State of Fluid Tailings Management for Mineable Oil Sands, 2019

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Telephone: 403-297-8311
Inquiries (toll free): 1-855-297-8311
Email: inquiries@aer.ca
Website: www.aer.ca
## Contents

Abbreviations ................................................................................................................................................ v

Executive Summary ..................................................................................................................................... vii

1 Introduction ............................................................................................................................................. 1

2 Purpose .................................................................................................................................................. 2

3 Regulatory and Operational Context ...................................................................................................... 2
  3.1 Regulatory Context ........................................................................................................................ 2
  3.2 Operational Context ........................................................................................................................ 3

4 2019 Reporting ....................................................................................................................................... 5
  4.1 2019 Report Review ..................................................................................................................... 5
    4.1.1 Ready-to-Reclaim Criteria and Trajectory ....................................................................... 5
    4.1.2 Environmental Performance Monitoring .......................................................................... 6
  4.2 Next Steps .................................................................................................................................... 6

5 Tailings Description ................................................................................................................................ 7

6 Fluid Tailings Treatment and Deposition ................................................................................................ 7

7 Regional Fluid Tailings Status ................................................................................................................ 8
  7.1 Fluid Tailings Treatment and Deposition .................................................................................... 11
  7.2 Water Volumes ........................................................................................................................... 13

8 Fluid Tailings Status ............................................................................................................................. 14
  8.1 Suncor – Base Plant ................................................................................................................... 14
    8.1.1 Fluid Tailings .................................................................................................................. 14
    8.1.2 Volume of Treated Fluid Tailings by Technology .......................................................... 17
    8.1.3 Treatment Operation and Continuous Improvement ..................................................... 17
    8.1.4 Technological Innovation in Fluid Tailings Treatment ................................................... 18
    8.1.5 Regulatory and Management Actions ........................................................................... 18
    8.1.6 Measurement System Audit Results ............................................................................. 18
  8.2 Syncrude – Mildred Lake ............................................................................................................ 19
    8.2.1 Fluid Tailings .................................................................................................................. 19
    8.2.2 Volume of Treated Fluid Tailings by Technology .......................................................... 22
    8.2.3 Treatment Operation and Continuous Improvement ..................................................... 23
    8.2.4 Technological Innovation in Fluid Tailings Treatment ................................................... 23
    8.2.5 Regulatory and Management Actions ........................................................................... 23
    8.2.6 Measurement System Audit Results ............................................................................. 24
<table>
<thead>
<tr>
<th>Section</th>
<th>Company</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.3</td>
<td>Syncrude – Aurora North</td>
<td>24</td>
</tr>
<tr>
<td>8.3.1</td>
<td>Fluid Tailings</td>
<td>24</td>
</tr>
<tr>
<td>8.3.2</td>
<td>Volume of Treated Fluid Tailings by Technology</td>
<td>26</td>
</tr>
<tr>
<td>8.3.3</td>
<td>Treatment Operation and Continuous Improvement</td>
<td>27</td>
</tr>
<tr>
<td>8.3.4</td>
<td>Technological Innovation in Fluid Tailings Treatment</td>
<td>27</td>
</tr>
<tr>
<td>8.3.5</td>
<td>Regulatory and Management Actions</td>
<td>27</td>
</tr>
<tr>
<td>8.3.6</td>
<td>Measurement System Audit Results</td>
<td>28</td>
</tr>
<tr>
<td>8.4</td>
<td>Canadian Natural Upgrading Limited – Muskeg River Mine</td>
<td>28</td>
</tr>
<tr>
<td>8.4.1</td>
<td>Fluid Tailings</td>
<td>29</td>
</tr>
<tr>
<td>8.4.2</td>
<td>Volume of Treated Fluid Tailings by Technology</td>
<td>31</td>
</tr>
<tr>
<td>8.4.3</td>
<td>Treatment Operation and Continuous Improvement</td>
<td>32</td>
</tr>
<tr>
<td>8.4.4</td>
<td>Technological Innovation in Fluid Tailings Treatment</td>
<td>32</td>
</tr>
<tr>
<td>8.4.5</td>
<td>Regulatory and Management Actions</td>
<td>33</td>
</tr>
<tr>
<td>8.4.6</td>
<td>Measurement System Audit Results</td>
<td>33</td>
</tr>
<tr>
<td>8.5</td>
<td>Canadian Natural Upgrading Limited – Jackpine Mine</td>
<td>33</td>
</tr>
<tr>
<td>8.5.1</td>
<td>Fluid Tailings</td>
<td>34</td>
</tr>
<tr>
<td>8.5.2</td>
<td>Volume of Treated Fluid Tailings by Technology</td>
<td>36</td>
</tr>
<tr>
<td>8.5.3</td>
<td>Treatment Operation and Continuous Improvement</td>
<td>37</td>
</tr>
<tr>
<td>8.5.4</td>
<td>Technological Innovation in Fluid Tailings Treatment</td>
<td>37</td>
</tr>
<tr>
<td>8.5.5</td>
<td>Regulatory and Management Actions</td>
<td>37</td>
</tr>
<tr>
<td>8.5.6</td>
<td>Measurement System Audit Results</td>
<td>37</td>
</tr>
<tr>
<td>8.6</td>
<td>Canadian Natural Resources Limited – Horizon</td>
<td>38</td>
</tr>
<tr>
<td>8.6.1</td>
<td>Fluid Tailings</td>
<td>38</td>
</tr>
<tr>
<td>8.6.2</td>
<td>Volume of Treated Fluid Tailings by Technology</td>
<td>40</td>
</tr>
<tr>
<td>8.6.3</td>
<td>Treatment Operation and Continuous Improvement</td>
<td>41</td>
</tr>
<tr>
<td>8.6.4</td>
<td>Technological Innovation in Fluid Tailings Treatment</td>
<td>41</td>
</tr>
<tr>
<td>8.6.5</td>
<td>Regulatory and Management Actions</td>
<td>43</td>
</tr>
<tr>
<td>8.6.6</td>
<td>Measurement System Audit Results</td>
<td>43</td>
</tr>
<tr>
<td>8.7</td>
<td>Imperial Oil Limited – Kearl</td>
<td>43</td>
</tr>
<tr>
<td>8.7.1</td>
<td>Fluid Tailings</td>
<td>43</td>
</tr>
<tr>
<td>8.7.2</td>
<td>Volume of Treated Fluid Tailings by Technology</td>
<td>45</td>
</tr>
<tr>
<td>8.7.3</td>
<td>Treatment Operation and Continuous Improvement</td>
<td>45</td>
</tr>
<tr>
<td>8.7.4</td>
<td>Technological Innovation in Fluid Tailings Treatment</td>
<td>45</td>
</tr>
</tbody>
</table>
8.7.5 Regulatory and Management Actions ................................................................. 46
8.7.6 Measurement System Audit Results ................................................................. 46
8.8 Suncor – Fort Hills ............................................................................................... 46
  8.8.1 Fluid Tailings .................................................................................................... 47
  8.8.2 Volume of Treated Fluid Tailings by Technology ............................................. 48
  8.8.3 Treatment Operation and Continuous Improvement ........................................ 49
  8.8.4 Technological Innovation in Fluid Tailings Treatment ..................................... 49
  8.8.5 Regulatory and Management Actions ............................................................. 49
  8.8.6 Measurement System Audit Results ............................................................... 49
9 Summary .................................................................................................................. 50
10 Future Reports ........................................................................................................ 51
Appendix 1 Tailings Treatment Technologies ............................................................. 55
Appendix 2 Tailings Field Inspection Summaries ....................................................... 59
Appendix 3 Fluid Tailings Volume Data ..................................................................... 111
Appendix 4 Water Volume Data .................................................................................. 113

Figures
Figure 1. Map of operating and proposed oil sands mining projects and tailings ponds/deposits ...... 4
Figure 2. Regional fluid tailings volumes and aggregate tailings profiles, 2014 to 2019 .................. 9
Figure 3. Change in annual fluid tailings volume in the Athabasca oil sands region, 2015 to 2019 ...... 10
Figure 4. Ponded water volume in tailings ponds, 2014 to 2019 ........................................... 13
Figure 5. New fluid tailings for Suncor Base Plant, 2014 to 2019 .......................................... 15
Figure 6. Legacy fluid tailings for Suncor Base Plant, 2014 to 2019 .................................... 16
Figure 7. New fluid tailings for Syncrude Mildred Lake, 2015 to 2019 .................................... 21
Figure 8. Legacy fluid tailings for Syncrude Mildred Lake, 2014 to 2019 ............................. 22
Figure 9. New fluid tailings for Syncrude Aurora North, 2014 to 2019 ............................... 25
Figure 10. Legacy fluid tailings for Syncrude Aurora North, 2014 to 2019 ........................... 26
Figure 11. New fluid tailings for CNUL Muskeg River Mine, 2015 to 2019 ............................ 30
Figure 12. Legacy fluid tailings for CNUL Muskeg River Mine, 2015 to 2019 ...................... 31
Figure 13. New fluid tailings for CNUL Jackpine Mine, 2015 to 2019 ............................ 35
Figure 14. Legacy fluid tailings for CNUL Jackpine Mine, 2015 to 2019 ............................ 36
Figure 15. New fluid tailings for CNRL Horizon, 2015 to 2019 ........................................ 39
Figure 16. Legacy fluid tailings for CNRL Horizon, 2015 to 2019 ..................................... 40
Figure 17. New fluid tailings for Imperial Kearl, 2014 to 2019 ....................................................... 44
Figure 18. New fluid tailings for Suncor Fort Hills, 2016 to 2019 ....................................................... 48

Table
Table 1. Treated fluid tailings volumes reported by operator, 2014 to 2019 ............................................. 12
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEPN-E</td>
<td>Aurora east pit north - east</td>
</tr>
<tr>
<td>AEPN-W</td>
<td>Aurora east pit north - west</td>
</tr>
<tr>
<td>AEPS</td>
<td>Aurora east pit south</td>
</tr>
<tr>
<td>AER</td>
<td>Alberta Energy Regulator</td>
</tr>
<tr>
<td>AFD</td>
<td>atmospheric fines drying</td>
</tr>
<tr>
<td>ASB</td>
<td>Aurora settling basin</td>
</tr>
<tr>
<td>BAW</td>
<td>beach above water</td>
</tr>
<tr>
<td>BBW</td>
<td>beach below water</td>
</tr>
<tr>
<td>BML</td>
<td>base mine lake (used interchangeably with WIP)</td>
</tr>
<tr>
<td>CNRL</td>
<td>Canadian Natural Resources Limited</td>
</tr>
<tr>
<td>CNUL</td>
<td>Canadian Natural Upgrading Limited</td>
</tr>
<tr>
<td>CST</td>
<td>coarse sand tailings</td>
</tr>
<tr>
<td>CT</td>
<td>composite tailings</td>
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<tr>
<td>CWR</td>
<td>clay-to-water ratio</td>
</tr>
<tr>
<td>CWZ</td>
<td>clear water zone</td>
</tr>
<tr>
<td>DDA</td>
<td>dedicated disposal area</td>
</tr>
<tr>
<td>EETA</td>
<td>east external tailings area</td>
</tr>
<tr>
<td>EIP</td>
<td>east in-pit</td>
</tr>
<tr>
<td>EPEA</td>
<td><em>Environmental Protection and Enhancement Act</em></td>
</tr>
<tr>
<td>ETA</td>
<td>external tailings area</td>
</tr>
<tr>
<td>ETF</td>
<td>external tailings facility</td>
</tr>
<tr>
<td>FFT</td>
<td>fluid fine tailings</td>
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<tr>
<td>FT</td>
<td>fluid tailings</td>
</tr>
<tr>
<td>IPC</td>
<td>in-pit cell</td>
</tr>
<tr>
<td>K1</td>
<td>Kearl plant 1</td>
</tr>
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<td>K2</td>
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Executive Summary

Alberta has eight operating oil sands mines, and by the end of 2019, each site had an approved tailings management plan. Under Directive 085: Fluid Tailings Management for Oil Sands Mining Projects, mine operators must annually submit tailings management reports that show how they are implementing their tailings management plans. This report summarizes the information for the 2019 reporting year and assesses the operators’ progress in managing fluid tailings. Operators continue to report improvements in their current tailings treatment technologies and the piloting and development of new technologies.

For management purposes, fluid tailings are categorized as legacy fluid tailings (fluid tailings stored before January 1, 2015) and new fluid tailings. The total volume of fluid tailings (new and legacy tailings combined) on oil sands mine sites in the Athabasca oil sands region has increased between 2014 and 2019, as expected based on the approved fluid tailings profiles. There was a decrease in the regional volume of water in tailings ponds from 2014 and 2017 and an increase from 2017 to 2019. This occurred with an overall increase in bitumen production and an increase in the number of mines operating between 2014 and 2019.

Included in the tailings management plans are profiles for both legacy and new fluid tailings volumes. Most fluid tailings volumes were within the sites’ legacy and new profiles, with the exception of Syncrude Mildred Lake. This site slightly exceeded its legacy fluid tailings profile from 2017 to 2019, but that did not trigger a change in management level as described in Directive 085 for these years. All operators reported that they were below their total volume triggers and total volume limits for new fluid tailings.

The tailings volumes in this report are presented as reported by the operators. In some instances, there was insufficient information for us to verify the operators’ data or analyses. In these instances, we requested clarification or additional data. Responses to these requests were not received before the writing of this report. Those responses, as well as further review of the fluid tailings volumes, including assessing if they meet ready-to-reclaim criteria, may lead to changes in the reported data or analyses from previous years and will be reflected in the 2020 report.

Operators are required to submit measurement system plans to show how they are measuring the performance of their tailings deposits. We have completed assessments of these plans related to determining whether a tailings deposit’s physical properties (subobjective 1 in Directive 085) are on a trajectory to support future stages of activity (i.e., next steps of reclamation). We are still assessing whether these plans address the need to minimize the effect the deposit has on the surrounding environment and ensure that it will not compromise the ability to reclaim the area to a locally common, diverse, and self-sustaining ecosystem (subobjective 2 in Directive 085).
1 Introduction

The Alberta Energy Regulator (AER) regulates oil sands mines and the associated management of fluid tailings as part of its mandate to ensure the safe, efficient, orderly, and environmentally responsible development of energy resources over the entire life cycle.

This report summarizes information submitted by oil sands mine operators in their annual tailings management reports.

Both an approved tailings management plan and an assessed measurement system plan are required in order the AER to assess the data in operators’ annual tailings management reports. In addition, both are required to assess fluid tailings inventory data as they allow for the determination of what volumes are considered ready to reclaim (RTR) and may therefore be removed from the fluid tailings inventory of the operator. Operator reports for 2019 must adhere to all reporting requirements in Directive 085: Fluid Tailings Management for Oil Sands Mining Projects and to conditions in each operator’s tailings approvals.

The AER has completed assessments of the measurement system plans submitted by operators related to determining whether a tailings deposit’s physical properties are on a trajectory to support future stages of activity (subobjective 1 in Directive 085). The AER is still assessing whether these plans address the need to minimize the effect the deposit has on the surrounding environment and ensure that it will not compromise the ability to reclaim the area to a locally common, diverse, and self-sustaining ecosystem (subobjective 2 in Directive 085). The tailings volumes in this report are presented as reported by operators and are subject to change upon further review of fluid tailings volumes, including assessing whether they meet RTR criteria.

Annual tailings management reports submitted by operators are reviewed by the AER’s expert staff. Their review may lead to the AER requesting further clarification or additional information from an operator. In addition, potential compliance issues are referred to the AER’s Compliance and Liability Management team.

