Techniques for management of tailings include treating the tailings to remove sand and a portion of the fines in a sand dump operation. The tailings are flowed down a beaching area to form a series of lifts. Compaction and drainage facilitate the formation of...
(57) **Abstract (continued):**

Compacted zones for each lift. Thin fine tailings are produced and are collected and sent for maturation. Drainage water is collected and removed from below the lifts. The techniques may be used to build a sand dump in a mine pit at least partially using the pit wall and other mining material. After maturation of the thin fine tailings, mature fine tailings may be retrieved from a maturation pond and dewatered by addition of a flocculant to form a flocculation material that is deposited onto sub-aerial deposition areas. Various tailings components such as coarse sand, fines and water can thus be effectively handled and managed.
ABSTRACT

Techniques for management of tailings include treating the tailings to remove sand and a portion of the fines in a sand dump operation. The tailings are flowed down a beaching area to form a series of lifts. Compaction and drainage facilitate the formation of compacted zones for each lift. Thin fine tailings are produced and are collected and sent for maturation. Drainage water is collected and removed from below the lifts. The techniques may be used to build a sand dump in a mine pit at least partially using the pit wall and other mining material. After maturation of the thin fine tailings, mature fine tailings may be retrieved from a maturation pond and dewatered by addition of a flocculant to form a flocculation material that is deposited onto sub-aerial deposition areas. Various tailings components such as coarse sand, fines and water can thus be effectively handled and managed.
TAILINGS MANAGEMENT TECHNIQUES AND SAND DUMP OPERATIONS FOR EXTRACTION TAILINGS

TECHNICAL FIELD

The technical field relates to handling, disposal and management of extraction tailings including water, sand and fines produced or derived from a mined ore extraction operation.

BACKGROUND

Extraction tailings, such as oil sands extraction tailings, are generated from extraction operations that separate valuable material from the mined ore. For example, in the oil sands industry, hydrocarbon extraction operations often use processes in which water is added to the oil sands ore to enable the separation of the valuable hydrocarbon fraction from the oil sands minerals. Once the hydrocarbon fraction is recovered, the residual water, unrecovered hydrocarbons and minerals are generally referred to as extraction tailings.

Conventionally, extraction tailings have been transported to a deposition site generally referred to as a “tailings pond” located close to the oil sands extraction facilities. A tailings pond can be contained within a dyke structure generally constructed by placing the coarse sand fraction of the tailings on beaches. The process water, unrecovered hydrocarbons, together with sand and fine minerals not trapped in the dyke structure flow into the tailings pond. In the tailings pond, solid mineral materials settle over time. The coarse sand tends to settle quickly to the bottom of the pond while the finer mineral solids settle much slower and tend to remain in suspension in the water phase creating a mature fine tailings (MFT) layer in the pond.

There are a number of challenges associated with the handling and disposal of extraction tailings. For example, the MFT in the tailings pond requires additional time and processing for reclamation to occur, while the settling of the coarse sand material decreases the liquid capacity of the pond leading to the need for additional ponds.

SUMMARY OF INVENTION

Various techniques are provided for treating and managing tailings.
In some implementations, there is a method for building an elevated sand dump from extraction tailings comprising sand, fines and water derived from a mined ore extraction operation, the method comprising:

providing a flow of the extraction tailings down at least one section of a sloped beaching area such that a substantial portion of the sand settles out of the tailings, thereby producing:

a series of overlying lifts comprising settled sand, some captured fines and water; and

thin fine tailings at a downstream end of the beaching area, the thin fine tailings comprising fines and water;

collecting the thin fine tailings next to the downstream end of the beaching area;

collecting drainage water below the lifts and removing the collected drainage water from below the lifts; and

compacting and draining at least a portion of each lift to produce a compacted zone of the corresponding lift, such that the overlying lifts include a series of overlying compacted zones.

In some implementations, the method further includes, for each lift:

ceasing the flow of the extraction tailings into the section of the sloped beaching area;

after ceasing the flow, completing the compacting and draining of the compacted zone sufficiently so as to be non-liquifiable prior to providing a subsequent flow of the extraction tailings thereon to produce a subsequent lift.

In some implementations, the step of collecting and removing the drainage water further comprises:

providing a drainage system below the beaching area for receiving drainage water and conveying the drainage water to a main collection zone; and
pumping water out of the main collection zone.

In some implementations, the drainage system comprises:

basal drains near a bottom of the sloped beaching area and configured so as to be spaced-apart and distributed across a width of the sloped beaching area in a generally lengthwise orientation with respect to the flow of the extraction tailings; and

collector drains in fluid communication with a plurality of the basal drains and configured so as to be spaced-apart and distributed along a length of the sloped beaching area in a generally transverse orientation with respect to the flow of the extraction tailings.

In some implementations, the main collection zone comprises at least one gravel pad located proximate to a discharge location of the flow of the extraction tailings.

In some implementations, the at least one gravel pad comprises multiple gravel pads, each being provided below a corresponding discharge location of the flow of the extraction tailings.

In some implementations, the gravel pads are fluidly connected to each other.

In some implementations, the basal drains comprise gravel channels and/or perforated pipes.

In some implementations, the collector drains comprise gravel channels.

In some implementations, the drainage system is sloped in a generally opposite orientation as a slope of the beaching area.

In some implementations, the step of providing the flow of the extraction tailings comprises expelling the extraction tailings from a tailings supply system down a starter dyke located along an upstream end of the beaching area.

In some implementations, the main collection zone is located in a lower region of the starter dyke.
In some implementations, the step of pumping water out of the main collection zone further comprises providing at least one well extending through the starter dyke and into the main collection zone; and retrieving the water in the main collection zone out through the at least one well.

In some implementations, the drainage system comprises a slope of at least 1% toward the starter dyke.

In some implementations, the compacted zones extend from the starter dyke in the downstream direction.

In some implementations, the compacted zones each have a length of at least about 100 meters from the starter dyke.

In some implementations, the method further includes providing a sets of lifts having corresponding compacted zones; and after each set of lifts, raising the starter dyke a sufficient elevation above a top one of the lifts to enable a subsequent set of lifts to be provided from the starter dyke.

In some implementations, the method further includes buttressing an upstream end of the starter dyke in order to support the raising thereof.

In some implementations, the compacting comprises stepping in the compacted zones and the raising of the starter dyke comprises stepping in the starter dyke.

In some implementations, the beaching area comprises an engineered bottom surface having a slope of at least 1% toward a TFT collection basin located next to the downstream end of the beaching area.

In some implementations, the method further includes allowing sufficient sand to enter the TFT collection basin to raise the bottom thereof in conjunction with elevation of the beaching area.

In some implementations, each section of the sloped beaching area comprises multiple panels and wherein the method further comprises sequentially flowing the extraction tailings into respective panels to form multiple panel lifts; and after ceasing the flow of the extraction tailings into each panel, providing a panel drainage time sufficient to
produce a drained compacted panel zone in the corresponding panel prior to repeating
the flow of extraction tailings therein.

In some implementations, each section comprises first, second and third panels, and the
method further includes:

flowing the extraction tailings into the first panel for a panel filling time of at least
20 days;

ceasing the flow of the extraction tailings into the first panel, and flowing the
extraction tailings into the second panel for the panel filling time;

ceasing the flow of the extraction tailings into the second panel, and flowing the
extraction tailings into the third panel for the panel filling time; and

repeating the above steps, wherein the panel drainage time for each panel is
approximately twice the panel filling time.

In some implementations, each panel comprises multiple cells and wherein the
extraction tailings are expelled concurrently or alternatingly into the cells.

In some implementations, the method further includes separating the cells with berms
during the flowing of extraction tailings therein.

In some implementations, each cell has a width between about 20 meters and about 70
meters; each panel has a width between about 40 meters and about 420 meters; and
each section has a width between about 120 meters and about 1000 meters.

In some implementations, the method further includes advancing a deposition outlet of
the extraction tailings progressively downstream in each cell to provide the flow of the
extraction tailings.

In some implementations, the advancing is done for a distance of about 80 meters to
about 300 meters from an initial deposition location.

In some implementations, the method further includes providing a spill box system at an
infeed region of each of the cells in order to decelerate the flow of the tailings sufficiently
to allow at least about 50 wt% or 60 wt% of the sand in the extraction tailings; and/or at
least about 40 wt% or about 50 wt% of the fines in the extraction tailings; to settle out of the decelerated flow of the tailings prior to flowing to the downstream end of the beaching area.

In some implementations, the sloped beaching area comprises an infeed region having a high slope and a main section having a low slope. The method may further include decelerating the flow of the tailings at the infeed region of the sloped beaching area sufficiently to allow at least about 50 wt% or 60 wt% of the sand in the extraction tailings; and/or at least about 40 wt% or about 50 wt% of the fines in the extraction tailings; to settle out of the decelerated flow of the tailings prior to flowing to the downstream end of the beaching area.

In some implementations, the step of decelerating the flow of the tailings comprises providing a spill box system at the infeed region of the sloped beaching area to produce a decelerated tailings overflow.

In some implementations, the spill box system comprises a barrier wall extending upward from the beaching area, the barrier wall having an upper edge over which the decelerated tailings overflow spills and then advances down the main section of the beaching area.

In some implementations, the method further includes:

- collecting the thin fine tailings in a collection basin;
- retrieving a stream of thin fine tailings from the collection basin; and
- supplying the stream of thin fine tailings to a maturation pond in order to generate mature fine tailings.

In some implementations, the step of retrieving the stream of thin fine tailings comprises:

- providing a barge in the collection basin;
- pumping the stream of the thin fine tailings from the collection basin via the barge.
In some implementations, the beaching area is flanked by side buttresses and the collection pond is bounded by an end dyke.

In some implementations, the side buttresses and/or the end dyke are at least partially provided by mine pit walls.

In some implementations, the method includes controlling a fluid level in the collection basin. In some implementations, the step of controlling the fluid level comprises limiting elevation fluctuations and/or maintaining sufficient hydrostatic pressure on beach below water to reduce or prevent sloughing of beach below water into the collection basin. In some implementations, elevation fluctuations of the fluid level are maintained to a maximum of 2 meters increase per week and 1 meter decrease per week. In some implementations, the collection basin is maintained below a volume of 3,000,000 m$^3$.

In some implementations, the step of providing the flow of tailings further comprises controlling back pressure of the extraction tailings. In some implementations, the step of controlling the back pressure comprises increasing back pressure by passing the extraction tailings through resistance piping for deposition of the extraction tailings at a proximate location of the beaching area; and/or decreasing back pressure by passing the extraction tailings through bypass piping in order to bypass at least part of the resistance piping, for deposition of the extraction tailings at a remote location of the beaching area. In some implementations, the resistance piping has an internal diameter sufficiently small to avoid slug flow and/or pressure transients.

In some implementations, the beaching area is between about 500 meters and about 1500 meters in length.

In some implementations, the step of compacting and draining is performed such that each compacted zone is between about 100 meters and about 300 meters in length from deposition of the extraction tailings. In some implementations, the compacting comprises track-packing with bulldozers. In some implementations, the compacted zone for each lift is between about 2m and about 8m in height.

In some implementations, the sand dump is provided in an in-pit mining location.

In some implementations, the method includes for each lift providing a non-compacted zone downstream of the corresponding compacted zone, so as to form a non-compacted
liquifiable tailings zone; enclosing and containing the non-compacted liquefiable tailings zone, comprising: buttressing sides of the non-compacted liquefiable tailings zone, and providing the series of the compacted zones in a stepped-in configuration such that the compacted zones form a compacted non-liquefiable region overlaying and buttressing a side of the non-compacted liquefiable tailings zone.

In some implementations, the extraction tailings are derived from an oil sands extraction operation.

In some implementations, there is provided a system for building an elevated sand dump from extraction tailings comprising sand, fines and water derived from a mined ore extraction operation, the system comprising:

  a starter dyke;

  a sloped beaching area extending from the starter dyke and having at least one section;

  a tailings supply system for providing a flow of the extraction tailings down the at least one section of a sloped beaching area such that a substantial portion of the sand settles out of the tailings, thereby producing:

  a series of overlying lifts comprising settled sand, some captured fines and water; and

  thin fine tailings at a downstream end of the beaching area, the thin fine tailings comprising fines and water;

  a collection area at a downstream end of the sloped beaching area for receiving the thin fine tailings;

  a drainage system located below the beaching area for collecting and removing drainage water from below the lifts; and

  compactors for compacting at least a portion of each lift to promote drainage and produce a compacted zone of the corresponding lift, such that the overlying lifts include a series of overlying compacted zones.
In some implementations, the tailings supply system is configured to periodically cease expelling the extraction tailings into the section of the sloped beaching area for completing the compacting and draining of the compacted zone sufficiently so as to be non-liquifiable prior to providing a subsequent flow of the extraction tailings thereon to produce a subsequent lift.

In some implementations, the drainage system comprises:

- a main collection zone; and
- drains located below the beaching area for receiving drainage water and conveying the drainage water to a main collection zone.

In some implementations, the system comprising well arrangement comprising at least one well extending into the main collection zone and at least one pump coupled to the at least one well for retrieving water from the main collection zone.

In some implementations, the drainage system comprises:

- basal drains near a bottom of the sloped beaching area and configured so as to be spaced-apart and distributed across a width of the sloped beaching area in a generally lengthwise orientation with respect to the flow of the extraction tailings, the basal drains being in fluid communication with the main collection zone; and
- collector drains in fluid communication with a plurality of the basal drains and configured so as to be spaced-apart and distributed along a length of the sloped beaching area in a generally transverse orientation with respect to the flow of the extraction tailings.

