

17. The Operator shall include in the project area a minimum setback of 250 m from the edge of the wetted width of the Athabasca River during spring flow, excluding the water intake facility.
18. The Operator shall,
 - (a) Before commencement of mining activities in the North Mine within 2 kilometers of the interim raw water pond, provide for the AER's approval a plan to relocate the raw water pond and mine the oil sands at that location.
 - (b) Recover the oil sands at the location of the interim raw water pond in accordance with the plan approved by the AER.
19. At least six months prior to the relocation and construction of a new Ore Preparation Plant, the Operator shall submit to the AER for approval detailed geotechnical designs.
20. The Operator shall submit an updated site-wide water management plan for approval no later than December 31, 2014.
21. The Operator shall achieve the
 - (a) profile specified in Appendix B, Table 1 and Figure 1; and
 - (b) profile specified in Appendix B, Table 2 and Figure 2.
22. The Operator shall not exceed
 - (a) any of the profile deviation trigger, total volume trigger, or total volume limit specified in Appendix B, Table 3; and
 - (b) the profile deviation trigger specified in Appendix B, Table 4.
23. If any limit or trigger in clause 22 is exceeded, the Operator shall comply with the management response or action directed by the AER.
24. The Operator shall provide by September 30, 2025, or such other date as the AER may stipulate, a revised end of mine life target that is no greater than 5 years of fluid tailings production for the profile for new fluid tailings.
25. The Operator shall not use the revised end of mine life target submitted under clause 24 unless the AER has revised Appendix B.
26. Subject to clause 27, the Operator shall achieve the ready to reclaim criteria set out in Appendix C.
27.
 - (a) If, at any time, the AER is not satisfied with the ready to reclaim criteria, the Operator shall address the issues, concerns or deficiencies identified in writing by the AER by the date specified by the AER.
 - (b) If, at any time, the Operator proposes any modifications or additions to the ready to reclaim criteria authorized by the AER, the Operator shall:
 - (i) address the requirements in *Directive 085: Fluid Tailings Management for Oil Sands Mining Projects*, as amended (hereinafter called *Directive 085*);
 - (ii) demonstrate that the proposed modifications or additions to the ready to reclaim criteria do not result in changes to any of the ready to reclaim trajectory, targeted ecosites, milestones, or fluid tailings profiles;
 - (iii) address any required updates to the measurement system plan; and
 - (iv) provide any other information the AER may require.