Further review by the AER after publication of this report of the information provided by the operators for 2019 may lead to changes in the data. Any changes will be incorporated into the 2020 edition of this report, which will be issued by September 30, 2021.
2 Purpose

The purpose of this report is to summarize information from individual operators based on Directive 085 requirements, including

- fluid tailings volumes for each operator and for the region;
- water volumes stored in tailings ponds for each operator and for the region;
- whether operators are within their approved fluid tailings profiles;
- site-wide fluid tailings management activities for each mine site;
- tailings treatment and the development of treatment technologies;
- project-specific performance;
- progress made in managing fluid tailings;
- alignment with approved tailings management plans.

This report also includes a summary of regulatory and management actions related to tailings taken by the AER.

This report does not address mine financial security, waterfowl protection, dam safety, or air emissions from tailings ponds. Information on these issues can be found on the AER website (www.aer.ca) or on the Alberta Environment and Parks’ oil sands information portal (http://osip.alberta.ca/). This report also does not include information on audits or inspections conducted by the Compliance and Liability Management team or information reported on the AER Compliance Dashboard. However, it does include a summary of tailings-related regulatory site inspections in 2019 (see appendix 2).

3 Regulatory and Operational Context

3.1 Regulatory Context

On March 13, 2015, the Government of Alberta released the Lower Athabasca Region: Tailings Management Framework for Mineable Oil Sands (TMF) to manage and decrease liability and environmental risk from the accumulation of fluid tailings on the landscape. The TMF’s goal is to “increase the rate of reclamation and enhance the reduction of tailings ponds,” and it establishes the following policy outcomes:

- land use must be returned to Albertans,
- sustainable ecosystem (after reclamation),
- liability is minimized to Albertans, and
- environmental effects are managed.
In support of the *Lower Athabasca Regional Plan*’s strategic direction of “encouraging timely and progressive reclamation,” the TMF provides guidance and an objective for managing fluid tailings so that both new and legacy tailings can be reclaimed in a timely manner. The TMF states the objective that fluid tailings accumulation be minimized by ensuring that fluid tailings are treated and reclaimed progressively during the life of an oil sands mining project and by ensuring that all of a project’s fluid tailings are ready to reclaim within ten years of the project’s end-of-mine life.


### 3.2 Operational Context

The following eight oil sands mining projects were operating in 2019:

- Suncor Energy Incorporated (Suncor) Base Plant, which includes the Millennium and North Steepbank Mines,
- Syncrude Canada Limited (Syncrude) Mildred Lake,
- Syncrude Aurora North,
- Canadian Natural Upgrading Limited (CNUL) Muskeg River Mine,
- CNUL Jackpine Mine,
- Canadian Natural Resources Limited (CNRL) Horizon,
- Imperial Oil Resources Limited (Imperial) Kearl, and
- Suncor Fort Hills.

On November 15, 2018, the AER approved the transfer of Total E&P Canada Limited’s Joslyn North Mine to CNRL. However, fluid tailings management reporting was not required for 2019 for the Joslyn mine (now called CNRL Horizon South).

On July 25, 2019, a joint review panel approved Teck Resources Limited’s (Teck’s) application for its Frontier Mine, but the project still requires federal approval. Teck has withdrawn its federal application. Fluid tailings management reporting for the Frontier Mine will be required if the mine is constructed and operations begin.

The locations of oil sands mining projects and their tailings ponds are shown in figure 1.
Figure 1. Map of operating and proposed oil sands mining projects and tailings ponds/deposits
4 2019 Reporting

The AER requires operators to report on the status of fluid tailings management at their sites by April 30 of each year in accordance with the AER’s Directive 085. For most operators, 2019 marked the third year for submitting annual tailings management reports. It was also the second year where all operators were required to meet full reporting requirements under Directive 085 and their conditions of approval. Operator submissions for 2019 were made available on the AER website, www.aer.ca, on May 22, 2020, under Providing Information > By Topic > Tailings.

On January 27, 2020, the AER directed the operators to provide the previous year’s measured tailings and fluid volumes, in the electronic format specified by the AER. Operators were allowed to select the year-end date of their choosing for the measured volumes they report. Operators must, however, notify the AER prior to the end of the reporting year to change the year-end reporting date. As a result, tailings and fluid volumes in this report are as-measured volumes for 2019.

4.1 2019 Report Review

As part of its review of the operators’ annual tailings management reports for 2019, the AER assessed the operators’ reported progress in fluid tailings management, including achieving RTR status, trends over time, consistency with previous annual reports, and compliance with approval conditions. The intent of the review is to ensure that

- operators are implementing their approved fluid tailings management plan, including confirming that conditions related to fluid tailings management are being met and stated milestones are being achieved;
- fluid tailings performance is in accordance with their profiles;
- fluid tailings performance is in accordance with volume triggers and limits;
- fluid tailings management level for each operation is identified;
- fluid tailings deposits are meeting RTR criteria and are on the applicable trajectory; and
- initiated mitigation actions and contingency plans are effective in managing fluid tailings and treated tailings deposit performance.

All oil sands mining operators had an approved tailings management plan by the end of 2019.

4.1.1 Ready-to-Reclaim Criteria and Trajectory

In 2019, operators were required to identify volumes of treated fluid tailings that met RTR criteria. The TMF and Directive 085 both require that the progress of fluid tailings and progress of treated fluid tailings be tracked from initial formation (accumulation) through to its initial RTR state and continuation on a trajectory showing that it remains in its approved RTR state. Tracking of fluid tailings progress includes
processing with an accepted technology, final placement of the tailings on the landscape, and achievement of the approved RTR trajectory and performance criteria. RTR criteria are used to track treated fluid tailings during the operational stage of the deposit to ensure that the deposit can be reclaimed as predicted in the life-of-mine closure plan.

In their 2019 reports, operators reported on the treated fluid tailings volumes that achieved RTR status during the current reporting period and confirmed that treated fluid tailings in deposits continued to meet the RTR trajectory approval conditions, identifying any volumes that need to be returned to the fluid tailings inventory. The tailings volumes in this report are presented as reported by the operators and are subject to change upon further review of fluid tailings volumes and performance with respect to meeting RTR criteria.

4.1.2 Environmental Performance Monitoring

*Directive 085* requires operators to summarize environmental performance monitoring reports highlighting the operator’s management of environmental effects and the potential impacts of fluid tailings management activities.

To avoid reporting duplication, the AER noted during the development of *Directive 085* that it may allow operators to refer to other reports already submitted to provide performance results for managing and minimizing environmental effects and the implications of fluid tailings management activities. Some 2019 operator tailings management reports refer more generally to other *Environmental Enhancement and Protection Act (EPEA)* environmental reports or provided information from these reports. As a result, the AER must do further review to verify the additional data and information or to clarify reported data and information in the referenced reports. With the exception of data on approval conditions for subobjective 2 RTR criteria and the assessment of the operators’ measurement system plans, this additional review of the referenced reports is not part of the evaluation of volumetric measurements for fluid tailings and treated fluid tailings management activities in 2019.

4.2 Next Steps

In areas where the AER identified gaps or areas requiring clarification in the annual tailings management reports submitted by operators in 2019, the AER has followed up with operators by requesting clarification or more information. This may lead to data corrections, changes in the RTR status of treated fluid tailings in a deposit, or changes in the fluid tailings inventory. Relevant information from responses to these requests for clarification that are not available at the time of writing this report will be included in the 2020 report, which will be issued in September 2021. Changes in the RTR status of a deposit may warrant mitigation or corrective action, and changes in the fluid tailings inventory may warrant additional fluid tailings management responses.
5 Tailings Description

About 20 per cent of Alberta’s oil sands reserves are recoverable by surface mining, which excavates oil sands using trucks and shovels. The oil sands are then transported to an extraction plant, where bitumen is separated from the sand. This bitumen can be sold as a product or upgraded to synthetic crude oil or other products, which are either used on site or sold.

Tailings are a by-product of the process used to extract bitumen from mined oil sands. Tailings are a mixture of sand, clay, water, silt, residual bitumen and other hydrocarbons, salts, and trace metals. During the early stages of mine operations, tailings are deposited into manmade aboveground structures called external tailings ponds. Once a mined-out area (pit) becomes available, tailings are stored in these mined-out areas (in-pit tailings ponds). Tailings ponds act both as a holding area from which water can be taken and recycled back into the bitumen extraction process and as a settling basin to separate water from tailings. Directive 085 defines fluid tailings as any fluid discard from bitumen extraction facilities containing more than five mass per cent suspended solids and having less than an undrained shear strength of five kilopascals. Ponded water is considered any liquid which contains less than five per cent solids. See Directive 085, appendix 1, for more definitions of terms related to tailings management.

The particles in a tailings pond settle out of the water at different rates. Sand particles tend to settle quickly. However, smaller particles of clay and silt (i.e., fines), 44 micrometres or less in diameter, tend to remain suspended in the water for longer periods, forming fluid tailings. Without intervention, fluid tailings can take decades to settle. This makes the management of fluid tailings an ongoing challenge for the oil sands mining industry.

Tailings generated as part of the mining and bitumen extraction process must be managed in accordance with Directive 085 and the conditions in the operators’ approvals.

6 Fluid Tailings Treatment and Deposition

Oil sands mine operators use various technologies to treat fluid tailings, with some operations using multiple technologies. Development and implementation of new technologies and continuous improvement of existing technologies is very important for the successful management of fluid tailings in the oil sands mining industry. The ability to successfully reclaim to target ecosites is also affected by the deposit design and operation, including the size and depth of the deposit, and the capping design, both of which are reflected in the RTR trajectory. A summary of the treatment technologies and typical treated tailings deposits from the tailings management plans is included in appendix 1.

Operators are required to obtain regulatory approval before implementing a new tailings treatment technology or constructing a deposit not already included in the current approval. The uncertainties and risks associated with in-deposit performance of demonstration technologies, including treated fluid tailings deposit capping, are described in the Directive 085 decision reports on the AER website.
7 Regional Fluid Tailings Status

Data in this report are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted by the operators. The tailings volumes are subject to change upon further review of fluid tailings volumes, including assessing whether they meet RTR criteria.

The total volume of fluid tailings, including both legacy and new fluid tailings, in the Athabasca oil sands region increased between 2014 and 2019, as expected based on the new and legacy profiles in the tailings management plans approved by the AER. Total fluid tailings volumes increased from 1075 million cubic metres (Mm³) in 2014 to 1270 Mm³ in 2019 (see figure 2 and appendix 3). An aggregate of both profiles for all operators in each year is included in figure 2.

From 2015 to 2019, the reported total volume of fluid tailings in the Athabasca oil sands region was below the aggregate of approved tailings profiles.

Figure 2 and figure 3 present fluid tailings inventory volumes as reported by the operators. Treated fluid tailings volumes identified by the operators as having met RTR status are not included in these volumes. This differs from the 2018 report, where volumes identified as having met RTR status were included.

The reported volume of fluid tailings added in the Athabasca oil sands region ranged from a high of 60.4 Mm³ in 2016 to a low of 17.1 Mm³ in 2017 (see figure 3). The drop in 2017 compared to 2016 occurred because some operators removed tailings volumes from their inventory that were claimed to have met RTR criteria. Bitumen production increased from 60.2 Mm³ in 2014 to 90.0 Mm³ in 2019. The volume of fluid tailings added to the landscape for 2017 was lower than reported in last year’s report due to an error in data where a decrease in volume was marked as an increase in volume.

The change in fluid tailings volume is the volume of fluid tailings for that reporting year minus the previous year’s volume of fluid tailings. Each bar in figure 3 represents the volume of fluid tailings added to the inventory. From 2015 to 2019, the volume of fluid tailings produced exceeded the volume of tailings reported by industry as achieving RTR status in its final landscape position, tailings which could then be removed from the fluid tailings volume inventory.
Notes: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the ready-to-reclaim criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

In 2018, Syncrude Aurora North and Mildred Lake data are as-measured values, not projected to year-end. Beginning in 2019, data are as-measured values, with the exception of Imperial Kearl, which provided year-end predicted values for 2019.

Figure 2. Regional fluid tailings volumes and aggregate tailings profiles, 2014 to 2019
Notes: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the ready-to-reclaim criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

In 2018, Syncrude Aurora North and Mildred Lake data are as-measured values, not projected to year-end. Beginning in 2019, data are as-measured values, with the exception of Imperial Kearl, which provided year-end predicted values for 2019.

Figure 3. Change in annual fluid tailings volume in the Athabasca oil sands region, 2015 to 2019
7.1 Fluid Tailings Treatment and Deposition

The reported volumes of treated fluid tailings produced each year by oil sands operators are in Table 1. Treated tailings volumes cannot be combined between technologies or between sites because of differences in technologies, deposit designs, deposit sizes, in-deposit performance of similar technologies, and differences in closure techniques or target ecosites.

Reported treated fluid tailings volumes do not necessarily equal the volume of treated fluid tailings in deposits meeting approved tailings management plan RTR criteria. The treated fluid tailings volume is a measure of the volume of fluid tailings to which a treatment technology is applied. The volume of treated tailings in a deposit meeting approved RTR criteria is based on the annual measurements of the tailings deposits.

Due to uncertainties in technology efficacy and deposit performance, uncertainties in capping techniques and capabilities, and deposit uncertainties to support target ecosites, most RTR criteria require additional monitoring, modelling, and assessments to prove capabilities and assure accuracy and reliability. Accordingly, future updates to RTR criteria are expected and may result in changes to volumes of treated fluid tailings reported as achieving RTR status.
### Table 1. Treated fluid tailings volumes reported by operator, 2014 to 2019, in million cubic metres

<table>
<thead>
<tr>
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<td>Composite tailings (CT)</td>
<td>5.7</td>
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<td>5.0</td>
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<td></td>
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<td>6.0</td>
<td>6.7</td>
<td>6.4</td>
<td>3.8</td>
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<td>19.4d</td>
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<tr>
<td></td>
<td>Enhanced spiked nonsegregat</td>
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<td></td>
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<td></td>
<td>ing tailings</td>
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</tr>
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<td>Imperial Kearl</td>
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<td>0.0</td>
<td>2.4i</td>
<td>8.5</td>
<td>8.7i</td>
<td>13.6</td>
</tr>
</tbody>
</table>

Note: Volumes cannot be added together between technologies or between sites because of the differences in technologies and differences in performance of similar technologies at different sites.

- Volume of CT slurry volume and CT beach deposit. Revised from CT beach deposit only reported in 2017.
- Thickened tailings combined with coarse sand tailings, whole tailings, and tailings solvent recovery unit material in a single deposit forms a north-pool-deposit-type deposit.
- Updated in April 2017 submission.
- Volume of TT slurry at solids content of average 23.6 per cent from 2014 to 2016.
- Volume of TT slurry at solids content of 21.9 per cent in 2017.
- Volume of TT slurry at solids content of average 15 per cent from 2014 to 2016.
- Volume of TT slurry at solids content of 13.7 per cent in 2017.
- Volume of NST.
- Volume of thickened tailings in deposit after secondary chemical treatment.
7.2 Water Volumes

Based on the data reported by operators, the volume of water contained in tailings ponds and deposits in the Athabasca oil sands region decreased from 408.4 Mm$^3$ in 2014 to 392.3 Mm$^3$ in 2017, then increased to 431.1 Mm$^3$ in 2018 and decreased to 418.1 Mm$^3$ in 2019 (see figure 4 and appendix 4). In 2019, total oil sands bitumen production also increased, rising from 60.2 Mm$^3$ in 2014 to 90.0 Mm$^3$ in 2019.

The water volumes are subject to change upon further review by the AER of pond and deposit volumes.

Note: Water volumes are presented as reported by operators and are subject to change upon further review by the AER.

Figure 4. Ponded water volume in tailings ponds, 2014 to 2019
8 Fluid Tailings Status

8.1 Suncor – Base Plant

Suncor Base Plant uses two primary fluid tailings technology treatments to manage its fluid tailings. First, Suncor Base Plant combines in-line flocculation with thin-lift drying in dedicated disposal area 1 (DDA1). Within one to two years, the treated tailings is excavated from DDA1 and moved to Mine Dump 9 (MD9) for co-disposal with overburden. DDA1 is therefore a temporary location because all tailings treated and placed in DDA1 are re-handled and moved to MD9.

