

Planning, Construction and Operational Challenges of Suncor's 1st Sand Dump

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Abstract

In 2009, Suncor Energy Inc.'s Oil Sands operation in Fort McMurray, AB, began the process of changing to a new technology for the treatment of the tailings streams coming from their water-based extraction process. This new treatment, known collectively as Tailings Reduction Operations (TRO™), is based on two primary technologies: Mature fine tailings (MFT) drying, and the construction of elevated and draining sand dumps.

Most of the public information on TRO™ has been focused on the MFT drying components, with less attention paid to the technically simpler but operationally complex systems required to build stacks of tailings sand contained within sand dykes at the rates required to sustain production.

This paper discusses the planning and operational challenges of constructing the sand dump rising at the rate of 20 meters per year while maintaining continuous oil sands production and structural integrity of the dump.

Background

Suncor Energy Inc. oil sands mines are located about 26km north of Fort McMurray, Alberta. Suncor is currently mining oil sands from its Millennium Mine producing about 158-180 million tonnes per year (Suncor, 2010). The Millennium Mine started production in 2001 and is expected to last until 2033. Another mine called North Steep Bank Extension Mine is expected to start production in 2012 thus splitting the production between the two mines for about 10 years. Bitumen is extracted from two primary extraction plants called Plant 86 and Plant 300.

Suncor is currently operating six active tailings ponds at various stages of their operational life. It has reclaimed one of its tailings ponds and two more are at different stages in the reclamation process.

Figure shows Suncor's oil sands mine and tailings operations.

