Subject:	**Reusable Tunnel Material (Final Draft)**
Project feature:	Tunnels
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1. Purpose

The purpose of this technical memorandum (TM) is to address soil material that would be removed from the ground during tunneling for the Delta Conveyance Project (Project) and is planned for use elsewhere within the project footprint to reduce reliance on imported materials. This material is referred to as reusable tunnel material (RTM).

Two alignments are considered in this TM, along with a varied range of flow capacities, the Central corridor and the Eastern corridor. The tunnels' internal diameters (IDs) would vary, depending on the project design flow capacity, but would be anticipated to range between 26 feet and 40 feet. Based on the two corridor options and range of potential tunnel diameters, the excavated volume of RTM from tunnel construction could vary between 7.5 and 19.5 million cubic yards. Attachment 1 presents the corridor options.

The purpose of this TM is to evaluate the properties of the RTM and for each option, to calculate the expected quantity of RTM, understand the requirements for processing the RTM, estimate the area required for temporary and permanent storage of RTM, determine where the RTM will be generated, where the RTM could be used and assess how the RTM could be transported. The TM also describes potential health and environmental conditions associated with the extracting, processing, storing, moving and reuse of RTM.

The TM describes the assumptions and approach used to develop the conclusions. Attachment 2 provides a table of inputs and assumptions applied to the investigation. The RTM generation quantities, locations, and schedule described in this TM were also used in a project-wide soil balance, which also accounts for surface borrow and shaft excavation quantities as described in the Soil Balance TM (DCA, 2021a). Note, this information is considered preliminary and will be subject to change as the project develops.

2. Anticipated Geotechnical Conditions in the Tunnel Zone

The Delta forms part of the San Francisco Bay estuary that extends into the Central Valley. The Central Valley is a sedimentary basin, approximately 435 miles long and up to 62 miles wide, which lies between the Sierra Nevada mountain range to the east and the Coast Ranges to the west.

2.1 Geomorphology and Geology

The Delta's geomorphology and surficial geology have been shaped by the landward spread of tidal environments resulting from sea level rise after the last glacial period. During the last glacial period,

approximately 15,000 years ago, the Pacific Coast was at least 6 miles west of its current position, the relative sea level was approximately 300 feet lower than present-day sea level, and the location of the present-day Delta was an arid alluvial floodplain. As a consequence, alluvial and eolian sand deposits underlie most of the late Holocene Delta soils (less than 11,000 years-old). Between 10,000 and 5,000 years ago, relative sea level rise was rapid, resulting in the landward transgression of the ocean through the Carquinez Strait and into the Central Valley, forming the Suisun Bay and the Delta. This period saw the widespread deposition of organic silt and clay across the former alluvial floodplain surface. Approximately 5,000 years ago, relative sea level rise slowed, and the deltaic environment remained in approximately its present position, with slow relative sea level rise balanced by vertical marsh growth through biomass accumulation and sediment deposition.

2.2 Tunnel Horizon Soils

The tunnel horizon is expected to be in the range of approximately 100 to 170 feet below the current ground surface and is anticipated to be excavated in the older soils of the former alluvial floodplain. Groundwater is typically 5 feet below ground surface and is controlled, over much of the area of the tunnel corridors, by farming activities, including irrigation and pumping to maintain groundwater levels below the root zones of cultivated crops.

Given their depth, their depositional history, and the shallow groundwater level, the soils are anticipated to be saturated mixtures of sands, silts and clays interfingering as the corridor passes from buried stream channels into old stream banks and overbank deposits.

2.3 Prior Reusable Tunnel Material Testing

During soils investigations for the prior California Waterfix project, soil samples from the tunnel horizon obtained from 19 boreholes along the Central Corridor were blended to generate a baseline sample of anticipated RTM. The blended sample was generally characterized as 44 percent sands and 56 percent clay and silt fines and was subjected to strength and environmental testing in its blended form as well as when mixed with three typical soil conditioners. The goal of the testing, the results from which were reported in the Reusable Tunnel Material Testing Report (URS, 2014), was to assess the effect of the soil conditioners on the suitability of the RTM for beneficial reuse. The evaluation included laboratory testing for strength, permeability and toxicity. This information was based on a limited number of borings from a corridor that differs slightly from the present one and the geology is expected to vary over the length of the corridors.

2.4 Bulking, Drying and Compacting

Excavated RTM would be in a less compact state than it is in the ground and with the addition of water and conditioners during the tunneling process, could be expected to occupy a greater volume. To account for this, a bulking factor is applied to the in-situ volume to estimate the excavated volume to appropriately account for the space required for processing the RTM and transportation. For the material expected to be excavated from the project area, a bulking factor of 1.3 has been applied based on published data for similar ground conditions.

$$\text{Wet Excavated Volume} = 1.3 \times \text{In Situ Volume}$$

Assuming the wet RTM was then dried prior to storage or use, a volume loss could be expected during the drying process. For the expected material and planned reduction in moisture content, the volume loss has been estimated to be 5 percent of the wet excavated volume.

Dry Excavated Volume Loss= (5%) x Wet Excavated Volume

Similarly, if the RTM was compacted, for example, for long-term storage or for use in embankments, the volume would be further reduced. To account for this, a compaction factor is applied to the dry excavated volume which is necessary to calculate the volume required for storage and other usage. For the material expected to be excavated from the project area, a compaction factor of 0.8 has been estimated for structural use.

Dry Fully Compacted Volume = 0.8 x Dry Excavated Volume

Attachment 3 provides calculations to confirm these values.

3. Tunneling

3.1 Tunnel Diameter

The tunnel diameter is directly related to the project design flows. At this time, the project design flow rates and resulting tunnel diameter are still to be confirmed, with four options under consideration. These are described in Table 1 below. Section 3.2 explains the tunnel sections noted in the table.

Table 1. Project Design Flow and Corresponding Tunnel Internal Diameters by Option

Tunnel Section	Option 1	Option 2	Option 3	Option 4
Project Design Flow (cfs)	3,000	4,500	6,000	7.500
Northern Tunnels (ft)	26	31	36	40
Main Tunnels (ft)	26	31	36	40
Southern Tunnels (ft)	38	38	38	40

Notes:

cfs = cubic foot (feet) per second

The required external diameter of the tunnel lining is a function of the required thickness of the tunnel lining which is directly related to the internal diameter. These have been determined based on experience with similar diameter tunnel projects in similar ground conditions and are shown for each tunnel diameter in Table 2 and explained in further detail in the Tunnel Lining Sizing Evaluation TM (DCA, 2021b). In addition to the tunnel lining thickness, the tunnel boring machine (TBM) shield thickness and radial overcut, in reference to the tunnel lining radius, needs to be accounted for to determine the excavated volume. Based on experience, these are assumed to be between 2.5 and 4.0 inches as shown in Table 2.

For this TM, the five possible tunnel diameters that occur within the four options shown in Table 1 have been considered and a resulting range of RTM volumes has been evaluated. The assumptions and resulting cutterhead/excavated area for each of the five internal tunnel diameters are presented in Table 2 below.

Table 2. Tunnel Lining and TBM Dimensions and Resulting Excavated Area

Tunnel lining ID (ft)	26.0	31.0	36.0	38.0	40.0
Lining thickness (in)	14.0	16.0	18.0	20.0	24.0
Tunnel lining external diameter (ft)	28.3	34.0	39.0	41.3	44.0
TBM tail can thickness (in)	2.5	3.0	3.5	3.75	4.0
Cutterhead offset (in)	2.5	3.0	3.5	3.75	4.0
TBM cutterhead diameter (ft)	29.2	34.7	40.2	42.6	45.3
TBM cutterhead (excavated area) (yd^2)	74	105	141	158	179

Notes:

in = inch(es)

ft = foot (feet)

yd^2 = square yard(s)

In addition, for the 7,500 cfs option only, there would be an additional tunnel from the South Delta Outlet and Control Structure to the C.W. "Bill" Jones Pumping Plant (Jones). It is estimated this tunnel would be 1.4 miles long, with a 20-foot ID and a 12-inch thick lining. As it is not part of the main tunnel system and only applies to the 7,500 cfs option, it is not included in every aspect of this TM but will be considered where applicable.

3.2 Central and Eastern Corridors

The Central and Eastern corridors include a northern tunnel between the intakes and the Twin Cities Complex, the main tunnel between the Twin Cities Complex and the Southern Forebay, and the southern tunnels between the Southern Forebay and the existing Harvey O. Banks Pumping Plant (Banks) intake channel.

3.2.1 Northern Section

The length of the northern tunnel between the intakes and Twin Cities Complex varies, depending on the intakes used, which is directly related to the project flow rates as follows:

- 3,000 cfs – Intake 5
- 4,500 cfs – Intakes 3 and 5
- 6,000 cfs – Intakes 3 and 5
- 7,500 cfs – Intakes 2, 3, and 5

Depending on the intake(s) used, the length of the northern tunnels would vary from 5.6 miles to 10.3 miles.