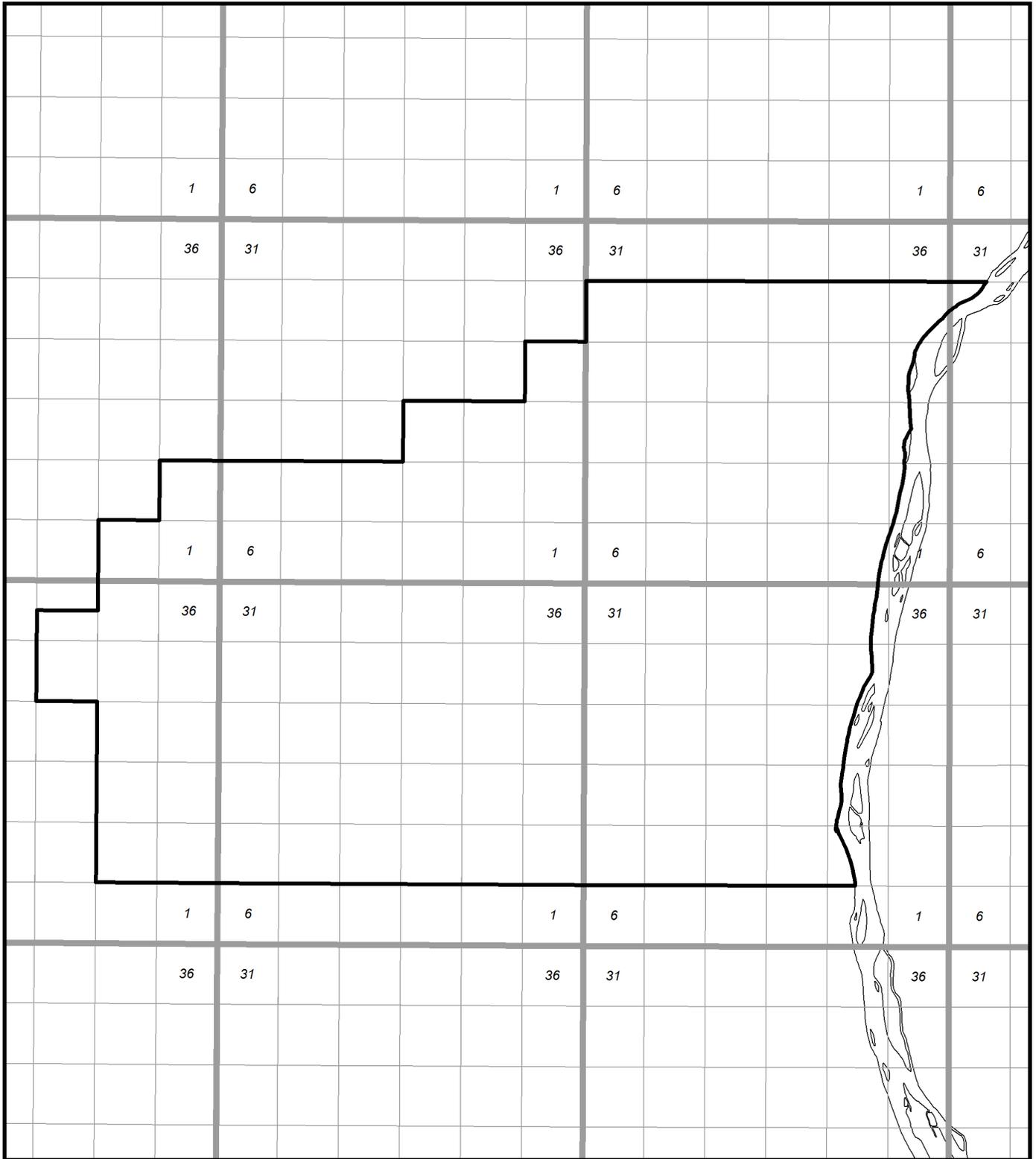
- (c) The Operator shall not use any modified or additional ready to reclaim criteria unless
 - (i) the Operator has provided the information required by subclause 27(b) to the satisfaction of the AER; and
 - (ii) the AER has revised Appendix C to allow the modified or additional ready to reclaim criteria.
- 28. The Operator shall provide by September 30, 2019, or such other date as the AER may stipulate, proposed ready to reclaim criteria for ETF/DDA1 that incorporates the ETF/DDA1 deposit monitoring results.
- 29. The submission in clause 28 shall include the information required by subclause 27(b).
- 30. The Operator shall not use the proposed ready to reclaim criteria for ETF/DDA1 unless
 - (a) The Operator has provided the information required by subclause 27(b) to the satisfaction of the AER; and
 - (b) The AER has revised Appendix C to allow the ready to reclaim criteria.
- 31. The Operator shall provide by September 30, 2018, or such other date as the AER may stipulate in writing, a flux, settlement, and consolidation model that is representative of ETF/DDA1, including the downslope of the deposit.
- 32. If the model in clause 31 is found deficient by the AER, the Operator shall correct all deficiencies identified in writing by the AER by the date specified by the AER.
- 33. The Operator shall place naphtha recovery unit tailings only in ETF/DDA1 unless written authorization or an approval amendment is granted by the AER.
- 34. The Operator shall provide, by September 30, 2021, or such other date as the AER may stipulate in writing, a plan that updates naphtha recovery unit tailings management.
- 35. The plan in clause 34 shall:
 - (a) address the application requirements specified in *Directive 085*;
 - (b) confirm the Operator's ability to meet clause 21;
 - (c) evaluate the options for treatment and placement of naphtha recovery unit tailings;
 - (d) evaluate the performance of past or current tailings deposits where similar tailings, tailings treatment technology, and targeted ecosites were proposed;
 - (e) explain how research results and long-term reclamation outcomes have been incorporated;
 - (f) mitigate uncertainties associated with naphtha recovery unit tailings, the proposed tailings treatment technology, tailings deposit performance, and ready to reclaim trajectory;
 - (g) explain how the naphtha recovery unit tailings management may influence the plan required by clause 37; and
 - (h) provide any other information the AER may require.
- 36. The Operator shall not remove any naphtha recovery unit tailings from the fluid tailings inventory unless the AER has revised Appendix C in accordance with clause 27.
- 37. The Operator shall submit, by September 30, 2025, or such other date as the AER may stipulate, a plan for the management of fluid tailings to be placed in DDA3 and DDA8-9.
- 38. The plan in clause 37 shall:
 - (a) ensure no water, including industrial wastewater, is placed above treated or untreated tailings for the purpose of creating an aquatic closure landscape;
 - (b) address the application requirements specified in *Directive 085*;
 - (c) confirm the Operator's ability to achieve clause 21 and 24;

- (d) evaluate the performance of past or current tailings deposits where similar tailings treatment technology and targeted ecosites were proposed;
 - (e) explain how research results and long-term reclamation outcomes have been incorporated;
 - (f) explain how the results of any capping research have been incorporated;
 - (g) mitigate uncertainties associated with the proposed tailings treatment technology, tailings deposit performance and ready to reclaim trajectory; and
 - (h) provide any other information the AER may require.
39. The Operator shall meet the milestones dates in Figure 8.1.1-1 of Application 1869003 or such other dates as the AER may stipulate.
40. The Operator shall provide 1 year prior to placement of fluid tailings or treated tailings in each of DDA2, DDA3, DDA4, DDA5, DDA6, DDA7, or DDA8-9, or such other date as the AER may stipulate, a plan that updates fluid tailings management.
41. The plan in clause 40 shall:
- (a) address the application requirements specified in *Directive 085*;
 - (b) confirm the Operator's ability to achieve clause 21;
 - (c) provide a flux, settlement, and consolidation model that is representative of the tailings deposit;
 - (d) evaluate the performance of past or current tailings deposits where similar tailings treatment technology and targeted ecosites were proposed;
 - (e) explain how research results and long-term reclamation outcomes have been incorporated;
 - (f) explain how the results of any capping research have been incorporated;
 - (g) mitigate uncertainties associated with the proposed tailings treatment technology, tailings deposit performance and ready to reclaim trajectory; and
 - (h) provide any other information the AER may require.
42. The Operator shall submit a research plan for the terrestrial and aquatic closure for any of the deposits upon request by the AER.
43. The Operator shall provide a capping research plan for NST and NST with fine fluid tailings additions by December 31, 2020, or such other date as the AER may stipulate.
44. The plan in clause 43 shall include:
- (a) an explanation and rationale for
 - (i) the research objectives;
 - (ii) hypothesis to be tested;
 - (iii) models to be developed;
 - (iv) key performance measures and criteria;
 - (v) the experimental controls, the design and methodology for the research, model, or technique, and the research monitoring plans and methodologies;
 - (vi) the applicability of each research objective to addressing the risks and uncertainties;
 - (vii) the applicability of each research objective to achieving the targeted ecosites and long-term reclamation outcomes;
 - (viii) the approach to incorporating research results into site specific plans,
 - (ix) the incorporation of existing research results to date (both general and site-specific) into the research plan; and