In some implementations, the main collection zone comprises a gravel pad located in a lower region of the starter dyke.

In some implementations, the at least one gravel pads comprises multiple gravel pads each located below a corresponding tailings deposition location.

In some implementations, the basal drains comprise gravel channels and/or perforated pipes.
In some implementations, the collector drains comprise gravel channels.

In some implementations, the drainage system has a slope that is in a generally opposite orientation as a slope of the beaching area.

In some implementations, the slope of the drainage system is at least about 1% toward the starter dyke.

In some implementations, the slope of the beaching area is at least about 1% toward the collection area.

In some implementations, each section of the sloped beaching area comprises multiple panels and wherein the tailings supply system is configured to sequentially flow the extraction tailings into respective panels to form multiple panel lifts.

In some implementations, the tailings supply system is further configured to cease the flow of the extraction tailings into each panel, providing a panel drainage time sufficient to produce the compacted zone lift in the corresponding panel prior to repeating the flow of extraction tailings therein.

In some implementations, each section comprises first, second and third panels, and wherein the tailings supply system is further configured to:

- flow the extraction tailings into the first panel for a panel filling time of at least 20 days;
- cease the flow of the extraction tailings into the first panel, and flow the extraction tailings into the second panel for the panel filling time;
- cease the flow of the extraction tailings into the second panel, and flowing the extraction tailings into the third panel for the panel filling time; and
- repeat the above steps, wherein the panel drainage time for each panel is approximately twice the panel filling time.

In some implementations, each panel comprises multiple cells and wherein the tailings supply system is further configured to expel the extraction tailings concurrently or alternatingly into the cells.
In some implementations, the tailings supply system further comprises a plurality of pipe discharge extensions progressively provided to extend tailings discharge into the beaching area for each cell.

In some implementations, each cell has a width between about 20 meters and about 70 meters; each panel has a width between about 40 meters and about 420 meters; and each section has a width between about 120 meters and about 1000 meters.

In some implementations, the system includes a tailings flow decelerator at an infeed region of each of the cells in order to decelerate the flow of the tailings sufficiently to allow at least about 50 wt% or 60 wt% of the sand in the extraction tailings; and/or at least about 40 wt% or about 50 wt% of the fines in the extraction tailings, to settle out of the decelerated flow of the tailings prior to flowing to the downstream end of the beaching area.

In some implementations, the tailings flow decelerator comprises a spill box system to produce a decelerated tailings overflow.

In some implementations, the spill box system comprises a barrier wall extending upward from the beaching area, the barrier wall having an upper edge over which the decelerated tailings overflow spills and then advances down the main section of the beaching area.

In some implementations, the system includes at least one retrieval apparatus for removing thin fine tailings from the collection area.

In some implementations, the retrieval apparatus comprises at least one barge in the collection area, the barge comprising a suction pipe extending into the collection area and a pump coupled to the suction pipe for pumping a stream of the thin fine tailings out of the collection area.

In some implementations, the system includes side buttresses flanking the beaching area and an end dyke defining a far end of the collection area.

In some implementations, the side buttresses and the end dyke are at least partially provided by mine pit walls.
In some implementations, the tailings supply system is configured for backpressure control.

In some implementations, the tailings supply system comprises:

- resistance piping for increasing backpressure for deposition of the extraction tailings at a proximate location of the beaching area;
- bypass piping to bypass at least part of the resistance piping for decreasing backpressure by passing the extraction tailings, for deposition of the extraction tailings at a remote location of the beaching area; and
- valves for switching the flow of the extraction tailings from the resistance piping to the bypass piping.

In some implementations, the tailings supply system comprises:

- a main tailings line supplying the extraction tailings from the extraction operation;
- a backpressure line section coupled to the main tailings line and configured to receive the extraction tailings therefrom and provide increased backpressure on the extraction tailings;
- at least one bypass line coupled to the main tailings line and configured to receive the extraction tailings therefrom and provide a lower level of backpressure compared to the backpressure line section;
- a first feed line coupled to the backpressure line section to receive the extraction tailings therefrom and to expel the extraction tailings at a proximate location of the beaching area;
- a second feed line coupled to the bypass line to receive the tailings therefrom and to expel the tailings at a remote location of the beaching area the bypass;
- valves coupled to the backpressure line section and the at least one bypass line;
- a backpressure controller for controlling the valves depending on proximate or remote expelling of the tailings.
In some implementations, the resistance piping has an internal diameter sufficiently small to avoid slug flow and/or pressure transients.

In some implementations, the collection area comprises a collection basin.

In some implementations, the system includes a level controller for controlling a fluid level in the collection basin.

In some implementations, the level controller is configured to limit elevation fluctuations and/or maintain sufficient hydrostatic pressure on beach below water to reduce or prevent sloughing of beach below water into the collection basin.

In some implementations, the level controller is configured to maintain elevation fluctuations of the fluid level to a maximum of 2 meters increase per week and 1 meter decrease per week.

In some implementations, the level controller is configured to maintain the collection basin below a volume of about 3,000,000 m³.

In some implementations, the beaching area is between about 500 meters and about 1500 meters in length.

In some implementations, the tailings supply system, the compactors and the drainage system are configured and controlled so as to produce compacted zones that are at least 100 meters in length from discharge of the extraction tailings.

In some implementations, the compactors comprise bulldozers.

In some implementations, the tailings supply system, the compactors and the drainage system are configured and controlled such that the compacted zones each have a lift height between about 2 meters and about 8 meters.

In some implementations, comprising at least one pressure vacuum relief valve provided at high points in the tailings supply system.

In some implementations, the sand dump is provided in an in-pit mining location.
In some implementations, the tailings supply system, the compactors and the drainage system are configured and controlled so as to:

provide for each lift a non-compacted zone downstream of the corresponding compacted zone, so as to form a non-compacted liquifiable tailings zone and

enclose and contain the non-compacted liquifiable tailings zone by buttressing sides of the non-compacted liquifiable tailings zone and providing the series of the compacted zones in a stepped-in configuration such that the compacted zones form a compacted non-liquifiable region overlaying and buttressing a side of the non-compacted liquifiable tailings zone.

In some implementations, the extraction tailings are derived from an oil sands extraction operation.

In some implementations, there is provided a method for treating tailings comprising:

discharging a tailings stream comprising coarse sand, fines and water and about 35 wt% to about 60 wt% solids into sloped beaching area to remove substantially all of the coarse sand and at least 40% of the fines in a sand dump structure, and to produce thin fine tailings comprising between about 5 wt% and about 10 wt% solids and at least 80 wt% fines on a per solids basis;

providing a stream of the thin fine tailings to a maturation pond to produce a supernatant substantially solids free water layer and a lower mature fine tailings layer, the mature fine tailings comprising between about 25 wt% and about 35 wt% solids and at least 80 wt% fines content on a per solids basis;

retrieving a stream of the mature fine tailings from the maturation pond;

supplying the stream of the mature fine tailings to a dewatering operation comprising:

  contacting the mature fine tailings with a flocculating reagent to produce a flocculation material; and

  depositing the flocculation material in a sub-aerial deposition area to produce released water and dewatered fines material.
In some implementations, the tailings stream comprises extraction tailings derived from a mined ore extraction operation.

In some implementations, the tailings stream has a specific gravity between about 1.39 and about 1.55.

In some implementations, the tailings stream comprises between about 50 wt% to about 60 wt% solids.

In some implementations, the thin fine tailings has a specific gravity below about 1.1.

In some implementations, the thin fine tailings has a fines content of at least about 95 wt% on a per solids basis.

In some implementations, the thin fine tailings has a fines content of at least about 98 wt% on a per solids basis.

In some implementations, capturing at least 50% of the fines of the tailing stream in the sand dump structure.

In some implementations, the method includes capturing at least 60% of the fines of the tailing stream in the sand dump structure.

In some implementations, the mature fine tailings retrieved from the maturation pond comprise between about 28 wt% and about 32 wt% solids and at least 90 wt% fines content on a per solids basis.

In some implementations, the mature fine tailings retrieved from the maturation pond comprise at least 95 wt% fines content on a per solids basis.

In some implementations, the method includes removing a stream of the substantially solids free water from the maturation tailings pond.

In some implementations, the method includes recycling the stream of the substantially solids free water to a mined ore extraction operation.

In some implementations, the method includes recycling a stream of the released water to the mined ore extraction operation.
In some implementations, the method includes:

mining a formation to produce mined ore for the extraction operation, a mine pit, and overburden material;

providing the mine pit for building the sand dump structure therein; and

providing at least a portion of the overburden material for buttressing the sand dump structure.

In some implementations, the method includes building the sand dump structure according to the method as defined above or herein.

In some implementations, the method includes building the sand dump structure using the system as defined in above or herein.

In some implementations, there is a method for treating tailings comprising:

providing a stream of the thin fine tailings comprising between about 5 wt% and about 10 wt% solids and at least 80 wt% fines on a per solids basis, to a maturation pond to produce a supernatant substantially solids free water layer and a lower mature fine tailings layer, the mature fine tailings comprising between about 25 wt% and about 35 wt% solids and at least 80 wt% fines content on a per solids basis, wherein the thin fine tailings are derived from a sand removal operation;

retrieving a stream of the mature fine tailings from the maturation pond;

supplying the stream of the mature fine tailings to a dewatering operation comprising:

contacting the mature fine tailings with a flocculating reagent to produce a flocculation material; and

depositing the flocculation material in a sub-aerial deposition area to produce released water and dewatered fines material.
In some implementations, the sand removal operation removes sand from extraction tailings derived from a mined ore extraction operation.

In some implementations, the extraction tailings stream has a specific gravity between about 1.39 and about 1.55.

In some implementations, the extraction tailings stream comprises between about 35 wt% to about 60 wt% solids.

In some implementations, the thin fine tailings has a specific gravity below about 1.1.

In some implementations, the thin fine tailings has a fines content of at least about 95 wt% on a per solids basis.

In some implementations, the thin fine tailings has a fines content of at least about 98 wt% on a per solids basis.

In some implementations, the method includes capturing at least 50% of the fines of the tailing stream in the sand dump structure.

In some implementations, the method includes capturing at least 60% of the fines of the tailing stream in the sand dump structure.

In some implementations, the mature fine tailings retrieved from the maturation pond comprise between about 28 wt% and about 32 wt% solids and at least 90 wt% fines content on a per solids basis.

In some implementations, the mature fine tailings retrieved from the maturation pond comprise at least 95 wt% fines content on a per solids basis.

In some implementations, the method includes removing a stream of the substantially solids free water from the maturation tailings pond.

In some implementations, the method includes recycling the stream of the substantially solids free water to a mined ore extraction operation.

In some implementations, the method includes recycling a stream of the released water to the mined ore extraction operation.
In some implementations, the method includes:

mining a formation to produce mined ore for the extraction operation, a
mine pit, and overburden material;

providing the mine pit for building the sand dump structure therein; and

providing at least a portion of the overburden material for buttressing the
sand dump structure.

In some implementations, the method includes building the sand dump structure
according to the method as defined herein.

In some implementations, the method includes building the sand dump structure using
the system as defined herein.

In some implementations, there is provided a method of producing bitumen from an oil
sands formation comprising:

mining the oil sand formation to produce mined ore and a mine pit;

supplying the mined ore to an extraction operation to produce extracted bitumen
and tailings comprising coarse sand, fines and water and about 35 wt% to about
60 wt% solids;

removing at least a portion of the coarse sand from the tailings in the mine pit, to
produce thin fine tailings comprising between about 5 wt% and about 10 wt%
solids and at least 80 wt% fines on a per solids basis;

supplying a stream of the thin fine tailings from the mine pit to a maturation pond
to produce an upper layer of substantially solids free water and a lower layer
comprising mature fine tailings comprising between about 25 wt% and about 35
wt% solids and at least 80 wt% fines content on a per solids basis; and

supplying a stream of the mature fine tailings to a dewatering operation
comprising:
contacting the mature fine tailings with a flocculating reagent to produce a flocculation material; and

depositing the flocculation material in a sub-aerial deposition area to produce released water and dewatered fines material.

recycling at least some of the substantially solids free water and/or the released water back into the extraction operation.

In some implementations, the extraction tailings stream has a specific gravity between about 1.39 and about 1.55.

In some implementations, the extraction tailings comprises between about 50 wt% to about 60 wt% solids.

In some implementations, the thin fine tailings has a specific gravity below about 1.1.

In some implementations, the thin fine tailings has a fines content of at least about 95 wt% on a per solids basis.

In some implementations, the thin fine tailings has a fines content of at least about 98 wt% on a per solids basis.

In some implementations, the method includes capturing at least 50 wt% of the fines of the tailing stream in the sand dump structure.

In some implementations, the method includes capturing at least 60 wt% of the fines of the tailing stream in the sand dump structure.

In some implementations, the mature fine tailings retrieved from the maturation pond comprise between about 28 wt% and about 32 wt% solids and at least 90 wt% fines content on a per solids basis.

In some implementations, the mature fine tailings retrieved from the maturation pond comprise at least 95 wt% fines content on a per solids basis.

In some implementations, the removing at least a portion of the coarse sand from the tailings is done by building a sand dump structure.
In some implementations, the method includes building the sand dump structure according to the method as defined in any one of claims 1 to 50.

In some implementations, the method includes building the sand dump structure using the system as defined in any one of claims 51 to 92.