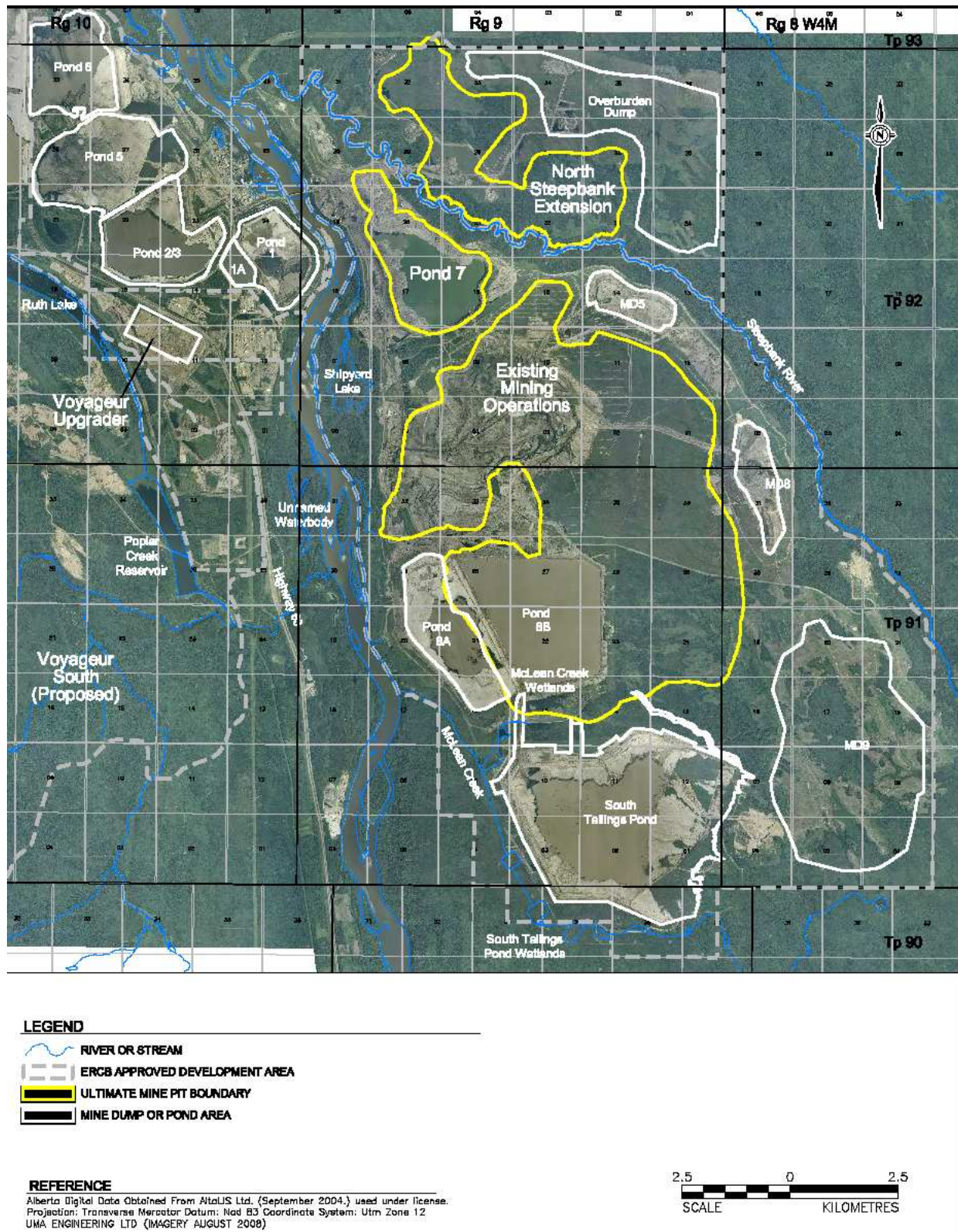


Figure 1: Suncor's oil sands mine and tailings operations

Oil sands mines produce tailings - left over material produced during the extraction process that separates bitumen from the oil sand. Tailings are a mixture of water, clay, sand and residual bitumen (McRoberts, 2008). When tailings are released to a pond, the heaviest material, mostly sand, settles to the bottom, while water rises to the top. The middle layer, the mature fine tailings (MFT), is made up of fine clay particles suspended in water. Some of these particles settle, but much remains suspended. The challenge is that MFT does not settle within a reasonable timeframe. As a result, Suncor has needed more and larger oil sands tailings ponds over the years (Suncor, 2011).

In the 1990s, Suncor pioneered consolidated tailings (CT) technology (Wells, 2010) to help speed up the consolidation of MFT into a soil-like deposit that can be re-vegetated and reclaimed. Since then Suncor has developed a new technique called the TRO™, which promises significant improvements. The implementation of the TRO™ is based on two primary technologies: MFT drying, and the construction of elevated and draining sand dumps.

MFT drying process (Wells, Revington, and Omotoso, 2011) involves converting fluid fine tailings more rapidly into a solid landscape suitable for reclamation. In this process, MFT is mixed with a polymer flocculent, then deposited in thin layers over sand beaches with shallow slopes. The resulting product is a dry material that is capable of being reclaimed in place or moved to another location for final reclamation. This drying process occurs over a matter of weeks, allowing for more rapid reclamation activities to occur. Further information on TRO™ process is available on Suncor's website (Suncor, 2010).

Under TRO™ scheme, extraction tailings will be deposited as segregating tailings (also called regular tailings or conventional tailings) into in-pit beaching areas initially enclosed by overburden starter berms. As the regular tailings are continuously discharged, the coarse sand settles out to form beaches which are sequentially raised over time through the step-over cell construction technique and continuously removing fluids to form a solid sand structure. Suncor's first such structure is called Sand Dump 8 (SD8).

The water and fines released from segregating tailings called thin fine tailings or TFT (5-10% solids by weight) will be collected in a small pond within the sand dump and then transferred to a settling pond for maturation to form MFT (30% solids by weight). After maturation, MFT will be subjected to the MFT drying process which is operated independently of ongoing beaching operations.

Dyke Construction

SD8 is a modified form of an in-pit Pond 8 which was under construction for containment of CT. Dyke 11 is under construction with B-Spec (Blend of low to medium plastic clay tills, lean oil sands, gravel and high fines sandy tills) and K-Spec (high plastic Clearwater or Clearwater derived till material, blended with low plasticity materials (tills and lean oil sands)) overburden material to a 330m elevation at slope of 7H: 1V as shown in Figure and Figure . A starter dyke (Dyke 12) is under construction up to the 285m elevation from pit bottom at 2H: 1V slope with overburden spec material. Dyke 12 will be constructed with sand through upstream cell construction to the same elevation as of Dyke 11. At this point upstream cell construction will continue all around the sand dump.