- (x) a summary of the research completed to date that relates to the objectives identified in (i);
 - (b) identification and explanation of research priorities that will ensure research results can be incorporated into site specific plans, including
 - (i) rationale for the sequence of the research;
 - (ii) timing of initiating and completing research; and
 - (iii) key activities.
 - (c) proposed schedule for research results and data submission, with a mechanism to track progress over time; and
 - (d) any other information the AER may require.
45. If the plan in clause 43 is found deficient by the AER, the Operator shall correct all deficiencies identified in writing by the AER by the date specified by the AER.
46. The Operator shall, in addition to any reporting requirements under *Directive 085*, provide in the annual fluid tailings management report:
- (a) for each treated tailings deposit, monitoring data including representative cross-sections to illustrate the variation of the following:
 - (i) sands to fine ratio;
 - (ii) effective stress;
 - (iii) deposit consolidation;
 - (iv) pore water pressure;
 - (v) clay type(s) and content (percentage);
 - (vi) any other parameter considered relevant by the Operator; and
 - (vii) any other parameter specified by the AER.
 - (b) the available storage capacity of each tailings deposit or tailings pond that contains water or tailings at the end of the reporting period; and
 - (c) annual storage capacity and volume requirements for the five years following the end of the reporting period.
47. The Operator shall not implement any individual plan in clauses 34, 37, and 40 unless written authorization or approval amendment for that plan is granted by the AER.
48. The Operator shall not place any water, which includes industrial wastewater, above treated or untreated tailings for the purpose of creating an aquatic closure landscape.
49. The Operator shall not release any substance to the surrounding environment except as authorized under the EPEA approval.
50. The Operator shall
- (a) notify the AER of any proposed on-site fluid tailings pilots, prototypes or demonstrations at least 6 months, or such other time as the AER may stipulate in writing, prior to any proposed construction or implementation; and
 - (b) not construct or implement any of the proposed on-site fluid tailings pilots, prototypes or demonstrations unless written authorization or approval amendment is obtained from the AER.

51. The Operator shall engage with stakeholders and indigenous communities on the activities undertaken under this Approval in respect of tailings management.
52. The Operator shall conduct an annual forum with stakeholders and indigenous communities on activities undertaken under this Approval in respect of tailings management.
53. The Operator shall report in the annual fluid tailings management report engagement efforts undertaken in the reporting period.
54. The report in clause 53 shall include the following:
 - (a) how the stakeholders and indigenous communities were identified for engagement;
 - (b) a list of stakeholders and indigenous communities identified in (a);
 - (c) objectives for engagement, including gathering input and feedback on the development of tailings management submissions from stakeholders and indigenous communities identified in (a);
 - (d) the type of engagement activity that was undertaken and the tailings management specific information that was provided to each stakeholder and indigenous community identified in (a);
 - (e) the specific frequency and duration of the engagement with each stakeholder and indigenous community identified in (a);
 - (f) what specific feedback was provided by each stakeholder and indigenous community identified in (a);
 - (g) what specific feedback on this report was provided by each stakeholder and indigenous community identified in (a);
 - (h) how the feedback and learnings from previous engagement will be incorporated into future engagement and into tailings management;
 - (i) how the Operator addressed any outstanding concerns arising from engagement; and
 - (j) outcomes from the annual forum.
55. The Operator shall apply for an amendment to this approval to align with any applicable government policy, including, but not limited to
 - (a) tailings water release;
 - (b) placement of any water above treated or untreated tailings to create a pit lake; and
 - (c) reclamation criteria.
56. The AER may,
 - (a) upon its own motion, or
 - (b) upon the application of an interested person,rescind or amend this approval at any time if, in the opinion of the AER, circumstances so warrant.
57. AER Approval No. 9752, 9752A, 9752B, 9752C, and 9752D are hereby repealed, rescinded, and replaced with AER Approval No. 9752E.