3.2.2 Main Section, Central Corridor

The main section of the Central corridor would extend from the Twin Cities Complex to the southwest through New Hope Tract, Staten Island, Bouldin Island, Venice Island, Mandeville Island, Bacon Island,

Woodward Island, Victoria Island and Byron Tract to the Southern Forebay. The tunnels in this section are referred to as the Main Tunnels of the Central corridor alternative and have a total length of 31.3 miles.

3.2.3 Main Section, Eastern Corridor

The main section of the Eastern corridor would extend from the Twin Cities Complex along a more easterly route through New Hope Tract, Canal Ranch Tract, Brack Tract, Terminous Tract, King Island and Rindge Tract to Lower Roberts Island where the corridor would turn southwest through Lower Roberts Island, Lower and Upper Jones Tracts, Woodward Island, Victoria Island and Byron Tract to the Southern Forebay. The tunnels in this section are referred to as the main tunnels of the Eastern corridor alternative and have a total length of 34.0 miles.

3.2.4 Southern Section

The southern section, common to both corridors, would include two parallel tunnels from the Southern Forebay to Banks approach channel, with a length of 1.7 miles each. The tunnels in this section are referred to as the southern tunnels.

3.3 Shafts

Along the tunnel, there are a number of shafts. Five different types of shafts would be constructed as part of the project, each serving a different purpose to support tunneling activities:

- Launch shafts – At these shafts, the TBM would be lowered into the ground and begin excavation. All of the RTM associated with a tunnel drive would be extracted at the respective launch site unless a working shaft was employed for that particular tunnel drive.
- Working shafts – These shafts, where used, would be located in close proximity to the launch shaft and once the TBM has passed through the working shaft, all surface operations associated with the tunnel drive would occur from this shaft including the supply of equipment and materials (such as tunnel lining segments) and the extraction of RTM. This would free up the launch shaft for other uses.
- Reception shafts – At these shafts, the TBMs would complete excavation and be extracted from the ground.
- Maintenance shafts – These shafts are located between the launch and reception shafts that the TBMs would pass through. These provide an opportunity to inspect and carry out maintenance and repairs to the cutterhead at the front of the TBM, the main bearing and other components that would otherwise be difficult to access during excavation.
- Launch and Reception shafts – These shafts would serve as both a launch shaft and reception shaft to facilitate the construction of adjacent tunnels in the same direction. These could be constructed as two independent shafts or one larger shaft to serve both functions.

Numerous permutations of drive and reception shafts were considered before a preferred scheme was selected for each corridor analyzed in this TM. These are shown on the map in Attachment 1, which includes all maintenance shafts. The tables below summarize each tunnel drive for the longest 7,500 cfs (40 ft ID tunnel) option, listing the shaft name, shaft type, tunnel section, tunnel drive direction (indicated by an arrow) and tunnel drive length. The tables omit the maintenance shafts for simplicity.

Table 3. Details for Central Corridor (7,500 cfs option).

Structure	Shaft Type and Tunnel Drive Direction	Drive Length
Intake No. 2 Shaft	Reception	
Northern Tunnels	↑	10.3 mi
Twin Cities Shaft	Launch	
Main Tunnels	↓	14.4 mi
Bouldin Island Shaft	Launch/Reception	
Main Tunnels	↓	10.2 mi
Bacon Island Shaft	Reception	
Main Tunnels	↑	6.7 mi
Southern Forebay (N+S) Shafts	Launch	
Southern Tunnels (1.67 miles x 2)	↓	3.3 mi
California Aqueduct Shaft	Reception	
Total		**44.9 mi**

Notes:

mi = mile(s)

Table 4. Details for Eastern Corridor (7,500 cfs option)

Structure	Shaft Type and Tunnel Drive Direction	Drive Length
Intake No. 2 Shaft	Reception	
Northern Tunnel	↑	10.3 mi
Twin Cities Shaft	Launch	
Main Tunnel	↓	12.7 mi
Terminous Tract Shaft	Reception	
Main Tunnel	↑	9.5 mi
Lower Roberts Island Shaft	Launch/Reception	
Main Tunnel	↑	11.8 mi
Southern Forebay (N+S) Shaft	Launch	
Southern Tunnels (1.67 miles x 2)	↓	3.3 mi
California Aqueduct Shaft	Reception	
Total		**47.6 mi**

Notes:

mi = mile(s)

3.3.1 Shaft material

This TM does not consider the material excavated during shaft construction in the volume calculations. At launch shafts, suitable material excavated from shaft construction would be used to fill any local borrow excavations, while unsuitable material (i.e. peat, topsoil) would be stockpiled onsite. At shafts where RTM would not be generated, material excavated from the shaft would be stockpiled locally. Soil generated from shaft excavation, shallow borrow and surface stripping is captured in the Soil Balance TM (DCA, 2021a). Shaft construction is addressed separately in the Shaft Conceptual Design TM (DCA, 2021c).

3.4 Tunnel Boring Machines

The tunnels would be excavated using a number of TBMs and for the known ground conditions along the corridors, the most appropriate type of TBM would be either an Earth Pressure Balance (EPB) TBM or a Slurry TBM. Typically, the contractor would make the final decision as to which type of machine to use and it is possible that both types would be employed across the project. The TBM selection would depend on the type of materials expected to be encountered during tunnel excavation and would be determined following additional geotechnical investigations.

3.4.1 Earth Pressure Balance Tunnel Boring Machine

With an EPB TBM, excavated material discharges from the TBM cutterhead chamber through a screw auger conveyor onto a belt conveyor, which transports the RTM back along the completed length of tunnel to the launch shaft. At the launch shaft, the RTM is lifted to the surface, typically by a vertical conveyor. EPB TBMs maintain pressure at the cutterhead by varying the speed at which the TBM is advanced in conjunction with the rate at which RTM is withdrawn from the cutterhead chamber by the screw auger. The soils within the screw auger are therefore a critical part of the ability to maintain a positive pressure at the cutterhead and soil conditioners may be added at the tunnel face and screw auger to achieve and promote uniform consistency of the soil within the auger and for their ability to avoid washing out of the auger.

3.4.2 Slurry Tunnel Boring Machines

With a slurry TBM, bentonite is mixed with water to create a slurry which is pumped to the tunnel face and held at pressure to support the ground. As material is excavated, it is mixed with the bentonite slurry in the cutterhead chamber to a consistency that allows the mixture to be pumped from the chamber back along the completed length of tunnel to the launch shaft and up to the ground surface within an enclosed pipe. Once at the surface, the excavated material would pass through a slurry screening plant to separate the RTM from the bentonite slurry, which would be reused in the excavation process.

4. Engineering Properties of Reusable Tunnel Material

Geotechnical tests were conducted on the baseline and conditioned soil samples, the results of which were presented in URS (2014). These samples were consistent with RTM expected to be generated from an EPB TBM. The purpose of these tests was to evaluate the strength, compressibility and constructability of conditioned soils for use as structural fill. The following tests were performed in accordance with ASTM International (ASTM) standards:

- Moisture content (ASTM D2216), Atterberg limits (ASTM D4318), gradation and hydrometer (ASTM D422)
- Optimum moisture content and maximum dry density (ASTM D698)

- Remolded unconsolidated undrained triaxial shear strength (ASTM D2850)
- Remolded consolidated undrained triaxial shear strength with pore pressure measurements (ASTM D4767)
- Remolded consolidation (ASTM D2435) and permeability (ASTM D5084)

Remolded specimens were compacted to 95 percent of maximum dry density at optimum moisture content determined in accordance with ASTM D698. It should be noted that conditioners were intentionally added to the soil samples at quantities beyond what would be typical for RTM so that the effects would be exaggerated in the laboratory testing.

4.1 Physical and Index Properties

While the total percent fines (silt and clay) remained relatively constant between the baseline and conditioned soil samples, the percent of silt size particles decreased and the percent of clay size particles increased in the conditioned soil samples. This was attributed to the soil conditioners' dispersive effects. This also affected the Atterberg limits, with the conditioners reporting higher liquid limits and plastic limits.

4.2 Strength and Compressibility

The results indicated a slight increase in compressibility and slight decrease in undrained shear strength for the conditioned soil samples that were also attributed to the soil conditioners' dispersive effects, which reduced inter-particle bonds. The changes were not considered significant.

4.3 Permeability

The hydraulic conductivity (vertical permeability) of the conditioned soil samples was substantially lower than the baseline samples, also attributed to the soil conditioners' dispersive effects that increased the percent of clay size particles and reduced the effective pore diameter.

4.4 Conclusions

The soil conditioner application rates used in the 2014 RTM testing program (URS, 2014) were stated to be purposefully greater than industry typical values. As a result, the observed effects of adding conditioners to the soil's geotechnical properties were likely magnified over what might be expected for RTM. Even with increased rates of conditioner application, the report noted that the testing indicated conditioned soil samples tested met current levee fill requirements. URS (2014) did recommend pinhole dispersion tests to evaluate the dispersive effects of the soil conditioners to confirm they were not erodible. Further, the RTM is generally anticipated to be suitable for use in the construction of water-holding embankments, such as that planned at the Southern Forebay. If the soils are found to be erodible, a zoned embankment core or a cutoff wall could be incorporated into the embankment design.