Second, Suncor Base Plant uses its permanent aquatic storage structure (PASS) technology for its DDA3 deposit in which its fluid tailings are treated with a coagulant and a flocculent prior to placement in a deposit.

In 2019, Suncor Base Plant reported that its new and legacy fluid tailings inventories are within the approved fluid tailings profiles.

8.1.1 Fluid Tailings

In 2019, Suncor Base Plant reported 263 Mm³ of total measured fluid tailings inventory (new and legacy fluid tailings combined), down from 273 Mm³ reported in 2018.

In accordance with the AER’s industry-wide Notice of Reporting Requirements Clarification letter of January 27, 2020, Suncor Base Plant has shifted its reporting of annual tailings volumes from projected year-end values to as-measured values beginning in 2019.

Suncor Base Plant claims 34 Mm³ of fluid tailings have achieved RTR status in 2019 and that the inventory has achieved the following subobjective 1 RTR criteria:

- For DDA1 to MD9:
  - Fluid tailings to achieve a clay-to-water ratio (CWR) greater than 0.5 in DDA1 based on deposit sampling.

- For DDA3:
  - Fluid tailings to achieve a CWR greater than 0.5 in DDA3 based on deposit sampling.
  - Expressed water from DDA3 treated tailings to achieve an annual average total suspended solids (TSS) concentration less than or equal to 500 ppm.

The volumes reported in 2019 fall within the currently approved profiles for both new and legacy fluid tailings inventories. Suncor Base Plant did not submit any data correction requests in 2019.
8.1.1.1 New Fluid Tailings

Suncor Base Plant’s approved new fluid tailings volume was 101 Mm³ for 2019.

Suncor Base Plant reported 101 Mm³ of new fluid tailings inventory in 2019 (see figure 5), an increase from 76 Mm³ in 2018. Suncor did not provide the volume of treated fluid tailings that exceeded the tailings management plan RTR criterion of a CWR of 0.5. As a result, the AER has requested further information to determine the appropriate volume of fluid tailings to be removed from the fluid tailings inventory, which may result in a change to the new fluid tailings inventory.

Suncor Base Plant has a total volume trigger of 281.0 Mm³ and a total volume limit of 393.4 Mm³ for new fluid tailings in its tailings management approval. Based on data reported in its 2019 annual tailings management report, Suncor Base Plant was within its new fluid tailings profile between 2015 and 2019, and did not exceed its total volume trigger or total volume limit for new fluid tailings in 2019.

Notes: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the ready-to-reclaim criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

Figure 5. New fluid tailings for Suncor Base Plant, 2014 to 2019
8.1.1.2 Legacy Fluid Tailings

Suncor Base Plant’s approved legacy fluid tailings volumes was 182 Mm³ for 2019. Suncor reported 162 Mm³ of legacy fluid tailings inventory in 2019, which was below its legacy fluid tailings profile for 2019 (see figure 6) and down from 176 Mm³ in 2018. Suncor did not provide the volume of treated fluid tailings that exceeded the tailings management plan RTR criterion of a CWR of 0.5. As a result, the AER has requested further information to determine the appropriate volume of fluid tailings to be removed from the fluid tailings inventory, which may result in a change to the legacy fluid tailings inventory.

Figure 6. Legacy fluid tailings for Suncor Base Plant, 2014 to 2019

Notes: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the ready-to-reclaim criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.
8.1.2 Volume of Treated Fluid Tailings by Technology

In the initial thin-lift drying area, DDA1, Suncor Base Plant reported 7.0 Mm³ of fluid tailings treated from the South Tailings Pond (STP) as achieving RTR status, with the DDA1-treated fluid tailings having an average CWR of 0.58. These values are similar to the 2018 reported value of 0.54. Suncor also reported that material treated in 2018 and earlier had decreased from a CWR of 1.17 to 0.88.

Suncor Base Plant did not provide the volume of treated fluid tailings that exceeded the tailings management plan RTR criterion of a CWR of 0.5. As a result, the AER has requested further information to determine the appropriate volume of fluid tailings to be removed from the fluid tailings inventory.

In DDA3, Suncor Base Plant reported that in DDA3 26.7 Mm³ of fluid tailings were treated with PASS technology and that the DDA3-treated fluid tailings had an average CWR of 0.47, which is below the RTR criterion of a CWR of 0.5, but higher than the 2018 reported CWR value of 0.39. Suncor reported that the volume of treated fluid tailings that exceeded the RTR criterion was 8.7 Mm³.

The expressed water quality measured in 2019 achieved an average TSS of 13 ppm, which meets the approved RTR criterion, and was lower than the TSS of 34 ppm reported in 2018.

Suncor Base Plant reported that the 14 Mm³ of fluid tailings treated in DDA3 in 2018 had an average CWR of 0.57 and claimed that in 2019 this material reached RTR status.

The AER is currently assessing whether the treated tailings volume or the volume removed from the fluid tailings inventories of Pond 5, MD9, or DDA3 have achieved RTR status.

8.1.3 Treatment Operation and Continuous Improvement

Suncor Base Plant reported that its tailings treatment technologies are operating as expected and are meeting performance criteria. Suncor also reported the following improvements in 2019:

- Changes were made to the flocculent injector design to improve the efficiency of the flocculent dispersion in fluid tailings, with a reduced amount of polymer.
- Online near infrared meters were tested to measure the clay content in the fluid tailings for feed monitoring and flocculent dosage control.

Suncor Base Plant reported successfully tying in fluid tailings feed from STP to DDA3 existing operations, enabling PASS technology to treat fluid tailings from Pond 8B and South Tailings Pond.

No change to expected treatment capacity was reported by Suncor based on the improvements stated above.
8.1.4 Technological Innovation in Fluid Tailings Treatment

Suncor Base Plant reported that both alum and ferric sulphate could act as acceptable coagulants in accelerating dewatering for fluid tailings treatment. A ferric sulphate trial helped validate that the quality of the release water in DDA3 is the same or better than using alum. Since ferric sulphate does not increase the fluid tailings gel strength as much as alum, it is reportedly easier to disperse flocculent in mature fine tailings.

Further details for the above innovations can be found in Suncor Base Plants 2019 tailings management report.

8.1.5 Regulatory and Management Actions

As noted in the AER’s letter to Suncor Base Plant regarding its 2018 annual tailings performance report and as stated in Decision 20171025A, deposit-wide averaging of CWR is unacceptable. Because Suncor Base Plant claimed RTR status for fluid tailings that had a deposit-wide CWR average greater than 0.5 but that contained fluid tailings that were less than 0.5, the AER has requested further information to determine the appropriate volume of fluid tailings to be considered as reaching RTR status and that can thereby be removed from the fluid tailings inventory. This may result in a change to the reported new fluid tailings inventory, legacy fluid tailings inventory, and volume of treated tailings.

Suncor Base Plant is operating at management level 1, as described in the TMF and Directive 085. No management actions were taken during the 2019 reporting period for Suncor Base Plant’s tailings management operations.

8.1.6 Measurement System Audit Results

The AER has completed its review of Suncor’s Base Plant measurement system plan for fluid tailings volumes and treated fluid tailings with respect to the RTR subobjective 1 measurements. The AER issued industry-wide and site-specific supplemental information requests (SIRs) with the intent to establish a baseline understanding of operators’ plans for measuring fluid tailings volumes, fluid tailings properties, and active treated tailings deposits in order to ensure operators are on a trajectory towards achieving their approved RTR subobjective 1 criteria.

The AER is continuing its review of the measurement system plan with respect to the subobjective 2 measurement components and froth treatment tailings streams. As a result, Suncor’s Base Plant measurement system was not audited in 2019. Once the AER’s review is complete, audits will occur as required.
8.2  Syncrude – Mildred Lake

The tailings management plan for Syncrude Mildred Lake was approved in part, and with conditions, in Decision 2019 ABAER 006: Syncrude Canada Ltd. Mildred Lake Extension Project and Mildred Lake Tailings Management Plan. Some portions of the plan were not approved and, as part of the decision, Syncrude was directed to provide an updated tailings management plan for approval by January 31, 2023, or other date stipulated by the AER in writing.

There are six tailings facilities currently in operation at Mildred Lake:

- Mildred Lake Settling Basin (MLSB)
- South West Sand Storage (SWSS)
- East In-Pit (EIP)
- South West In-Pit (SWIP) major and minor
- North Mine South Pond (NMSP)
- North Mine South Pond East Deep Cake (NMSPE Deep Cake)

MLSB and SWSS are the only out-of-pit facilities at the site. The tailings facilities vary in their primary functions, contents, and sizes. Each facility except for the EIP currently provides fluid and solid tailings storage for the site. West In-Pit / Base Mine Lake (WIP/BML) is a water-capped demonstration pit lake and EIP is in the final stages of landform construction and reclamation for closure purposes. Closure landform construction and reclamation activities (placement of reclamation material and planting towards achieving the ecosite targets) continued on a large area of the EIP deposit in 2019. At Mine Waste Dump 1 and SWSS, reclamation activities continued on a shallow deposit of centrifuge cake.

Composite tailings (CT) and fluid tailings centrifugation are the primary fluid tailings treatment technologies currently used at Mildred Lake. No significant changes were made to either tailings treatment process in 2019.

In 2019, Syncrude reported that its new fluid tailings inventories were within the approved new fluid tailings profile. Syncrude also reported that its legacy fluid tailings inventory was slightly above the approved legacy tailings profile in 2019 but remained below its 20 per cent profile deviation trigger.

8.2.1 Fluid Tailings

In 2019, Syncrude Mildred Lake reported a total of 501.7 Mm³ of fluid tailings (new and legacy fluid tailings combined).

In accordance with the AER’s industry-wide Notice of Reporting Requirements Clarification letter of January 27, 2020, Syncrude Mildred Lake has shifted its reporting of annual tailings volumes from projected year-end values to as-measured values beginning in 2019.
Syncrude claimed that 23.9 Mm$^3$ of fluid tailings have met subobjective 1 RTR criteria, which requires the following:

- CT to achieve 65 per cent solids content by weight within one year of tailings placement, based upon deposit sampling; and

- centrifuged cake deep deposits to achieve 50 per cent solids content by weight within one year of tailings placement, based upon deposit sampling.

The volumes reported in 2019 are within the approved fluid tailings profile for the new fluid tailings inventory and were slightly above for the legacy fluid tailings inventory, but remained below the 20 per cent deviation trigger for legacy fluid tailings.

### 8.2.1.1 New Fluid Tailings

Syncrude Mildred Lake reported 81.2 Mm$^3$ of new fluid tailings inventory in 2019 (see figure 7), which is an increase from 65.2 Mm$^3$ in the 2018 report. The approved new fluid tailings profile for 2019 was 93.8 Mm$^3$. The 2019 fluid tailings inventory was below this profile. The total volume trigger for new fluid tailings volume is 151 Mm$^3$ and the total volume limit is 211.4 Mm$^3$, neither of which were exceeded in 2019. The new fluid tailings inventory for 2016 exceeded the profile; however, this was before Syncrude Mildred Lake had an approved fluid tailings profile. From 2017 to 2019, Mildred Lake’s new fluid tailings inventory was within the approved new fluid tailings profile.

### 8.2.1.2 Legacy Fluid Tailings

Syncrude Mildred Lake reported 420.5 Mm$^3$ of legacy fluid tailings inventory in 2019 (see figure 8), which is a decrease from 427.1 Mm$^3$ in the 2018 report. The approved legacy tailings profile in 2019 was 400.9 Mm$^3$. The measured 2017 to 2019 fluid tailings inventories were slightly above the approved legacy tailings profile, but remained below the 20 per cent deviation trigger.
Notes: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the ready-to-reclaim criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

**Figure 7.** New fluid tailings for Syncrude Mildred Lake, 2015 to 2019
Notes: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the ready-to-reclaim criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

**Figure 8. Legacy fluid tailings for Syncrude Mildred Lake, 2014 to 2019**

### 8.2.2 Volume of Treated Fluid Tailings by Technology

In 2019, Syncrude Mildred Lake reported treating a total of 5.0 Mm³ of fluid tailings. Treatment by CT technology accounted for 1.2 Mm³ within the CT beach deposit and 3.8 Mm³ of centrifuge cake in the NMSPE.

In 2019, Syncrude reported 23.9 Mm³ of fluid tailings achieved RTR status as follows:

- 2.8 Mm³ of CT in SWIP Major,
- 1.4 Mm³ of CT in NMSP, and
- 19.7 Mm³ of centrifuge cake in NMSPE Deep Cake.
8.2.3 Treatment Operation and Continuous Improvement

Syncrude Mildred Lake reported no significant changes to the CT process in 2019. CT production was mainly reduced due to lower oil sands production and reprioritizing of sand use for activities such as additional containment construction and EIP capping. CT production was also restricted from the beginning of May to the end of July in 2019 due to a functional failure on the dredge, which is the main supply of fluid fine tailings (FFT) to CT. This resulted in the lower-than-expected CT production in 2019.

Syncrude identified a discrepancy between its calculated sand-to-fines ratio (SFR) based on plant instrumentation and its sampled SFR results from the CT samples collected at the Aurora North site. This discrepancy is also applicable to the Mildred Lake CT plant. Syncrude identified a potential source of error in the sampling method used by the laboratory. Syncrude initiated a process in 2019 to improve the sampling method and will implement those changes in 2020. The discrepancy could be a reason for the lowered quarterly average SFR. As a result, the AER has requested further information and will follow up with Syncrude on its progress throughout 2020 and into 2021.

The FFT centrifugation plant treated 4.7 Mm³ of FFT in 2019, down from 7.6 Mm³ in 2018. As a result, Syncrude produced less centrifuge cake in 2019: 3.8 Mm³ of cake in 2019 versus 6.38 Mm³ in 2018. The AER has requested further information to understand the reason for the lowered cake production in 2019. Improvements were implemented in 2019 for the FFT centrifugation plant, including troubleshooting issues with the surge pond pumps, making mechanical changes to the FFT supply dredges, and setting up a cake production task force to improve the performance of the FFT centrifugation plant. Syncrude continues to evaluate ways to improve reliability and optimize plant operations.

8.2.4 Technological Innovation in Fluid Tailings Treatment

Syncrude Mildred Lake reported the following technological innovations and field tests in 2019:

- Base Mine Lake Demonstration: The most recent summary report (2019 Base Mine Lake Monitoring and Research Summary Report: Results from 2013-2018) was submitted June 27, 2019, and contains the most recent results from the Base Mine Lake Demonstration.

- FFT Accelerated Dewatering Phase 3: Monitoring is ongoing for cells constructed in 2017 and 2018. Further details can be found in Syncrude Mildred Lake’s 2019 tailings management report.

8.2.5 Regulatory and Management Actions

The Syncrude Mildred Lake site is operating at management level 1, as described in the TMF and Directive 085. No management actions were taken during the 2019 reporting period for Mildred Lake’s tailings management operations.
8.2.6 Measurement System Audit Results

Syncrude Mildred Lake was granted an extension to submit its measurement system plan to the AER by June 30, 2020, instead of January 16, 2020. Syncrude submitted its measurement system plan on June 30, 2020.

The AER completed its review of the measurement system plan with respect to measuring fluid tailings volumes and treated fluid tailings to determine achievement of RTR subobjective 1. The AER issued industry-wide and site-specific SIRs to establish a baseline understanding of operators’ plans for measuring fluid tailings volumes, fluid tailings properties, and active treated tailings deposits in order to ensure that operators are on a trajectory towards achieving their approved RTR subobjective 1 criteria.