END OF DOCUMENT



T.98

T.97

T.96

T.95

W4M

R.13

R.12

R.11

R.10

**CANADIAN NATURAL RESOURCES LIMITED
OIL SANDS PROJECT**

APPENDIX A TO APPROVAL NO. 9752E

The AER does not warrant the accuracy or completeness of the information contained in this map and is not responsible for any errors or omissions in its content and accepts no liability for the use of this information.

Base Data Provided by Spatial Data Warehouse Ltd., 2003

Legend

 OSCA Approval Area



0 1.25 2.5 5 7.5 10
 Kilometers

CANADIAN NATURAL RESOURCES LIMITED
APPENDIX B TO APPROVAL NO. 9752E
Table 1. Profile for New Fluid Tailings

Year	Approved Profile New FT Inventory (million cubic metres)	Year	Approved Profile New FT Inventory (million cubic metres)	Year	Approved Profile New FT Inventory (million cubic metres)
2015	14.3	2032	198.0	2049	180.9
2016	37.4	2033	196.1	2050	180.5
2017	51.0	2034	195.3	2051	177.8
2018	67.6	2035	192.1	2052	178.9
2019	82.9	2036	191.6	2053	176.1
2020	95.1	2037	188.2	2054	177.2
2021	111.5	2038	188.6	2055	177.0
2022	121.8	2039	185.8	2056	177.0
2023	130.3	2040	187.8	2057	177.0
2024	141.3	2041	186.1	2058	177.0
2025	148.8	2042	184.4	2059	177.0
2026	153.5	2043	182.6	2060	177.0
2027	161.0	2044	183.9	2061	177.0
2028	172.4	2045	183.5	2062	137.2
2029	176.8	2046	181.5	2063	137.2
2030	183.4	2047	180.6	2064	137.2
2031	189.9	2048	181.3	2065	0.0

Table 2. Profile for Legacy Fluid Tailings

Year	Approved Profile Legacy FT Inventory (million cubic metres)
2015	66.2
2016	66.2
2017	66.2
2018	66.2
2019	66.2
2020	62.6
2021	57.7
2022	52.4
2023	47.1
2024	41.8
2025	36.5
2026	31.2
2027	25.9
2028	20.5
2029	15.2
2030	9.9
2031	4.6
2032	0.0