URS (2014) did note that the RTM will be saturated and significantly exceed the moisture content range necessary to meet compaction requirements. The conditioned soil samples from the testing program were approximately 20 to 25 percent greater than the optimum moisture content for compaction.

5. Environmental Properties of RTM

URS (2014) presented the results of environmental testing performed on composite samples of soil in both the conditioned and unconditioned states. The purpose of the 2014 environmental testing was to assess the effect of the conditioner on the leachability of naturally occurring soil constituents and to assess the nature of the conditioners themselves.

The primary source of existing environmental data for the native soil and groundwater was the Environmental Sampling Report – Phase 1 Geotechnical Investigations (DWR, 2010), which presents the analytical results from soil and water samples collected during previous geotechnical investigations for the Central corridor from a full range of depths.

Additional environmental sampling was performed as part of the Fiscal Year 2020-2021 (FY20-21) field investigation program (DCA, 2021). Sampling was performed for the Central and Eastern corridors.

This section summarizes the environmental testing on composite samples and the findings of the environmental sampling from the two geotechnical investigations.

5.1 Key Findings

Environmental specialists reviewed the three sources of data with specific reference to background levels of naturally occurring metals in the US (USGS, 2013) and with regard to human health and ecological risks associated with the extracting, processing, storing, moving and reuse of the anticipated RTM. They noted the following:

- Petroleum hydrocarbons and pesticide residues were not detected in soil samples from the corridor.
- Metals and inorganic elements were detected throughout the soil profile resembling naturally occurring levels with the exception of cadmium.
- Cadmium was detected at concentrations greater than naturally occurring levels (DWR, 2010) but far below environmental screening levels for health or ecological impacts. It was noted that cadmium levels often track with zinc levels in the soil, and zinc was not detected at levels above those considered to be background.
- Arsenic concentrations detected in the soil pose no greater risk to human health and the environment than those present in native soils and the addition of conditioners does not affect the concentrations of arsenic.
- Total chromium analyzed was indistinguishable from naturally occurring levels.
- Mercury concentration detected was below naturally occurring levels.
- The limited analytical results suggest that odor impacts associated with volatile sulfides in soil are unlikely to pose an impact to humans.
- When blended with native soil in tunneling, the soil conditioners do not pose a health hazard to humans or the environment.
- The extracting, handling, storing and reuse of soils could likely result in emissions of dust. An analysis of the potential impacts is needed to identify appropriate mitigation measures.
- Following excavation, RTM would be tested in accordance with the requirements of the Central Valley Regional Water Quality Control Board and the Department of Toxic Substance Control.

5.2 Reusable Tunnel Material Chemical Constituents

As noted above, metals and inorganic elements were detected throughout the soil profile resembling naturally occurring levels. Certain metals and inorganic elements in soil are of interest because of specific concerns about toxicity or mobility. These include arsenic, chromium and mercury, which are discussed in further detail below.

5.2.1 Cadmium

Cadmium was reported to be detected in all samples at concentrations ranging from 2.8 to 10 milligrams per kilogram (mg/kg) (DWR, 2010). While the analytical results have been validated, they are considered anomalous when compared with typical background levels which, in soil, do not exceed 0.3 mg/kg. Cadmium was futher analyzed in soil samples collected in the FY20-21 field investigation program and was not detected at a concentration greater than 1 mg/kg in any soil sample (DCA, 2021). Though the earlier results are considered anomalous, the values as reported in the environmental sampling report do not appear to represent a health or ecological impact when compared with environmental screening levels. All results fall below the Tier 1 Environmental Screening Level (ESL) (RWQCB, 2019) for cadmium of 78 mg/kg in soil.

5.2.2 Arsenic

Arsenic poses human health and environmental hazards with high levels of exposure in the in soil. Arsenic is naturally occurring in the environment, in many cases at levels well below those posing human health and ecological risks. Naturally occurring levels of arsenic in soil in the United States (U.S.) average about 6.4 mg/kg though concentrations in soil upwards of 100 mg/kg have been reported in the USGS's sampling data. Cleanup decisions for arsenic to protect human health at contaminated sites are generally based on concentrations of 30 to 100 mg/kg and above in soil (Davis et al, 2001). Arsenic concentrations detected in the soil as reported in the environmental sampling report range from <1.0 to 4.7 mg/kg (DWR, 2010). Arsenic concentrations detected during the FY20-21 field investigation program range from <1.0 to 23.4 mg/kg (DCA, 2021). Therefore, human health and environmental risks from arsenic in RTM would be no different from the risk of arsenic in native soils. The results from testing conditioned soil showed that the addition of soil conditioners does not appear to affect the concentrations of arsenic.

5.2.3 Chromium

Chromium in the environment is present in multiple oxidation states with different levels of toxicity. Most chromium in soil is in the form of insoluble, low-toxicity trivalent chromium. A fraction of the chromium in soil might be present as soluble, higher-toxicity hexavalent chromium depending on the soil chemistry. Lower pH conditions, coupled with elevated manganese in soil, promotes the oxidation of trivalent chromium to the hexavalent species. Similarly, higher pH conditions, coupled with elevated iron in soil, promotes the reduction of hexavalent to lower-toxicity trivalent chromium. Chromium in solution detected in water is considered hexavalent as this is the soluble species. Total chromium analyzed in soil in the environmental sampling report is indistinguishable from background levels. The environmental sampling report did not analyze manganese, iron, hexavalent chromium nor pH in soil or water samples and therefore does not provide additional information about the potential for forming hexavalent chromium in soil.

Hexavalent chromium was not analyzed in the environmental sampling report (DWR, 2010). Hexavalent chromium was not detected in soil during the FY20-21 field investigation program with a detection limit of 0.005 mg/kg (DCA, 2021). The RTM testing report analyzed the pH for both native soil and soil treated

with soil conditioners and found a range from pH of 8 to 9 (URS, 2014). This is generally considered a neutral range and not the low pH values at which hexavalent chromium might form in soil. The available information suggests that chromium in soil is most likely present as low-toxicity trivalent chromium.

5.2.4 Mercury

Mercury concentration detected in soil during environmental sampling typically ranged from <0.01 to 0.045 mg/kg (DWR, 2010). Mercury was not detected in approximately half of the soil samples collected. Similarly, mercury was not detected in soil during the FY20-21 field investigation program with a reporting limit of <0.5 mg/kg (DCA, 2021). The analytical reporting limits differed between the investigations but the findings of both are lower than the Tier 1 ESL of 13 mg/kg. The average mercury concentration in U.S. soils is 0.05 mg/kg (USGS, 2013). In flooded environments, such as wetlands, inorganic mercury can be metabolized by anaerobic microbes to methylmercury, which is more toxic and bioaccumulates readily into aquatic organisms. While soils deep below the ground surface, such as the tunneling depth, may be anoxic, the biological activity in deep soils is very low and may not support the metabolism of inorganic mercury to methyl mercury. The introduction of soil conditioners increases soil moisture content and whilst this might further depress the oxygen content in soil, it is not likely that the addition of soil conditioners would increase the potential formation of methylmercury in soil.

Methylmercury was not analyzed in the environmental sampling report (DWR, 2010). Methylmercury was detected in a few samples with estimated concentrations up to 0.245 ng/g (DCA, 2021). All the detected concentrations are considered very low, as these are less than the reporting limit for methylmercury (<0.4 ng/g). No background level in soil has been estimated for methylmercury. However, all concentrations detected fell below a risk-based screening level in soil based on a residential exposure scenario, the Tier 1 Environmental Screening Level (ESL) (RWQCB, 2019).

5.2.5 Organic Substances

Organochlorine pesticides (dichlorodiphenyltrichloroethane (DDT) and dieldrin) were detected in a few soil samples in the FY20-21 field investigation program. These are residual levels from historical use of organochlorine pesticides which ended in the 1970s. Detected concentrations of DDT ranged from 9.75 to 24.1 ug/kg, compared with a Tier 1 ESL of 1.1 ug/kg for a hypothetical residential scenario. Detected concentrations of dieldrin ranged from 4.8 to 216 ug/kg compared with a Tier 1 ESL of 0.46ug/kg for residential land use.

Polycyclic Aromatic Hydrocarbons (PAHs) were also detected in some soil samples. The PAH naphthalene was detected at a concentration of 51 ug/kg in one sample, compared with the residential Tier 1 ESL of 42 ug/kg.

Some of the concentrations of organochlorine pesticides and PAHs detected were higher than their respective Tier 1 ESLs based on a hypothetical residential scenario. However, a hypothetical residential exposure scenario uses the conservative assumption that an individual is exposed to contaminants in soil daily over their lifetime. Actual contact by humans with RTM is likely to be at a much lower frequency, duration and intensity, with corresponding risks from contact with these substances in soil also being much lower.

5.2.6 Sulfides

Volatile reduced sulfur compounds, when emitted into the air, can produce objectionable odors for example, the characteristic ‘rotten-egg’ odor associated with hydrogen sulfide. Hydrogen sulfide results

from the anaerobic metabolism by soil microbes in flooded or waterlogged soils. Reduced sulfur compounds are a feature in estuarine or riparian soils and represent conditions that differ from the soil conditions expected to be encountered in the project corridor at the tunnel depth. Though limited sampling and analytical data for sulfide is available from the project corridor, it is consistent with literature findings.