In some implementations, there is provided a use of a mine pit for containing a sand dump structure built according to the method defined herein.

In some implementations, there is provided a sand dump structure built according to the method defined herein.

In some implementations, there is provided a sand dump structure comprising a lower non-compacted liquifiable tailings zone and an enclosure comprising side buttresses buttressing sides of non-compacted liquifiable tailings zone and a compacted region comprising compacted non-liquifiable tailings zone overlaying and buttressing a side of the non-compacted liquifiable tailings zone.

In some implementations, there is provided a method of treating tailings comprising enclosing and containing a non-compacted liquifiable tailings zone with side buttresses buttressing sides of the non-compacted liquifiable tailings zone and a compacted non-liquifiable tailings region comprising compacted and drained tailings, the compacted non-liquifiable tailings region overlaying and buttressing a side of the non-compacted liquifiable tailings zone, thereby providing a stable elevated tailings containment structure.

In some implementations, the stable elevated tailings containment structure is built according to the method as defined in any one of the methods and/or the systems as defined herein.

**BRIEF DESCRIPTION OF DRAWINGS**

Fig 1 is a process block diagram.

Fig 2 is a top plan partial transparent view schematic of a sand dump operation.

Fig 3 is a side cross-sectional partial transparent view schematic of a sand dump operation.
Fig 4 is a top plan view schematic of a sand dump operation.

Fig 5 is a top plan view schematic of a sand dump operation.

Fig 6 is a perspective view schematic of a location for a sand dump operation.

Fig 7 is a side cross-sectional partial transparent view schematic of a sand dump operation.

Fig 8 is a perspective view schematic of part of a sand dump operation.

Fig 9 is a top plan view schematic of part of a sand dump operation.

Fig 10 is a top plan view schematic of part of a sand dump operation.

Fig 11 is a top plan view schematic of part of a sand dump operation.

Fig 12 is a top plan view schematic of part of a sand dump operation.

Fig 13 is a process block diagram.

Fig 14 is another process block diagram.

Figs 15a to 15c are side cross-sectional view schematics and Fig 15d is a top perspective view schematic of a TFT collection basin.

Fig 16 is a perspective partially transparent view schematic showing a geothermal exchange system.

DETAILED DESCRIPTION

Various techniques are described below related to the handling, disposal and treatment of extraction tailings.

“Extraction tailings” include sand, water and fines. Extraction tailings may also include other components such as residual compounds from the mined ore and/or the extraction process. Extraction tailings are a by-product of a mined ore extraction operation and may include a variety of different by-product and/or underflow streams. For example, the extraction tailings may include cyclopac underflow, various flotation tailings such as
tertiary floatation tailings, and other underflow streams that may be produced in separators such as cyclones, centrifuges and/or thickeners that may be involved in the given extraction process. The extraction tailings may be provided continuously and directly from an extraction facility or from a temporary storage area. In the context of such extraction tailings, mineral fractions with a particle diameter greater than 44 microns are referred to as "sand". Mineral fractions with a particle diameter less than 44 microns are referred to as "fines". Mineral fractions with a particle diameter less than 2 microns are generally referred to as "clay", although in some instances "clay" may refer to the actual particle mineralogy. The relationship between sand and fines in tailings reflects the variation in the mined ore make-up, the chemistry of the process water and the extraction processes.

In some implementations, extraction tailings are processed in a sand dump operation, which will be described further below. It should be noted that the techniques will be largely described for oil sands applications, but the techniques can also be used for extraction tailings derived from other types of mined ore extraction.

**Context of sand dump operations**

Referring to Fig 1, in an oil sands mining and extraction operation, the hydrocarbon containing formation 10 is mined in a mining operation 12 and the resulting ore 14 is supplied to an extraction operation 16. Water 18 and other chemical agents are used to separate hydrocarbons 20, such as bitumen. The extraction operation produces extraction tailings 22, which include water, sand, fines and unrecovered hydrocarbons.

The extraction tailings 22 may then be supplied to a sand removal operation 24, which may also be referred to herein as a sand dump operation. The sand dump operation 24, which will be further described below, produces an elevated sand structure 26, recovered water 28 and thin fine tailings (TFT) 30 that includes water and fines. It should be noted that the recovered water may be combined with the TFT to produce a single TFT outlet stream 30, as will be discussed further below.

The TFT 30 may be supplied to a maturation operation 32 in order to allow the fines to consolidate and generate, over time, mature fine tailings (MFT) 34. The maturation operation 32 may include one or more ponds that are relatively small in size compared to conventional tailings ponds. The maturation operation 32 may be part of an overall
water and fines management system that receives TFT and other used water streams, enables settling of the fines over time, and can be used to withdraw water for recycling and MFT 34 for dewatering. The conventional method supplied tailings streams containing coarse sand that accumulated in the bottom of the tailings ponds, increasing the elevation of the pond bottom, and leading to reduced pond capacity and thus the construction of additional ponds. In contrast, the coarse sand in the extraction tailings is captured in the sand dump operation 24. When the coarse sand has been removed from the extraction tailing, the TFT stream 30 can be supplied to the water and fines management system that can be operated such that capacity and/or containment issues are reduced.

In the maturation operation 32, there may be a single pond that receives TFT and allows settling of the fines so as to form a top stratum of free water that can be recycled back into upstream processes, followed by lower layers of increasing solids content. The layer near the bottom of the pond may be about 30 wt% solids and may be referred to as MFT.

The MFT 34 may then be supplied to an MFT dewatering operation 36, which may include the addition of a dewatering chemical 38, such as a polymer flocculant, to the MFT in order to produce flocculated MFT that can be deposited in lifts into deposition cells. Once the flocculated MFT is deposited, released water 40 separates in order to form a dry material 42 that is trafficable and for which reclamation is facilitated.

**Overview of sand dump operation**

Referring now to Figs 2 and 3, the sand dump operation 24 will be further described. The extraction tailings 22 are supplied via pipeline and are expelled down a starter dyke 44 and flow down a section of a sloped beaching area 46. The sloped beaching area is subdivided into various areas that will be described further below. As the extraction tailings 22 flow down the section of the beaching area 46, a portion of the sand settles out of the extraction tailings and produces a wet sandy lift 48 on the beaching area 46. The wet sandy lift 48 includes settled sand, some captured fines and water. A thin fine tailings (TFT) stream 50 is also produced at a downstream end of the beaching area 46. The TFT stream 50 includes mainly fines and water and typically has a solids content of about 5 wt% to 10 wt%.
The TFT stream 50 is collected in a collection basin 52 located next to the downstream end of the beaching area 46. A retrieval apparatus 54, which may include at least one barge and pumping arrangement, may be used to retrieve TFT from the collection basin 52 for supplying to the maturation operation 32 to produce MFT. The retrieval apparatus 54 may also be operated in order to maintain an appropriate level in the TFT pond 52 with respect to the sand lifts in the beaching area.

Referring to Fig 3, once a wet sandy lift 48 has been deposited on a section of the beaching area, the flow of the extraction tailings 22 into that section of the beaching area 46 is stopped. Compactors 56, which may be dozers or the like, are provided for compacting a part of the wet sandy lift 48 to produce a compacted lift 58 for a compacted zone 59 of the beaching area 46. The compacted zone 59 is followed by a downstream non-compacted zone that leads into the TFT collection basin 52. Fig 3 illustrates a dry, compacted lift 58 below a subsequently deposited wet sandy lift 48 and a compactor 56 that is in the process of compacting the upstream zone of the newly deposited wet sandy lift 48 in order to create another compacted lift. The compacted zone may be obtained by using bulldozers that spread and compact the deposited material, while the remaining fluid may travel in meandering streams down the non-compacted zone allowing additional sand and some fines to remain on the non-compacted part of the beaching area.

Referring back to Figs 2 and 3, a drainage system 60 is provided below the beaching area 46 for facilitating drainage and collection of water from the extraction tailings 22. Collected drainage water is removed from below the beaching area, for example by channeling the water in the opposite direction as the flow of the extraction tailings over the beaching area 46. The collected drainage water may then be retrieved from the drainage system 60 via a well arrangement 62 to obtain a tailings water stream 64. Drainage occurs under the influence of gravity and is also expedited by the compacting of the wet sandy lift.

Returning to Fig 3, after compaction the lift is allowed to undergo further draining and drying over a certain period of time to produce a compacted lift. It should be understood that the dry compacted lift may still have some water content, but has sufficient geotechnical properties according to the design characteristics of the lifts and the overall sand dump structure. It one scenario, the compacted lifts may reach a dilated or non-
liquifiable state prior to any subsequent lifts of extraction tailings. The geotechnical targets of obtaining non-liquifiable compacted zones may be obtained through sufficient compaction and sufficient compaction, draining and drying time. After an appropriate draining and drying time, a subsequent deposition of extraction tailings 22 may occur on top of the previous lift. Over time, multiple sand lifts are provided in order to form an elevated geotechnically stable sand landform.

The compacted zones may be tested to determine whether they have reached a non-liquifiable state by performing cone penetration tests. A test cone probe may be pushed tip side down into the compacted zone in order to obtain various data such as friction, water table, soil classification and so on. The cone data may be subjected to a liquefaction assessment utilizing various geotechnical equations in order to determine whether the compacted zone is non-liquifiable. The entire compacted zone may be compacted and drain sufficiently to reach the non-liquifiable state prior to discharging a subsequent lift. In addition, the cone testing may be correlated with other parameters of the sand dump construction, including as compaction and draining time for example, in order to prepare a performance based specification. The performance based specification may include minimum bulldozing and/or drainage time to achieve non-liquifiable compacted zones. The performance based specification may be used instead of the cone test for various lifts, although a cone test may be used on a less frequent basis.

Other parameters that may be measured include the water table or phreatic surface. The water table may be determined for each compacted zone lift. In some scenarios, sufficient compaction, draining and drying are performed such that the water table level is at least 2 meters below the top surface of the compacted zone. The drainage system aids in drawing down the water table. Additional measurement devices may be included in the sand dump operation, such as movement detectors and/or water pressure detectors to detect changes in pore water pressure.

It has been found that the compaction time and draining time have an impact on achieving non-liquifiable properties of the compacted zone.

Referring to Figs 2 and 6, there are side buttresses 66 on either side of the beaching area 46 and a downstream dyke 68 enclosing the TFT collection basin 52. In some
implementations, the beaching area 46 is provided in an in-pit mining location and the
downstream dyke 68 and/or side buttresses 66 may be at least partly made of existing
pit walls. As the sand landform elevates and fills the pit, the TFT pond and the starter
dyke are also raised in elevation.

The sand landform can be built up vertically to a high elevation, backfilling the mine pit
with sand and some fines from extraction tailings. In order to maintain geotechnical
integrity for such massive sand structures, the sand dumps are properly drained,
compacted and buttressed.

Various implementations and optional techniques related to the sand dump operation will
be described in further detail below.

**Drainage system**

In some implementations, as illustrated in Fig 2, the drainage system 60 includes a set
of basal drains 70 that may be provided running in a generally longitudinal orientation
with respect to the length of the beaching area. The basal drains 70 may be configured
to have a slope that is generally opposite to the slope of the beaching area. For
instance, the set of basal drains 70 may be installed sloping at about 0.5% grade or
about 1% grade toward the starter dyke 44 to collect seepage water and channel the
water for collection.

In addition, the existing mine pit bottom may be modified to build an engineered pond
bottom 72 sloping at about 1% grade from starter dyke 44 to the TFT collection basin 52.
The engineered pond bottom may be a graded area having a 1% slope and made of
material that will not be carried or washed away due to the flow of the water toward the
TFT collection basin. The sloped engineered pond bottom 72 facilitates positive drainage
at the initial discharge to avoid water pooling against the starter dyke 44 to help avoid
building beach below water next to the dyke.

The engineered pond bottom 72 may be provided above the drainage system 60 and
they may be spaced apart by an interval. The interval may be provided to allow hydraulic
communication between the engineered pond bottom 72 and drainage system 60 and
may be composed of materials to provide transition toward the basal drains 70. In some
scenarios, the interval may include an upper layer including tailings sand for filtering out
fines, an intermediate layer including porous material that may be called transition sand, a gravel or rocks layer and finally perforated piping as basal drains 70 for collecting the drainage water and channeling it toward the starter dyke 44.

Still referring to Fig 2, the drainage system 60 may also include collector drains 74 that may be configured in generally transverse relation to the basal drains 70 and communicate with the basal drains 70. The collector drains 74 enable the basal drains 70 to be interconnected such that if one of the basal drains 70 becomes clogged the water can flow through one of the collector drains to join another basal drain 70. This facilitates robust drainage of the water and removal from below the beaching area 46. The basal drains and the collector drains facilitate compaction and geotechnical stability in the beach area. The drainage system 60 may also include a main collection zone 76 communicating with at least some of the basal drains 70 and including gravel pads 78 into which the basal drains 70 discharge the drainage water. The gravel pads 78 are interconnected to allow water to fluidly communicate between them. The basal drains, collector drains and/or main collection zone may be constructed using a variety of materials, for example gravel or wash rock, and may also include transition materials for hydraulic connection with overlying zones.

Turning now to Figs 2, 4, 5 and 9 to 11, the beaching area may be sub-divided into multiple sections, each of which is divided into multiple panels, which in turn are divided into multiple cells. Fig 2 shows two sections, each having three panels, and each panel having four cells, while the other Figs show four sections with a similar panel and cell configuration to Fig 2. It should be understood that various other arrangements and number of panels per section and cell per panel may be used. More regarding the sub-division of the beaching area and its operation will be discussed further below.