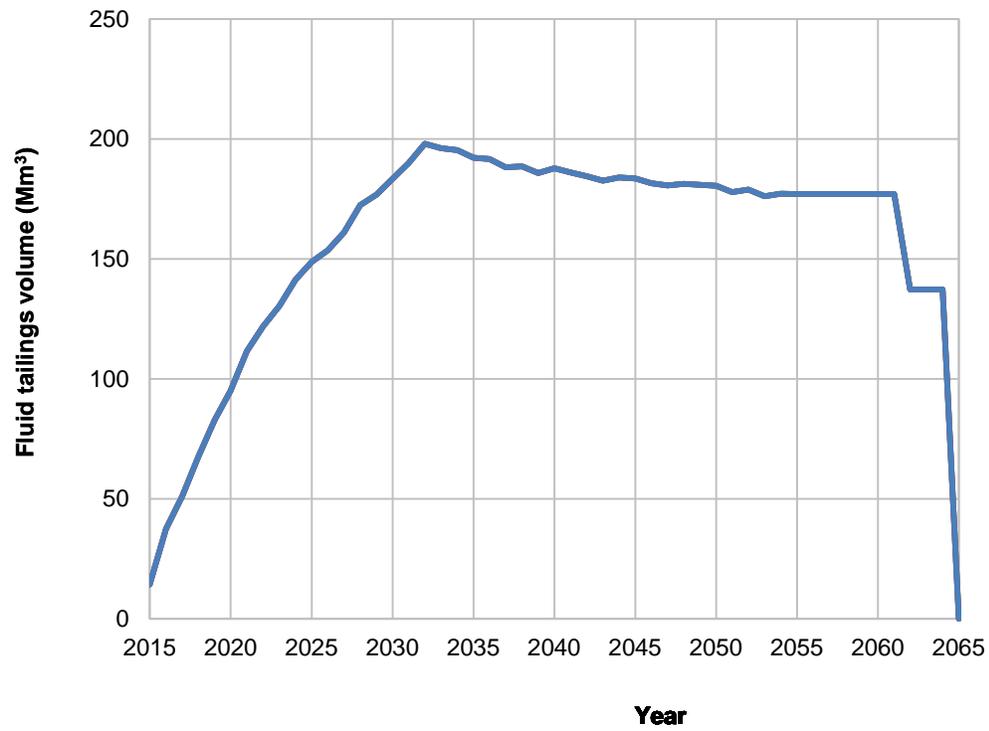


Figure 1. Profile for New Fluid Tailings

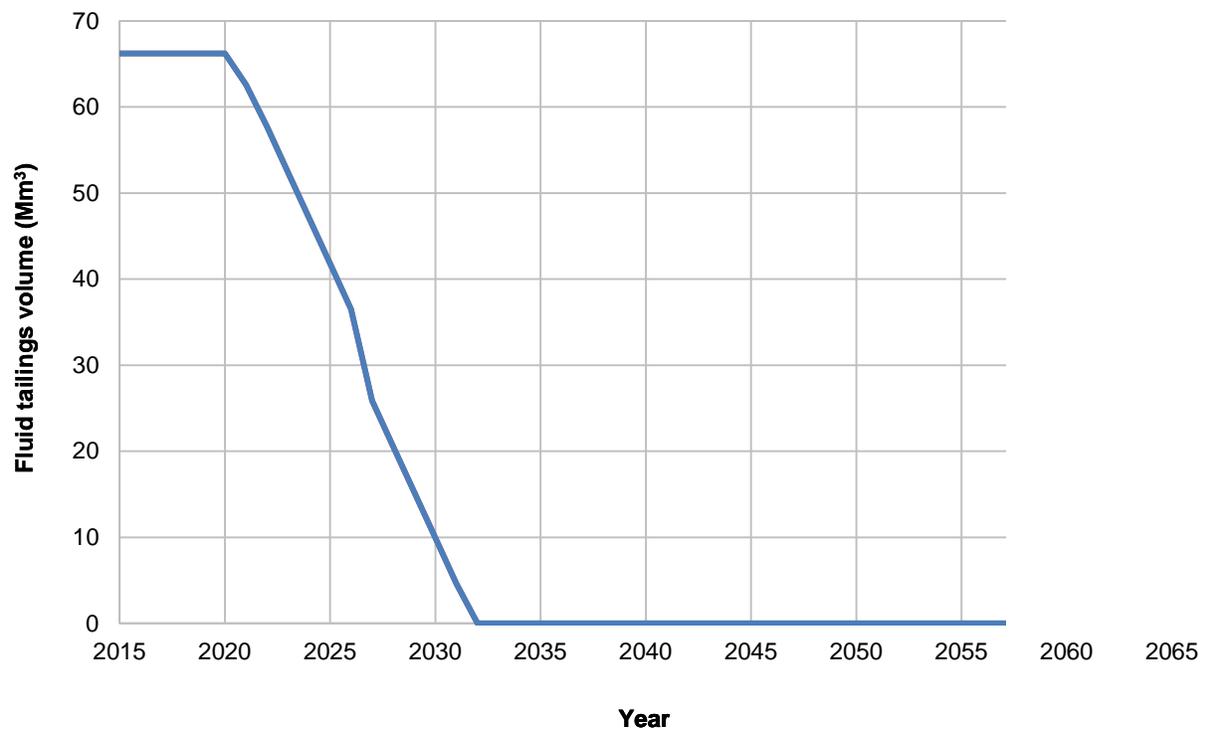


Figure 2. Profile for Legacy Fluid Tailings

Table 3. Thresholds for Profile for New Fluid Tailings

Threshold Type	Trigger or Limit	Calculation Factors
Profile Deviation Trigger	20 per cent	$\text{annual deviation percent}_{\text{year}} = \frac{\text{New FT Inventory}_{\text{year}} - \text{Approved Profile New FT Inventory}_{\text{year}}}{\text{Approved Profile New FT Inventory}_{\text{year}}}$ $\text{profile deviation trigger}_{\text{year}} = \frac{\sum_{i=\text{year}-5}^{\text{year}} (\text{annual deviation percent}_i)}{\text{Count}(\text{annual deviation percent}_i; \text{annual deviation percent}_{i-5})}$
Total Volume Trigger	198 million cubic metres	n/a
Total Volume Limit	277 million cubic metres	n/a

Table 4. Thresholds for Profile for Legacy Fluid Tailings

Threshold Type	Trigger or Limit	Calculation Factors
Profile Deviation Trigger	20 per cent	$\text{annual deviation percent}_{\text{year}} = \frac{\text{Legacy FT Inventory}_{\text{year}} - \text{Approved Profile Legacy FT Inventory}_{\text{year}}}{\text{Approved Profile Legacy FT Inventory}_{\text{year}}}$ $\text{profile deviation trigger}_{\text{year}} = \frac{\sum_{i=\text{year}-5}^{\text{year}} (\text{annual deviation percent}_i)}{\text{Count}(\text{annual deviation percent}_i; \text{annual deviation percent}_{i-5})}$

CANADIAN NATURAL RESOURCES LTD.

APPENDIX C TO APPROVAL NO. 9752E

Table 1. RTR Criteria for Canadian Natural Resources Ltd. ETF/DDA1, DDA2, DDA4, DDA5, DDA6, and DDA7

<u>Deposit</u>	<u>Subobjective</u>	<u>RTR criteria</u>
<u>DDA1/ETF, DDA2, DDA4, DDA5, DDA6, DDA7</u>	Subobjective 1	70 per cent solids by weight (w/w) within 1 year of tailings placement 81 per cent solids by weight (w/w) within 5 years of achieving 70 per cent solids by weight (w/w)
	Subobjective 2	Groundwater is monitored as required by <i>Environmental Protection and Enhancement Act (EPEA)</i> Approval No. 149968, as amended or renewed Maintain the water table at a depth between 2 and 4 metres

Appendix 2 Submissions and Deposit Milestones Timeline

				DDA2 commences						DDA4 commences	DDA3 commences
Month	2017	2018	2019	2020	2021	2022		2025	2026	2027	2028
April		Additional reporting under <i>Directive 085</i> commences (annually)									
June		Measurement system plan submission									
September		Flux and consolidation model for ETF/DDA1	Plan updating DDA2 fluid tailings management Propose additional RTR criteria for ETF/DDA1		Plan updating NRU tailings management	Expiration of variance of the requirements under section 2 of <i>Directive 082</i>		Revised end of mine life target Plan for DDA3 and DDA8-9 fluid tailings management	Plan updating DDA4 fluid tailings management	Plan updating DDA3 fluid tailings management	
December	MFRMP reporting commences (every six months)			Capping research plan							

Not shown: DDA5, DDA6, DDA7, and DDA8-9 commencement dates or plans updating fluid tailings management 1 year prior to placement of fluid tailings or treated tailings in each of these tailings deposits.