From a total of eight leachate samples collected (water samples), sulfide was not detected in four. The remaining four results were rejected because the holding times had been exceeded. The limited analytical results, along with literature information, suggests odor impacts associated with volatile sulfides in soil are unlikely to pose a nuisance impact to humans. In addition, hydrogen sulfide produces detectable odors that are below the levels that produce adverse health effects in humans. Therefore, hydrogen sulfide levels in the air not detectable by odor also are not likely to pose a human health hazard. Volatile reduced sulfide compounds in air or soil also are not likely to represent a hazard to wildlife.

5.2.7 Conditioners

The soil conditioning agents are liquid formulations containing mixtures of long-chained fatty acids or glycosides with acid, alcohol or ether functional groups that provide good surfactant properties. The liquid formulations, when handled by workers, pose eye and skin irritation hazards and recommendations for the use of personal protective equipment should be provided in the Safety Data Sheets (SDS). Spills from the liquid formulation that runoff to surface water may pose a hazard to aquatic organisms. When blended with native soil after use in a TBM, the soil conditioners do not pose a health hazard to humans or the environment.

The soil conditioners consist of slightly ionized organic molecules, which would not affect soil pH. As noted, soil pH levels measured in native and conditioned soils were within a range of pH 8 to 9, or relatively neutral levels. While the pH effects in soil would not affect the leachability of metals from treated soil, the soil conditioning agents might act as chelating agents, which could mobilize metals in soil. The leachability of metals from both native and conditioned soil was tested in URS (2014). The results from the testing report showed that leachable concentrations from soil, both in native and conditioned soils, were very limited and far less than state leachability standards for hazardous wastes. Additional soil sampling and testing in the future would confirm the leachability of conditioned soils.

Ultimately, the contractor would be required to verify, by certification of the supplier, that the additives used for soil conditioning during tunneling operations were inert, biodegradable and nontoxic to prevent contamination of the surrounding ground and the RTM.

6. Health, Environment and Ecology

6.1 Overview

This section discusses the results of the existing data evaluation to assess the potential impacts to human health, wildlife and the environment associated with extracting, handling, storing and reuse of RTM.

6.2 Health and Environmental Hazards

Potential hazards to human health, wildlife and the environment associated with RTM include metals and inorganic elements normally present in soil, organic compounds introduced to surface soil (such as

agricultural pesticides), improper release of hazardous materials or petroleum products and potential chemical additives included in soil conditioners used during tunneling.

As discussed, a review of prior environmental test results performed on native soils and conditioned soils concluded that metals and inorganic elements detected throughout the soil profile resemble naturally occurring levels, apart from cadmium. The addition of commercial soil conditioners did not increase the leachability of the naturally occurring constituents, nor did they present a human or ecological health risk.

The process of extracting, handling, storing and reuse of RTM, as with any soil materials, may emit particulate matter into the air which potentially represents a respiratory health hazard to humans and wildlife. These hazards may be present if there are potentially complete exposure pathways from RTM to humans and wildlife. Additionally, leachate from the RTM may come into contact with groundwater or surface water, which may present additional pathways to humans and wildlife.

6.2.1 Dust

As is common with earth moving projects, the potential air quality impacts would be analyzed as part of the regulatory process to identify appropriate mitigation measures to control dust emissions into the air and meet regulatory requirements.

6.2.2 Water

As is common with earth moving projects, the potential water quality impacts would be analyzed as part of the regulatory process to identify appropriate mitigation measures to control potential impacts of runoff and seepage into surface water and groundwater from stored RTM. Leachability testing reported in URS (2014) indicates that the addition of soil conditioners does not increase the mobility of metals in stored material. Drying the RTM would further reduce the leachability.

The results from the RTM testing report (URS, 2014) also indicate that leachate would be below the regulatory thresholds for treatment and disposal.

If quick lime is employed as a drying agent to the RTM, any water captured during processing or storage of the RTM should be tested for pH to determine if neutralization, by addition of acid, to lower the pH, is needed before disposal. pH testing can be performed in a laboratory with a typical turnaround time of 1 to 2 weeks or for efficiency, on-site testing kits could be used to provide reliable real time results.

6.2.3 Testing

As RTM is excavated, it would need to be stockpiled in a temporary holding area. A sample from the stockpile would be tested in accordance with the requirements of the Central Valley Regional Water Quality Control Board and the Department of Toxic Substance Control. Similarly, leachate collected from the temporary holding area would be subjected to the same testing before it is used or released to surface waterways.

The RTM would be tested for the presence of hazardous materials at concentrations exceeding regulatory threshold criteria to confirm the interpretation of the environmental testing data presented herein. If identified as hazardous, the entire temporary stockpile would be transported to a licensed disposal location for those constituents. If the RTM is not found to be hazardous, it would be released to be processed as described later in this TM.

7. Reusable Tunnel Material Volumes

As discussed in Section 3.3, RTM would be generated at the TBM launch shafts and working shafts. The volume of RTM generated at each of these shafts would be a function of the tunnel diameter and length. The tunnel diameter options are summarized in Table 1.

The wet excavated volumes of RTM that would be generated and need to be processed at each launch shaft for each option would be as follows:

Table 5. Wet Excavated RTM Volume Generated at Each Shaft for Each Option of Central Corridor

Shaft	Option 1 (M yd3)	Option 2 (M yd3)	Option 3 (M yd3)	Option 4 (M yd3)
Twin Cities	3.4	5.4	7.3	10.2
Bouldin Island	1.7	2.4	3.2	4.1
Southern Forebay	2.4	2.8	3.4	4.1
Total	7.5	10.7	13.9	18.4

Notes:

M = million(s)

yd^3 = cubic yard(s)

Table 6. Wet Excavated RTM Volume Generated at Each Shaft for Each Option of Eastern Corridor

Shaft	Option 1 (M yd3)	Option 2 (M yd3)	Option 3 (M yd3)	Option 4 (M yd3)
Twin Cities	3.1	5.0	6.7	9.4
Lower Roberts Island	1.6	2.3	3.1	3.9
Southern Forebay	3.2	4.0	5.0	6.2
Total	7.9	11.3	14.8	19.5

Notes:

M = million(s)

yd^3 = cubic yard(s)

From the above tables it can be seen that depending on the corridor and tunnel diameter, the volume of RTM to be processed ranges from 7.5 to 19.5 million cubic yards. The calculations of these volumes can be seen in Attachment 4.

For the additional tunnel between the Southern Forebay Complex and Jones, which is only applicable for the 7,500 cfs option, 0.15 million cubic yards of wet excavated RTM would be generated.

7.1 Rate of Excavation

The rate at which RTM would be generated at each launch shaft site would depend on the tunnel diameter and the linear distance the TBM could be expected to travel over a given time period. Typically, the advance rate would be slower to begin with as the TBM is fully assembled and the tunneling crew become familiar with the machine. Following this start up period, the TBM would typically advance at an average rate for the rest of the drive although it will vary day to day to allow time for inspection, maintenance and extending the TBM equipment as the tunnel length increases.

The average excavation rates assumed for the tunnel diameters being considered are shown in Table 7. These were estimated based on experience of other similar size tunnels in similar ground conditions.

Table 7. Average TBM Advance and Excavation Rates for Each Tunnel Internal Diameter

Tunnel ID (ft)	26	31	36	38	40
Average TBM advance rate (ft/day)	50	46	40	38	36

At times, the TBM's can be expected to operate at a peak excavation rate which is estimated to be double the average excavation rate shown in the table above. Again, this is estimated based on experience of other similar size tunnels in similar ground conditions. It is estimated the peak excavation rate can be sustained for a maximum of 20 straight working days or 1 month out of every 6 months without interruption for inspection, maintenance and extending the TBM equipment. This is a practical limit as when a TBM advances it will need to stop periodically in order to extend the temporary rail lines, power supply, lighting, ventilation system, conveyors etc.

For the additional tunnel between the Southern Forebay Complex and Jones, which is only applicable for the 7,500 cfs option, the average excavation rate is assumed to be 55 feet per day.

8. Reusable Tunnel Material Processing

All of the RTM would be tested for hazardous materials as it is excavated prior to further processing. The RTM that is to serve no further purpose could be stored wet or dry, whilst any RTM that is intended to be used for embankment construction would have to undergo further processing to reduce the moisture content. This section describes the process involved for natural drying, assisted natural drying and mechanical drying of RTM excavated by EPB TBM. For a slurry TBM, the excavated material would be pre-processed in the slurry separation plant and thus the requirement to further dry the RTM would be less.

8.1 Moisture Content

The naturally occurring moisture content of the ground in the tunnel zones is expected to average 31 percent (URS, 2014). With the addition of conditioners and water used in the tunneling process, the excavated material can be expected to have a moisture content varying from 38 percent to 45 percent (URS, 2014). For these RTM calculations an average value of 41.5 percent moisture content has been assumed for the excavated material.