The AER is continuing its review of the measurement system plan with respect to subobjective 2 measurement components and froth treatment tailings streams. Once the review is complete, audits will occur as required.

8.3 Syncrude – Aurora North

In 2019, there were three tailings facilities in operation at Aurora North: the Aurora Settling Basin (ASB), Aurora East Pit North - East (AEPN-E) and Aurora East Pit South (AEPS). The ASB is the only out-of-pit facility at the site. The tailings deposits vary in their primary functions, contents, and sizes. The ASB, AEPN-E and AEPS currently provide the fluid tailings storage for the site.

The Aurora East Pit North - West (AEPN-W) has been filled with coarse sand to form the base of the future Fort Hills Dump expansion.

Syncrude Aurora North continued to use CT as its primary fluid tailings treatment in 2019. No significant changes were made to the CT process.

In 2019, Syncrude reported that its measured fluid tailings inventory was within the approved new and legacy fluid tailings profile for Aurora North.

8.3.1 Fluid Tailings

In 2019, Syncrude Aurora North reported a total of 127.4 Mm³ of fluid tailings (new and legacy fluid tailings combined).

In accordance with the AER’s industry-wide Notice of Reporting Requirements Clarification letter of January 27, 2020, Syncrude Aurora North has shifted its reporting of annual tailings volumes from projected year-end values to as-measured values beginning in 2019.
Syncrude reported that in 2019 9.6 Mm³ of fluid tailings met the subobjective 1 criteria for RTR status, which requires CT to achieve 65 per cent solids content by weight within one year of tailings placement, based upon deposit sampling.

The volumes reported in 2019 are within the approved profiles for both new and legacy fluid tailings inventories.

8.3.1.1 New Fluid Tailings

Syncrude Aurora North reported 44.2 Mm³ of new fluid tailings inventory in 2019 (see figure 9), which is an increase from 37.0 Mm³ in 2018. The approved new fluid tailings profile in 2019 was 72.0 Mm³. The total volume trigger for new fluid tailings is 113 Mm³ and the total volume limit is 158 Mm³, neither of which were exceeded in 2019. And the new fluid tailings inventory was within the approved new fluid tailings profile from 2015 to 2019.

![Graph of new fluid tailings for Syncrude Aurora North, 2014 to 2019](image)

Notes: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the ready-to-reclaim criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

**Figure 9.** New fluid tailings for Syncrude Aurora North, 2014 to 2019
8.3.1.2 Legacy Fluid Tailings

Syncrude reported 83.1 Mm³ of legacy fluid tailings inventory in 2019 (see figure 10), which is a decrease from 88.2 Mm³ in 2018. The approved legacy fluid tailings profile in 2019 was 94.0 Mm³. The legacy fluid tailings inventory was below the approved legacy tailings profile from 2015 to 2019.

Figure 10. Legacy fluid tailings for Syncrude Aurora North, 2014 to 2019

8.3.2 Volume of Treated Fluid Tailings by Technology

In 2019, Syncrude Aurora North reported treating a total of 23.9 Mm³ of fluid tailings, all by CT technology, which was deposited in the AEPS and AEPN-E.
Syncrude reported 9.6 Mm³ of fluid tailings achieved RTR status in 2019 as follows:

- 8.9 Mm³ in the AEPN-E, and
- 0.7 Mm³ in AEPS.

8.3.3 Treatment Operation and Continuous Improvement

No significant changes to the CT process were reported in 2019. CT production increased from 2018, but was still lower than expected. Syncrude reported that this was due to a shift in sand prioritization in 2019. Syncrude reported depositing 19.2 Mm³ of straight coarse tails (SCT) in AEPN-E and 1.7 Mm³ SCT in AEPN-W. Both AEPN-E and AEPN-W were originally planned to be completed in 2018 according to Syncrude’s approved tailings management plan. Syncrude did not explicitly say sand prioritization had changed; therefore, the AER is seeking clarification on the lower-than-expected CT production.

Syncrude identified a discrepancy between its calculated sand-to-fines ratio (SFR) based on plant instrumentation and its sampled SFR results from the CT samples collected at the Aurora North site. This discrepancy is also applicable to the Mildred Lake CT plant. Syncrude identified a potential source of error in the sampling method used by the laboratory. Syncrude initiated a process in 2019 to improve the sampling method and will implement those changes in 2020. As a result, the AER has requested further information and will follow up with Syncrude on its progress throughout 2020 and into 2021.

8.3.4 Technological Innovation in Fluid Tailings Treatment

Syncrude reported the following technological innovations and field tests in 2019 for Aurora North:

- Tailings Co-Deposition: To further advance the technology, Syncrude is currently developing a field pilot program for 2020 for co-deposition of flocculated FFT and CT at AEPS. The objective of the field pilot will be to observe the CT and flocculated FFT co-deposit formation and long-term performance in an unconstrained flow condition to determine the applicability of the technology at a larger scale.

Further details can be found in Syncrude Aurora North’s 2019 tailings management report.

8.3.5 Regulatory and Management Actions

On December 18, 2018, Syncrude submitted a plan for alternative fluid tailings treatment technologies in compliance with clauses 9 and 10 of its approval. The AER considered the submission incomplete because it did not include adequate information to meet the requirements of section 9.8.2 of Directive 085. On March 28, 2019, Syncrude submitted its revised alternative technologies plan. The AER found it to be compliant and has no further concerns.
The Aurora North site is operating at management level 1, as described in the TMF and Directive 085. No management actions were taken during the 2019 reporting period for Aurora North’s tailings management operations.

8.3.6 Measurement System Audit Results

The AER completed its review of Syncrude’s measurement system plan for Aurora North with respect to measuring fluid tailings volumes and treated fluid tailings to determine achievement of RTR subobjective 1. The AER issued industry-wide and site-specific SIRs to establish a baseline understanding of operators’ plans for measuring fluid tailings volumes, fluid tailings properties, and active treated tailings deposits in order to ensure that operators are on trajectory towards achieving their approved RTR subobjective 1 criteria.

The AER is continuing its review of the measurement system plan with respect to subobjective 2 measurement components and froth treatment tailings streams. As a result, Syncrude Aurora North’s measurement system was not audited in 2019. Once the review is complete, audits will occur as required.

8.4 Canadian Natural Upgrading Limited – Muskeg River Mine

CNUL Muskeg River Mine reported four active tailings deposits on site: the external tailings facility (ETF), in-pit cell 1 (IPC1), in-pit cell 2 (IPC2), and in-pit cell 3 (IPC3). In 2019, CNUL reported that the south expansion area (SEA) no longer contains fluid tailings (FT) as it has been infilled.

CNUL’s primary strategies for treating fluid tailings at the site are thickened tailings (TT), North-Pool-Deposit-type deposits (co-deposition of TT, coarse sand tailings [CST], whole tailings [WT], and TSRU), and atmospheric fines drying (AFD).

In the ETF, fluid tailings are transferred to IPC2, reclaimed water from the clear water zone (CWZ) is transferred to IPC1, and CST is deposited along the southern side of the pond. In 2019, CST was hydraulically placed to cap the North Pool Deposit (NPD). Individual containment cells were constructed within this capped area and AFD material was poured and dried there over the latter portion of the year.

IPC1 currently acts as a clarification pond by accepting water transfers from ETF, IPC2, and IPC3 before water is transferred to the recycle water pond. IPC1 contains temperature tailings solvent recovery unit (TSRU) tailings and CST.

IPC2 is classified as an “emergency out” facility to be used for deposition of TT to manage recycle water quality, control the rate of rise in IPC3 pond elevation, and allow for unplanned TT pipeline maintenance.

IPC3 also contains a NPD-type deposit with CST beaches. Volumes reported for IPC3 reflect only the portion of beach considered an NPD-type deposit. Tailings streams that discharged into IPC3 during the reporting period included CST/WT, high-temperature TSRU tailings, low-temperature TSRU tailings, and
TT. A mixed deposit in the southeast corner of the facility is forming with the deposition of TT, TSRU, and CST tailings streams.

CNUL reported that in the ETF, most of the NPD-type deposit has been hydraulically sand capped. AFD drying cells have been established on top of the cap. Treated AFD material was left in place through winter 2019 and is scheduled for removal in 2020.

In its 2019 fluid tailings management report, CNUL described the transition of tailings deposits from operations to reclamation activities. In 2019, process water and fluid tailings were transferred out of the ETF (aboveground tailings storage facility) to allow in-filling with coarse sand tailings. The SEA is an annex of the ETF that was used for fluid tailings storage. CNUL reported that all fluid material and nearly all soft, fines-rich material have been transferred from the SEA to the ETF. The SEA was then infilled and capped with coarse sand tailings.

8.4.1 Fluid Tailings

CNUL Muskeg River Mine reported a total of 126.1 Mm³ of fluid tailings (new and legacy fluid tailings combined) in 2019, compared to 121.7 Mm³ in 2018. CNUL also reported that a total of 21.3 Mm³ of material achieved RTR status, meaning that the material reached 70 per cent solids by weight, based on deposit sampling.

In accordance with the AER’s industry-wide Notice of Reporting Requirements Clarification letter of January 27, 2020, CNUL Muskeg River Mine has shifted its reporting of annual tailings volumes from projected year-end values to as-measured values beginning in 2019.

In the 2019 annual tailings management report submitted by CNUL Muskeg River, CNUL reported that the 2015–2018 fluid tailings profile inventory volumes in its accounting table (appendix 3 of Directive 085) were interpolated to mid-year (June 30) volumes from year-end predicted values submitted in previous years. The AER is reporting previously submitted values for 2015–2018 for consistency.

The volumes reported by CNUL in 2019 were within the approved profiles for both new and legacy fluid tailings inventories.

8.4.1.1 New Fluid Tailings

CNUL Muskeg River Mine reported 36.6 Mm³ of new tailings inventory in 2019 (see figure 11), an increase from the 29.7 Mm³ reported in 2018. The site has a total volume trigger of 69 Mm³ and a total volume limit of 97 Mm³ for new fluid tailings, neither of which were exceeded in 2019. The new tailings inventory also did not exceed the new fluid tailings profile between 2015 and 2019.
CNUL Muskeg River Mine reported an inventory of 89.5 Mm³ of legacy fluid tailings in 2019, which is below its approved legacy fluid tailings profile (see figure 12) and a decrease of 2.5 Mm³ from 2018.

Figure 11. New fluid tailings for CNUL Muskeg River Mine, 2015 to 2019
8.4.2 Volume of Treated Fluid Tailings by Technology

In 2019 IPC 3 used TT to develop an NPD-type deposit, with a total volume of 53.4 Mm³. Both IPC 2 and IPC 3 have received TT deposition; however, IPC 2 only received a minimal slurry volume during emergency conditions (see section 8.4.5).

CNUL Muskeg River Mine stated that 1.3 Mm³ of fluid tailings were treated in the AFD drying area within the ETF. CNUL also reported that 2.5 Mm³ of treated fluid tailings in the ETF within the beach below water (BBW) area of the NPD achieved RTR status. CNUL Muskeg River Mine did not place treated tailings into the ETF in 2019.
8.4.3 Treatment Operation and Continuous Improvement

CNUL Muskeg River Mine reported continued improvement of its tailings technologies and deposition strategies in 2019.

IPC3 was the primary location for the NPD-type deposit development in 2019. CNUL Muskeg River Mine has indicated that an assessment comparing the NPD and IPC3 deposits using the 2018 and 2019 data may inform future optimization efforts.

8.4.4 Technological Innovation in Fluid Tailings Treatment

CNUL pursues technological innovation in fluid tailings management at both the Muskeg River Mine and Jackpine Mine and the findings may be applied to either site. The following are the technological innovations and pilots reported in 2019:

- Tailings Consolidation Casing Experimental Pilot Project: The objective of this pilot is to measure the consolidation properties that govern storage and settlement of tailings. The representative properties have been used to scale up modelling to a field scale to compare the performance of tailings treatment options and are used to investigate the impact that treatment technologies may have on reclamation objectives. Monitoring each casing (vertical tube) continued through 2019 to provide the data needed to evaluate consolidation.

- Modified Atmospheric Fines Drying: This involves placing flocculated fluid fine tailings on tailings beaches and allowing seasonal drying and a full freeze/thaw cycle to be completed after which another lift (layer) is placed on top. The treated AFD material is relocated to a dump, ultimately becoming part of the dry tailings structure. In 2019, samples were collected to determine the effects of the freeze/thaw cycle and material properties before capping.

- Soft Deposit Capping – Centrifuge Cake Test Cell Capping: Initially, this test began as a material loading capping study and has since developed into a study focused on exploring other capping options for improving strength and consolidation. Additional efforts included evaluating different vegetation species. In 2019, multiple field programs and evaluations were completed on the centrifuge cake cells.

- Geotube Pilot Program: This pilot is assessing the feasibility of geotubes (or geobags) in the context of creating terrestrial, out-of-pit, reclamation features with treated FFT. The objective of the pilot is to assess and demonstrate the commercial viability and economic feasibility of geobags in FFT service. Specifically, evaluating the key components of scaling factors, stackability, and chemical treatments. In 2019 field sampling, determination of dewatering performance and consolidation evaluations within the geotubes were completed.

- FFT Pressure Filtration Pilot: The filter press is a technology that delivers rapid water recovery from FFT by mechanically pressing water out of the fine clay slurry to form a dense cake suitable for
immediate transport to a reclamation area. The added step of chemically treating the FFT before mechanical filtration is a crucial part of the process. The site pilot program was completed in September 2019, which confirmed assumptions on commercial design and operation.

Further details can be found in the CNUL Muskeg River Mine 2019 tailings management report.

8.4.5 Regulatory and Management Actions

Regulatory actions taken by the AER in 2019 were as follows:

- The AER eliminated the RTR criteria for IPC2 based on the responses to the 2018 tailings management report SIRs. The CT deposits between 2014 and 2015 have been reclassified as CST, and TT deemed as an emergency pour, thus neither deposit is considered treated tailings.

- The AER has determined that the modelling methodology used by CNUL is aligned with industry practices, which address the application of deposit averaging for solids content within the modelling process for tailings annual reporting, as first reported within the 2018 AER fluid tailings report.

The Muskeg River Mine is operating at management level 1, as described in the TMF and Directive 085. No management actions were taken during the 2019 reporting period for tailings management operations.

8.4.6 Measurement System Audit Results

The AER completed its review of CNUL’s measurement system plan for the Muskeg River Mine with respect to measuring fluid tailings volumes and treated fluid tailings to determine achievement of RTR subobjective 1. The AER issued industry-wide and site-specific SIRs to establish a baseline understanding of operators’ plans for measuring fluid tailings volumes, fluid tailings properties, and active treated tailings deposits in order to ensure that operators are on a trajectory towards achieving their approved RTR subobjective 1 criteria.

The AER is continuing its review of the measurement system plan with respect to subobjective 2 measurement components and froth treatment tailings streams. As a result, no audit of the measurement system was conducted in 2019. Once the review is complete, audits will occur as required.

8.5 Canadian Natural Upgrading Limited – Jackpine Mine

CNUL Jackpine Mine currently stores tailings in the External Tailings Facility (ETF) and Fluid Cell 1. The ETF consists of three storage areas: the Dedicated Disposal Area 1 (DDA1), Sand Cell 1 (SC1), and Sand Cell 2 (SC2).

The primary method of treatment for fluid tailings is the co-deposition of TT, CST, and WT, referred to as a “mixed deposit” (different from Muskeg River Mine’s NPD-type deposit), and the use of centrifuges.
TT and centrifuge product are both placed in DDA1, which was the primary deposit location for treated tailings in 2019. DDA1 also receives CST.

The fluid tailings and water generated from DDA1 flow to SC1 through an open channel established in 2018. During 2020, the cross-dike separating DDA1 and SC1 will be overtopped, and the two ponds will be merged for reporting purposes.