Referring back to Fig 2, in some implementations there may be a plurality of interconnected gravel pads 78 that may be arranged one per beaching panel. For example, when there are twelve panels as illustrated in Figs 4, 5 and 9 to 11, there may be twelve gravel pads. The gravel pads may fluidly communicate by means of interconnecting conduits and/or gravel trenches. Alternatively, there may be fewer gravel pads that are interconnected or a single gravel pad that extends the entire length of the multiple panels.
Fig 2 illustrates one basal drain 70 per cell, but the basal drains may be arranged in various other configurations. For example, there may be a basal drain 70 every 100m, while the cells are about 65m wide, thereby providing an uneven distribution of basal drains 70 compared to the cell arrangement.

The basal drains 70 may also extend down the beaching area to various lengths. For example, the basal drains 70 may extend below the compacted zone 59 that extends from the starter dyke a certain distance toward the TFT collection basin. The drainage system 60 may end at or just past the compacted zone 59. The drainage water that drains in the non-compacted zone can flow toward and be collected in the TFT collection basin 52 to form part of the TFT.

Referring to Figs 2 and 3, the well arrangement 62 may be provided to retrieve drainage water from the gravel pads 78 of the drainage system 60. The well arrangement 62 may include various vertical wells 80 that are drilled into respective gravel pads 78. These wells 80 may be associated with pumps and connected to each other through a set of common collectors for pumping the water back over the starter dyke 44 and back into a water collection area.

After laying down a number of compacted lifts, a secondary drainage system may be installed and may substantially resemble the bottom drainage system that is illustrated in the Figures, although a secondary drainage system would be stepped further into the beach and closer to the TFT collection basin and would thus be shorter. The secondary drains may be built every 20 meters in elevation and may include laying perforation piping transversely across the beaching area and including headers to collect the water from such perforated piping. The secondary drains may be provided so as to remove water from the upper face of the compacted zones to facilitate construction, and need not be designed for providing increased strength for the overall structure.

**Beaching area sub-division and operation**

The sand dump operation provides a sand structure derived from extraction tailings that may be built at a high rate of rise, particularly in the event of high and continuous flow rates of extraction tailings.
In some instances, providing a beaching area that is sub-divided into multiple areas can facilitate high throughput of extraction tailings.

Referring to Fig 4, in some implementations the beaching area 46 includes multiple sections 82 each of which includes multiple panels 84 that, in turn, each include multiple cells 86. In Fig 4, there are four sections, each including three panels, and each panel includes four cells. It should be mentioned that the beaching area 46 may include different numbers of sections, panels and cells.

Figs 4, 5 and 9 to 11 also indicate some optional widths of the sections. It should be understood that the sections 82, panels 84 and cells 86 may be configured to have a variety of different widths. For example, each cell 86 may have a width between about 20m to 70m and each panel 84 may have a width between about 40m to about 420m depending the number of cells 86 per panel and the width of each cell 86. The width of a given panel 84 may be considered as the sum of the widths of the cells 86 in that panel. The sections 82 may each have a width of about 120m to about 1000m, again depending on the number and width of the panels 84 and cells 86 within the sections 82. In some implementations, the dimensions of the sections 82, panels 84 and cells 86 may be adapted to the constraints of a given in-pit location that is suitable for building an elevated sand structure.

In some implementations, the width and number of the sections, panels and cells is determined based on the dimensions of an existing dyke and/or mine pit that will be used for the sand dump location. Mine pits may have a variety of forms suitable for such sand dump operations. The width of the cells may be sufficiently small to facilitate deposition of the tailings, as larger cell widths can lead to challenges in flowing tailings in a controlled manner.

The beaching area and its associated sub-divisions may have a variety of different lengths. In one scenario, the length of the beaching area may be between about 500m and about 1500m, or from about 750m to about 1250 km, for example. In some scenarios, the compacted zone may have a length sufficient to provide required geotechnical stability to the upstream dyke. For example, the compacted zone may have a length of at least 10%, 20%, 25% or 30% of the total initial length of the beaching area. For a beaching area of about 1 km, the compacted zone may be at least 100m, although
it may be 250m or 300m to ensure greater geotechnical strength. The length may depend on the slope of the beaching area, the composition and flow rate of the deposited extraction tailings, the compaction properties of the compacted lifts, the size of the compacted zone, the geotechnical properties of the upstream dyke, among other factors.

In some scenarios, the compacted zones are dimensioned in accordance with the qualities of available material for use as buttressing. For example, shorter compacted zones leads to more buttress materials required for construction of the buttress (see character 66 of Fig 7). In one example, compacted zones of about 100m lead to a buttress 66 reaching about 385 meters in elevation, whereas compacted zones of about 250 meters lead to a buttress 66 reaching about 365 meters. The 20 meters difference in elevation corresponds to a massive quantity of material that would be required for the higher buttress, such that the mining activities may not be able to easily furnish the required buttress material (e.g. made from overburden). Thus, the dimensions of the compacted zones may be tailored or adjusted in accordance with the availability of overburden material and the mining plan.

In addition, the dimensions of the compacted zones may change at different elevations. For example, the compacted zone may initially be about 250 meters to about 300 meters long, and at later stages of the sand dump construction the compacted zones may be extended to about 500 meters. The lengthening of the compacted zones may be done in order to increase the strength of the structure and may be adjusted depending on availability of buttress material. The use of sand for providing strength and stability to the structure may also be preferred at certain stages of construction due to its relatively lower cost compared to other types of material such as dirt.

The length of the beaching area also has an influence on the fines capture in the sand dump. Longer beaching will tend to lead to greater fines capture in the sand structure.

The extraction tailings may include about 35 wt% to about 60 wt% solids, of which about 10 wt% to about 20 wt% is fines and about 80 wt% to about 90 wt% is coarse sand on a per solids basis. The rest of the extraction tailings include mainly water with some residual bitumen.
In some scenarios, the compacted zone receives at least 40 wt%, 50 wt% or 60 wt% of the sand contained in the extraction tailings. The remaining sand may be captured in the rest of the sand dump operation, in the non-compacted zone and the TFT collection basin. The compacted zone may also receive at least 40 wt%, 50 wt%, 60 wt% or 65 wt% of the fines contained in the extraction tailings. The remaining fines may report to the non-compacted zone and the TFT collection basin.

In an example with a beaching area of about 1 km and a compacted zone of about 250m to about 300m, about 65 wt% of the fines were captured in the overall sand dump including the compacted zone, the non-compacted zone and the TFT collection basin, and the remaining fines were send with the TFT stream to the maturation pond.

In general, shorter beaching areas lead to lower fines capture. Shorter beaches may also result in more of the coarse sand material to be carried to the TFT collection basin, and thus the tailings supply and deposition characteristics may be coordinated with the length and management of the beaching area.

The quantity of fines, coarse sand and water that report to the different parts of the sand dump may also be modified using overboards, which can be operated periodically to discharge the extraction tailings directly into the non-compacted zone.

The sand dumping process may include multiple phases. The phases will be described below in relation to an example sand dump implementation having the following example features with reference to Figs 4 and 5:

2.6km wide starter dyke;

1km long engineered pond bottom maintaining a 1% slope;

4 beach sections, each section of 645m width;

3 panels per section, each panel of 216m width; and

4 cells per panel, each cell of 54m width.

The deposition procedure into the various parts of the beaching area 46 may be divided into different phases, each phase including the deposition of extraction tailings 22 into some of the panels 84 while other panels 84 do not receive extraction tailings. In
addition, the extraction tailings 22 may be supplied from one or more tailings sources. Fig 4 illustrates the scenario where there are two tailings sources I and II which may be two different extraction facilities.

Referring to Fig 4, in phase 1 four lines 88a, 88b, 88c, 88d deposit extraction tailings 22 into the sand dump, with one section 82 devoted to each line. The dark lines indicate lines that are depositing extraction tailings 22. During phase 1, the extraction tailings supply lines 88 may run down a drop in elevation (e.g. of about 45m) over a few hundred meters distance, which can be seen as occurring down a descending ramp 89 in Fig 6. Starting from the original ground elevation (e.g. of about 350m), the extraction tailings 22 run down the ramp 89 eventually reaching the starter dyke 44 elevation (e.g. of about 285m), and may start discharging at an elevation of about 280m. Each tailings line 88 may be configured to discharge at varying lengths within its planned construction section on the starter dyke 44. The length of discharge may vary, for example, from a few meters to several hundred meters (e.g. 900m from the landing point on the starter dyke, which includes 650m panel width in addition to 250m of compacted beach for the longest line section in one example). In Fig 4, one of three lines from source I is discharging at lengths varying from 750m to 1650m from the landing point on the starter dyke 44.

In some implementations of phase 1, it may take approximately 30 days to build one 5m high, 250m long and 217m wide panel 84 with approximately 60% fines capture, which is the amount of sand retained in the cell divided by the total sand supplied from the tailings line. It should be understood that the time to build a lift in a panel 84 may vary depending on a number of factors, such as lift height, panel and cell width and length, tailings flow rates and composition, and so on. In one example, 30 days is taken as an approximate time for building a lift in a panel and has been coordinated with the number of panels and the compaction and draining time that is provided to obtain the dewatered lift. Once a panel 84 is complete, the lines 88 switch to the next panel allowing drainage to the first panel. Since the extraction facility will typically operate in continuous production, line configurations and maintenance may be provided to minimize the amount of discharge out of the cells needed during the installation of switches in the subsequent panels.

Referring to Fig 5, in phase 2 six lines deposit into the sand dump, where two panels 84 are devoted to each line 88. Phase 2 may be referred to as a steady state operation
where two beach sections 82 are built in a generally simultaneous fashion, one from the source I tailings lines 88a, 88b, 88c and the other from source II tailings lines 88d, 88e, 88f. In some implementations, it may take approximately 6 weeks to build sections 1 and 4, and then another 6 weeks to build sections 2 and 3. During the period when sections 1 and 4 are drying, preparation work for the next 5m lift can be undertaken on those sections. This preparation work includes items such as installation of lines and switches, and possibly the installation of secondary drains. Secondary drains may be laid down, if required, every four lifts (e.g. 20m in elevation). Corresponding pumping wells may be provided for the secondary drainage system.

Regarding the beach construction in phase 2, every fourth lift may have a 30m wide tailings corridor, such that the tailings supply piping can be moved up to the new tailings pipe corridor every fourth lift. Fig 7 illustrates that every fourth lift has a longer step-in for the compacted beach region. As soon as the tailings corridor moves to the higher elevation in sections 1 and 4, the basal water pumping wells 80 in the corresponding gravel pads 78 can be removed and placement of overburden buttress can commence to build up the corresponding section of the starter dyke 44. The pumping wells 80 may be drilled into newly constructed buttress. Once pumping wells 80 are in place in sections 1 and 4, the wells from sections 2 and 3 can be removed, buttress material may be placed in in the corresponding sections of the starter dyke 44, and the wells 80 can then be re-drilled in those sections. The gravel pads 78 may be interconnected so that while some of the pumping wells 80 are removed, the remaining wells 80 in other sections can stay operational to maintain removal of drainage water from the drainage system 60.

Referring to Fig 7, as subsequent lifts are laid and compacted, the elevation of the compacted zone rises. The lifts are also stepped into the beach, which means that subsequent lifts are deposited further and further downstream. This stepping in of subsequent lifts and the compacted zone produces a compacted beach region overlaying a non-compactcd beach region. Fig 7 illustrates the general configuration of the sand structure where the compacted beach region has various notches, resulting from the stepping in of the tailings deposition and the compaction. Each notch represents a lift. The notches occur in a series of three notches with a small plateau followed by one notch with a longer plateau. The first three lifts each involve a short step-in, while the fourth lift involves a longer step-in to provide the tailings pipe corridor.
Each lift provides a slope of about 2H:1V, while the overall slope of the four lifts is about 4H:1V. When the tailings supply piping is moved from a lower to a new higher corridor, the descending ramp 89 (illustrated in Fig 6) may be re-configured since the tailings supply pipeline no longer needs to descend to such a low elevation. Thus, every four lifts, the descending ramp and the corresponding tailings piping can be reconfigured for the new elevation at which the extraction tailings will be deposited. In addition, once all of the tailings supply piping is relocated to the higher corridor, backfilling behind the dyke can occur to provide stability. The initial backfill may be the waste spec buttress 87, and the subsequent backfill may be G-Spec.

Referring still to Fig 7, the sand dump structure may include a liquifiable tailings material (e.g. illustrated as the non-compact region) that is enclosed by mine pit walls (not illustrated here) and an overlying non-liquifiable tailings material (e.g. illustrated as the compacted region).

Phase 3 may be implemented once the starter dyke 44 is built to a similar elevation as the surrounding buttresses and dykes 66, 68, which may include surrounding pit walls. At this point, the extraction tailings deposition can encircle the in-pit sand dump structure, thus releasing some of the pressure of working in such a confined and congested area as an in-pit location.

In some implementations, when depositing extraction tailings 22 into a given panel 84, all of the cells 86 in the panel 84 may be built in parallel, either using a single tailings line 88 per panel as in Fig 5 or using a tailings line 88 for every two panels as in Fig 4. In some implementations, the deposition of extraction tailings 22 from a given tailings line 88 may be switched from one cell 86 to another frequently in order to build up the lift in the panel 84.