For the RTM that would be used in the construction of the Southern Forebay, it has been determined that the moisture content would have to be reduced to an optimum range of between 17 percent and

21 percent (for clay-rich soils) and the maximum allowable moisture content should be no more than 3 percent above optimum being 20 percent to 24 percent. This range represents typical values for embankment fill and is consistent with the previously conducted compaction test results (URS, 2014). Based on this, for these RTM calculations, a target moisture content of 22 percent has been assumed.

8.2 Natural Drying

Where drying of RTM is not required for construction uses elsewhere on the project, the process would follow the flowchart shown on Figure 1 and described below.

The excavated material would be transferred from the shaft by conveyor to a temporary wet stockpile area where it would be piled up to a maximum of 10 feet in height by bulldozers. The temporary wet stockpiles would be designed to accommodate one week's worth of RTM at peak excavation rate. Once a week's worth (or other amount to be determined by the contractor) of RTM is placed in the temporary wet stockpile area, it would be isolated whilst a sample is taken and tested for hazardous materials. Meanwhile, stockpiling would continue in a second and subsequent temporary wet stockpile areas. Filling of the temporary stockpiles would occur whenever a TBM advances and hence is expected to be a 20 hour/day operation. Any leachate or runoff from the temporary wet stockpiles would be collected and tested before being used or released.

Once the test results have been received, the temporary wet stockpile can be emptied with the use of bulldozers pushing the RTM into central conveyor pits. It is anticipated that it would take two weeks to empty a full wet stockpile area based on a 10 hour working day and as such a total of four temporary wet stockpile areas would be required with one being filled, one being tested and two being emptied at any one time. Additionally, it is recommended that a further two contingency stockpiles of the same size are provided to accommodate any unforeseen delays.

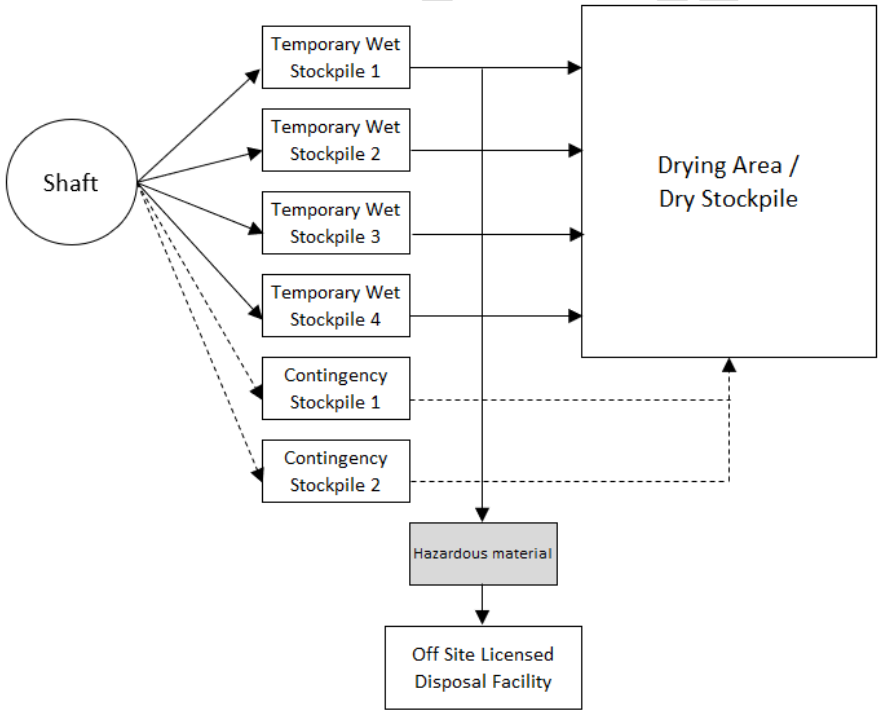

Figure 1. Natural Drying Flowchart

If the test results suggest that a sample was hazardous, all of the RTM from that stockpile would be removed from site and taken to a licensed disposal facility. If the test results deem the sample as non-hazardous, the RTM would be transferred by wheel loader, or other method to be determined by the contractor, to a specific cell within the drying area. During the wet season the RTM will be piled up within the drying cell until the dry season. At the beginning of the dry season the RTM piles and any subsequent RTM generated would be spread out by bulldozers within its respective cell to a depth of 18 inches and allowed to dry for a minimum of three weeks with no additional effort applied to accelerate the drying process since the soil is not needed for structural fill as part of the project. This duration was calculated based on an average volume of water that would need to be extracted of 1.65 gallons per cubic foot of soil and an evaporation rate of 0.21 inch per day over a given area, estimated from the California Irrigation Management Information System data for the period of April 2019 until March 2020. The drying time calculation can be found in Attachment 4. Once dry, at the end of the third week, a compactor would roll over the RTM to compact it in place, preparing the ground for the next lift. Each cell will be designed to hold one week's worth of RTM at 18 inches high. The wet season is conservatively estimated to last 7 months of the year and as such, a total of 37 cells will be required with 15 of those being used twice within an annual cycle. The process would continue as tunnel excavation advances up to a final height specific to each location and option.

The following table shows the range of total temporary stockpile areas allocated at each launch shaft site to process the RTM generated at that site using the natural drying method. The drying area / permanent stockpile sizes are discussed in Section 9.

Table 8. Range of Areas Allocated for RTM Processing at Each Launch Shaft for Different Tunnel Diameter Options

Location	Natural Drying (min. dia. – max. dia.)
Twin Cities	20 – 33 acres
Bouldin Island / Lower Roberts Island	10 – 17 acres
Southern Forebay	26 – 33 acres

Table 9 shows the estimated range of earth moving equipment for the natural drying method along with a summary of the hours used, the power consumption and the capital and operating costs per tunnel drive. The range varies according to tunnel diameter and assumed excavation rate. The values are the same regardless of corridor. Costs are estimated in 2020 dollars and do not account for escalation.

Table 9. Range of Earth Moving Equipment Required Per Tunnel Drive for Different Tunnel Diameter Options

Per Tunnel Drive		Natural Drying (min. dia. – max. dia.)
Earth-moving Equipment	Bulldozers	12 - 12
	Tractors	0 - 0
	Motor Scrapers	0 - 0
	Wheel Loaders	1 - 2
	Compactor	1 - 1

Table 9. Range of Earth Moving Equipment Required Per Tunnel Drive for Different Tunnel Diameter Options

Per Tunnel Drive		Natural Drying (min. dia. – max. dia.)
Total	Equipment Quantity	14 - 15
	Annual Working Hours	10,100 - 17,100
	Power Requirements (MWh/yr)	2,000 - 3,400
	Capital Cost	$2.6M - $2.8M
	Annual Operating Cost	$1.1M - $1.8M

Notes:

M = million(s)

MWh/yr = megawatt-hour(s) per year

8.3 Assisted Natural Drying

For assisted natural drying, the process would follow the flowchart shown in Figure 2 and described below. As RTM is excavated, it would be transferred from the shaft to a temporary wet stockpile area where it would be piled, tested and then emptied as described for the “Natural Drying” option discussed above. Similarly, if the test results suggested that a sample is hazardous, all the RTM from that stockpile would be removed from site and taken to a licensed disposal facility. If the RTM is deemed non-hazardous and the weather is favorable, it would be moved directly to a drying area. If the RTM is non-hazardous and the weather is unfavorable, it would be moved to a wet storage area.