CST continues to be discharged into SC1 to form conventional CST beaches.

Fluid tailings from SC1 are constantly dredged to provide feed for the centrifuge operation. CST are discharged into SC2 to develop cell-constructed beaches and form conventional CST beaches.

Fluid Cell 1 was used for water and fluid tailings storage during the reporting period. Fluid tailings were transferred from SC1 in the latter half of 2016; however, there were no transfers during this reporting period.

8.5.1 Fluid Tailings

In accordance with the AER’s industry-wide Notice of Reporting Requirements Clarification letter of January 27, 2020, CNUL Jackpine Mine has shifted its reporting of annual tailings volumes from projected year-end values to as-measured values beginning in 2019.

In the 2019 annual tailings management report submitted by CNUL Jackpine Mine, CNUL reported that the 2015-2018 fluid tailings profile inventory volumes in its accounting table (appendix 3 of Directive 085) were interpolated to mid-year (June 30) volumes from year-end predicted values submitted in previous years. The AER is reporting previously submitted values for 2015-2018 for consistency.

CNUL Jackpine Mine reported a total of 25.9 Mm³ of fluid tailings (new and legacy fluid tailings combined) in 2019, compared to 28.0 Mm³ in 2018. CNUL Jackpine Mine reported that 0.7 Mm³ of fluid tailings met RTR criteria for the TT mixed deposit in DDA1 for 2019.

8.5.1.1 New Fluid Tailings

CNUL Jackpine Mine reported 3.9 Mm³ of new fluid tailings in 2019 (see figure 13), a decrease from the 6.0 Mm³ reported in 2018. Jackpine Mine has a total volume trigger of 26 Mm³ and a total volume limit of 36 Mm³ for new fluid tailings, which were not exceeded in 2019. The new fluid tailings inventory also did not exceed the profile between 2015 and 2019.
Alberta Energy Regulator

State of Fluid Tailings Management for Mineable Oil Sands, 2019

Notes: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the ready-to-reclaim criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

Figure 13. New fluid tailings for CNUL Jackpine Mine, 2015 to 2019

8.5.1.2 Legacy Fluid Tailings

CNUL Jackpine Mine reported an inventory of 22 Mm³ of legacy fluid tailings in 2019, which is within its legacy fluid tailings profile (see figure 14) and is unchanged from 2018. According to its profile, no legacy tailings will be treated and the legacy volume will remain unchanged until 2023.
8.5.2 Volume of Treated Fluid Tailings by Technology

CNUL Jackpine Mine reported that a total volume of 16.3 Mm³ of TT was deposited in DDA1. The TT deposited obtained an average solid content of 13.3 per cent and an average fines content of 73.3 per cent. CNUL reported that 0.7 Mm³ in DDA1 achieved the RTR criteria.

CNUL Jackpine Mine reported 2.1 Mm³ of centrifuged tailings produced and deposited in DDA1 with an estimated average solids content 44.7 per cent. In 2019, CNUL Jackpine Mine applied for a new RTR criteria for its centrifuge and CST mixed deposits. The AER is currently reviewing this submission. As a result, centrifuge mixed deposit volumes were not claimed to have achieved the RTR criteria at this time.
8.5.3 Treatment Operation and Continuous Improvement

CST were deposited in all ponds except Fluid Cell 1 in 2019, with a focus on DDA1 and SC 1 during the reporting period. Beaching operations in DDA1 produced a deposit that is characteristically different from beaching operations in other ponds. This has largely been attributed to the presence of centrifuge product and TT, and the high ratio of BBW deposition to beach above water (BAW) deposition. This deposition methodology in DDA1 has resulted in higher fines capture. The extent of the fines capture continues to be evaluated in this mixed deposit. An increased density of investigation holes in the pond survey for DDA1 is planned to better understand the impacts that the CST component has on beach performance and site fines capture.

Currently in DDA1, centrifuge deposits are formed through the co-deposition of centrifuge tailings and CST. As the AER is currently reviewing CNUL’s submission for RTR criteria for centrifuge, no comment was made by the AER on performance in 2019. However, CNUL reports that improvements in deposit performance were noted for the mixing of centrifuge tailings and CST compared to observed pure centrifuge tailings deposits in DDA1.

8.5.4 Technological Innovation in Fluid Tailings Treatment

CNUL pursues technological innovation in fluid tailings management at both the Muskeg River Mine and Jackpine Mine and the findings may be applied to either site. See section 8.4.4 for details on the current technological research.

8.5.5 Regulatory and Management Actions

CNUL Jackpine Mine provided an updated mine plan on September 30, 2019, which addressed the AER’s concerns identified in last year’s AER fluid tailings report related to the alignment of the tailings management plan with the life-of-mine plan or life-of-mine closure plan and consistency with targeted reclamation outcomes.

The Jackpine Mine is operating at management level 1, as described in the TMF and Directive 085. No management actions were taken during the 2019 reporting period for tailings management operations.

8.5.6 Measurement System Audit Results

The AER has completed its review of CNUL’s measurement system plan for the Jackpine Mine with respect to measuring fluid tailings volumes and treated fluid tailings to determine achievement of RTR subobjective 1. The AER issued industry-wide and site-specific SIRs to establish a baseline understanding of operators’ plans for measuring fluid tailings volumes, fluid tailings properties, and active treated tailings deposits in order to ensure that operators are on a trajectory towards achieving their approved RTR subobjective 1 criteria.
The AER is continuing its review of the measurement system plan with respect to subobjective 2 measurement components and froth treatment tailings streams. As a result, no audit was conducted on Jackpine Mine’s measurement system. Once the review is complete, audits will occur as required.

8.6 Canadian Natural Resources Limited – Horizon

Horizon has one operating external tailings facility called external tailings facility / dedicated disposal area 1 (ETF/DDA1), which contains WT, NST, and NRU treatment streams. The ETF/DDA1 also serves as a recycle water pond to the plant. Nonsegregating tailings (NST) is the primary fines tailings treatment process at Horizon, in conjunction with its Mature Fine Tailings Reduction Mine Plan, which targets a low fines ore to reduce fluid tailings generation. At the end of 2019, CNRL Horizon was operating five NST lines and three Naphtha Recovery Unit (NRU) lines, with carbon dioxide being injected into NST and NRU lines. CNRL Horizon plans to deposit tailings into a second facility called dedicated disposal area 2 (DDA2) beginning in 2020.

In 2019, the Joslyn North Mine was acquired from Total E&P Canada Limited by CNRL. CNRL has applied to integrate the mine’s lease area with the existing Horizon Mine. This application includes an updated tailings management plan and life-of-mine plan. This application is still under review.

8.6.1 Fluid Tailings

In accordance with the AER’s industry-wide Notice of Reporting Requirements Clarification letter of January 27, 2020, CNRL Horizon has shifted its reporting of annual tailings volumes from projected year-end values to as-measured values beginning in 2019.

CNRL Horizon reported 146.7 Mm³ of total fluid tailings inventory for 2019, up from 131.8 Mm³ in 2018.

CNRL Horizon claimed that a total of 78.3 Mm³ of NST beach volume achieved the following RTR criteria:

- 70 per cent solids by weight within one year of tailings placement, and
- 81 per cent solids by weight within five years of achieving 70 per cent by weight.

The treated NRU tailings do not have an approved RTR criteria. The associated volume will therefore remain on the fluid profile until one is approved. The resulting total treated tailings volume that met RTR criteria in 2019 was 77.0 Mm³.

In last year’s fluid tailings report, the AER noted that CNRL had modified its previously reported volumes of fluid tailings inventory, which has been resolved to the AER’s satisfaction.
8.6.1.1 New Fluid Tailings

CNRL Horizon reported a new fluid tailings inventory of 81.6 Mm³ in 2019 (see figure 15). The site has a total volume trigger of 198 Mm³ and a total volume limit of 277 Mm³ for new fluid tailings, which were not exceeded in 2019. The new tailings inventory did not exceed the approved profile between 2015 and 2019.

CNRL Horizon provided a prorated new fluid tailings profile for 2019 of 79.1 Mm³ in its submission; however, the approved new fluid tailings profile for 2019 is 82.9 Mm³.

Figure 15. New fluid tailings for CNRL Horizon, 2015 to 2019
8.6.1.2 Legacy Fluid Tailings

CNRL Horizon reported a legacy fluid tailings inventory of 65.1 Mm³ in 2019, a reduction in legacy fluid tailings of 1.1 Mm³ (see figure 16). CNRL Horizon was within its approved legacy fluid tailings profile between 2015 and 2019.

![Graph showing Legacy fluid tailings for CNRL Horizon, 2015 to 2019]

Notes: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the ready-to-reclaim criteria. Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

Figure 16. Legacy fluid tailings for CNRL Horizon, 2015 to 2019

8.6.2 Volume of Treated Fluid Tailings by Technology

CNRL Horizon reported treating the following fluid tailings volumes in 2019:

- 156.3 Mm³ of new fluid tailings via NST,
- 20.8 Mm³ of new fluid tailings via treated NRU tailings, and
• 1.1 Mm³ of legacy fluid tailings via enhanced spiked NST. The treated tailings is from piloted technology, which is described in section 8.6.4.

CNRL Horizon reported a total treated fluid tailings volume of 177.1 Mm³. The AER notes that treated NRU tailings do not have an approved RTR criteria. Therefore, the associated volume will not be removed from the fluid tailings profile until one is approved. The resulting total for treated fluid tailings is 156.3 Mm³ (new fluid tailings), and 1.1 Mm³ (legacy fluid tailings).

CNRL claimed that a total of 78.3 Mm³ of NST beach volume achieved RTR criteria: 77.0 Mm³ generated via NST and enhanced NST and 1.3 Mm³ generated via NRU volumes. Given that the treated NRU tailings do not have an approved RTR criteria, the associated volume will remain on the fluid profile until one is approved. The resulting total treated tailings volume claimed to have met the RTR criteria is 77.0 Mm³.

8.6.3 Treatment Operation and Continuous Improvement

CNRL Horizon reported no improvement in NST “on-specification run time” compared with 2018. CNRL Horizon reported in its 2016 tailings management plan an on-specification run time target of 85 per cent for its NST plant generation before 2023 and reported an average on-specification run time of 56.6 per cent in 2018 and 2019, which was down from 70 per cent in 2017. Because this is the second consecutive year of no improvement in on-specification run time, the AER has requested clarification for the lower-than-predicted tailings treatment performance and operations.

CNRL Horizon reported that NST density can be improved by addressing the condition of equipment in extraction and has proposed a series of process changes to the on-specification production in 2019:

• Primary Cyclones: CNRL Horizon optimized the maintenance strategy for its primary cyclones to reduce downtime, resulting in meeting on-specification NST density targets more frequently.

• Secondary Cyclones: CNRL Horizon observed an increase in NST density when new secondary cyclones were installed on one extraction train. CNRL Horizon concluded that the impact of wear was significant, and has committed to replacing all worn units on existing trains and developing a new maintenance strategy in 2020.

• Mature Fine Tailings Reduction Mine Plan: CNRL continued to implement its plan to reduce the overall fines content of the feed ore being processed. Selective mining techniques are implanted to segregate high fines content zones within the ore body at the mine face.

8.6.4 Technological Innovation in Fluid Tailings Treatment

CNRL Horizon piloted a new spray tailings technology during the summer of 2019, which focused on treating fluid tailings without chemical amendment. The pilot consisted of spraying a thin layer of screened fluid tailings on a road and letting it dry atmospherically.
CNRL Horizon reported continued refinement of its existing tailings technologies and deposition strategies. The following are the main technologies in development throughout the 2019 reporting period at Horizon:

- Enhanced NST: This technology is comprised of an inline flocculant (polymer) injected into the NST close to the pipe discharge and prior to deposition to improve the performance of NST by increasing overall fines capture during deposition. The consolidation performance and fines dynamic segregation of enhanced NST were assessed in a laboratory throughout 2019 and the results are being analyzed.

- Enhanced Spiked NST: This technology is comprised of injecting fluid tailings inline and then injecting flocculant (polymer) inline close to the discharge point of an NST stream. Enhanced spiked NST was piloted in 2019 and its performance will continue to be evaluated in the next few years. The consolidation performance and fines dynamic segregation of enhanced spiked NST were assessed in a laboratory throughout 2019 and the results are being analyzed.

- Inline Particle Size Distribution Analysis: Until recently, the oil sands industry had not been able to operate inline particle size distribution analyzers on tailings infrastructure efficiently due to bitumen fouling. The objective of the project was to identify methods that would prevent bitumen fouling and verify the accuracy of inline particle size distribution analyzers.

- Proprietary Third-Party Bitumen and Naphtha Recovery: CNRL engaged in developing the scope and cost for deploying a bitumen and naphtha recovery technology at Horizon. Primary goals are to recover the bulk of residual bitumen and naphtha in the NRU. In addition, an experimental program to test the thickening and consolidation behavior of the NRU tailings was conducted, with varying levels of residual bitumen and naphtha.

- NST Revegetation: To address some of the knowledge gaps to the potential success of NST reclamation, a project comprising seven studies is being undertaken by the University of Alberta and CNRL. Five of the seven studies were completed in 2019.

- In-Pit Extraction Process: This is an alternative bitumen extraction process that separates oil sands ore into coarse and fine solids, bitumen froth, and water. After separation, the bitumen froth is transported to the froth treatment plant for further processing, and the coarse and fine solids are recombined into dry tailings.

- Coke Pour Benches on NST Beach: The use of coke to construct pour benches on the NST deposit in the ETF/DDA1. The pour benches were constructed on the NST BAW deposit to provide a means of discharging NST farther into the ETF/DDA1 in order to provide additional NST beach storage and to test the use of coke as a capping material for NST.

Further details can be found in CNRL Horizon’s 2019 tailings management report, appendix B.
8.6.5 Regulatory and Management Actions

CNRL Horizon is operating at management level 1, as described in the TMF and Directive 085. No management actions were taken during the 2019 reporting period for Horizon’s tailings management operations.

8.6.6 Measurement System Audit Results

The AER completed its review of CNRL’s measurement system plan for Horizon with respect to measuring fluid tailings volumes and treated fluid tailings for determining achievement of RTR subobjective 1. The AER issued industry-wide and site-specific SIRs to establish a baseline understanding of operators’ plans for measuring fluid tailings volumes, fluid tailings properties, and active treated tailings deposits in order to ensure that operators are on a trajectory towards achieving their approved RTR subobjective 1 criteria.

The AER is continuing its review of the measurement system plan with respect to subobjective 2 measurement components and froth treatment tailings streams. As a result, Horizon’s measurement system was not audited in 2019. Once the AER’s review is complete, audits will occur as required.

8.7 Imperial Oil Limited – Kearl

Imperial Kearl reported that the only active tailings deposit is its External Tailings Area (ETA), which is split into the west ETA (WETA) and the east ETA (EETA). The EETA contains the approved area where Imperial Kearl is to place treated tailings within thickened tailings (TT) panels. In 2019, coarse sand tailings (CST), flotation tailings, and tailings solvent recovery unit (TSRU) tailings from Kearl plant 1 (K1) continued discharging into the WETA. The CST from Kearl plant 2 (K2) were discharged into the EETA, but not into its TT panels. The flotation tailings and TSRU tailings from K2 continued discharging into the same areas of the WETA as the K1 streams.

Imperial Kearl’s primary fines treatment technology is the production of TT that are produced by flocculating flotation tailings and fluid tailings in the thickeners and re-flocculating the stream using chemical injection (secondary chemical treatment) before it is discharged to the TT panels.

In 2019, Imperial Kearl reported that it was managing its fluid inventory within its approved new fluid tailings profile and that its thickener was performing as expected, with some variations observed in the deposit, which will be discussed further on.