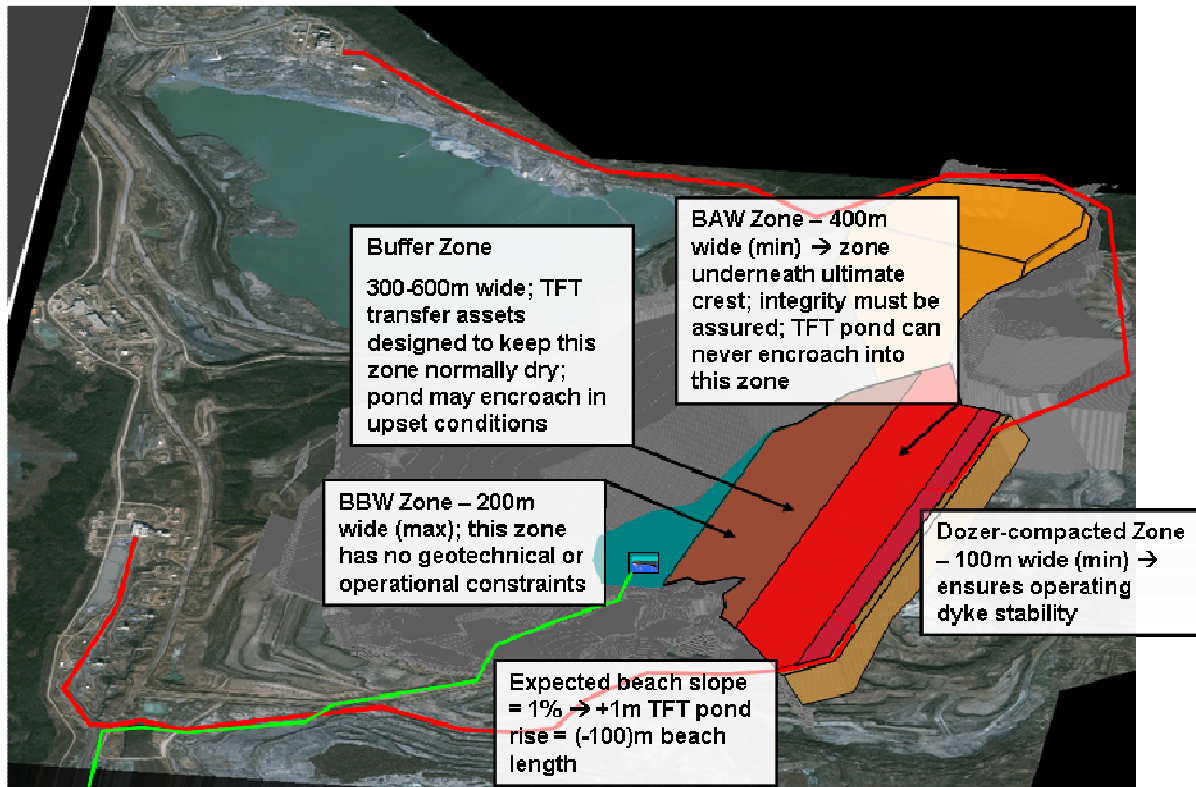


Figure 2: Location of Sand Dump 8

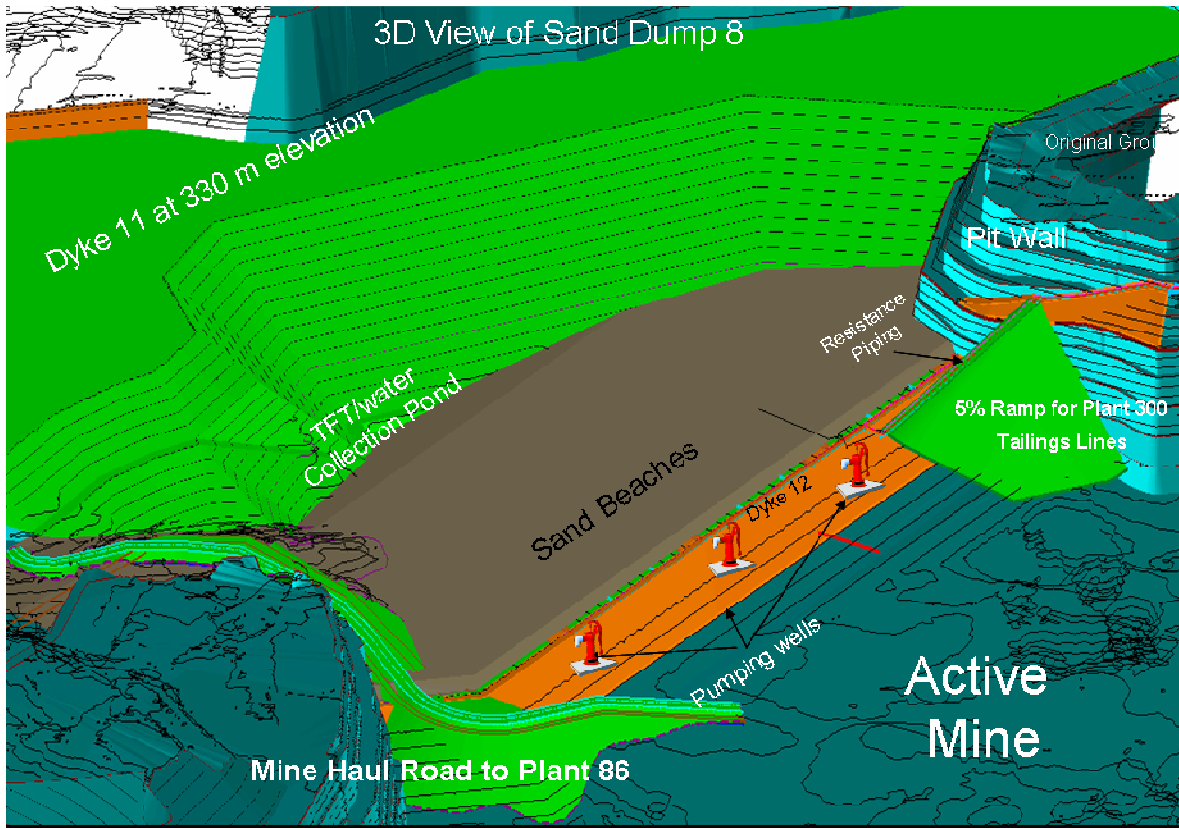


Figure 3: 3D view of Sand Dump 8 at startup

As shown in Figure 3 and Figure 4, Dyke 12 is the integral part of sand dump structure to be constructed by the tailings sand. Dyke 12 is about 2.6km long and is sole recipient of sand deposition for the first three years of SD8 operation starting in April 2012. The dyke is designed to be sloped at a 4H: 1V ratio to maximize sand storage in the structure. The dyke will be constructed in repeated 5m lifts as step over cell construction as explained in Figure 5. The first three 5m lifts will be set at 10m step over and the fourth lift at 30m step over to accommodate a tailings line corridor.