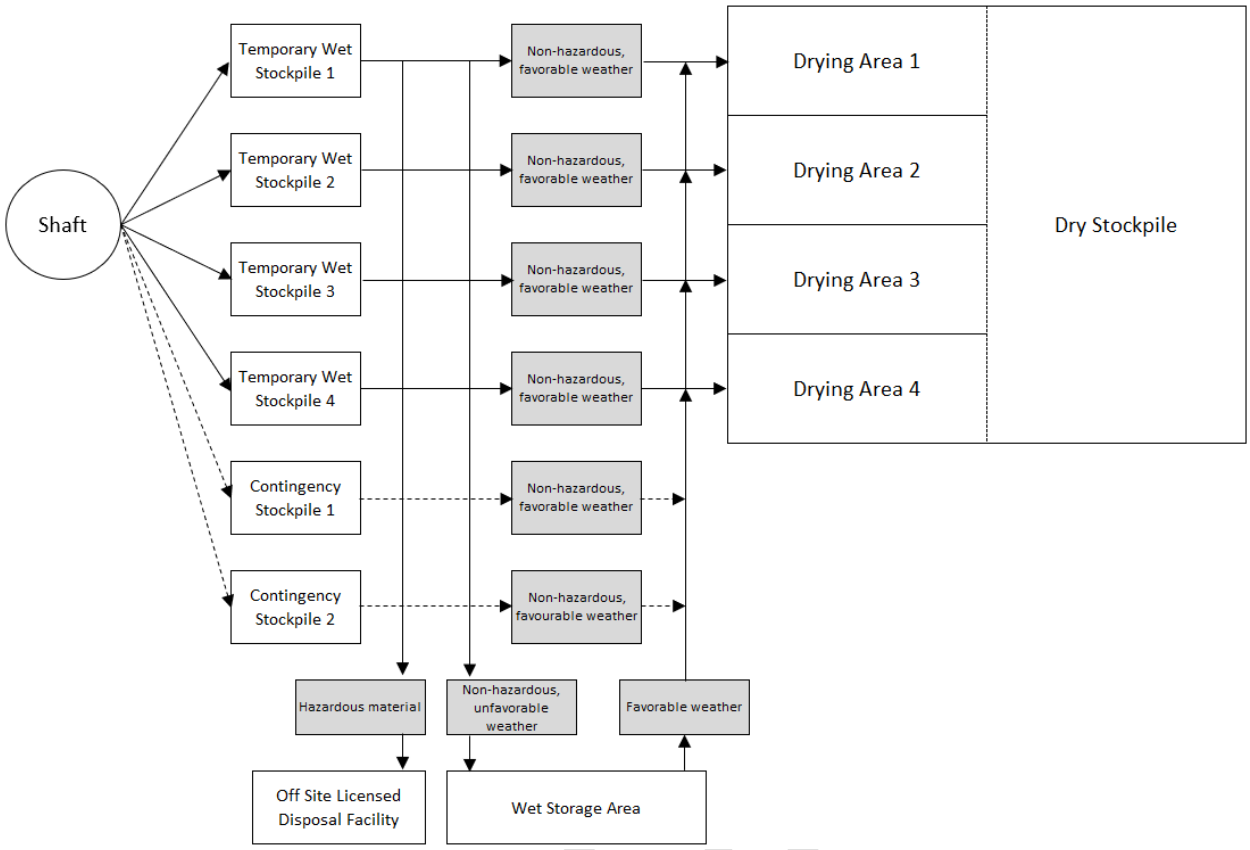

Figure 2. Assisted Natural Drying Flowchart

The wet storage area is designed to accommodate six months' worth of RTM, based on average excavation rates, with the assumption that another months' worth of RTM could be accommodated in either the drying area or dry stockpile area, providing storage for up to 7 months' of unfavorable weather. Conveyors are anticipated to transport the RTM from the temporary wet storage areas to the wet storage area and bulldozers are anticipated to be used to push the material up to 5 ft high.

During favorable weather, RTM from the temporary wet stockpiles would be transported by conveyor, directly to one of four drying areas. The drying areas would be sized to accommodate a full temporary wet stockpiles' worth of RTM each, that is a week's worth of RTM at peak excavation rate, where it would be spread out to a height of no more than 18 inches. During periods of favorable weather when tunnel excavation is below peak rate, the drying areas would have additional capacity and any material in the wet storage area can be moved to fill up the available area.

Once the RTM was deposited in the drying area, bulldozers would be used to spread it out and tractors would pass over the areas several times a day, disking, ripping, and tilling the RTM to promote drying. RTM would remain in the drying areas for at least three weeks of favorable weather as for the 'Natural Drying' option to achieve the desired optimum moisture content.

During a rainfall event, it can be assumed any RTM laid out for drying would cease to dry any further. However, a smooth wheel compactor or similar equipment could be used to seal the top of the drying bed in case of a rainstorm approaching to limit the increase in moisture content.

Once dry, the RTM would be piled up by bulldozers and moved by motor scrapers to be deposited in the dry stockpile area. The size of the area would vary by site and be designed to accommodate the full volume of RTM for the relative tunnel drive at a height specific to each location. If the RTM in a dry stockpile was required for use elsewhere, it is anticipated that it would be removed by wheel loaders and conveyors onto trucks or rail cars.

8.4 Mechanical Drying

For mechanical drying, the process would follow the flowchart shown in Figure 3 and described below. As RTM is excavated it would be transferred from the shaft by conveyor to one of two areas depending on the excavation rate. If the excavation rate is at or below the average excavation rate, the RTM would be transferred directly to the mechanical drying area to be processed, reducing the moisture content to the desired optimum level. From the mechanical drying area, the RTM would be transported by conveyor to a temporary dry stockpile where it would be held and tested for hazardous content. There would be three temporary dry stockpiles with one being filled, one being tested and one being emptied at any one time, plus a fourth contingency stockpile of the same size to accommodate any unforeseen delays. The stockpiles would be sized for a week's worth of RTM at average excavation rate piled up to 10 feet high and would be filled and emptied by bulldozers.

If the test results suggest that the sample is hazardous, the RTM from that stockpile would be removed from site and taken to a licensed disposal facility. If the RTM is deemed non-hazardous the RTM would be transported by conveyor directly to the dry stockpile area.

If the excavation rate is above average, the RTM produced in excess of average would be transferred to a temporary wet stockpile area where it would be piled up to a maximum of 5 feet in height by bulldozers. The temporary wet stockpiles would be designed to accommodate one week's worth of RTM above average excavation rate each. There would be three temporary wet stockpiles with one being filled, one being tested and one being emptied at any one time, plus a fourth contingency stockpile of the same size to accommodate any unforeseen delays. Similar to the "Natural Drying" and "Assisted Natural Drying" scenarios, once a week's worth (or other amount to be determined by the contractor) of RTM is placed in the temporary wet stockpile area, it would be isolated whilst a sample is taken and tested for hazardous materials. Meanwhile, stockpiling would continue in a second and subsequent temporary wet stockpile areas. Once the test results have been received, the temporary wet stockpile can be emptied with the use of bulldozers pushing the RTM into central conveyor pits.

If the test results suggest that the sample was hazardous, the RTM from that stockpile would be removed from site and taken to a licensed disposal facility. If the RTM is deemed non-hazardous, the RTM would be transported by conveyor to one of three locations.

If, at any time, the excavation rate is below average, it is presumed that the mechanical dryers would be working below capacity and could be used to process additional RTM from the temporary wet storage area. Once dry, the RTM could be transferred directly to the dry stockpile area having already been tested.

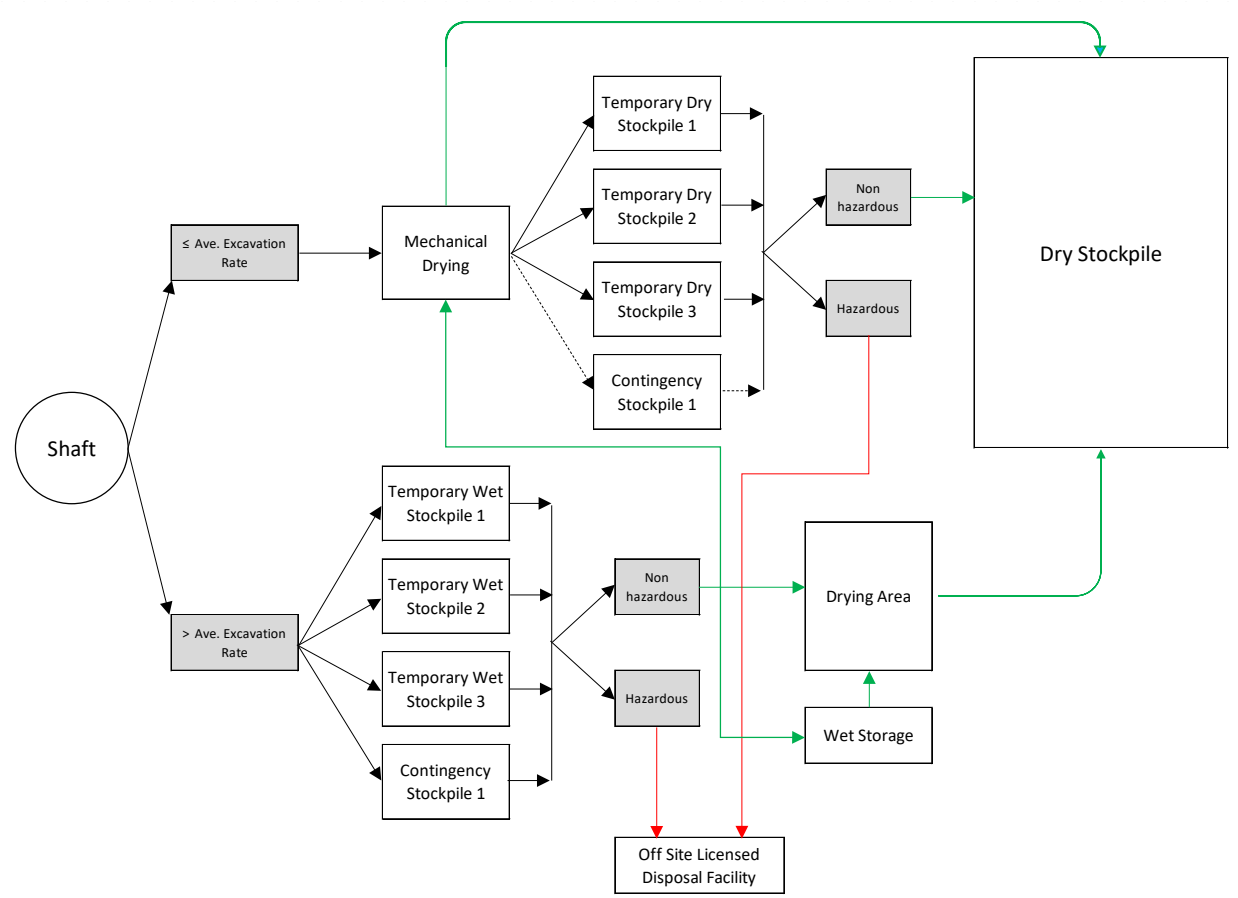

Figure 3. Mechanical Drying Flowchart

If the excavation rate is at or above average, the temporary wet stockpiles could be emptied with the RTM transferred either directly to a drying area or to a wet storage area until space becomes available in the drying area. The wet storage area would function as described for the "Assisted Natural Drying" scenario being designed to accommodate four weeks' worth of RTM at average excavation rate up to 5 ft high.