8.7.1 Fluid Tailings

Imperial Kearl reported a total estimate of 62.1 Mm³ of new fluid tailings in 2019 at Kearl, which was below its approved profile limit of 113 Mm³. Imperial did not provide an as-measured volume for 2019. The AER has requested as-measured volumes for 2018 and 2019.
Imperial Kearl does not have any legacy fluid tailings volumes.

Imperial Kearl has submitted that since the start of TT production, a total of 9.1 Mm³ of treated fluid tailings (about 67 per cent of the total deposited TT volume) has achieved the RTR subobjective 1 criteria, which requires the EETA to achieve 65 per cent solids content by weight within one year of tailings placement, based upon deposit sampling.

**8.7.1.1 New Fluid Tailings**

Imperial Kearl reported 62.1 Mm³ of new fluid tailings inventory in 2019 (see figure 17). The approved new fluid tailings profile for 2019 was 113.0 Mm³. The total volume trigger for new fluid tailing is 180 Mm³ and the total volume limit is 252 Mm³, neither of which were exceeded. The new fluid tailings inventory was also within the new fluid tailings profile from 2014 to 2019.

![Figure 17. New fluid tailings for Imperial Kearl, 2014 to 2019](image)

Notes: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the ready-to-reclaim criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.
8.7.1.2 Legacy Fluid Tailings

Imperial Kearl does not have any legacy fluid tailings (i.e., fluid tailings in storage before January 1, 2015). The small amount of fluid tailing that were on site in 2014 were considered new fluid tailings to simplify fluid tailings management and reporting. All fluid tailings on site are considered new fluid tailings.

8.7.2 Volume of Treated Fluid Tailings by Technology

Imperial Kearl reported producing 13.6 Mm³ of TT in 2019 and 9.1 Mm³ of TT achieving the approved RTR criteria within the TT panels.

8.7.3 Treatment Operation and Continuous Improvement

In 2019, Imperial Kearl reported that its TT deposit is performing largely as expected. To date, about two-thirds of the deposit (by volume) has achieved RTR subobjective 1 criteria. Thickener underflow solid content results, at about 36 per cent, were slightly below the target of 40 per cent solids content. Factors contributing to under performance were lower underflow densities to manage thickener bed levels and mechanical equipment challenges. Though thickener underflow densities were below expected, the samples taken after secondary chemical injection continued to demonstrate as-expected overall thickener and system performance. Imperial Kearl reports TT material that has met 67 per cent solids content, achieving the approved RTR criteria. In addition, Imperial uses SFR (ranging from 0.5 to 2.0) and clay content 10 to 30 per cent) to monitor the performance of TT.

Initiatives have been developed in 2019 to enhance the overall TT deposit performance, including the following operational improvements:

- Relocating the TT deposition points (due to stacking of the deposit) to directly discharge to soft zones of the deposit to improve SFR.
- Implementing measures to maintain one smaller pond within the TT panel and continuous improvement initiatives related to chemical selection and optimization (pursuant to approvals for trial applications submitted to the AER).
- Evaluating several other mitigations, such as chemical additions to the CST stream to further improve beach capture, CST and TT co-deposition, and in-line flocculation of FT directly.

8.7.4 Technological Innovation in Fluid Tailings Treatment

Imperial Kearl submitted the following pilot applications in 2019:

- Inline Flocculation On-Site Tailings Pilot Update – Phase 1: The proposed first phase of the trial was to extract fluid tailings from the WETA and treat it using the existing secondary chemical injection as
an in-line flocculation system. The flocculated material would then be deposited in thin layers within the EETA.

- Inline Flocculation On-Site Fluid Tailings Pilot Phase 2: This pilot focused on evaluating an enhanced inline flocculation treatment using a three-chemical treatment (flocculant, colloidal silica, and coagulant) compared with a single flocculant treatment. The pilot was carried out from July to October 2019.

- Alternative Flocculant Field Trial: This pilot is to evaluate the use of a new anionic polyacrylamide polymer flocculant for the thickener and another for the secondary injection. Preliminary review of the 2019 trial data indicated that the operating conditions encountered during the trial may not have represented the full operational envelope of the facilities.

Further details can be found in Imperial Kearl’s 2019 tailings management report.

8.7.5 Regulatory and Management Actions

Kearl is operating at management level 1, as described in the TMF and Directive 085. No management actions were taken in 2019 for Kearl’s tailings management operations.

8.7.6 Measurement System Audit Results

The AER completed its review of Imperial’s measurement system plan for Kearl with respect to measuring fluid tailings volumes and treated fluid tailings to determine achievement of RTR subobjective 1. The AER issued industry-wide and site-specific SIRs to establish a baseline understanding of operators’ plans for measuring fluid tailings volumes, fluid tailings properties, and active treated tailings deposits in order to ensure that operators are on a trajectory towards achieving their approved RTR subobjective 1 criteria.

The AER is continuing its review of the measurement system plan with respect to subobjective 2 measurement components and froth treatment tailings streams. As a result, Kearl’s measurement system was not audited in 2019. Once the AER’s review is complete, audits will occur as required.

8.8 Suncor – Fort Hills

The Fort Hills Mine started production in December 2017, which is when tailings placement began in the Out-of-Pit Tailings Area. The AER approved Suncor’s tailings management plan for Fort Hills in Decision 20190225A in February 2019. Suncor Fort Hills is proposing to start fluid tailings treatment and placement in its dedicated disposal area (DDA) in 2024.

Since Suncor Fort Hills did not have any fluid tailings inventory prior to 2016, it does not have any legacy fluid tailings, and all of its fluid tailings are considered new fluid tailings.
Suncor Fort Hills does not have an approved tailings treatment technology. The AER has authorized the continued use of existing infrastructure, specifically the continued use of thickeners, which are expected to provide a benefit to tailings management as they can decrease the volumes of fluid tailings generated. As part of Fort Hill’s tailings management plan, Suncor proposed treating fluid tailings using a single technology, which is the PASS technology. The AER has not approved the PASS technology and has imposed multiple conditions on Suncor Fort Hills as part of Decision 20190225A, including the following:

- By September 30, 2021, Suncor Fort Hills is required to submit a plan for conducting a demonstration to test the performance of PASS technology.
- By September 30, 2023, Suncor Fort Hills is required to submit feasible alternative treatment technologies and an implementation plan to manage the volume of fluid tailings planned to be treated by the PASS technology and subsequently water capped.

Suncor Fort Hills reported that the new fluid tailings inventory was within its approved profile for 2019.

8.8.1 Fluid Tailings

In accordance with the AER’s industry-wide Notice of Reporting Requirements Clarification letter of January 27, 2020, Suncor Fort Hills reports as-measured values for annual tailings volumes.

In 2019, Suncor Fort Hills reported 17 Mm³ of new fluid tailings inventory. The 2019 report is the first year that Suncor Fort Hills has had to submit an annual tailings report.

Suncor Fort Hills did not report any tailings meeting RTR criteria as it does not have approved RTR criteria. Suncor Fort Hills is required to provide RTR criteria as part of its updated tailings management plan to be submitted within two years from the start of its demonstration of PASS technology, or by September 30, 2026, whichever date occurs first.

8.8.1.1 New Fluid Tailings

Suncor Fort Hills reported an inventory of 17 Mm³ of new fluid tailings (see figure 18), 12 Mm³ below its approved new fluid tailings profile of 29 Mm³ for 2019.

Fort Hills has a total volume trigger of 125 Mm³ and a total volume limit of 175 Mm³ for new fluid tailings, neither of which were exceeded in 2019. The tailings inventory was also within the new fluid tailings profile for 2018 and 2019.
8.8.2 Volume of Treated Fluid Tailings by Technology

Suncor Fort Hills is not reporting any volume of treated fluid tailings for 2019 because it does not have an approved fluid tailings treatment technology. Suncor Fort Hills is required to submit a plan for demonstrating the PASS technology by December 30, 2021. Suncor Fort Hills is also required to provide RTR criteria as part of its updated tailings management plan to be submitted within two years from the start of its PASS technology demonstration, or by September 30, 2026, whichever date occurs first.
8.8.3 Treatment Operation and Continuous Improvement

Suncor Fort Hills reported that tailings management is progressing as planned; however, the AER noted underperformance of Suncor Fort Hills’ thickener. The AER is currently monitoring this aspect of the Fort Hills tailings operations and has requested more information.

8.8.4 Technological Innovation in Fluid Tailings Treatment

Suncor Fort Hills reported three focus areas with respect to its PASS technology development:

- Defining an operating envelope to ensure that the settlement and geochemical outcomes in the South Pit DDA meet the desired targets.
- Defining the influence of asphaltenes and solvent from the Tailings Solvent Recovery Unit (TSRU) tailings on the deposit performance, including vapour-liquid equilibria experiments to assess the degradation of paraffinic solvent (pentane) in TSRU.
- Evaluating alternative immobilization and dewatering chemistries (coagulant and polymers) better suited to treating combined fluid and TSRU tailings.

Suncor also reported bench scale testing on a new flocculent that is anticipated to improve thickener performance based on the specific clays found in the ore at Fort Hills.

Further details can be found in the Suncor Fort Hills 2019 tailings management report.

8.8.5 Regulatory and Management Actions

On April 4, 2019, Suncor requested that the AER reconsider Decision 2019225A, pursuant to section 42 of the Responsible Energy Development Act. The request for reconsideration is currently under consideration by the AER.

Suncor Fort Hills is operating at management level 1, as described in the TMF and Directive 085. No management actions were taken during 2019 for tailings management operations at Fort Hills.

8.8.6 Measurement System Audit Results

The AER completed its review of Suncor’s measurement system plan for Fort Hills with respect to measuring fluid tailings volumes and treated fluid tailings to determine achievement with RTR subobjective 1. The AER issued industry-wide and site-specific SIRs to establish a baseline understanding of operators’ plans for measuring fluid tailings volumes, fluid tailings properties, and active treated tailings deposits in order to ensure that operators are on a trajectory towards achieving their approved RTR subobjective 1 criteria.
The AER is continuing its review of the measurement system plan with respect to subobjective 2 measurement components and froth treatment tailings streams. As a result, Fort Hills’ measurement system was not audited in 2019. Once the AER’s review is complete, audits will occur as required.

9 Summary

Tailings management under Directive 085 continued in 2019. Beginning with the 2018 reporting year, full Directive 085 reporting was required from operators. By the end of 2019, all eight operating oil sands mines had approved tailings management plans in place.

The AER has assessed measurement system plans submitted by operators related to subobjective 1 and continues to assess these plans for subobjective 2. Following measurement system plan assessments for subobjective 2, future reports of treated fluid tailings volumes described as meeting the RTR status will be assessed and reported on. The AER notes that changes to fluid tailings volume inventories may result from reviews of reported data. Requests for clarification or additional data have been issued to operators for more information and explanations necessary to validate reported results.

The total volume of fluid tailings (new and legacy tailings combined) on oil sands mine sites in the Athabasca oil sands region has increased between 2014 and 2019, as reported by the individual operators and as expected based on their combined approved fluid tailings profiles. The regional volume of water in tailings ponds decreased slightly between 2014 and 2017. It then increased from 2017 to 2019. This occurred with an overall increase in bitumen production from 2014 to 2019. In addition, more mines became operational between 2014 to 2019.

Based on the volumes reported in 2019 annual reports submitted by operators, most of the operators’ fluid tailings volumes were within their approved new and legacy profiles, with the exception of Syncrude Mildred Lake, which exceeded its legacy fluid tailings profile from 2017 to 2019, but was below the 20 per cent deviation trigger for both years. All operators were below their new fluid tailings total volume triggers and total volume limits. Where information was insufficient for the AER to verify operators’ data or analyses, the AER issued requests for clarification or additional data. Responses to these requests were not received before finalizing this report. Responses may lead to changes in reported data or analyses from previous years, which will be reflected in the 2020 report.
Operators continue to report on improvements in tailings treatment technologies, pilot new technologies, and work on developing new technologies to treat fluid tailings. The AER will review and evaluate technologies and deposit designs that show promise for treating and reducing fluid tailings volumes. Based on operating conditions, future submissions and applications to the AER are expected from the operators on

- updated tailings management plans;
- research and monitoring information that resolves outstanding risks and uncertainties about reclaiming treated fluid tailings deposits (including settlement, capping, and capping material availability);
- justification for RTR criteria and trajectories proposed for the demonstrated fluid tailings treatment technologies that will allow operators to achieve their targeted range of ecosites;
- justification that fluid tailings inventory profile requirements can be met; and
- a feasible alternative to water capping at sites wherever it has been proposed as a treatment.

The AER and Government of Alberta review the TMF, Directive 085, and operator tailings management plans every five years. Operator EPEA approvals are required to be renewed every 10 years. These review timelines ensure that updates and changes based on changes to policy and performance can be made.

10 Future Reports

The AER will continue public reporting and will ensure the transparency of fluid tailings monitoring data received from operators. Now that all operators’ tailings management plans are approved, future AER reports on tailings management will

- evaluate regional performance against the TMF’s outcomes and objectives,
- identify operators that are performing well and those that need to make improvements (in accordance with Directive 085), and
- incorporate a summary evaluation of environmental effects and reclamation performance reporting that may include references to other required reports (e.g., EPEA reports) and linkages to EPEA and reclamation regulation.

Future submissions from operators are required in the coming years that will inform evaluations of regional and individual operations’ tailings management performance. These reports include the following:

- Suncor Base Plant:
  - September 30, 2020: A plan that updates Pond 6 fluid tailings management.
- September 30, 2023: A plan that updates MD9 tailings management.
- September 30, 2023: A plan for updates to tailings management for Ponds 1A and 2/3.
- September 30, 2024: A plan that updates Pond 7 fluid tailings management.

- **Syncrude Mildred Lake:**
  - January 31, 2023: An update to its tailings management plan.

- **Syncrude Aurora North:**
  - December 31, 2023: An updated to its tailings management plan.

- **CNUL Muskeg River Mine:**
  - September 30, 2020: An update on TSRU tailings management.
  - April 30, 2022: An amendment application for its tailings management plan.
  - One year prior to fluid or treated tailings placement in a tailings facility, an updated tailings management plan.
  - September 30, 2020: A consolidation model or engineering analysis for Cell 1 and Cell 3.

- **CNUL Jackpine Mine:**
  - September 30, 2020: An update on TSRU tailings management.
  - April 30, 2022: An amendment application for its tailings management plan.
  - One year prior to fluid or treated tailings placement in a tailings facility, an updated tailings management plan.

- **CNRL Horizon:**
  - December 31, 2020: A capping research plan for NST.
  - September 30, 2025: A revised end-of-mine-life target with new fluid tailings profile.
  - September 30, 2025: A plan for the management of fluid tailings placed in the proposed end pit lake.
  - One year prior to placement of fluid or treated tailings, a plan that updates fluid tailings management for all tailings facilities.

- **Imperial Kearl:**
  - June 30, 2021: An update to its tailings management plan.
- Suncor Fort Hills:
  - September 30, 2021: A plan for the PASS technology demonstration.
  - September 30, 2023: An update on TSRU tailings management.
  - September 30, 2023: A plan for the feasible alternative technologies to PASS technology.
  - September 30, 2026 or within 24 months of commencement of the pilot, whichever date occurs first: An application for an updated tailings management plan.
Appendix 1  Tailings Treatment Technologies

Thin-Lift Drying
Thin-lift drying is a process whereby fluid tailings are removed from tailings ponds and mixed with additives that bind the particles in the fluid tailings together. The fluid tailings with the additives are then thinly spread over a large area. Gravity and capillary action allow the water to drain away, and ambient conditions (evaporation and freeze/thaw cycles) facilitate the drying of fluid tailings within a couple of weeks. Once dry, another layer, or “lift,” is added and the process is repeated.