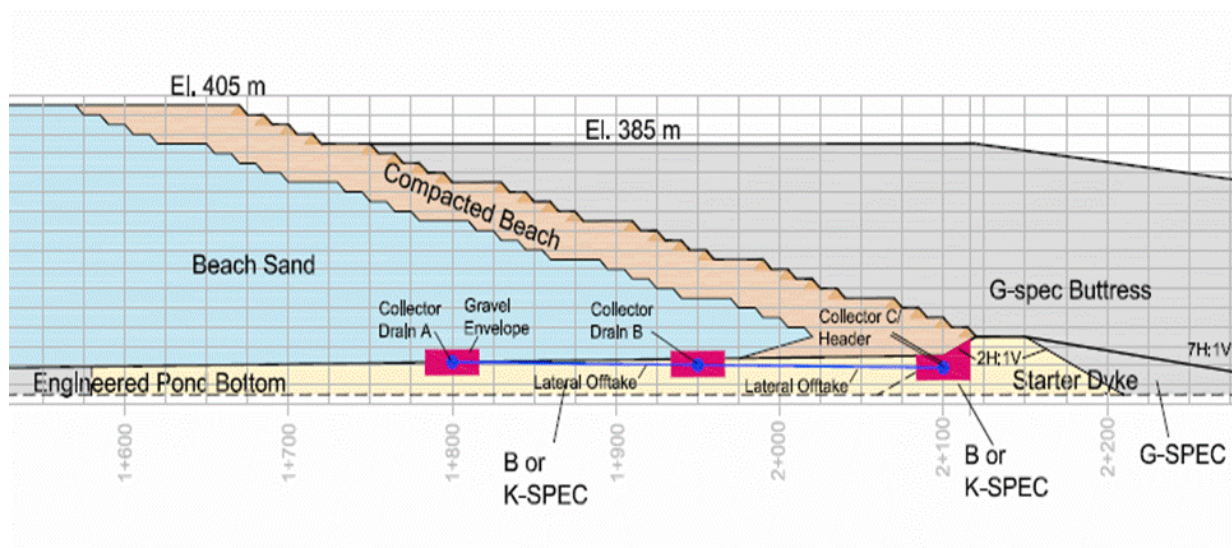


Figure 4: Dyke 12 design

At full production, between 85Mm³ to 88Mm³ of sand is planned to be hydraulically deposited into the sand dump. The sand deposition will begin at 275m elevation off the starter dyke. The dump will rise at the rate of about 20m per year until 2017 and then at a slower rate when sand dump 9 starts up in 2018. The structure will be built to a final 405m elevation. In order to maintain high geotechnical integrity for such a massive sand structure, the sand beaches are planned to be properly drained, compacted and buttressed.

The existing mine pit bottom is being modified to build an “Engineered Pond Bottom” sloping at 1% grade from starter dyke to the water collection pond. This is to provide positive drainage at the initial discharge to avoid water pooling against the starter dyke eliminating the chances of building beach below water next to the dyke.

A set of basal drains are being installed sloping at 1% in the opposite direction of the engineered pond bottom to collect seepage water. They are connected through collector drains to common collector headers which discharge water into gravel pads. There will be a total of 12 interconnected gravel pads, all with pumping wells drilled into them for dewatering. The pumping wells will be connected to each other through a set of common collectors and pumped over Dyke 12 and back into a water collection area in the sand dump.

Geotechnical design requires a waste dump buttress downstream of the dyke crest at an overall slope of 7H: 1V for support of Dyke 12. The buttress will be built with waste called G-Spec (Low shear strength, high moisture content Pleistocene silts, sands and clayey tills) and therefore called G-Spec Buttress. Rate of rise and sequence of construction of the buttress will match the dyke. The buttress must stay within a 50m maximum height differential of the dyke crest. The pumping wells will be removed in an area where the G-Spec buttress is sequenced for construction and re-drilled upon completion. As all collection pads are inter-connected, there will be no impact on dyke drainage during buttress construction. Figure explains the sequence of buttress construction and drilling of pumping wells.