Once in the drying area, the RTM would be spread out up to 18 in high for a minimum of 3 weeks of favorable weather whilst being disked several times a day to promote drying as for the assisted natural drying scenario. The drying area would be designed to accommodate six weeks' worth of RTM at average excavation rate. Therefore, between the three working temporary wet stockpiles, the wet storage area and the drying area, there would be enough capacity to accommodate 13 weeks' worth, or 3 months' worth, of RTM at average excavation rate.

Once dry, the RTM would be transferred from the drying area to the dry stockpile area, the size of which would vary by site being designed to accommodate the full volume of RTM for the relative tunnel drive at a height specific to each location and moved off site, if required, as for the "Assisted Natural Drying" scenario.

Various methods of mechanical drying were investigated and two feasible options are discussed below. The intention is that the contract documents would not specify a method of drying but allow the contractor to propose what they believe to be the most appropriate method for processing the RTM. The DCA and DCO are currently discussing options to potentially pilot test some drying alternatives. The

research suggested that both centrifuges and belt presses cannot achieve the desired moisture content whilst filter presses cannot meet the excavation rates for this project.

8.4.1 Thermal Dryers

One possible method of mechanical drying would be the use of thermal paddle dryers. Komline-Sanderson manufactures the K-S Paddle Dryer which is capable of achieving the desired optimum moisture content of 22 percent by removing a predetermined weight of water controlled by an automatic weir. It would be necessary to test sample material to determine the exact specifications of the dryer.

The K-S paddle dryers have dual counter rotating agitators with intermeshing hollow wedge-shape paddles that result in uniform heating and optimized heat transfer. The use of hollow heated paddles and a jacketed trough provides for a large amount of heat transfer area in a compact machine. Localized mixing around each self-cleaning paddle creates a homogeneous mixture. The paddles are slow moving, in the region of four revolutions per minute and as such, very little noise is produced typically less than the limit for which ear defenders are required.

Dust control can be achieved in various ways, including an off-gas condenser system such as a spray tower condenser, which would condense the water vapor and any particulate that is entrained in the water vapor as it is generated or a baghouse.

The K-S Paddle Dryer typically has a lifespan of 5 to 10 years depending on the abrasivity of the material being processed and regular inspection and maintenance is recommended to minimize the likelihood of the dryers requiring replacement during construction. The features of an example K-S Paddle Dryer are summarized in the Table 10 below.

Table 10. Features of K-S Paddle Dryer

Manufacturer	Komline-Sanderson
Machine	K-S Paddle Dryer
Model	16W-3200
Capacity	520 yd^3 / day
Length	55 ft
Width	13 ft
Height	14 ft
Weight	113 tons
Heat source power required	32 MMBtu/hr
Motor power required	186 kW
Equipment cost	$4,500,000 per unit

Notes:

kW = kilowatt(s)

MMBtu/hr = million British thermal unit(s) per hour

The motors are electrically-powered and the heat source could be electrically powered or powered by natural gas or propane. For the calculations in Attachment 4, natural gas has been assumed.

Given the size, power requirement and cost of these dryers, it is recommended that they are only provided to meet average excavation rates. The process described above outlines how to process RTM when excavation is above average.

To meet the expected average excavation rate, multiple dryers would be required for a single launch shaft site and the exact number would vary for each of the excavation rates. In addition to the calculated number of dryers, it is recommended that an additional two dryers be provided for each tunnel drive as a contingency. Taking this into account, a total of between six to nine dryers would be required for each tunnel drive. Calculations showing the exact number for each option can be found in Attachment 4.

8.4.2 Rotary Dryers

Another possible method of mechanical drying would rotary dryers. Vulcan Drying Systems manufactures rotary dryers for a number of industries and could custom make them to dry RTM. The RTM would be fed via continuous feed into the rotary dryer, which would consist of a correctly sized drum and a burner mounted in a concurrent configuration. The amount of heat applied would be controlled to achieve the desired optimum moisture content of 22 percent. The dried product would be discharged to a transfer conveyor and vapor from the process would be pulled through a baghouse which would remove fine particulates from the vapor stream. The features of an example rotary dryer are summarized in Table 11 below.

Table 11. Features of Rotary Dryer

Manufacturer	Vulcan Drying Systems
Machine	Custom-made
Capacity	1,460 yd^3 / day
Length	75 ft
Width	30 ft
Height	20 ft
Weight	100 tons
Heat source power required	57 MMBtu/hr
Motor power required	190 kW
Equipment cost	$400,000 per unit

Notes:

kW = kilowatt(s)

MMBtu/hr = million British thermal unit(s) per hour

Whilst a single system could be custom designed to process all of the RTM at any required excavation rate, this would not provide any contingency or redundancy should the system encounter any down time. For this reason, a number of smaller systems are recommended. As a minimum it is recommended that a single system would be designed to process half of the required volume and hence two systems per tunnel drive would be provided. Furthermore, it is recommended that an additional dryer system be provided for each tunnel drive as a contingency. Calculations showing the requirements of rotary dryers can be found in Attachment 4.

Similar to the thermal dryers, the motors are electrically-powered and the heat source could be electrically powered or powered by natural gas or propane. For the calculations in Attachment 4, natural gas has been assumed.

8.5 Comparison of Natural and Mechanical Drying

The total area required for processing and storage of RTM varies by site and for each corridor and tunnel diameter option. Similarly, the equipment used in the processing, as well as the power requirement and cost of that equipment, is directly related to the excavation rate and tunnel diameter.

The following table shows the range of areas allocated at each launch shaft site to process the RTM generated at that site for each of the two drying methods. The permanent stockpile sizes are discussed in Section 9. Regardless of the site, of the two drying options, mechanical drying requires the smallest area.

Table 12. Range of Areas Allocated for RTM Processing at Each Launch Shaft for Different Tunnel Diameter Options

Location	Assisted Natural Drying (min. dia. – max. dia.)	Mechanical Drying (min. dia. – max. dia.)
Twin Cities	146 – 253 acres	81 – 137 acres
Bouldin Island / Lower Roberts Island	73 – 126 acres	40 – 69 acres
Southern Forebay	191 – 253 acres	105 – 137 acres

Table 13 shows the estimated range of earth moving equipment for each drying method. Table 14 shows the range of equipment requirements for the “Mechanical Drying” option. Each lists the quantities and a summary of the hours used, the power consumption and the capital and operating costs per tunnel drive. The range varies according to tunnel diameter and assumed excavation rate. The values are the same regardless of corridor. Costs are estimated in 2020 dollars and do not account for escalation.

Table 13. Range of Earth Moving Equipment Required Per Tunnel Drive for Different Tunnel Diameter Options

Per Tunnel Drive		Assisted Natural Drying (min. dia. – max. dia.)	Mechanical Drying (min. dia. – max. dia.)
Earth-moving Equipment	Bulldozers	17 - 18	10 - 10
	Tractors	2 - 3	2 - 2
	Motor Scrapers	2 - 4	0 - 0
	Wheel Loaders	1 - 2	2 - 4
	Compactor	1 - 2	1 - 2
Total	Equipment Quantity	23 - 29	15 - 18
	Annual Working Hours	29,800 - 51,700	13,900 - 24,200
	Power Requirements (MWh/yr)	6,300 - 10,900	3,100 - 5,500
	Capital Cost	$5.5M - $7.8M	$2.5m - $2.9M
	Annual Operating Cost	$3.2M - $5.5M	$1.5M - $2.6M

Notes:

M = million(s)

MWh/yr = megawatt-hour(s) per year

Table 14. Range of Drying Equipment Requirements Per Tunnel Drive for Different Tunnel Diameter Options

Per Tunnel Drive		Thermal Dryers (min. dia. – max. dia.)	Rotary Dryers (min. dia. – max. dia.)
Mechanical Drying Equipment	Quantity	6 - 9	3 - 4
	Annual Working Hours	30,600 - 45,900	15,300 - 20,400
	Natural Gas Power (MMBtu/yr)	980 - 1,500	870 - 1,200
	Electrical Power (MWh/yr)	5,700 - 8,600	2,900 - 3,900
	Capital Cost	$27.0M - $40.5M	$1.2M - $1.6M
	Annual Operating Cost	$8.3m - $12.4m	$7.1m - $9.5m

8.5.1 Drying Summary

Comparing the tables above with the equivalent tables for the natural drying option in Section 8.2 shows that the natural drying option requires the fewest resources in terms of equipment power and cost. Where RTM must be dried, a smaller area and less earth moving equipment is required for the "Mechanical Drying" option. However, this is counterbalanced by the need for mechanical dryers, leading

this option to have a greater power requirement and cost, despite the fact that some power would be supplied by natural gas and electricity.