In terms of timing, the process may be conducted such that construction of the first lift in all four beach sections across the dyke may take approximately 90 days for a lift of about 5m. Deposition in the first panel of each section may begin on day 1 and complete on day 30. By the time the third panel of each section completes (on day 90), the first panel would have been draining for 60 days and is ready to receive a subsequent lift.

In some implementations, the initial stages of the tailings deposition may occur in low elevation in-pit location and the pipeline that supplies the extraction tailings drop
significantly in elevation over a short distance to reach the starter dyke. For example, the drop may be about 45m or more depending on the depth of the in-pit location. Such a rapid drop in elevation with little resistance can cause the fluid velocity of the tailings to increase such that high energy discharge from the lines could result in operational challenges, such as beach erosion and difficulty in beach construction, among others. To regulate the discharge velocity at various elevations and lengths, a combination of varying lengths of resistance piping and by-passes may be provided, as will be discussed further below.

Deposition from a given line may occur in a single cell at a time. As sand is deposited into a cell, bulldozers may be provided to maintain the construction of side dykes between adjacent cells and accelerate compaction through track-packing. The cells may be divided into compacted and non-compacted zones during construction. The compacted zones may be sloped beaches that may be about 250-300m long, where dozers push tailings material to construct dykes and track-pack the material to help release water. Regarding the relationship of the TFT collection basin 52 and the beaching area 46, the beach above water may be about 1 km long, of which about 250-300m may be the compacted zone 59.

A panel may be deemed complete once a target lift height of the compacted zone has been reached for each of the cells in that panel. The lift heights may be between about 2m and about 8m, between about 4m and about 6m, or, as in one example, about 5m. The sand dump structure may be designed and operated to rise about 20m in height each year or complete a 5m lift across all four sections every three months. The compacted zone length may be provided to co-ordinate with the lift height and buttress construction. The non-compacted zones may be designed to have zero geotechnical stability, no dozer activity, and tailings may be deposited through overboards, which are lines that deposit the extraction tailings into the non-compacted zone of the beaching area. An overboard line may be provided for each incoming tailings line 88. The overboard lines may be used for various reasons, such as when no activity such as compaction is occurring in the beaching area. The water within the compacted zone either travels to the TFT pond through dozer track-packing or is sent via the drainage system to the pumping wells. The drainage water may then be pumped to a separate water storage area, into the non-compacted zone to flow down to the TFT collection basin or directly into the basin.
TFT collection and handling

In some implementations, the sand dump operation may be provided to store a maximum amount of sand as beach above water while keeping the amount of fluids in the collection basin to a minimum for operation of the barges. TFT released from hydraulically placed sand beaches is collected in the relatively small TFT collection basin at the toe of the sand lifts.

In some implementations, the TFT collection basin may be restricted in terms of volume and elevation fluctuations. The TFT collection basin may also be operated at a density of about 1.1 SG or below, which may typically be around 1.04 SG. The volume of the TFT collection basin may be limited to a maximum of about 3Mm³, while its elevation may be restricted to about +2m to -1m per week by geotechnical design. These elevation fluctuation limits provide geotechnical stability that the hydrostatic pressure of the water provides to the non-compacted zone that is proximate the TFT collection basin. Should the collection basin level decrease too rapidly, the unstable material, or beach below water (BBW) could slough into the collection basin, decreasing basin capacity. This sloughing can also flatten the BBW slopes, which were designed at about 6%.

Referring to Fig 3, both the level and depth of the TFT collection basin 52 can be controlled by controlling the flow rate at which the TFT is retrieved from the basin 52, for example by adjusting pump speed. The TFT may be pumped to a larger water pond (e.g. used for MFT maturation) using a retrieval apparatus 54 that may include a set of three independent trains of barges. Two of the barge systems are configured to be capable of handling average flow rates required to maintain the designed fluid volumes in the TFT collection basin 52, while the third may be provided to support maintenance outages and unusual rainfall events. Each barge 54 may be equipped with a GPS level transmitter that can allow the collection basin elevation to be monitored. The depth may be monitored by a plunge level transmitter and may be monitored to prevent the suction pipes 91 extending from the barges from plugging with coarse material. The suction pipes 91 may be attached to an adjustable ladder, and controlled through a winch, should the level of coarse solids within the basin 52 approach the suction intake. The retrieval apparatus may be configured to have a capacity to quickly draw down the TFT collection basin 52. Nevertheless, the rate of draw down may be controlled and held in check, as overly rapid draw down could cause sloughing of the beach and potentially creating large disruptive waves and/or sanding in the barge lines.
The barges may each have one or more pumps. Gland seal water for the TFT barge pumps may be supplied from three separate lines, mounted on a floating walkway and/or floating in the TFT collection basin. In some scenarios, the slurry from the TFT collection basin may be treated to obtain acceptable gland seal water, although water may be provided from another source.

During the winter season in some locations such as northern Alberta, Canada, the water temperature of the discharge streams coming from the tailings lines may be close to the freezing point upon reaching the TFT collection basin 52. To offset this, the TFT lines that supply the TFT to the larger water pond may be heated, e.g. by providing heat tracing and/or insulation, to keep them from freezing. Maintaining access to the barges through the winter for consistent barge operation may be facilitated by various methods. A channel may be kept open to access the barges year round. A bubbler system may also be used to avoid freezing in certain locations of the TFT collection basin, e.g. proximate to catwalks and the barges. It has nevertheless been found that even at relatively cold temperatures the TFT collection basin may operate at about 9°C near the top, and thus heating may not be required for various situations.

Together with the beaching area 46 of the sand dump, the elevation of the TFT collection basin 52 may rise about 20 m per year. The initial in-pit TFT pipe corridor may be provided a rising grade from the TFT collection basin out of the mine pit and toward a larger pond. This initial TFT pipe corridor may last until the TFT collection basin elevation reaches about 10 m below the elevation of surrounding dykes and buttresses, e.g. 320 m in an example case. In order to maintain the pipelines to the barges as the TFT collection basin 52 and the beaching area 46 rise, the TFT corridor may be raised as well. Referring to Fig 15a to 15d, the initial tailings corridor 85 that is adequate as the TFT collection basin 52 is at lower elevations (Figs 15a to 15c) may eventually become too low for containment of the TFT as the elevation increases and thus a new TFT pipe corridor 83 may be built at a higher elevation (Fig 15d). For example, the new TFT corridor 83 may be built about 5 m higher than the existing one. A set of new pipelines can be laid out in the new TFT corridor 83 and connected to the barges. Pipelines from the previous corridor 85 may be removed, the corridor 85 may be raised 10 m high (which makes it 5 m higher than other corridor 83) and the pipelines may be reinstalled. Such a sequenced elevating of two TFT corridors 83, 85 and their alternate use may be implemented throughout operational life of the sand dump operation. Two sets of
corridors may be built side by side so that at any given time one is in operation and the other is under construction.

**Geotechnical design and dyke construction**

Referring to Fig 6, in some implementations the starter dyke 44 may be constructed starting from the mine pit bottom and using overburden spec material. The starter dyke 44 may have an approximate 2H:1V initial slope. During the process as the beaching area 46 rises, the starter dyke 44 may be constructed with sand through upstream cell construction to eventually reach the same elevation as the surrounding buttresses and/or dykes, which may include mine pit walls, at which point upstream cell construction may continue all around the initial in-pit sand structure. It should be understood that the starter dyke 44 may have various other constructions and configurations.

In one example, the starter dyke 44 may be about 2.6km long and may be the sole recipient of sand deposition for the first years of the sand dump operation. The starter dyke 44 may be designed to rise at an overall slope of about 4H:1V, as shown in Fig 7, to enhance sand storage in the structure. The dyke may be constructed in repeated 5m lifts with a step-over cell construction. The first three 5m lifts may be set at 10m step over and the fourth lift at 30m step over to accommodate a tailings line corridor.

The surrounding dykes and buttresses may be constructed with B-Spec material, which is a blend of low to medium plastic clay tills, lean oil sands, gravel and high fines sandy tills; K-Spec, which is high plastic Clearwater or Clearwater derived till material, blended with low plasticity materials (tills and lean oil sands); and overburden material, to a 330m elevation at a slope of 7H:1V.

In an example, at full production between about 85Mm³ and about 88Mm³ of sand may be hydraulically deposited into the sand dump. The sand deposition may begin at 275m elevation off the starter dyke 44 and the dump may rise at the rate of about 20m per year.

Referring to Fig 7, for geotechnical considerations the sand dump operation may include a waste dump buttress 87 downstream of the dyke crest at an overall slope of 7H:1V for support of the starter dyke 44. The waste dump buttress 87 may be built with waste
called G-Spec, which is low shear strength, high moisture content Pleistocene silts, sands and clayey tills, and may be referred to as the G-Spec buttress 87. It may also be built with other materials. Rate of rise and sequence of construction of the waste dump buttress 87 may be done to match the starter dyke 44. The waste dump buttress 87 may stay within a 50m maximum height differential of the starter dyke crest.

Referring now to Fig 8, the pumping wells 80 may be removed in an area where the G-Spec buttress 87 is sequenced for construction and re-drilled upon completion. As the gravel pads 78 of the drainage system 60 are inter-connected, impact on dyke drainage during buttress construction can be reduced or avoided. Fig 8 illustrates the sequence of buttress construction and drilling of pumping wells 80.

Referring to Fig 7, for further geotechnical considerations the compacted sand beach region is provided downstream from the starter dyke crest to provide added strength to the dyke structure. If the strength and length of compacted beach region is sufficient, the elevation difference between the starter dyke crest and the G-Spec buttress may be increased.

In some implementations, the rate of rise of the beaching area 46 is balanced against allowing sufficient time for drainage from the lifts while maintaining stability during the placement of saturated sand. In one example, a minimum drainage time of 30 days for a lift before placement of the next lift. A construction sequence including deposition, compaction and draining stages having sufficient time intervals may be implemented to ensure that the lifts are allowed sufficient time for drainage before the subsequent lift is placed. Figs 10 and 12 illustrate example deposition and draining schedules for multi-panel arrangements.

**Extraction tailings transport and deposition system**

Referring to Figs 4, 5 and 11, the sand dump operation may also include a tailings supply system 90 that is configured and operated to handle high throughput of the extraction tailings, which may also undergo a notable drop in elevation upstream of the deposition location.

The tailings supply system 90 may include a dyke pipe 92 that may be a straight pipe extending along the starter dyke 44, laterals branching off of the dyke pipe 92, switching
valves installed on pedestal points for switching the deposition to the desired outlet, and nipple pipes that discharge onto the beach. Various other tailings supply system 90 arrangements may also be provided for transporting the extraction tailings to various deposition locations of the beaching area. The deposition locations may include a series of locations along the starter dyke for deposition in a generally co-directional manner from each location, and may also include one or more other locations around the sides of the sections.

*Back Pressure Control System*

Referring to Fig 5, during steady state operation the extraction tailings may be transported via six pipelines to the deposition areas. The various lines of the tailings supply system 90 may be polymer lined carbon steel pipes (lined with a urethane-based compound such as Iracore™ lined carbon steel pipes), carbon steel pipes and polymer lined resistance piping. Lining such as Iracore™ lining may be used to extend the life of the piping compared to that of carbon steel. The carbon steel lining may be used around deposition areas where wear is less of a concern.

Referring to Fig 11, a back pressure control system 94 may be provided to limit or prevent open-channel and/or unsteady flow in the lines of the tailings supply system 90, particularly on the descending ramp 89 into the sand dump area. Open-channel or slug flow in the lines could result in a column rejoinder effect that poses a risk to equipment integrity through pipe movement. The back pressure control system 94 may be provided to limit or prevent open-channel and/or slug flow by maintaining positive pressure and full-pipe flow throughout the lines for normal operating conditions, which may include turndown and peak flow/desanding.

Referring still to Fig 11, the back pressure control system 94 may include smaller inner diameter resistance pipe 96 and larger diameter bypass piping 98, with pressure indication provided to allow controlled dilution water addition, if desired. Dilution water may be added to the extraction tailings to further reduce open-channel flow and may be done near the extraction operation.

For each beach section, the length of the resistance pipe 96 may be different and may also change with deposition elevation. By using a certain length of smaller inner diameter piping, the higher pressure gradient of this resistance piping 96 can provide
sufficient backpressure to eliminate slug flow and pressure transients within the pipeline. The bypass piping 98 station may include one or multiple bypass lines 100, 102 and double block-and-bleed switching valves, which allows flow to be diverted from the resistance pipe 96 to a parallel bypass line via switching valves. Some of the valves are illustrated in Figs 4 and 5.

In operation, depending on the distance for the extraction tailings 22 to travel to the given panel 84, the appropriate bypass line 100, 102 may be used. For example, referring to Fig 11, when depositing into close panel C location, the bypass piping 98 may be avoided to allow the tailings to flow through the entire length of resistance piping 96 to provide sufficient back pressure. When depositing in the furthest away panel A location, the longest bypass line 100 may be used to minimize the passage of the tailings through the resistance piping 96. When depositing in intermediate panel locations, such as panel B or the near location of panel A, an intermediate bypass line 102 may be used so that the tailings can pass through a portion of the resistance piping 96.

When sufficient sand has been deposited in a panel for a given lift height (e.g. 5m lift), the panel may be allowed to dry for a 30 day period and active deposition switches to a different location. When it is time to move back into a dried beach section, the laterals and switching valves may be relocated to new pedestals on the next 5m lift and deposition can resume. The beaching area elevation may rise at a rate of 20 m/year and a portion of the resistance piping can be removed for each new lift to control pressure transients and alleviate losses in horsepower from tailings supply pumps.