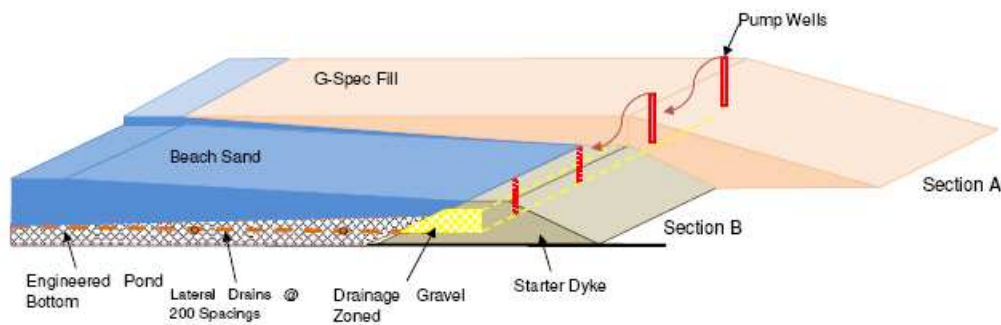


Figure 5: G-Spec Buttress and pumping wells

Geotechnical design also requires at least a 100m wide compacted sand beach zone (as shown in Figure) upstream from the dyke crest whereas Tailings Operations are targeting a 250m wide compacted beach zone. The additional 150m compacted zone will provide added strength to the dyke

structure. Consequently the elevation difference between the dyke crest and the G-Spec buttress could be increased. Suncor successfully completed a beach trial in South Tailings Pond (STP) in the winter of 2010/2011 to test the rate of rise and beach compaction.

The rate of rise must be balanced against allowing sufficient time for drainage from the beaches while maintaining stability during the placement of saturated sand. Suncor standard requires a minimum of 30 days drainage time for cells and beaches before placement of the next dyke lift. The current design calls for a clear construction sequence and operating discipline to ensure that the cells and the beaches are allowed sufficient time for drainage before the subsequent lift is placed.

Dyke 12 has been divided in four equal sections each about 650m wide. Each section is further divided into three panels each 217m wide. Each panel is sub-divided into four cells each 54m wide as shown in Figure . All four cells in a panel will be built in parallel with a single tailings line, switching discharge from one to the other frequently. The dyke will be constructed in three distinctive phases dependent on the incoming amount of sand and time available for drainage.