Suncor Base Mine uses thin-lift drying technology to move treated fluid tailings material that meets the initial drying area ready-to-reclaim (RTR) criteria to its final placement location. This technology is referred to as a tailings reduction operation by Suncor and as atmospheric fines drying by CNUL Muskeg River Mine.

Thickened Tailings as an Initial Treatment
Thickened tailings (TT) is a process whereby fluid tailings from bitumen extraction plants are sent directly to a thickener, where flocculants are added to bind the smaller particles together, creating TT. The warm water released from the tailings is recycled back into the extraction plant. The process is an initial stage of fluid tailings treatment, and operators employ different secondary stages of treatment and placement of TT for treated fluid tailings deposits.

The Suncor Fort Hills Mine, CNUL Muskeg River Mine, CNUL Jackpine Mine, and Imperial Kearl use conventional thickeners to produce a TT stream, with some variations. Operators use the following as a second stage of treatment:

- CNUL Muskeg River Mine is co-depositing TT, tailings solvent recovery unit tailings, whole tailings, and coarse sand tailings in a single deposit, creating a north-pool-deposit type;
- CNUL Jackpine Mine is co-depositing TT, whole tailings, and coarse sand tailings in a single deposit, creating a mixed-deposit type;
- Imperial Kearl treats TT with a secondary polymer addition before placement in its tailings deposit.

Operators are targeting a terrestrial closure with wetlands for their deposits and are required to provide updated modelling for the deposits. Suncor Fort Hills is not targeting a terrestrial closure for their thickener.

Nonsegregating Tailings and Composite Tailings Deposits
Nonsegregating tailings (NST) technology requires the use of a thickener. The TT is mixed with sand from the extraction plant and an added coagulant. The mixture is then placed into a tailings deposit.
Composite tailings (CT) are similar to NST. The difference is that instead of using TT, fluid tailings from ponds are mixed with sand from the extraction plant and a coagulant is added to the mixture. The mixture is then placed into a tailings deposit.

CNRL Horizon uses NST technology. CT is used by Syncrude Mildred Lake, Syncrude Aurora North, and CNUL Muskeg River Mine, with some variations.

CNRL Horizon, Syncrude, and CNUL are targeting a terrestrial closure with wetlands for their deposits and are required to provide updated modelling and RTR trajectory for the deposits.

**Fluid Tailings Centrifugation**

Fluid tailings centrifugation is a process whereby fluid tailings are removed from the tailings ponds and a flocculent is added to bind the small particles together. The mixture is pumped into a centrifuge where the water is spun out. The dewatered tailings are placed in a deposit.

Syncrude Mildred Lake and CNUL Jackpine Mine use fluid tailings centrifugation on their sites. Syncrude Mildred Lake is currently pilot testing unique capping techniques required for centrifuge cake deposits.

Both operators are targeting a terrestrial closure with wetlands for their deposits. CNUL is required to update its centrifuge initial RTR criteria and both operators are required to provide updated modelling and RTR trajectory for deposits, particularly to understand performance in deposits of increasing sizes.

**Permanent Aquatic Storage Structure**

Suncor is demonstrating performance of a new treatment technology in its commercial scale implementation of the permanent aquatic storage structure (PASS) technology. Phase 1 is the initial treatment of fluid tailings through the addition of a coagulant and a flocculent that are then placed in a deposit. The AER has approved the implementation of phase 1 only, subject to approval conditions to manage uncertainties and long-term reclamation risks since performance assumptions have not been verified at the scale and complexity of Suncor’s dedicated disposal area 3 (DDA3). Suncor is required to prove the efficacy of a unique capping technique to provide a terrestrial closure on PASS-treated fluid tailings.

Suncor is required to

- validate its RTR criteria and RTR trajectory performance for phase 1 at a large scale, and
- submit research and implementation plans for terrestrial or aquatic closure options for phase 1 PASS-treated tailings in DDA3 to support a decision for the proposed closure approach in 2023.
Water-Capped Tailings

Water-capped tailings is an unapproved technology that is currently in the demonstration and experimental phase at Syncrude and Suncor. Water-capping technology involves placing water above untreated tailings (Syncrude Base Mine Lake at the Mildred Lake Mine) or treated tailings (phase 1 PASS-treated tailings in Suncor demonstration pit lake at the Suncor Base Mine) to create a water-capped deposit (e.g., a water-capped pit lake) as a landscape feature.

The proposed water capping of untreated or treated fluid tailings at oil sands mines is not authorized by the AER because the technology is subject to further assessment, research, and future policy. With the exception of the identified demonstrations, all tailings management plan approvals prohibit the creation of a water-capped pit lake. The AER’s decision about water-capped pit lakes, including their prohibition and the need for feasible alternative tailings treatment technologies, is provided in the water-capping technology section of tailings management plan decision reports and in operator approvals.
Appendix 2  Tailings Field Inspection Summaries

- Summary of the AER 2019 Tailings Field Inspection for Suncor Base Plant
- Summary of the AER 2019 Tailings Field Inspection for Syncrude Mildred Lake
- Summary of the AER 2019 Tailings Field Inspection for Syncrude Aurora North
- Summary of the AER 2019 Tailings Field Inspection for CNUL Jackpine Mine
- Summary of the AER 2019 Tailings Field Inspection for CNUL Muskeg River Mine
- Summary of the AER 2019 Tailing Field Inspection for CNRL Horizon
- Summary of the AER 2019 Tailings Field Inspection for Imperial Kearl
- Summary of the AER 2019 Tailing Field Inspection for Suncor Fort Hills
Summary of the AER 2019 Tailings Field Review
Suncor Energy Inc.
Base Plant
OSCA Approval No. 8535N
EPEA Approval No. 92-04-18

Date
September 17, 2019

Purpose
Observe high priority tailings facilities and the tailings testing progress.
The inspector’s findings from this visit are independent, will be followed upon separately.

Agenda - Tailings Locations

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>What</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00 am</td>
<td>Main Security Gate</td>
<td>Safety Talk, FLHA, board bus,</td>
</tr>
<tr>
<td>9:30 to 10:15</td>
<td>Pond 7</td>
<td>FTT Relocation Area, Tour / Inspection of Area</td>
</tr>
<tr>
<td>10:15 to 11:30</td>
<td>DDA3</td>
<td>Polymer Pad, Deposit Area</td>
</tr>
<tr>
<td>11:30 to 12:15</td>
<td>Pond 8B</td>
<td>Tour of Area, ADW Screens</td>
</tr>
<tr>
<td>12:15 to 13:15</td>
<td>DPL (Lake Miwasin)</td>
<td>Tour Area and Wetlands</td>
</tr>
<tr>
<td>13:15 to 14:45</td>
<td>MD9</td>
<td>Dried Tailings Placement</td>
</tr>
<tr>
<td>14:45 to 15:30</td>
<td>Drive to Main Gate</td>
<td>Drop off AER &amp; AEP at Security Gate</td>
</tr>
</tbody>
</table>
Highlights

AER staff had the opportunity to visit the above mentioned areas on the Suncor Base Plant Site. No deficiencies were observed.

Highlights from the site visit included:

1. Observing the early work approved installation of Froth Treatment Lines on the west side of the Athabasca in preparation for future relocation of FTT discharge to Pond 7. (Application in progress)

2. Attending the future deposition site for Froth Treatment Tailings in Pond 7

3. An observation of the progress being made in removal of fluid tailings from Pond 8B to both allow for treatment of legacy fluid tailings, as well as allow for the future mining through the current Pond 8B location.

4. Observation of the polymer prep facility for treatment of fluid tailings with PASS for deposition into DDA3

5. Observation of MD9, and a demonstration of the ponding water in the center of the MD9 co deposit that must be mitigated on an ongoing basis

6. Progress of DDA3 infilling with PASS treated tailings
Figure 1 – DDA3 Water return, at future FTT discharge location in Pond 7
Figure 2 – Pond 7 – Site of Future FTT Discharge
Figure 3 – Kemira Flocculant Storage tanks at the DDA3 Polymer preparation pad
Figure 4 – Dredges removing Fluid Tailings from Pond 8B to be treated with PASS technology
Figure 5 – Debris management system at Pond 8B; removing debris from recovered Fluid Tailings prior to PASS treatment
Figure 6 – Lake Miwasin (formerly Demonstration Pit Lake) at Suncor Base Mine; PASS technology prototype
Figure 7 – Ponded water in centre of MD9 co-disposal facility – ongoing challenge
Figure 8 – DDA3 in September of 2019, after approx. 14 months of infilling with PASS treated tailings
Figure 9 – PASS Treated tailings being actively discharged down ramp into DDA3
Summary of the AER 2019 Regulatory Tailings Field Visit

Syncrude Canada Ltd.
Aurora North and Mildred Lake Sites
OSCA Approval No. 10781L
EPEA Approval No. 0000026-02-XX

Date
Site visit: September 18, 2019
Report generated: October 18, 2019

Purpose
To observe high-priority tailings facilities and the progress of tailings testing.
Any inspector’s findings from this visit are independent and will be followed up on separately.

Background
1. East In-Pit / Sandhill Fen CT Capping and Reclamation

EIP was commissioned as a tailings storage facility in 1999. It was the primary deposition area for CT upon commercial implementation of the technology in 2000. CT deposition in EIP was complete as of July 2011. The facility has also been a deposition area for coarse tailings. Coarse tailings is being deposited to support landform construction in preparation for subsequent reclamation material placement.

The Sandhill Fen Research Watershed area was Syncrude’s first wetland reclamation pilot on a composite tailings deposit. The area was a former mine that has been back-filled with composite tailings and capped with a tailings sand cap. The area was reclaimed to a wetland upland complex and has been monitored since commissioning in 2012. Surface water quality has been sampled yearly, throughout the open water months from the outflow of the watershed. Parameters examined include metals, nutrients, major anions and cations, naphthenic acids, total hydrocarbons, PAH’s and pH.

2. Base Mine Lake – Water capping MFT test facility

BML is the first full-scale commercial demonstration of the end pit lake technology in the oil sands industry. The FFT is physically sequestered below a combination of oil sands process-affected water (OSPW) and fresh water.

3. SWSS External Sump and the Mixed Deposit

Testing determined that the material contained in the External Sump was weak viscous Fluid Fine Tails (FFT) with a discontinuous thin dried crust. Below the crust, the material generally had a gradual strength increase as depth increases. Syncrude treated the site with FFT overburden Kc co-mixing.
4. **W1 Thin Lift Centrifuge Cake**

The W1 cake deposit was the first Dedicated Disposal Area (DDA) for centrifuged cake at the Mildred Lake site, and was operated from 2012 to 2015. The cake material was hauled from the cake plant to the deposit by truck and deposited into the DDA cells in maximum 2m lifts. In 2014, additional lifts were placed on top of previous lifts prior to 18 months drying time.

5. **NMSPE FFT Centrifuge Cake Deep Deposit**

Cake deposition commenced in 2015 when the full scale FFT centrifugation plant was commissioned. The cake material is being deposited by truck into a chute located at the north east corner of the deposit. The general slope of the cake surface is trending from north to south. Cake release water and precipitation runoff flow to the south and are dewatered regularly with a land based pumping system.

7. **Deep Centrifuge Cake Pilot Cells**

In order to test potential mitigation measures for future full scale centrifuge cake deposits, one of the test cells was constructed with a geotextile layer installed on top of the cake surface. Shortly after the deposits were filled with cake, two of the test cells were mechanically capped with coke. In 2015, the deposits were capped with a layer of Kc clay to form a trafficable surface.

In October 2018 Syncrude conducted a small scale field prototype on the W4 overburden facility. In this test, the FFT was first pumped into the co-mix deposit and the overburden material was then added to the deposit using excavators. A ratio of 2.1 overburden to 1 FFT was kept for the deposit in order to achieve roughly 72.5% solid contents. The volume of the co-mix within the test cell was roughly 1,130 m³ of FFT and 2,689 m³ of overburden material.
## Mildred Lake Site Visit Locations and Field Assessment Notes

<table>
<thead>
<tr>
<th>Item</th>
<th>Agenda</th>
<th>Tailings deposit</th>
<th>Observation / heard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>East In-pit</td>
<td>Sandhill Fen, CT capping, and reclamation</td>
<td>Reported progress on reclamation is good, and aligned with stated research goals. Long term reclamation site with 35+ years of work required prior to expected reclamation certification.</td>
</tr>
<tr>
<td>2</td>
<td>Base Mine Lake</td>
<td>Water capping MFT test facility and dredging</td>
<td>Reported progress on surface water quality. Syncrude indicates that the FFT is settling as predicted by the numerical model, the mudline is declining in elevation year over year, and the water cap is increasing in depth. Dredging efforts to remove bitumen mats ongoing.</td>
</tr>
<tr>
<td>3</td>
<td>SWSS – External Sump</td>
<td>MFT and mixture of tailings types</td>
<td>Nothing of concern was noted during the visit.</td>
</tr>
<tr>
<td>4</td>
<td>W1 Overburden Dump</td>
<td>Thin lift centrifuge cake deep deposit</td>
<td>AER staff walked on deposit. Nothing of concern was noted during the site.</td>
</tr>
<tr>
<td>5</td>
<td>North Mine South Pit East</td>
<td>FFT Centrifuge Cake Deep Deposit</td>
<td>AER staff were not able to approach the deposit.</td>
</tr>
<tr>
<td>7</td>
<td>W4 Overburden Dump</td>
<td>Centrifuge Cake Pilot Cells and FFT / Overburden Co-mix Pilot Demonstration</td>
<td>Very little of note was visible. Deposits were capped with no apparent issues.</td>
</tr>
</tbody>
</table>
Photos

Base Mine Lake and Bitumen Dredging Activities

SWSS External Sump
W1 Thin Lift Centrifuge Cake Disposal Site

North Mine South Pit East - FFT Centrifuge Cake Deep Deposit
W4 Deep Centrifuge Cake Pilot Cells and FFT/Overburden Co-mix Pilot
Summary of the AER 2019 Regulatory Tailings Field Visit

Syncrude Canada Ltd.
Aurora North Site
OSCA Approval No. 10781L
EPEA Approval No. 0000026-02-XX

Date
Site visit: September 17, 2019
Report generated: October 17, 2019

Purpose
To observe high-priority tailings facilities and the progress of tailings testing.
The inspector’s findings from this visit are independent and will be followed up on separately.

Background

AEPS CT/fFFT Co-deposition Pilot: The field pilot scope includes construction of a commercial scale fFFT plant and co-deposition of CT and fFFT into the Aurora East Pit South (AEPS) pond. The pilot plant will be designed to produce up to 2,000 m³ of fFFT per hour with a target to process up to 4 Mm³ of FFT between spring and fall of 2020. This will result in a deposit size of roughly 2 Mm³ of fFFT after initial dewatering.

Following the pilot plant operation, a discrete fFFT deposit is expected to form under the water cap towards the south end of AEPS, which will later be capped by CT as AEPS continues to be filled. The fFFT deposit will constitute approximately 0.33% of the AEP deposit by volume and approximately 5% of AEP by area.

Fort Hills Dump Stage 3: The Fort Hills Dump (FHD) accommodates out-of-pit storage of mine overburden and interburden waste. Stage 3 of the dump is being placed on top of 75 m of tailings sand deposits contained in Aurora East Pit Northwest (AEPN-W) with the dump toe extending slightly into Aurora East Pit Northeast (AEPN-E). AEPN-E was initially designed as a fluid collection pond, but also received composite tailings (CT) and coarse sand tailings. The zone that will support the Stage 3 toe east of Dyke 1N is comprised of CT and track-packed beached sand.