Pressure Vacuum Relief Valve (PVRV)

Pressure vacuum relief valves (PVRVs) may be provided for pipelines transporting extraction tailings from the tailings sources and those lines transferring TFT from the TFT collection basin 52. The PVRVs may be located at high points, where a low pressure point may exist in the line. Each PVRV is a combined vacuum breaker and air release valve. The PVRV allows for air intake during line drainage and facilitates that the given pipeline maintains a positive pressure during operation. The PVRV also allows for the discharge of entrained air that may collect at the pipeline high points during line
filling and when recovering to normal flow from below minimum flow, in order to prevent transients.

**Deposition deceleration**

In some implementations, the initial flow of the extraction tailings 22 deposited down the starter dyke 44 may be decelerated to reduce or prevent beach erosion and/or the tendency for the tailings to flow down into the TFT collection basin 52 with insufficient settling of the sand. Decelerating the flow of the tailings at the initial region of the sloped beaching area can promote sand to settle out of the decelerated flow of the tailings that flow down the main section of the beaching area prior to flowing into the collection basin 52.

Referring to Fig 9, the deceleration may be provided by spill box systems 104 at an upstream region of the sloped beaching area 46. There may be a spill box system 104 for each panel. Each spill box system 104 may include a barrier wall extending upward from the surface of the beaching area 46. The flow of extraction tailings down the relatively steep starter dyke encounters the barrier and accumulates until the tailings spill over an upper edge of the barrier wall, thereby producing a decelerated tailings overflow that advances down the main section of the beaching area 46 at a rate that allows sufficient settling of the sand.

In some implementations, spill box system may include a weir that is wedged into the beach at the far end of the compacted zone. The weir may be held in place by piles of sand of other material that are provided at either side of the weir. The weir may be about 3m wide and may act as a small dam. The weirs may be installed on a cell by cell basis, as needed. Once the deposition is complete in a given cell, the weir may be substantial covered with the lift, and a loader may be used to pull the weir upward and then reinstall it by placing piles of material at either side. The weirs can thus be reused for subsequent lifts.

**Sand dump geothermal exchange system**

Referring to Fig 16, in some implementations, a geothermal exchange system 110 may be provided within the sand structure in order to overcome some challenges in heat recovery.
In extraction and upgrading operations, low-grade process waste heat and excess fuel gas are frequently available in certain areas of the operation (e.g. upgrading), though timing of these surpluses frequently does not align with hot water and steam demands in other areas of the operation (e.g. extraction). Upgrading and other processes typically produce excess heat and fuel gas during summer when demands for hot water, especially in extraction, are at a minimum; though in winter when extraction's hot water demands and other uses of heat are at a maximum, there may be a shortage of hot water and less waste heat to recover.

Bitumen production may be hot water limited in winter, so an increase in winter hot water availability may increase bitumen production. Also, the ability to store excess heat during a surplus (typically in summer) and use it later during hot water shortages in winter, would decrease overall energy intensity and emissions intensity.

The sand dump structure described above may be leveraged in order to provide geothermal heat exchange opportunities, for example between extraction and upgrading operations or between various different units within a given mining and extraction operation. The large volume of sand deposited to form sand dump structure provides a geothermal heat storage potential of the sand structure and underlying ground. These sand dumps, once completed, may for example be in excess of 100 m high.

Geothermal heat exchange would enable storing surplus heat for later use, using the heat storage capacity of the sand dump structure. When surplus heat is available in the form of hot water, it may be circulated through an underground closed loop (e.g. constructed using pipes), heating the sand dump material. During times when heat and hot water are in short supply (typically in winter), cold fluid (e.g. glycol or water) may be circulated through this same closed loop and is thereby pre-heated. This pre-heating can reduce heating loads and allowing a greater volume of hot water to be produced.

Traditional geothermal heat exchange projects use multiple wells, typically drilled 30 m or deeper, with pipes then inserted in the well, and cemented in place with a heat-conducting grout. The drilling of these wells is generally the stumbling block for geothermal exchange projects as the costs of drilling and piping tend to be very expensive, and ultimately make the project uneconomic.
The sand dump operation enables a geothermal piping network 112 to be installed by laying pipes on the engineered pond bottom beneath a the beaching area, or potentially installed in portions of active beach during SD8 operation post-startup. During times of excess heat, hot water (for example, from the process effluent water system, or from boilers fuelled by excess refinery fuel gas) can be circulated through these pipes, heating the surrounding sand material, which acts as a storage medium. During times when hot water is needed, the system can be reversed, and used to pre-heat water being sent to extraction, the process effluent water system or other processes.

_Tailing management and integration of sand dump with MFT maturation and dewatering operations_

In some implementations, the sand dump operation enables extraction tailings to be deposited into in-pit beaching areas initially enclosed by overburden starter berms. As the extraction tailings are continuously discharged, the coarse sand settles out to form beaches which are sequentially raised over time and continuously removing fluids to form a solid sand structure.

As discussed above, the water and fines released from segregating tailings is collected in a small collection basin as TFT (typically about 5 wt% to about 10 wt% solids) within the sand dump area and is then transferred to a larger settling pond for maturation to form MFT (about 30% solids by weight). After maturation, MFT may be subjected to MFT drying processes, which may be operated independently of ongoing sand dump beaching operations.

In the larger settling pond, water may be retrieved and transferred to other ponds involved in a tailings water management system, and the water may eventually be recycled back to the extraction operation as process effluent water, for example.

Referring to Figs 13 and 14, tailings management techniques will be described. The tailings management techniques include the pre-conditioning of extraction tailings 22 to substantially reduce or remove the coarse sand in a sand structure and produce a TFT stream 30 that is supplied to a water and fines management system 114 to treat the remaining fines in the tailings from which sand has been removed.

Referring to Fig 13, the tailings management system may be integrated with various aspects of the mining operation. The mining operation 12 includes removal of
overburden 118 and other material from the formation that may not meet specifications for processing as ore in the extraction operation 16. In addition, the mining operation 12 creates mine pits 120 where material has been removed. An example mine pit is illustrated in Fig 6. Returning to Fig 12, the mine pit 120 may be used as a location for the sand dump operation 24, which may also be referred to as a sand removal or separation operation.

Referring to Figs 14, the extraction tailings 22, which may be derived from multiple extraction facilities 16a, 16b, are provided to at least one of the sand dump operations 24a. It should be noted that there may be more than one sand dump operation 24a, 24b, 24c, that may have similar configurations and may be used in parallel. Each sand dump may be sized and configured in accordance with the given mine pit in which it is located. In some scenarios, one sand dump 24a may be operated until the beaching area is close to the top of the mine pit, at which point the extraction tailings supply to the first sand dump 24a may decrease and a second sand dump 24b may begin operation. In this manner, mine pits that are generated by the mining operation may be backfilled with the coarse sand material of the formation after that has been subjected to extraction. Each sand dump operation 24 includes a main beaching area 46 where the coarse sand is captured along with a portion of the fines in the extraction tailings 22, and a downstream TFT collection area, which may take the form of a small pond or basin. The TFT can then be retrieved from the TFT basin 52 and supplied to the next stage of the tailings management system.

Referring to Fig 13, the TFT stream 30 includes mostly water and typically between about 5 wt% and about 10 wt% solids, substantially all of which are fine solids below 44 microns. The TFT stream is supplied to the water and fines management system 114.

Referring now to Fig 14, the water and tailings management system may include at least one pond 116 that receives the TFT stream 30 and allows settling of the fines. This pond may be referred to as a maturation pond 116, because the fines settle to form layers of material having different fines content. The maturation pond 116 includes a top free water layer 122 as well as subsequent layers 124, 126, 128 that have increasing fines content. The lower layer 128 of the maturation pond may have a fines content of about 25 wt% to about 35 wt%, and may generally be referred to as MFT. Depending on the previous use and history of the maturation pond 116, there may be a bottom sand layer; however, this sand layer would not increase in elevation as rapidly as in conventionally
tailings ponds, since the TFT stream 30 entering the maturation pond has substantially no coarse sand that would settle rapidly to the bottom. The bottom of the maturation pond may rise at a very slow rate due to slow settling of fines. The other intermediate layers 124, 126 may have other solids content ranges, such as between about 1 wt% and about 10 wt% for layer 124 and between about 10 wt% and about 25 wt% for layer 126.

Referring to Figs 13 and 14, the free water of the maturation pond 116 may be retrieved as recycled free water 130 back into the extraction operation. In some scenarios, the maturation pond is thus also used as a water storage pond from which recycle water can be obtained for various uses.

Referring to Fig 14, in another scenario, at least a portion of the free water layer 122 of the maturation pond 116 may be retrieved and supplied to a second pond 132, which may be referred to as a water storage pond. The amount of transferred water 134 that is fed to the water storage pond 132 may be controlled based on the capacity in the maturation pond 116 and the requirements of recycle water in the extraction operation. The water storage pond 132 may also be provided with pumps and piping in order to retrieve and provide recycle water 136 to the extraction operation. It should be understood that the water and fines management system may include one or more maturation ponds 116, and optionally one or more additional holding ponds where water may be held prior to recycling.

Referring still to Fig 14, an MFT stream 34 may be retrieved from the lower MFT layer 128 of the maturation pond 116 and supplied to the MFT dewatering and drying operation 36. The MFT stream may be retrieved so as to have desired solids content, e.g. around 30 wt%, which may be the highest solids content of the fines containing layers in the maturation pond 116. The MFT stream 34 may be pre-treated in one or more pre-treatment units 136 for chemistry adjustment and/or screening out or any debris that may be contained in the stream. The pre-treated MFT stream 138 is then contacted with a dewatering chemical such as a flocculating reagent 38 in a mixing unit 140. The resulting flocculating material 142 may then be shear conditioned in a conditioning stage 142, which may include a pipeline of a certain length for pipeline shearing or another type of device. The shear conditioning may be conducted such that the flocculated material has a structure which enables relatively high amounts of released water to separate from the flocs. The conditioned flocculated material 146 may
be deposited onto sub-aerial deposition cells 148 in thin lifts, allowing the released water 40 to flow away and be collected. The deposited lift may then be allowed to further dewater and dry to form the relatively dry material with high fines content.

Referring to Fig 13, the dried material 42 may be used as part of the backfilling and/or construction material for the sand dump operation 24. The released water 40, as well as the other water streams 136, 130 may be recycled to various processing units in the extraction operation 16 or other facilities.

Referring to Fig 7, the constructed sand dump may have a compacted region formed of the overlaying and stepped-in compacted zones. The compacted region may enclose a non-compact region below. The rear buttresses backfill behind the compacted region to provide geotechnical strength to the structure. Depending on the dimensions of the sand dump structure, the compacted region may have a certain size and configuration, that may be achieved by providing certain thicknesses of the compacted zones and/or the degree of compacting and/or drying for the compacted zones.

Whereas conventional tailings management used large tailings ponds for placing coarse sand, fine and water in the extraction tailings, the techniques described herein provide separation step for removing substantially all of the coarse sand from the extraction tailing prior to subsequent water and fines management. Some implementations provide various advantages, such as facilitating smaller and fewer ponds for efficient use of land, earlier reclamation activities in the sand dump area that is trafficable, enhanced fines capture in the sand dump and thus reducing the amount of thin fine tailings that are discharged into the water and fines management system, greater amounts of free water in the ponds available for recycle, generally steady-state operations for treating MFT, as well as a variety of integrated use of material including water and solids.
CLAIMS

1. A method for building an elevated sand dump from extraction tailings comprising sand, fines and water derived from a mined ore extraction operation, the method comprising:

   providing a flow of the extraction tailings down at least one section of a sloped beaching area such that a substantial portion of the sand settles out of the tailings, thereby producing:

   a series of overlying lifts comprising settled sand, some captured fines and water; and

   thin fine tailings at a downstream end of the beaching area, the thin fine tailings comprising fines and water;

   collecting the thin fine tailings next to the downstream end of the beaching area;

   collecting drainage water below the lifts and removing the collected drainage water from below the lifts; and

   compacting and draining at least a portion of each lift to produce a compacted zone of the corresponding lift, such that the overlying lifts include a series of overlying compacted zones.

2. The method of claim 1, further comprising for each lift:

   ceasing the flow of the extraction tailings into the section of the sloped beaching area;

   after ceasing the flow, completing the compacting and draining of the compacted zone sufficiently so as to be non-liquefiable prior to providing a subsequent flow of the extraction tailings thereon to produce a subsequent lift.

3. The method of claim 1 or 2, wherein the step of collecting and removing the drainage water further comprises:

   providing a drainage system below the beaching area for receiving drainage water and conveying the drainage water to a main collection zone; and
pumping water out of the main collection zone.

4. The method of claim 3, wherein the drainage system comprises:

basal drains near a bottom of the sloped beaching area and configured so as to be spaced-apart and distributed across a width of the sloped beaching area in a generally lengthwise orientation with respect to the flow of the extraction tailings; and

collector drains in fluid communication with a plurality of the basal drains and configured so as to be spaced-apart and distributed along a length of the sloped beaching area in a generally transverse orientation with respect to the flow of the extraction tailings.

5. The method of claim 4, wherein the main collection zone comprises at least one gravel pad located proximate to a discharge location of the flow of the extraction tailings.

6. The method of claim 5, wherein the at least one gravel pad comprises multiple gravel pads, each being provided below a corresponding discharge location of the flow of the extraction tailings.