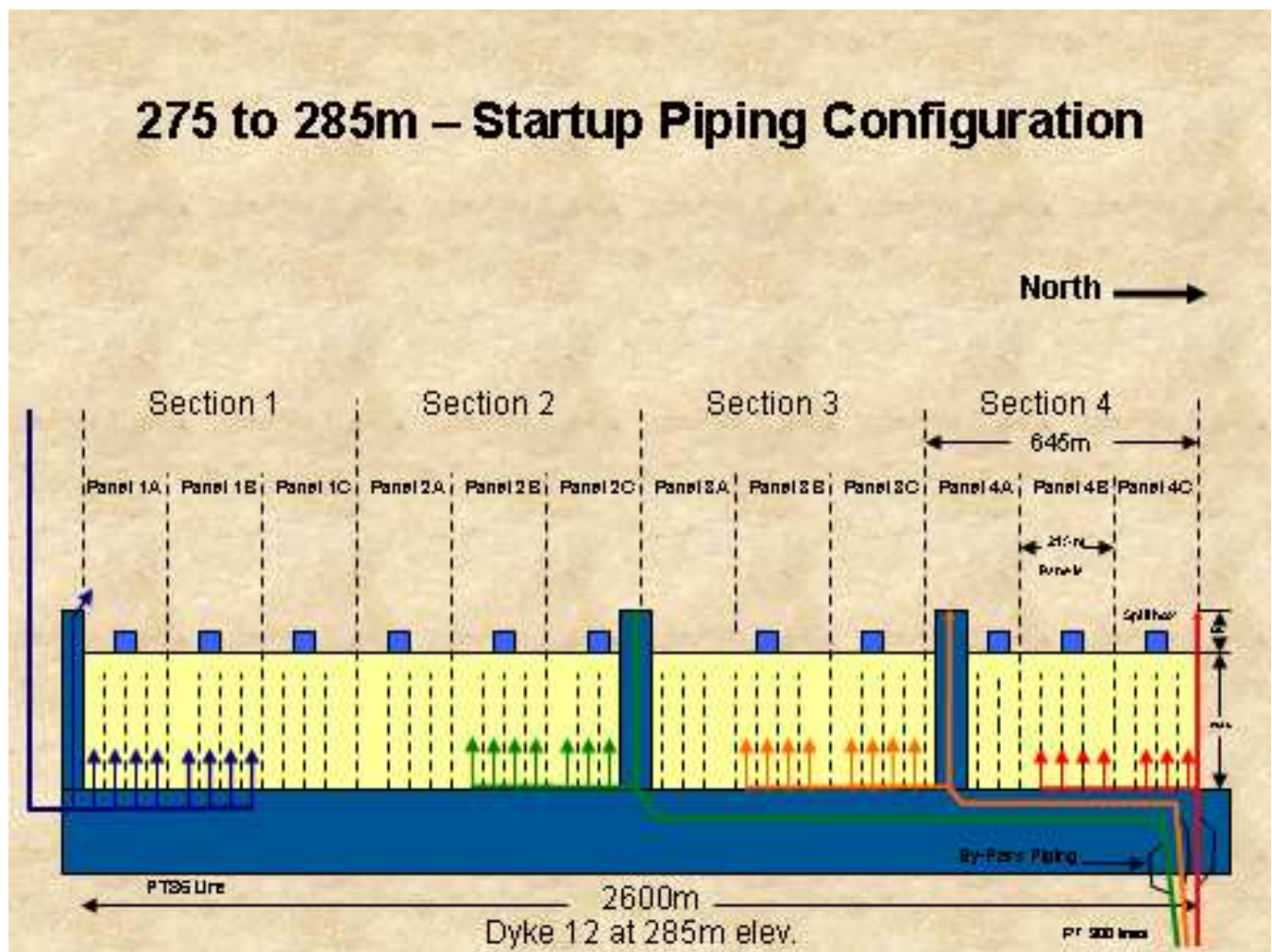


Figure 6: Start-up piping layout

Phase 1

Phase 1 deposition begins in April 2012 with three tailings lines from Plant 300 and one tailings line from Plant 86. Each line will have its own beach section to build (comprised of 3 panels with four cells per panel). It will take approximately 30 days to build one 5m high, 250m long and 217m wide panel assuming 60% sand capture (amount of sand retained in the cell divided by the total sand supplied from the tailings line). Once a panel is complete, the lines will switch to the next panel allowing drainage to the first panel. Since the plant operates in continuous production, a detailed line maintenance schedule has been developed to minimize the amount of discharge out of the cells needed during the installation of switches in the subsequent panels.

Figure 7 shows the number of days required (90 total) to construct the first 5m lift in all four beach sections across the dyke. Deposition in the first panel of each section starts on day 1 and completes 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.

280 Lift April 1, 2012 – June 30, 2012

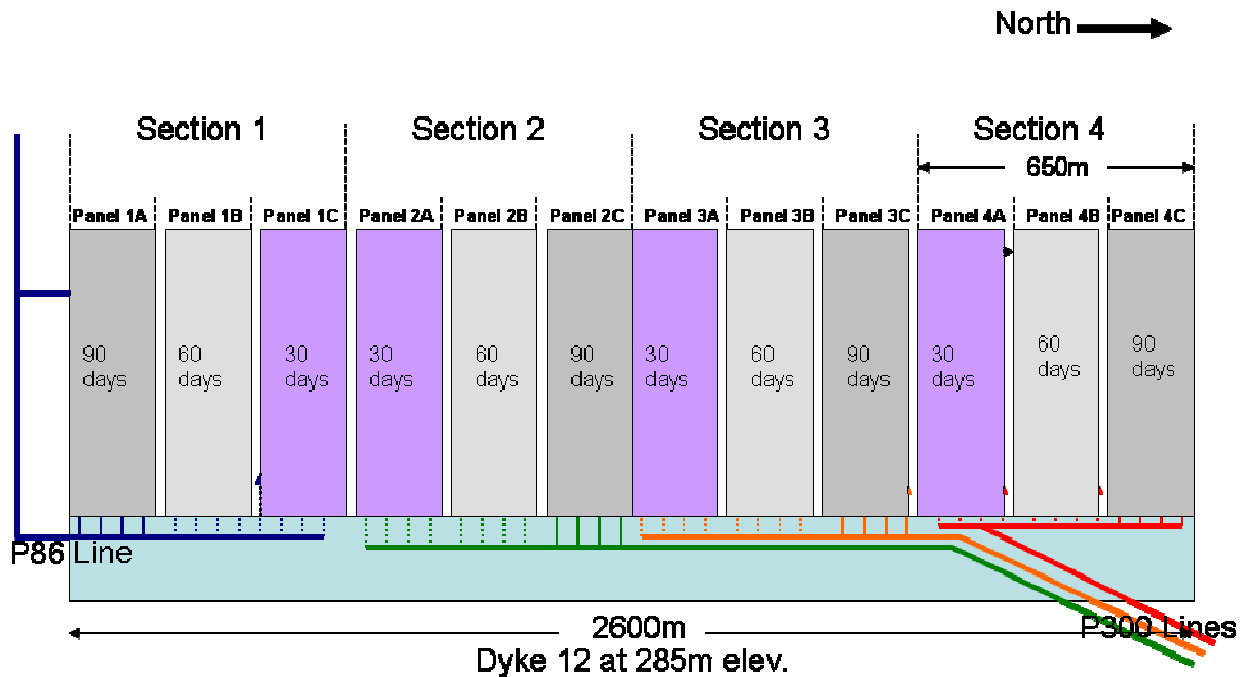


Figure 7: Drainage times for beaches

During Phase 1, the tailings lines run down a 45m drop in elevation over a few hundred meters distance. Starting from the original ground elevation of about 350m, they run down the slope to the starter dyke elevation of 285m, and will start discharging at an elevation of 280m. Each tailings line is required to discharge at varying lengths within its planned construction section on the starter dyke. The length varies from a few meters to 900m (650m panel width + 250m compacted beach) for the longest

line section. One of three lines from Plant 300 will be discharging at lengths varying from 750m to 1650m from the landing point on Dyke 12.