Area 2 / Stanley Creek Infill: Area 2 is required to support FHD Stage 4, which transcends north of Syncrude’s previously approved MSL for the Aurora North site. The development of Area 2 is also required for reclamation stockpile space in 2020 to support mine advance and supporting activities. In the event that storage capacity in the Fort Hills Dump (due to stability concerns of dumping overburden on a coarse sand deposit), this area would be used for additional overburden storage.
### Agenda and Field Review Notes

<table>
<thead>
<tr>
<th>Item</th>
<th>Agenda</th>
<th>Tailings deposit</th>
<th>Observation / heard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aurora East Pit South</td>
<td>CT/IFFT Co-deposition pilot construction</td>
<td>Construction had not begun on the pilot at the time of the visit. Nothing of concern was observed during the visit.</td>
</tr>
<tr>
<td>2</td>
<td>Fort Hills Dump Stage 3</td>
<td>CST and overburden</td>
<td>Construction of the initial 5m lift of Phase 3 was ongoing at the time of the visit. Nothing of concern was observed.</td>
</tr>
<tr>
<td>3</td>
<td>Area 2 / Stanley Creek Infill</td>
<td>MFT and mixture of tailings types</td>
<td>Site prep was ongoing in Area 2 at the time of the visit. Nothing of concern was observed.</td>
</tr>
</tbody>
</table>
Photos

AEPS and location of future CT/fFFT Co-deposition Pilot

Fort Hills Dump Stage 3
Area 2 / Stanley Creek Infill
Summary of the AER 2019 Tailings Field Review
Canadian Natural Upgrading Limited
Muskeg River Mine
Jackpine Mine
OSCA Approval No. No. 8512J
OSCA Approval No. No. 9756H

Date
September 30 and October 1, 2019

Purpose
Observe high priority tailings facilities and the tailings testing progress. The inspector’s findings from this visit are independent, will be follow upon separately

Agenda

Day 1: Jackpine Mine

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:00 pm</td>
<td>MRM Advanced Gate</td>
<td>AER sign-in at MRM Security</td>
</tr>
<tr>
<td>12:30 pm</td>
<td>JPM Mine Services Building</td>
<td>Review JPM map, inspection review, safety moment &amp; FLHA</td>
</tr>
<tr>
<td>1:00 pm</td>
<td>JPM Tour</td>
<td>1. Sand Cell 2 – MAFD 2. DDA1 – Centrifuge 3. Centrifuge Capping Test 4. Fluid Cell 1</td>
</tr>
<tr>
<td>4:00 pm</td>
<td>Leave for MRM Advanced Gate</td>
<td>End of Inspection</td>
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Day 2: Muskeg River Mine

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 am</td>
<td>MRM Advanced Gate</td>
<td>AER sign-in at MRM Security</td>
</tr>
<tr>
<td>8:30 am</td>
<td>MRM Truck Shop C</td>
<td>Review JPM map, inspection review, safety moment &amp; FLHA</td>
</tr>
<tr>
<td>9:00 am</td>
<td>MRM AM Tour</td>
<td>1. IPC2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. P-NST Area and Filter Press</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Lower AFD</td>
</tr>
<tr>
<td>11:30</td>
<td>Lunch</td>
<td></td>
</tr>
<tr>
<td>12:30</td>
<td>MRM PM Tour</td>
<td>1. ETF – NPD and Upper AFD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. ETF – TT Deposition Area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. ETF – South Infilling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. SEA – Infilling</td>
</tr>
<tr>
<td>4:00 pm</td>
<td>Leave for MRM Advanced Gate</td>
<td>End of Inspection</td>
</tr>
</tbody>
</table>
Day 1: Jackpine Mine

What We Observed and Heard:

Sand Cell 2 – MAFD
- AFD material was placed on sandy beach of North East corner of Sand cell 2
- Observed foot trafficability;
- Below crust, the mud is still soft; and
- Released water drains into the pond.

DDA1 – Centrifuge
- DDA1, centrifuged material is mixed with coarse tailings due to ongoing dyke construction;
- Thickened tailings line still goes to DDA1, so as fluid tailings line; and
- AER noticed progressions within the centrifuged area since the last time we visited.
Centrifuge Capping Test

- The testing area is fenced; and
- Surface of the area is foot trafficable (sampling work was just completed for this year).

Fluid Cell 1

- Active use for water and fluid tailings storage; fluid transfer between FC1 and DDA1
Day 2: Muskeg River Mine

What We Saw or Heard:

ETF-South Expansion Area (SEA)
- Observed that SEA area has been backfilled and capped by tailings sand. Only small area left wet and soft;
- and
- Two areas have been reclaimed and seeded.

ETF NPD
- 3-meter tailings sand cap has been placed;
- The AER can’t really see exactly how NPD has progressed since the last time we visited, but can visual confirm area is bigger than before;
- Settlement monitoring is in place.
AFD

- About meter to meter and half of AFD material was placed.

GeoTubes testing
- Testing was done about a year ago;
- Bags sized up to 100m × 400m; and
- three bags placed on top of each other.

Filter press test
- 15 dry ton per hour capacity was tested in August;
- Testing design included 2 holding tanks for FT feed and 6 clarifier tanks prior to introducing FT to filter;
- Treated material was tested for compacting.
Summary of the AER 2016 Regulatory Tailings Field Visit
Canadian Natural Resources Ltd.
Horizon Site
OSCA Approval No. 9752
EPEA Approval No. 00149968-01-00

Date
Site visit: August 21, 2018
Report generated: September 28, 2018

Purpose
To observe high-priority tailings facilities and the progress of tailings testing.

The inspector’s findings from this visit are independent and will be followed up on separately.

Background
IPEP: CNRL has authorization for a 500 t/hr pilot, the In-Pit Extraction Process (IPEP), described as an innovative low-impact bitumen extraction and tailings treatment process utilizing screw conveyors, dewatering screens and centrifuges to generate dry, stackable tailings. Results from the test are expected to be included in the annual tailings performance reports. AER staff toured the IPEP facility, handled IPEP tailings that were 4 days old, then visited the deposition site at an inpit dump.

Dyke 21: The TMP mine/tailings plan includes the construction of a set of perimeter dykes for the first in-pit deposit, DDA2. Construction has begun on Dyke 21, spanning the eastern side of the containment. AER staff toured the northern edge of the dyke, where the dyke is abutting original ground at the pit limit.

Coke pour berms: CNRL has authorization to create three berms, 400 m long x 50 m wide x 5 m high, on the beach of the ETF/DDA1 in order to extend the beach length and increase the total material placed within the structure. AER staff visited one of the sites at which a berm will be constructed in the fall of 2018.

NST Plant: CNRL’s approved tailings treatment technology is non-segregating tailings. These tailings are created blending coarse sand with flocculent and a fines stream. Performance of the plant is monitored using an extensive set of sampling and measurement tools. AER staff toured the plant in which the NST is made.
## Agenda and Field Review Notes

<table>
<thead>
<tr>
<th>Item</th>
<th>Agenda</th>
<th>Tailings deposit</th>
<th>Observation / heard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IPEP pilot</td>
<td>IPEP and inpit dump</td>
<td>IPEP project successful to date. Potential for dry tailings based on decreased sand removal during extraction phase (ie. no PSV). Some saturated tailings still present in dump.</td>
</tr>
<tr>
<td>2</td>
<td>Dyke 21 tie-in to original ground</td>
<td>Future DDA2</td>
<td>Dyke construction progressing as per design and schedule</td>
</tr>
<tr>
<td>3</td>
<td>Dyke 10 / ETF</td>
<td>DDA1</td>
<td>Locations for testing coke pour berms appeared normal with low geotechnical and environmental risks</td>
</tr>
<tr>
<td>4</td>
<td>NST plant</td>
<td>N/A</td>
<td>Tour of NST plant. Nothing of note.</td>
</tr>
</tbody>
</table>
Horizon Site Visit Locations
Photos

Conveyor to IPEP facility

IPEP Tailings

IPEP tailings in inpit dump
2019 Tailings Site Visit – Imperial Kearl

Date: Oct 2, 2019

Agenda (see attachment)

9:30 am: Arrival at the main gate
10:00 am: Meeting with IOL personnel
10:30 am: Field inspection (WETA, TSRU, ETA TT deposits, ILF Phase 1, in-line floc test areas)
2:00 pm: Debrief
2:30 pm: Departure

What We Saw or Heard:

Enhanced Inline Flocculation (eLIF) Pilot

- The filling of the testing cells were about two weeks prior to the site visit.
• For the cell used triple chemicals:
  
  o Same Kemera PAM and similar dosage was used to the other cell. In addition, small dosage of Al2(SO4)3 and silica were used.

ETF TT panel:

• Observed bigger area ponded with water.

• Two panels will merge in future, released water will flow to the Northeast corner of the combined panel. Instead of both panels, will be one merged area.

• About two meter of water level difference between the TT panel and the coarse tailings area in EETA.
TSRU

- TSRU has been “co-deposited” with coarse tailings in reality, due to dyke construction happens at the same time as TSRU is placed.

- Sharper BBW slope

Conclusion:

Observed IOL’s progress and ongoing mitigations and improvements. Still lots work. Overall, very informative site visit!
Summary of the AER 2019 Tailings Field Review

Suncor Energy Inc.
Fort Hills
OSCA Approval No. 9241H
EPEA Approval No. 151469-01-01

Date
September 20, 2019

Purpose
Observe high priority tailings facilities and the tailings testing progress.
The inspector’s findings from this visit are independent, will be followed upon separately.

Agenda and Field Review Notes

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<th>LOCATION</th>
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</thead>
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<tr>
<td>9:00 am</td>
<td>Arrive at Main Gate</td>
</tr>
<tr>
<td></td>
<td>Suncor staff to meet the AER staff at Main Gate</td>
</tr>
<tr>
<td></td>
<td>Receive visitor passes</td>
</tr>
<tr>
<td></td>
<td>Depart for Fort Hills Mine admin bldg.</td>
</tr>
<tr>
<td>9:30 am</td>
<td>Arrive at Fort Hills Mine Admin bldg.</td>
</tr>
<tr>
<td></td>
<td>Introductions – AER, Suncor Fort Hills personnel</td>
</tr>
<tr>
<td></td>
<td>Overview of where we are going – with map/air photo</td>
</tr>
<tr>
<td></td>
<td>PPE Check</td>
</tr>
<tr>
<td></td>
<td>Safety / FLHA prior to departure</td>
</tr>
<tr>
<td>10:30 am</td>
<td>Thickener Operations &amp; Status</td>
</tr>
<tr>
<td></td>
<td>Obtain personal H2S / CO monitors</td>
</tr>
<tr>
<td></td>
<td>View thickener from underside</td>
</tr>
<tr>
<td></td>
<td>Ascend to view thickener topside, rake, bitumen recovery system</td>
</tr>
<tr>
<td></td>
<td>View thickener control room</td>
</tr>
</tbody>
</table>
11:30 am | Tour of OPTA facility
- Visit overburden placement on west dyke
- Visit cell construction areas on east side of OPTA
- Visit TT discharge on OPTA
- Visit TSRU discharge on OPTA

1:00 pm | Mine Pit
- Observe Devonian groundwater seepage to understand potential impact to tailings placement schedule & capacity

1:45 pm | Return to Fort Hills Mine Admin Bldg.
- Return personal H2S / CO detectors

2:00 pm | Fort Hills Security Gate
- Guests return to their vehicles

**Highlights**

AER staff had the opportunity to visit the above-mentioned areas on the Fort Hills site. Overall, the plant and tailings sites are very well laid out. The AER was pleased to see the bitumen recovery system on the Fort Hills thickener, something that has not been observed previously. Cell construction is progressing as per design and schedule. The AER observed a Devonian seepage in the South Pit, which is the only area of concern. Field inspectors will work with Fort Hills and AER tailings engineers as this situation is monitored going forward and mitigating actions are put in place.
Overview Map of site visit
Figure 1 – Coarse Tailings lines running from Plant to OPTA at Fort Hills
Figure 2 - Typical Overburden placement – OPTA dyke
Figure 3 – Fort Hills thickener – underside view
Figure 4 – Bitumen collection system on Fort Hills Thickener
Figure 5 – Top side view of Thickener & Rake assembly at Fort Hills
Figure 6 – Thickener discharge into OPTA at Fort Hills
Figure 7 – Typical cell construction on east side of OPTA – Fort Hills
## Appendix 3  Fluid Tailings Volume Data

<table>
<thead>
<tr>
<th>Project</th>
<th>Pond</th>
<th>Fluid tailings (Mm$^3$)</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
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<tr>
<td>Suncor Base Plant</td>
<td>Pond 1A</td>
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<td>10.1</td>
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<td>10.1</td>
<td>10.4</td>
<td>10.4</td>
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<tr>
<td></td>
<td>Pond 2/3</td>
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<td>38.3</td>
<td>35.0</td>
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<td>32.7</td>
<td>33.6</td>
<td>29.8</td>
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<td></td>
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<td></td>
<td>Pond 6</td>
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<td>DDA1 (Pond 8A)</td>
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<td>Total</td>
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<td>316.1</td>
<td>316.4</td>
<td>300.3</td>
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<td>Syncrude Mildred Lake</td>
<td>Mildred Lake settling basin</td>
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<td>177.6</td>
<td>168.1</td>
<td>167.5</td>
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<td>Southwest sand storage</td>
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<td></td>
<td>West in-pit (i.e., BML)</td>
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<td>N/A</td>
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<td>Southwest in-pit major</td>
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<td>39.4</td>
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<td>37.2</td>
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<td>North mine south pit west major</td>
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<td>1.4</td>
<td>3.6</td>
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<td>16.2</td>
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<td>Syncrude Aurora North</td>
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<td>Aurora east pit northeast</td>
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<td>Aurora east pit northwest</td>
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<td>0.3</td>
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<td></td>
<td>Aurora east pit south</td>
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<td>N/A</td>
<td>8.4</td>
<td>10.9</td>
<td>13.2</td>
<td>12.6</td>
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<tr>
<td></td>
<td>Total</td>
<td></td>
<td>113.0</td>
<td>127.9</td>
<td>131.2</td>
<td>136.9</td>
<td>133.2</td>
<td>137.0</td>
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</table>
## Fluid Tailings Management for Mineable Oil Sands, 2019

<table>
<thead>
<tr>
<th>Project</th>
<th>Pond</th>
<th>Fluid tailings (Mm³)</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
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<tbody>
<tr>
<td>CNUL Muskeg River Mine</td>
<td>External tailings facility</td>
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<td>62.4</td>
<td>63.7</td>
<td>58.3</td>
<td>57.9</td>
<td>51.7</td>
<td>50.4</td>
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<tr>
<td></td>
<td>South expansion area</td>
<td></td>
<td>0.5</td>
<td>0.8</td>
<td>1.5</td>
<td>1.3</td>
<td>0.2</td>
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<tr>
<td></td>
<td>In-pit cell 1</td>
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<td>23.0</td>
<td>24.3</td>
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<td>30.8</td>
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<td>N/A</td>
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<td>7.7</td>
<td>26.5</td>
<td>28.1</td>
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<td></td>
<td>2.1</td>
<td>5.6</td>
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<td>12.5</td>
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<td>0.8</td>
<td>5.7</td>
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N/A: Not applicable

Tailings volume totals in this table may not match the company reports due to rounding. Data provided by operators in their tailings management reports were only to one decimal place. Reported data may not include the removal of volumes considered ready to reclaim.

Tailings volumes for 2017 year-end are estimates based on mid-year survey data and estimates based on production from end of surveys to 2017 year-end, except for Suncor.

Syncrude Mildred Lake and Aurora North volumes for 2018 are as measured and not year-end projections, which the other operators provided.

Imperial Kearl volumes for 2019 are year-end projections and not as measured, which the other operators provided.

Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing volumes that meet the ready-to-reclaim criteria.
### Appendix 4  Water Volume Data

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N/A: Not applicable.

Water volume totals in this table may not match the company reports due to rounding. Data provided by operators in their tailings management reports were only to one decimal place. Water volumes are presented as reported by operators and are subject to change upon further review by the AER.