Appendix 3 ***EPEA* Tailings Research Report and End-Pit Lake Research and Development Report Letter**

<original dated>

By e-mail only

Calgary Head Office
Suite 1000, 250 – 5 Street SW
Calgary, Alberta T2P 0R4
Canada

www.aer.ca

Casey McWhan, VP Bitumen Production
Canadian Natural Resources Limited
Suite 2500, 855 – 2nd Street SW
Calgary, AB T2P 4J8

E-mail: Casey.McWhan@cnrl.com

Canadian Natural Resources Limited
Horizon Oil Sands Processing Plant and Mine Tailings Management Plan
Tailings Research Report and End Pit Lake Research and Development Report

Dear Mr. McWhan:

In accordance with clause 6.1.2(f), of *Environmental Protection and Enhancement Act (EPEA)* Approval No. 149968-01-00, as amended, the Alberta Energy Regulator (AER) requires the following be submitted with and reported on in the Tailings Research Report:

- For the terrestrial ecosystem research:
 - Capping objectives in addition to rooting-zone protection for tailings deposits and
 - Geotechnical stability of reclaimed surfaces over time
- For the wetland ecosystem research:
 - Environmental fate, including degradation rates of potentially toxic components in tailings release waters
 - Identification of local native wetland vegetation species suitable to inhabit the tailings wetlands
 - Seepage of tailings and placed coversoil, subsoil, or overburden release water in groundwater or surface water
 - Validation that developing wetlands are from surface drainage and not breakthrough to the surface from NST

- For CO₂ injection research:
 - The quantity of CO₂ sequestered in the deposit
 - Impacts to water and air quality from CO₂ injection

In accordance with clause 6.2.4(p), of *EPEA* Approval No. 149968-01-00, as amended, the AER requires the following be submitted with and reported on in the End Pit Lake Research and Development Report:

- the applicability of Syncrude Canada Limited Base Mine Lake (BML) research to Canadian Natural's TMP
- how Canadian Natural will address uncertainties and risks where BML research is not applicable

If you have any questions regarding this correspondence, please contact Kenneth Yap at (780) 642-9245 or Kenneth.Yap@aer.ca.

Regards,

<original signed by>

Paul Ferensowicz

cc: Anita.Sartori@cnrl.com
Michelle.MacDonald@cnrl.com
Allen.Xu@aer.ca
Camille.Almeida@aer.ca
Stacy.MacDonald@aer.ca
Kenneth.Yap@aer.ca
Steven.Vanlingen@aer.ca
Rob.Cruickshank@aer.ca
Sasha.Desjardins@aer.ca

Appendix 4 ***EPEA* Life of Mine Closure Plan, Mine Reclamation Plan, and Annual Reclamation Progress Tracking Report Letter**

<original dated>

Calgary Head Office
Suite 1000, 250 – 5 Street SW
Calgary, Alberta T2P 0R4
Canada

By e-mail only

www.aer.ca

Casey McWhan, VP Bitumen Production
Canadian Natural Resources Limited
Suite 2500, 855 – 2nd Street SW
Calgary, AB T2P 4J8

E-mail: Casey.McWhan@cnrl.com

Canadian Natural Resources Limited
Horizon Oil Sands Processing Plant and Mine Tailings Management Plan
Life of Mine Closure Plan, Mine Reclamation Plan, and Annual Reclamation Progress Tracking
Report Requirements

Dear Mr. McWhan:

In accordance with clause 7.2.9 (n) of *Environmental Protection and Enhancement Act (EPEA)* Approval No. 149968-01-00, as amended, the Alberta Energy Regulator (AER) requires the following be submitted as part of the Life of Mine Closure Plan and Mine Reclamation Plan:

- research results for capping objectives in addition to rooting zone protection for tailings deposits;
- material balances for sand and any other suitable capping materials to meet terrestrial and wetland outcomes, which shall include accounting for limited drilling data, tailings treatment technology performance demands, landform development and stability, settlement management, expressed tailings pore water control, water table control, landform contouring, and the suitability of the capping material's chemical and physical properties;
- rationale for defining capping requirements for NST or NST with fine fluid tailings additions in the dedicated disposal areas, including additional information on the capping requirements for landform development and stability, settlement management, expressed tailings pore water control, water table control, and landform contouring to facilitate the flushing of salts from the capping material and control expressed tailings pore water;
- contingency plans for capping material shortages;

- evaluate the significance of the change in DDA8-9 lake configuration and end pit lake (EPL) 1 and EPL2 sustainability;
- a summary ecosite table that includes an acceptable distribution of reclaimed wetland types and ecosite phases that supports a range of land uses, including commercial forest, biodiversity, wildlife habitat, and traditional use;
- a map showing the spatial extent and distribution of wetlands, including reclaimed and treatment wetlands; and
- demonstrate alignment with the Tailings Management Plan.