A 45m drop in elevation with little resistance will cause fluid velocity to increase. High energy discharge off of pipes could cause serious safety issues to the people and the equipment working on the tailings lines or on the beaches. A higher discharge velocity could cause serious beach erosion and challenges in beach construction. To regulate the discharge velocity at various elevations and lengths, a complex combination of varying lengths of resistance piping and by-passes are designed to be installed on the descending ramp.

Figure illustrates the resisting piping and by-passes required for one of the three Plant 300 lines.

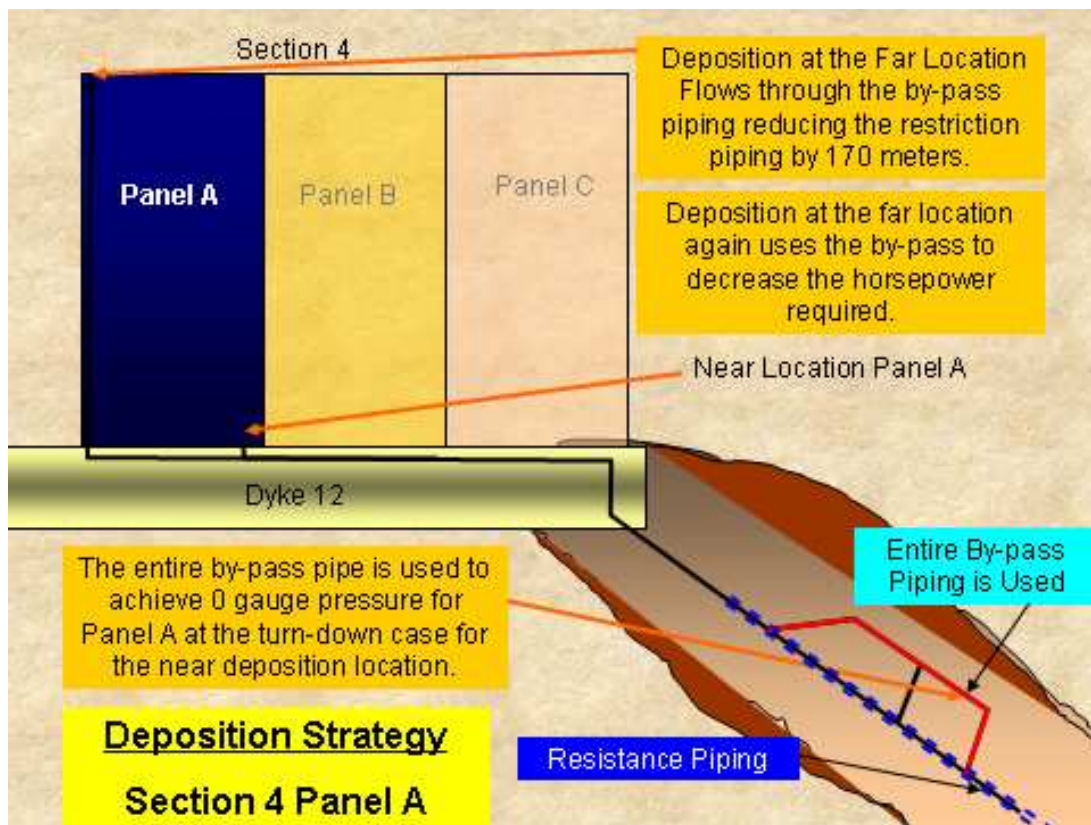


Figure 8: Resistance piping layout

Phase 2

Suncor is currently building the dykes and beaches of the South Tailings Pond with Plant 86 tailings. This operation will be complete in May 2013, at which time the remaining tailings lines will start deposition on Sand Dump 8. This is a steady state operation where two beach sections will be built simultaneously, one from Plant 300 tailings lines and the other from Plant 86 tailings lines. It will take approximately 6 weeks to build sections 1 and 4 then another 6 weeks to build sections 2 and 3 as shown in Figure . During the period when sections 1 and 3 are drying, preparation work for the next 5 meter lift will be undertaken on them. This includes items such as installation of lines & switches, and the installation of secondary drains.