7. The method of claim 6, wherein the gravel pads are fluidly connected to each other.

8. The method of any one of claims 4 to 7, wherein the basal drains comprise gravel channels and/or perforated pipes.

9. The method of any one of claims 4 to 8, wherein the collector drains comprise gravel channels.

10. The method of any one of claims 3 to 9, wherein the drainage system is sloped in a generally opposite orientation as a slope of the beaching area.

11. The method of any one of claims 3 to 10, wherein the step of providing the flow of the extraction tailings comprises:

expelling the extraction tailings from a tailings supply system down a starter dyke located along an upstream end of the beaching area.
12. The method of claim 11, wherein the main collection zone is located in a lower region of the starter dyke.

13. The method of claim 12, wherein the step of pumping water out of the main collection zone further comprises:

   providing at least one well extending through the starter dyke and into the main collection zone; and

   retrieving the water in the main collection zone out through the at least one well.

14. The method of any one of claims 11 to 13, wherein the drainage system comprises a slope of at least 1% toward the starter dyke.

15. The method of any one of claims 11 to 14, wherein the compacted zones extend from the starter dyke in the downstream direction.

16. The method of claim 15, wherein the compacted zones each have a length of at least about 100 meters from the starter dyke.

17. The method of any one of claims 14 to 16, further comprising:

   providing a sets of lifts having corresponding compacted zones; and

   after each set of lifts, raising the starter dyke a sufficient elevation above a top one of the lifts to enable a subsequent set of lifts to be provided from the starter dyke.

18. The method of claim 17, further comprising:

   buttressing an upstream end of the starter dyke in order to support the raising thereof.

19. The method of claim 17 or 18, wherein the compacting comprises stepping in the compacted zones and the raising of the starter dyke comprises stepping in the starter dyke.
20. The method of any one of claims 1 to 19, wherein the beaching area comprises an engineered bottom surface having a slope of at least 1% toward a TFT collection basin located next to the downstream end of the beaching area.

21. The method of claim 20, further comprising allowing sufficient sand to enter the TFT collection basin to raise the bottom thereof in conjunction with elevation of the beaching area.

22. The method of any one of claims 1 to 21, wherein each section of the sloped beaching area comprises multiple panels and wherein the method further comprises:

   sequentially flowing the extraction tailings into respective panels to form multiple panel lifts; and

   after ceasing the flow of the extraction tailings into each panel, providing a panel drainage time sufficient to produce a drained compacted panel zone in the corresponding panel prior to repeating the flow of extraction tailings therein.

23. The method of claim 22, wherein each section comprises first, second and third panels, and wherein the method further comprises:

   flowing the extraction tailings into the first panel for a panel filling time of at least 20 days;

   ceasing the flow of the extraction tailings into the first panel, and flowing the extraction tailings into the second panel for the panel filling time;

   ceasing the flow of the extraction tailings into the second panel, and flowing the extraction tailings into the third panel for the panel filling time; and

   repeating the above steps, wherein the panel drainage time for each panel is approximately twice the panel filling time.

24. The method of claim 22 or 23, wherein each panel comprises multiple cells and wherein the extraction tailings are expelled concurrently or alternatingly into the cells.

25. The method of claim 24, further comprising:
separating the cells with berms during the flowing of extraction tailings therein.

26. The method of claim 24 or 25, wherein:

   each cell has a width between about 20 meters and about 70 meters;

   each panel has a width between about 40 meters and about 420 meters; and

   each section has a width between about 120 meters and about 1000 meters.

27. The method of any one of claims 24 to 26, further comprising advancing a deposition outlet of the extraction tailings progressively downstream in each cell to provide the flow of the extraction tailings.

28. The method of claim 27, wherein the advancing is done for a distance of about 80 meters to about 300 meters from an initial deposition location.

29. The method of any one of claims 24 to 28, further comprising:

   providing a spill box system at an infeed region of each of the cells in order to decelerate the flow of the tailings sufficiently to allow:

      at least about 50 wt% or 60 wt% of the sand in the extraction tailings;

      and/or

      at least about 40 wt% or about 50 wt% of the fines in the extraction tailings;

   to settle out of the decelerated flow of the tailings prior to flowing to the downstream end of the beaching area.

30. The method of any one of claims 1 to 29, wherein the sloped beaching area comprises an infeed region having a high slope and a main section having a low slope, and the method further comprises:

   decelerating the flow of the tailings at the infeed region of the sloped beaching area sufficiently to allow:
at least about 50 wt% or 60 wt% of the sand in the extraction tailings; and/or

at least about 40 wt% or about 50 wt% of the fines in the extraction tailings;

to settle out of the decelerated flow of the tailings prior to flowing to the downstream end of the beaching area.

31. The method of claim 30, wherein the step of decelerating the flow of the tailings comprises:

providing a spill box system at the infeed region of the sloped beaching area to produce a decelerated tailings overflow.

32. The method of claim 31, wherein the spill box system comprises:

a barrier wall extending upward from the beaching area, the barrier wall having an upper edge over which the decelerated tailings overflow spills and then advances down the main section of the beaching area.

33. The method of any one of claims 1 to 32, further comprising:

collecting the thin fine tailings in a collection basin;

retrieving a stream of thin fine tailings from the collection basin; and

supplying the stream of thin fine tailings to a maturation pond in order to generate mature fine tailings.

34. The method of claim 33, wherein the step of retrieving the stream of thin fine tailings comprises:

providing a barge in the collection basin;

pumping the stream of the thin fine tailings from the collection basin via the barge.
35. The method of any one of claims 33 to 26, wherein the beaching area is flanked by side buttresses and the collection pond is bounded by an end dyke.

36. The method of claim 35, wherein the side buttresses and/or the end dyke are at least partially provided by mine pit walls.

37. The method of any one of claims 33 to 36, further comprising:

   controlling a fluid level in the collection basin.

38. The method of claim 37, wherein the step of controlling the fluid level comprises:

   limiting elevation fluctuations and/or maintaining sufficient hydrostatic pressure on beach below water to reduce or prevent sloughing of beach below water into the collection basin.

39. The method of claim 38, wherein elevation fluctuations of the fluid level are maintained to a maximum of 2 meters increase per week and 1 meter decrease per week.

40. The method of any one of claims 33 to 39, wherein the collection basin is maintained below a volume of 3,000,000 m³.

41. The method of any one of claims 1 to 40, wherein the step of providing the flow of tailings further comprises controlling back pressure of the extraction tailings.

42. The method of claim 41, wherein the step of controlling the back pressure comprises:

   increasing back pressure by passing the extraction tailings through resistance piping for deposition of the extraction tailings at a proximate location of the beaching area; and/or

   decreasing back pressure by passing the extraction tailings through bypass piping in order to bypass at least part of the resistance piping, for deposition of the extraction tailings at a remote location of the beaching area.

43. The method of claim 42, wherein the resistance piping has an internal diameter sufficiently small to avoid slug flow and/or pressure transients.
44. The method of any one of claims 1 to 43, wherein the beaching area is between about 500 meters and about 1500 meters in length.

45. The method of any one of claims 1 to 44, wherein the step of compacting and draining is performed such that each compacted zone is between about 100 meters and about 300 meters in length from deposition of the extraction tailings.

46. The method of any one of claims 1 to 45, wherein the compacting comprises track-packing with bulldozers.

47. The method of any one of claims 1 to 46, wherein the compacted zone for each lift is between about 2m and about 8m in height.

48. The method of any one of claims 1 to 47, wherein the sand dump is provided in an in-pit mining location.

49. The method of any one of claims 1 to 48, further comprising:

   for each lift providing a non-compacted zone downstream of the corresponding compacted zone, so as to form a non-compacted liquefiable tailings zone;

   enclosing and containing the non-compacted liquefiable tailings zone, comprising:

   buttressing sides of the non-compacted liquefiable tailings zone; and

   providing the series of the compacted zones in a stepped-in configuration such that the compacted zones form a compacted non-liquefiable region overlaying and buttressing a side of the non-compacted liquefiable tailings zone.

50. The method of any one of claims 1 to 49, wherein the extraction tailings are derived from an oil sands extraction operation.

51. A system for building an elevated sand dump from extraction tailings comprising sand, fines and water derived from a mined ore extraction operation, the system comprising:

   a starter dyke;
a sloped beaching area extending from the starter dyke and having at least one section;

a tailings supply system for providing a flow of the extraction tailings down the at least one section of a sloped beaching area such that a substantial portion of the sand settles out of the tailings, thereby producing:

   a series of overlying lifts comprising settled sand, some captured fines and water; and

   thin fine tailings at a downstream end of the beaching area, the thin fine tailings comprising fines and water;

a collection area at a downstream end of the sloped beaching area for receiving the thin fine tailings;

a drainage system located below the beaching area for collecting and removing drainage water from below the lifts; and

compactors for compacting at least a portion of each lift to promote drainage and produce a compacted zone of the corresponding lift, such that the overlying lifts include a series of overlying compacted zones.

52. The system of claim 51, wherein the tailings supply system is configured to periodically cease expelling the extraction tailings into the section of the sloped beaching area for completing the compacting and draining of the compacted zone sufficiently so as to be non-liquifiable prior to providing a subsequent flow of the extraction tailings thereon to produce a subsequent lift.

53. The system of claim 51 or 52, wherein the drainage system comprises:

   a main collection zone; and

   drains located below the beaching area for receiving drainage water and conveying the drainage water to a main collection zone.
54. The system of claim 53, further comprising well arrangement comprising at least one well extending into the main collection zone and at least one pump coupled to the at least one well for retrieving water from the main collection zone.

55. The system of claim 53 or 54, wherein the drainage system comprises:

   basal drains near a bottom of the sloped beaching area and configured so as to be spaced-apart and distributed across a width of the sloped beaching area in a generally lengthwise orientation with respect to the flow of the extraction tailings, the basal drains being in fluid communication with the main collection zone; and

   collector drains in fluid communication with a plurality of the basal drains and configured so as to be spaced-apart and distributed along a length of the sloped beaching area in a generally transverse orientation with respect to the flow of the extraction tailings.

56. The system of claim 55, wherein the main collection zone comprises a gravel pad located in a lower region of the starter dyke.

57. The system of claim 56, wherein the at least one gravel pads comprises multiple gravel pads each located below a corresponding tailings deposition location.

58. The system of claim 56 or 57, wherein the basal drains comprise gravel channels and/or perforated pipes.

59. The system of any one of claims 56 to 58, wherein the collector drains comprise gravel channels.

60. The system of any one of claims 51 to 59, wherein the drainage system has a slope that is in a generally opposite orientation as a slope of the beaching area.

61. The system of 60, wherein the slope of the drainage system is at least about 1% toward the starter dyke.

62. The system of claim 60 or 61, wherein the slope of the beaching area is at least about 1% toward the collection area.
63. The system of any one of claims 51 to 62, wherein each section of the sloped beaching area comprises multiple panels and wherein the tailings supply system is configured to sequentially flow the extraction tailings into respective panels to form multiple panel lifts.

64. The system of claim 63, wherein the tailings supply system is further configured to cease the flow of the extraction tailings into each panel, providing a panel drainage time sufficient to produce the compacted zone lift in the corresponding panel prior to repeating the flow of extraction tailings therein.

65. The system of claim 64, wherein each section comprises first, second and third panels, and wherein the tailings supply system is further configured to:

   flow the extraction tailings into the first panel for a panel filling time of at least 20 days;

   cease the flow of the extraction tailings into the first panel, and flow the extraction tailings into the second panel for the panel filling time;

   cease the flow of the extraction tailings into the second panel, and flowing the extraction tailings into the third panel for the panel filling time; and

   repeat the above steps, wherein the panel drainage time for each panel is approximately twice the panel filling time.

66. The system of any one of claims 63 to 65, wherein each panel comprises multiple cells and wherein the tailings supply system is further configured to expel the extraction tailings concurrently or alternatingly into the cells.

67. The system of claim 66, wherein the tailings supply system further comprises a plurality of pipe discharge extensions progressively provided to extend tailings discharge into the beaching area for each cell.

68. The system of claim 66 or 67, wherein each cell has a width between about 20 meters and about 70 meters; each panel has a width between about 40 meters and about 420 meters; and each section has a width between about 120 meters and about 1000 meters.
69. The system of any one of claims 66 to 68, further comprising a tailings flow decelerator at an infeed region of each of the cells in order to decelerate the flow of the tailings sufficiently to allow at least about 50 wt% or 60 wt% of the sand in the extraction tailings; and/or at least about 40 wt% or about 50 wt% of the fines in the extraction tailings, to settle out of the decelerated flow of the tailings prior to flowing to the downstream end of the beaching area.

70. The system of claim 69, wherein the tailings flow decelerator comprises a spill box system to produce a decelerated tailings overflow.

71. The system of claim 70, wherein the spill box system comprises a barrier wall extending upward from the beaching area, the barrier wall having an upper edge over which the decelerated tailings overflow spills and then advances down the main section of the beaching area.

72. The system of any one of claims 51 to 71, further comprising at least one retrieval apparatus for removing thin fine tailings from the collection area.

73. The system of claim 72, wherein the retrieval apparatus comprises at least one barge in the collection area, the barge comprising a suction pipe extending into the collection area and a pump coupled to the suction pipe for pumping a stream of the thin fine tailings out of the collection area.

74. The system of any one of claims 51 to 73, further comprising side buttresses flanking the beaching area and an end dyke defining a far end of the collection area.