In accordance with clause 7.3.21 (o) of *EPEA* Approval No. 149968-01-00, as amended, the AER requires the following be submitted with and reported on in the Annual Reclamation Progress Tracking Report:

- material balances for sand and any other suitable capping materials to meet terrestrial and wetland outcomes

If you have any questions regarding this correspondence, please contact Margaret Magai at (780) 642-9139 or Margaret.Magai@aer.ca.

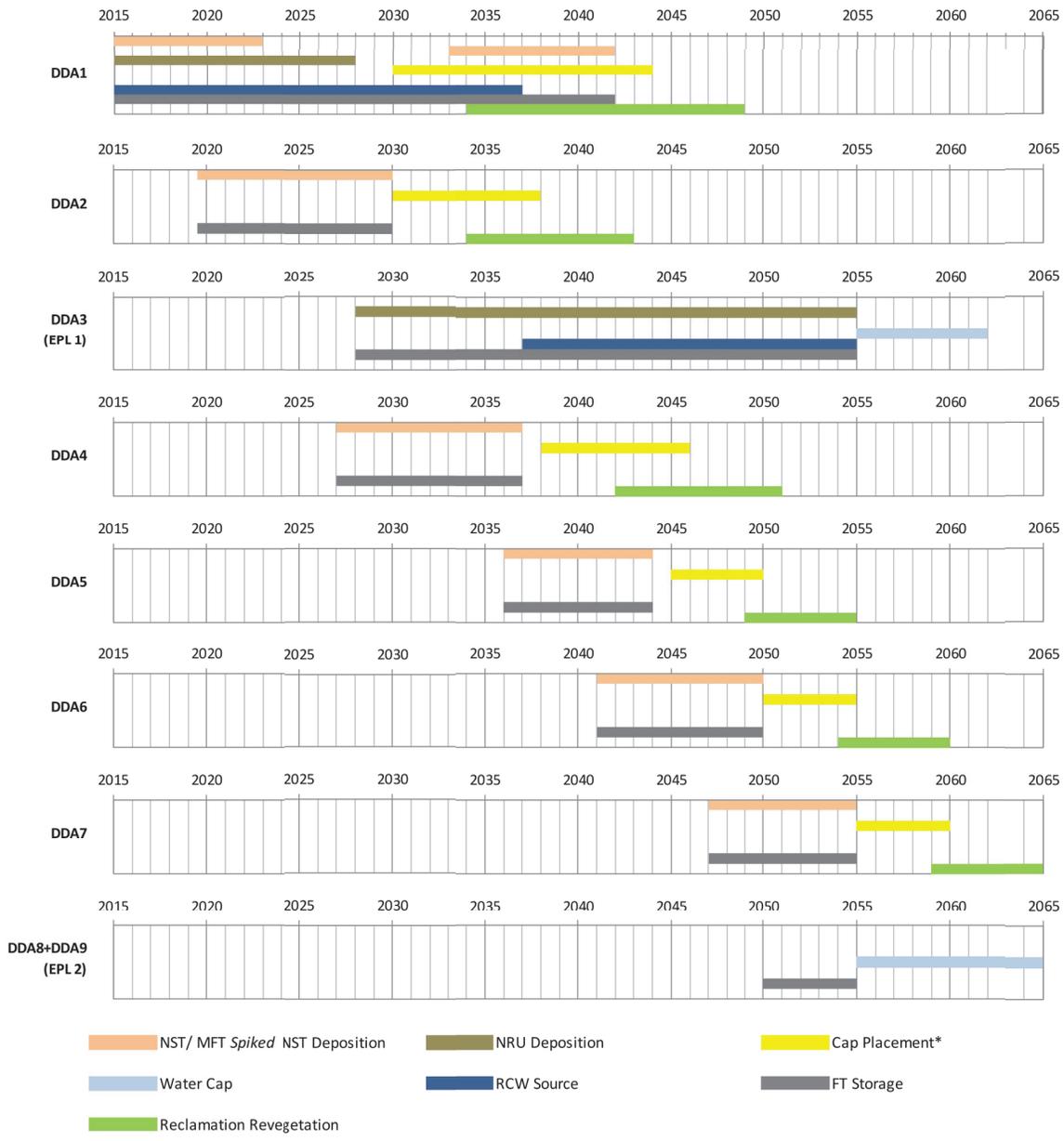
Regards,

<original signed by>

Paul Ferensowicz

cc: Anita.Sartori@cnrl.com
Michelle.MacDonald@cnrl.com
Allen.Xu@aer.ca
Camille.Almeida@aer.ca
Stacy.MacDonald@aer.ca
Margaret.Magai@aer.ca
Steven.VanLingen@aer.ca
Rob.Cruickshank@aer.ca
Sasha.Desjardins@aer.ca

Appendix 5 Deposit Milestones



* Hydraulic cap placement assumed in the schedule.