Phase 2 Steady State Construction

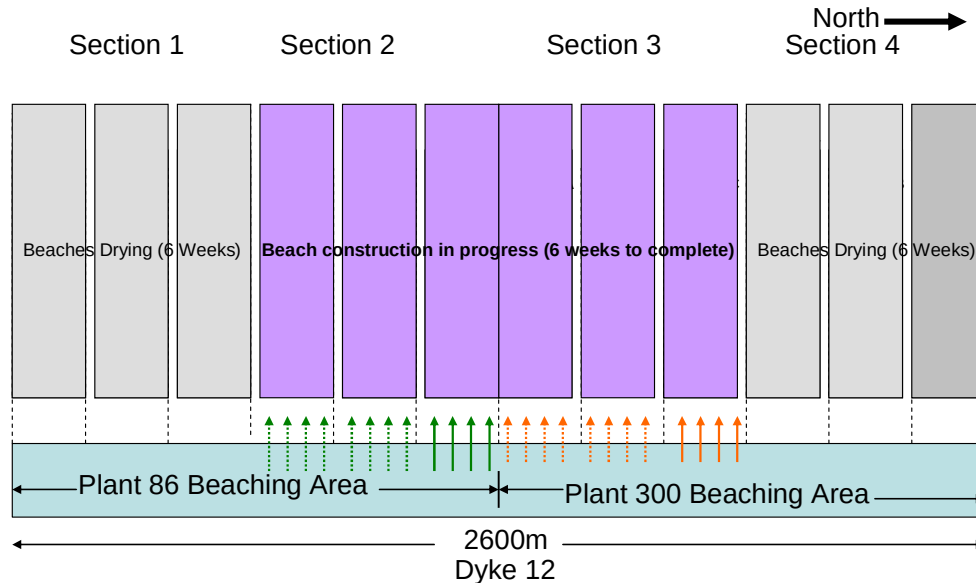


Figure 9: Beach construction in Phase 2

Every fourth lift will have a 30m wide tailings corridor as shown in Figure . As soon as the tailings corridor moves to the higher elevation in sections 1 and 4, the basal water pumping wells in the corresponding gravel pads will be removed and the placement of the overburden buttress will commence. The pumping wells will be drilled into newly constructed buttress. Once pumping wells are in place in sections 1 and 4, the wells from sections 2 and 3 will be removed, buttress placed and re-drilled. All gravel pads are interconnected so that while half of the pumping wells are removed, the remaining half will stay operational.

Phase 3

Once Dyke 12 is built to a 330m elevation, tailings deposition will encircle the Sand Dump thus releasing some of the pressure of working in such a confined and congested area as Dyke 12.

Fluid Management

SD8 is designed to store a maximum amount of sand as beach above water while keeping the amount of fluids to a bare minimum for the barges operation. Thin fine tails released from hydraulically placed sand beaches will be collected in a small TFT collection pond at the toe of the sand dump. The TFT will be pumped to the South Tailings Pond using a set of three independent trains of barges and 36" lines. Two of the systems are capable of handling average flow rates required to maintain the designed fluid volumes in the TFT pond, while the third is provided to support maintenance outages and unusual rainfall events. In the event of a total failure of the TFT system, the fluid volume in the TFT pond may exceed design capacity and could potentially impact beach strength by creating beach below water. In the event of an extended outage of the TFT system, a contingency tailings discharge option in Pond 7

will be utilised. Once recovered, the system has a capacity to quickly draw down the TFT pond, but a restriction is in place to keep the rate of draw down in check. A quick draw down must not occur as it could cause slumping of the beach potentially creating a tsunami wave or sanding in the barges.

The beach above water is expected to be about a kilometre long upstream. During the winter season, the water temperature of the discharge streams coming from the tailings lines is expected to be close to the freezing point when it reaches TFT pond. To offset this, the TFT lines from SD8 to STP are heat traced to keep them from freezing. Maintaining access to the barges through the winter is critical for consistent barge operation. Various options are being explored to break the anticipated ice in the TFT pond and ultimately keep a channel open to access the barges year round. A bubbler system has also been added into the design of the catwalks and the barges to keep them from freezing in the winter months.

Together with the SD8, the elevation of the TFT pond is expected to rise about 20m per year. The initial TFT corridor is expected to last until the TFT pond elevation reaches 320m. In order to maintain the pipelines to the barges as SD8 and the TFT pond rises, the TFT corridor is required to be raised as well. At this time, another TFT corridor will be built 5m higher than the existing one. A set of new pipelines will be laid out and connected to the barges. Pipelines from previous corridor will be removed, the corridor raised 10m high (which makes it 5m higher than other corridor) and pipelines reinstalled. A sequenced raise of both corridors and their alternate use will be required through out operational life of SD8. A detailed plan is currently being developed to continuously build two sets of corridors side by side so that at any given time one is in operation and the other is under construction.

Conclusion

Suncor's sand dump is a complex sand structure built at a high rate of rise. It poses unique challenges during all of the construction stages. A strict planning, operational, maintenance and safety discipline is required for safe and reliable construction of the landform.

Acknowledgements

Thanks to Suncor's planning, operational, construction and E-Houses teams who are working hard to meet the challenge.

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