75. The system of claim 74, wherein the side buttresses and the end dyke are at least partially provided by mine pit walls.

76. The system of any one of claims 51 to 75, wherein the tailings supply system is configured for backpressure control.

77. The system of claim 76, wherein the tailings supply system comprises:

   resistance piping for increasing backpressure for deposition of the extraction tailings at a proximate location of the beaching area;
bypass piping to bypass at least part of the resistance piping for decreasing backpressure by passing the extraction tailings, for deposition of the extraction tailings at a remote location of the beaching area; and

valves for switching the flow of the extraction tailings from the resistance piping to the bypass piping.

78. The system of 76, wherein the tailings supply system comprises:

a main tailings line supplying the extraction tailings from the extraction operation;

a backpressure line section coupled to the main tailings line and configured to receive the extraction tailings therefrom and provide increased backpressure on the extraction tailings;

at least one bypass line coupled to the main tailings line and configured to receive the extraction tailings therefrom and provide a lower level of backpressure compared to the backpressure line section;

a first feed line coupled to the backpressure line section to receive the extraction tailings therefrom and to expel the extraction tailings at a proximate location of the beaching area;

a second feed line coupled to the bypass line to receive the tailings therefrom and to expel the tailings at a remote location of the beaching area the bypass;

valves coupled to the backpressure line section and the at least one bypass line;

a backpressure controller for controlling the valves depending on proximate or remote expelling of the tailings.

79. The system of claim 77 or 78, wherein the resistance piping has an internal diameter sufficiently small to avoid slug flow and/or pressure transients.

80. The system of any one of claims 51 to 79, wherein the collection area comprises a collection basin.
81. The system of claim 80, further comprising a level controller for controlling a fluid level in the collection basin.

82. The system of claim 81, wherein the level controller is configured to limit elevation fluctuations and/or maintain sufficient hydrostatic pressure on beach below water to reduce or prevent sloughing of beach below water into the collection basin.

83. The system of claim 82, wherein the level controller is configured to maintain elevation fluctuations of the fluid level to a maximum of 2 meters increase per week and 1 meter decrease per week.

84. The system of any one of claims 81 to 83, wherein the level controller is configured to maintain the collection basin below a volume of about 3,000,000 m³.

85. The system of any one of claims 51 to 84, wherein the beaching area is between about 500 meters and about 1500 meters in length.

86. The system of any one of claims 51 to 85, wherein the tailings supply system, the compactors and the drainage system are configured and controlled so as to produce compacted zones that are at least 100 meters in length from discharge of the extraction tailings.

87. The system of any one of claims 51 to 86, wherein the compactors comprise bulldozers.

88. The system of any one of claims 51 to 87, wherein the tailings supply system, the compactors and the drainage system are configured and controlled such that the compacted zones each have a lift height between about 2 meters and about 8 meters.

89. The system of any one of claims 51 to 88, further comprising at least one pressure vacuum relief valve provided at high points in the tailings supply system.

90. The system of any one of claims 51 to 89, wherein the sand dump is provided in an in-pit mining location.

91. The method of any one of claims 51 to 90, wherein the tailings supply system, the compactors and the drainage system are configured and controlled so as to:
provide for each lift a non-compacted zone downstream of the corresponding compacted zone, so as to form a non-compacted liquifiable tailings zone and enclose and contain the non-compacted liquifiable tailings zone by buttressing sides of the non-compacted liquifiable tailings zone and providing the series of the compacted zones in a stepped-in configuration such that the compacted zones form a compacted non-liquifiable region overlaying and buttressing a side of the non-compacted liquifiable tailings zone.

92. The system of any one of claims 41 to 76, wherein the extraction tailings are derived from an oil sands extraction operation.

93. A method for treating tailings comprising:

   discharging a tailings stream comprising coarse sand, fines and water and about 35 wt% to about 60 wt% solids into sloped beaching area to remove substantially all of the coarse sand and at least 40% of the fines in a sand dump structure, and to produce thin fine tailings comprising between about 5 wt% and about 10 wt% solids and at least 80 wt% fines on a per solids basis;

   providing a stream of the thin fine tailings to a maturation pond to produce a supernatant substantially solids free water layer and a lower mature fine tailings layer, the mature fine tailings comprising between about 25 wt% and about 35 wt% solids and at least 80 wt% fines content on a per solids basis;

   retrieving a stream of the mature fine tailings from the maturation pond;

   supplying the stream of the mature fine tailings to a dewatering operation comprising:

       contacting the mature fine tailings with a flocculating reagent to produce a flocculation material; and

       depositing the flocculation material in a sub-aerial deposition area to produce released water and dewatered fines material.

94. The method of claim 93, wherein the tailings stream comprises extraction tailings derived from a mined ore extraction operation.
95. The method of claim 94, wherein the tailings stream has a specific gravity between about 1.39 and about 1.55.

96. The method of any one of claims 93 to 95, wherein the tailings stream comprises between about 50 wt% to about 60 wt% solids.

97. The method of any one of claims 93 to 96, wherein the thin fine tailings has a specific gravity below about 1.1.

98. The method of any one of claims 93 to 97, wherein the thin fine tailings has a fines content of at least about 95 wt% on a per solids basis.

99. The method of any one of claims 93 to 98, wherein the thin fine tailings has a fines content of at least about 98 wt% on a per solids basis.

100. The method of any one of claims 93 to 99, comprising capturing at least 50% of the fines of the tailing stream in the sand dump structure.

101. The method of any one of claims 93 to 100, comprising capturing at least 60% of the fines of the tailing stream in the sand dump structure.

102. The method of any one of claims 93 to 101, wherein the mature fine tailings retrieved from the maturation pond comprise between about 28 wt% and about 32 wt% solids and at least 90 wt% fines content on a per solids basis.

103. The method of any one of claims 93 to 102, wherein the mature fine tailings retrieved from the maturation pond comprise at least 95 wt% fines content on a per solids basis.

104. The method of any one of claims 93 to 103, further comprising removing a stream of the substantially solids free water from the maturation tailings pond.

105. The method of claim 104, further comprising recycling the stream of the substantially solids free water to a mined ore extraction operation.

106. The method of claim 105, further comprising recycling a stream of the released water to the mined ore extraction operation.
107. The method of claim 105 or 106, further comprising:

mining a formation to produce mined ore for the extraction operation, a
mine pit, and overburden material;

providing the mine pit for building the sand dump structure therein; and

providing at least a portion of the overburden material for buttressing the
sand dump structure.

108. The method of any one of claims 93 to 107, further comprising building the sand
dump structure according to the method as defined in any one of claims 1 to 50.

109. The method of any one of claims 93 to 107, further comprising building the sand
dump structure using the system as defined in any one of claims 51 to 92.

110. A method for treating tailings comprising:

providing a stream of the thin fine tailings comprising between about 5 wt% and
about 10 wt% solids and at least 80 wt% fines on a per solids basis, to a
maturation pond to produce a supernatant substantially solids free water layer
and a lower mature fine tailings layer, the mature fine tailings comprising
between about 25 wt% and about 35 wt% solids and at least 80 wt% fines
content on a per solids basis, wherein the thin fine tailings are derived from a
sand removal operation;

retrieving a stream of the mature fine tailings from the maturation pond;

supplying the stream of the mature fine tailings to a dewatering operation
comprising:

contacting the mature fine tailings with a flocculating reagent to produce a
flocculation material; and

depositing the flocculation material in a sub-aerial deposition area to
produce released water and dewatered fines material.
111. The method of claim 110, wherein the sand removal operation removes sand from extraction tailings derived from a mined ore extraction operation.

112. The method of claim 111, wherein the extraction tailings stream has a specific gravity between about 1.39 and about 1.55.

113. The method of any one of claims 110 to 112, wherein the extraction tailings stream comprises between about 35 wt% to about 60 wt% solids.

114. The method of any one of claims 110 to 113, wherein the thin fine tailings has a specific gravity below about 1.1.

115. The method of any one of claims 110 to 114, wherein the thin fine tailings has a fines content of at least about 95 wt% on a per solids basis.

116. The method of any one of claims 110 to 115, wherein the thin fine tailings has a fines content of at least about 98 wt% on a per solids basis.

117. The method of any one of claims 110 to 116, comprising capturing at least 50% of the fines of the tailing stream in the sand dump structure.

118. The method of any one of claims 110 to 117, comprising capturing at least 60% of the fines of the tailing stream in the sand dump structure.

119. The method of any one of claims 110 to 118, wherein the mature fine tailings retrieved from the maturation pond comprise between about 28 wt% and about 32 wt% solids and at least 90 wt% fines content on a per solids basis.

120. The method of any one of claims 110 to 119, wherein the mature fine tailings retrieved from the maturation pond comprise at least 95 wt% fines content on a per solids basis.

121. The method of any one of claims 110 to 120, further comprising removing a stream of the substantially solids free water from the maturation tailings pond.

122. The method of claim 121, further comprising recycling the stream of the substantially solids free water to a mined ore extraction operation.
123. The method of claim 122, further comprising recycling a stream of the released water to the mined ore extraction operation.

124. The method of claim 122 or 123, further comprising:

   mining a formation to produce mined ore for the extraction operation, a mine pit, and overburden material;

   providing the mine pit for building the sand dump structure therein; and

   providing at least a portion of the overburden material for buttressing the sand dump structure.

125. The method of any one of claims 110 to 124, further comprising building the sand dump structure according to the method as defined in any one of claims 1 to 50.

126. The method of any one of claims 110 to 125, further comprising building the sand dump structure using the system as defined in any one of claims 51 to 92.

127. A method of producing bitumen from an oil sands formation comprising:

   mining the oil sand formation to produce mined ore and a mine pit;

   supplying the mined ore to an extraction operation to produce extracted bitumen and tailings comprising coarse sand, fines and water and about 35 wt% to about 60 wt% solids;

   removing at least a portion of the coarse sand from the tailings in the mine pit, to produce thin fine tailings comprising between about 5 wt% and about 10 wt% solids and at least 80 wt% fines on a per solids basis;

   supplying a stream of the thin fine tailings from the mine pit to a maturation pond to produce an upper layer of substantially solids free water and a lower layer comprising mature fine tailings comprising between about 25 wt% and about 35 wt% solids and at least 80 wt% fines content on a per solids basis; and

   supplying a stream of the mature fine tailings to a dewatering operation comprising:
contacting the mature fine tailings with a flocculating reagent to produce a flocculation material; and

depositing the flocculation material in a sub-aerial deposition area to produce released water and dewatered fines material.

recycling at least some of the substantially solids free water and/or the released water back into the extraction operation.

128. The method of claim 127, wherein the extraction tailings stream has a specific gravity between about 1.39 and about 1.55.

129. The method of claim 127 to 128, wherein the extraction tailings comprises between about 50 wt% to about 60 wt% solids.

130. The method of any one of claims 127 to 129, wherein the thin fine tailings has a specific gravity below about 1.1.

131. The method of any one of claims 127 to 130, wherein the thin fine tailings has a fines content of at least about 95 wt% on a per solids basis.

132. The method of any one of claims 127 to 131, wherein the thin fine tailings has a fines content of at least about 98 wt% on a per solids basis.

133. The method of any one of claims 127 to 132, comprising capturing at least 50 wt% of the fines of the tailing stream in the sand dump structure.

134. The method of any one of claims 127 to 133, comprising capturing at least 60 wt% of the fines of the tailing stream in the sand dump structure.

135. The method of any one of claims 127 to 134, wherein the mature fine tailings retrieved from the maturation pond comprise between about 28 wt% and about 32 wt% solids and at least 90 wt% fines content on a per solids basis.

136. The method of any one of claims 127 to 135, wherein the mature fine tailings retrieved from the maturation pond comprise at least 95 wt% fines content on a per solids basis.
137. The method of any one of claims 127 to 136, wherein the removing at least a portion of the coarse sand from the tailings is done by building a sand dump structure.

138. The method of claim 137, further comprising building the sand dump structure according to the method as defined in any one of claims 1 to 50.

139. The method of claim 137, further comprising building the sand dump structure using the system as defined in any one of claims 51 to 92.

140. Use of a mine pit for containing a sand dump structure built according to the method of any one of claims 1 to 50.

141. A sand dump structure built according to the method of any one of claims 1 to 50.

142. A sand dump structure comprising a lower non-compacted liquifiable tailings zone and an enclosure comprising side buttresses buttressing sides of non-compacted liquifiable tailings zone and a compacted region comprising compacted non-liquifiable tailings zone overlaying and buttressing a side of the non-compacted liquifiable tailings zone.

143. A method of treating tailings comprising enclosing and containing a non-compacted liquifiable tailings zone with side buttresses buttressing sides of the non-compacted liquifiable tailings zone and a compacted non-liquifiable tailings region comprising compacted and drained tailings, the compacted non-liquifiable tailings region overlaying and buttressing a side of the non-compacted liquifiable tailings zone, thereby providing a stable elevated tailings containment structure.

144. The method of claim 143, wherein the stable elevated tailings containment structure is built according to the method as defined in any one of claims 1 to 50 and/or the system as defined in any one of claims 51 to 92.
Deposition Strategy
Section 4 Panel A

The entire by-pass pipe is used to achieve 0 gauge pressure for Panel A at the turn-down case for the near deposition location.

Deposition at the far location flows through the by-pass piping reducing the restriction piping by 170 meters.

Deposition at the far location again uses the by-pass to decrease the horsepower required.

Entire by-pass Piping is Used

Resistance Piping (96)