NOTE:

1. Years shown in chart represents end of year.

PROJECT		HORIZON OIL SANDS D085 APPLICATION FLUID TAILINGS MANAGEMENT PLAN	
TITLE		DDA TAILINGS DEPOSITION, CAPPING AND RECLAMATION SCHEDULE	
PROJECT No.	41074-00014	FILE No.	100-55-0001-REV-R-2011
DESIGN	MB	DATE	05/09/2016
CADD	SA	DATE	05/09/2016
CHECK	SP	DATE	05/22/2016
REVIEW	PLD	DATE	05/22/2016
		SCALE	NOT TO SCALE
		TYR	
		FIGURE: 8.1.1-1	

Appendix 6 Measurement System Plan Requirements Letter

<original dated>

Calgary Head Office
Suite 1000, 250 – 5 Street SW
Calgary, Alberta T2P 0R4
Canada

By e-mail only

www.aer.ca

Casey McWhan, VP Bitumen Production
Canadian Natural Resources Limited
Suite 2500, 855 – 2nd Street SW
Calgary, AB T2P 4J8

E-mail: Casey.McWhan@cnrl.com

Canadian Natural Resources Limited
Horizon Oil Sands Processing Plant and Mine Tailings Management Plan
Oil Sands Conservation Act Approval 9752E
Measurement System Plan Requirements

Dear Mr. McWhan:

In accordance with *Directive 085: Fluid Tailings Management for Oil Sands Mining Projects*, the Alberta Energy Regulatory (AER) requires Canadian Natural Resources Limited (Canadian Natural) to submit by June 30, 2018, or on such other date stipulated by the AER, a measurement plan for fluid tailings, treated tailings volumes and ready to reclaim (RTR) criteria (subobjective 1 and subobjective 2 in Appendix C) in Approval No. 9752E.

The measurement plan must include the following:

- Key definition of parameters for fluid tailings and RTR criteria measurements.
- Reference of standards and procedures used to measure fluid tailings, treated tailings, and RTR criteria.
- An explanation of and justification for measurement procedures that are unique to Canadian Natural and this plan.
- Evidence that the plan will address the measurement outcomes as per section 5 of *Directive 085*, as amended.
- An explanation of how each of the tailings deposit's RTR criteria will be measured, calculated and reported.

- A description of the tailings deposit survey program.
- Justification of how measurement, sampling, and spacing intervals will show the variation of the deposit properties, and verify that the tailings deposit is achieving RTR criteria.
- Identify if any material in the deposit is not achieving RTR criteria.
- Any other information the AER may require.

Where measurement plans exist for either subobjective, Canadian Natural may incorporate references to other plans, such as the groundwater monitoring program.

Canadian Natural must also ensure that the measurement system plan developed aligns with the Groundwater Monitoring Program authorized under its EPEA approval.

If you have any questions regarding this correspondence, please contact Jim Jordan at (403) 297-8504 or jim.jordan@aer.ca.

Regards,

<original signed by>

Paul Ferensowicz

cc: Anita.Sartori@cnrl.com

Tara.Wang@aer.ca

Sheena.Nixon@aer.ca

Eric.Chiu@aer.ca

Jim.Jordan@aer.ca

Michelle.MacDonald@cnrl.com

Steven.vanLingen@aer.ca

Rob.Cruickshank@aer.ca

Stacy.MacDonald@aer.ca

Appendix 7 Decommissioning Plan for Dams

<original dated>

Calgary Head Office
Suite 1000, 250 – 5 Street SW
Calgary, Alberta T2P 0R4
Canada

By e-mail only

www.aer.ca

Casey McWhan, VP Bitumen Production
Canadian Natural Resources Limited
Suite 2500, 855 – 2nd Street SW
Calgary, AB T2P 4J8

E-mail: Casey.McWhan@cnrl.com

Canadian Natural Resources Limited
Horizon Oil Sands Processing Plant and Mine Tailings Management Plan
Dam Decommissioning

Dear Mr. McWhan:

In accordance with section 32 of the *Water (Ministerial) Regulation* and subject to *Water Act* Approval No. 00201931-01-00, at this time the Alberta Energy Regulator (AER) requires the following for decommissioning any dams associated with tailings ponds or deposits:

Canadian Natural Resources Limited (Canadian Natural) shall, at least 12 months prior to commencing capping activities at any tailings pond or deposit, provide the AER with a plan for decommissioning of the dams.

Canadian Natural shall not implement the plan for decommissioning of any of the dams unless written authorization or approval amendment for the plan is granted by the AER.

If you have any questions regarding this correspondence, please contact Tim Eaton at (403) 297-6855 or tim.eaton@aer.ca.

Regards,

<original signed by>

Paul Ferenowicz

cc: Anita.Sartori@cnrl.com
Michelle.MacDonald@cnrl.com

inquiries 1-855-297-8311
24-hour
emergency 1-800-222-6514

Tim.Eaton@aer.ca
Allen.Xu@aer.ca
Camille.Almeida@aer.ca
Stacy.MacDonald@aer.ca
Kenneth.Yap@aer.ca
Steven.Vanlingen@aer.ca
Rob.Cruickshank@aer.ca
Sasha.Desjardins@aer.ca

Appendix 8 Canadian Natural Site Map