In addition to these factors, the construction schedule must also be considered to determine the most appropriate method for drying the RTM. As the "Assisted Natural Drying" option is dependent on the weather, it cannot be guaranteed throughout the year whereas mechanical drying would allow year-round processing and a steady rate of production of dried RTM.

Detailed calculations to show the areas and equipment requirements for each of these options can be found in Attachment 4.

8.6 Quicklime

High calcium quicklime could be added to the RTM to expedite drying. Quicklime and hydrated lime are highly effective at drying wet clays and silty soils. Typically, 3 to 5 percent of the weight of soil is required. The use of quicklime however, presents notable health and safety hazards for workers in the form of eye, skin and respiratory tract irritation. Safe handling practices and personal protective equipment are required as per the safety data sheet for the product. URS (2014) showed that RTM treated with quicklime measured approximately pH13, which would make it unsuitable for plant growth.

8.7 Site Preparation

Consideration should be given to each of the RTM processing areas to confirm the ground is sufficiently prepared for all loading and operations that are expected. Temporary stockpiles are expected to be concrete structures with walls on three sides at least 3 ft above the designed stockpile height. They are also expected to have two centrally located conveyor pits into which the RTM can be pushed by bulldozer and underground channels for the conveyors to transport the RTM away from the temporary stockpiles to next processing area. For the wet temporary stockpiles, drainage should be incorporated into the floor design to catch run off and leachate for testing, treatment or both. For the mechanical drying option, given the size, weight and quantity required, site preparation (including solid foundations) would be required to support the dryers.

9. Reusable Tunnel Material Storage

The area required for storage of RTM is dependent on a number of inputs including the tunnel diameter which directly correlates to the volume of RTM, how high the RTM can be stored at any given location, how much borrow is planned to be used at each site which would need to be replaced, and how much of the RTM is to be used for other purposes.

In the temporary situation, sufficient area will be provided to stockpile all RTM at the site where it would be generated, but subject to area and height restrictions discussed below. The temporary storage stockpile area and height for each option are summarized in Tables 15 and 16 below. In the permanent situation, sufficient area would be provided to stockpile all surplus RTM at the site at which it would be generated. For the dual launch shaft sites at Twin Cities and the Southern Forebay it is assumed the RTM from both tunnel drives would be consolidated into a single permanent stockpile. The permanent storage stockpile areas and heights for each option are summarized in Tables 17 and 18 below.

The quantities described below were developed in conjunction with the project-wide soil balance as described in the Soil Balance TM (DCA, 2021a), which includes consideration of on-site borrow, other on-

site material sources, fill needs across the project and specifically at Twin Cities, includes the demolished ring levee material that will be added to the stockpile. The assumed stockpile heights discussed below are based on a review of geotechnical conditions using available information and would be subject to revision based on collection of site-specific subsurface data, testing, geotechnical analyses and consideration of other site factors that may pose restrictions.

Table 15. Temporary Stockpile Areas and Heights for Each Option of Central Corridor

Shaft	Option 1		Option 2		Option 3		Option 4	
	Area (acres)	Height Above Grade (ft)	Area (acres)	Height Above Grade (ft)	Area (acres)	Height Above Grade (ft)	Area (acres)	Height Above Grade (ft)
Twin Cities North	17	20	39	20	56	20	94	20
Twin Cities South	42	20	70	20	99	20	132	20
Bouldin Island	129	7	168	7	196	8	225	9
Southern Forebay North	140	4	165	5	185	6	193	7
Southern Forebay South	159	4	124	5	104	6	96	7

Table 16. Temporary Stockpile Areas and Heights for Each Option of Eastern Corridor

Shaft	Option 1		Option 2		Option 3		Option 4	
	Area (acres)	Height Above Grade (ft)	Area (acres)	Height Above Grade (ft)	Area (acres)	Height Above Grade (ft)	Area (acres)	Height Above Grade (ft)
Twin Cities North	20	20	43	20	60	20	99	20
Twin Cities South	44	20	67	20	93	20	122	20
Lower Roberts	129	5	168	6	196	7	225	8
Southern Forebay North	180	6	202	7	219	9	225	11
Southern Forebay South	109	6	86	7	70	9	64	11

Table 17. Permanent Stockpile Areas and Heights for Each Option of Central Corridor

Shaft	Option 1		Option 2		Option 3		Option 4	
	Area (acres)	Height Above Grade (ft)	Area (acres)	Height Above Grade (ft)	Area (acres)	Height Above Grade (ft)	Area (acres)	Height Above Grade (ft)
Twin Cities	15	15	52	15	130	15	275	15
Bouldin Island	129	5	168	5.5	196	6	225	7
Southern Forebay	0	0	0	0	0	0	0	0

Table 18. Permanent Stockpile Areas and Heights for Each Option of Eastern Corridor

Shaft	Option 1		Option 2		Option 3		Option 4	
	Area (acres)	Height Above Grade (ft)	Area (acres)	Height Above Grade (ft)	Area (acres)	Height Above Grade (ft)	Area (acres)	Height Above Grade (ft)
Twin Cities	15	15	84	15	159	15	291	15
Lower Roberts	33	15	50	15	71	15	93	15
Southern Forebay	0	0	17	15	30	15	51	15

At the Twin Cities Complex, it is anticipated that the RTM generated would be mechanically dried since a portion would be needed at the Southern Forebay for embankment construction. At this site a borrow pit would be excavated and a portion of the RTM generated would also be used to restore topography at the site. For the temporary case, the dried RTM would be stockpiled to a maximum height of 20 feet. This would require between 17 and 132 acres per tunnel drive for the Central Corridor and between 20 and 122 acres per tunnel drive for the Eastern Corridor. For the permanent case, the volume to be transported to the Southern Forebay would differ for the different flow rate options and corridors and the surplus from both tunnel drives, would be stockpiled on site following completion of tunneling and combined with the demolished ring levee material to a maximum height of 15 feet with varying areas. This would require between 15 and 275 acres for the Central Corridor and between 15and 291 acres for the Eastern Corridor.

At Bouldin Island on the Central corridor, all of the RTM generated is expected to remain on site following the “Natural Drying” process and no borrow is planned. In this case, between 129 and 225 acres is required for this process with the temporary stockpile remaining in place to become the permanent stockpile. In the temporary case the stockpile is anticipated to vary in height from 7 feet to 9 feet depending on the option and in the permanent case following drying and natural consolidation the stockpile is anticipated to vary in height from 5 feet to 7 feet accounting for potential settlement of the stockpile as discussed in Section 9.1 Settlement.

At Lower Roberts Island on the Eastern corridor, a borrow pit is anticipated to be excavated. All of the RTM generated is expected to remain onsite following the “Natural Drying” process and used to backfill the borrow pit with the surplus being stored above grade. In the temporary case, between 129 and

225 acres are required for this process with the height varying between 5 feet and 8 feet. In the permanent case, following completion of tunneling, the RTM would be consolidated up to a maximum height of 15 feet and varying in area from 33 acres to 93 acres accounting for potential settlement of the stockpile as discussed in Section 9.1 Settlement. At the Southern Forebay it is anticipated that the RTM generated would be mechanically dried, with the majority being used for embankment construction. In the temporary case, an area of 289 acres has been allocated within the footprint of the Southern Forebay to store RTM which would be proportionately split between the north and south tunnel drives resulting in a maximum possible stockpile height of between 4 feet and 7 feet for the Central Corridor and between 6 feet and 11 feet for the Eastern Corridor. In the permanent case an area has been identified to the north of the Southern Forebay to stockpile surplus RTM up to maximum height of 15 feet. For the Central Corridor option all of the RTM will be used with no surplus to stockpile. For the Eastern Corridor option however, due to the construction schedule, RTM would be required for embankment construction prior to completion of tunneling from this site and hence surplus RTM will be stockpiled on site requiring between 17 and 51 acres.

For the additional tunnel connecting the project to the CVP, which is only applicable for the 7,500 cfs option, it is anticipated that the RTM would be stored temporarily on the launch shaft site for testing and then transported to the Southern Forebay for processing and stockpiling following the same procedure as for the "Natural Drying" option. A total of 5 acres would be required to stockpile this RTM based on an assumed maximum stockpile height of 15 feet. Calculations showing the volume of RTM generated and the areas required for each stage of the process can be found in Attachment 4.

The areas presented above include a 5 percent allowance for working space and vehicle maneuvering and the RTM would be placed with side slopes similar to the soil's natural angle of repose or as recommended by the project geotechnical engineers. For simplicity, side slopes are not accounted for in the calculations directly and would only have a negligible effect on volume calculations for such large areas with comparatively small heights. Any difference in volume resulting from side slopes is more than accounted for in the 5 percent allowance for working space and vehicle maneuvering. Areas designated for long term storage of RTM would be stripped of topsoil prior to placement of the RTM. Stripped topsoil would be stockpiled and re-spread over these areas after the RTM is placed and the stockpiles would be planted with erosion control grasses.

Detailed calculations to show the areas for each tunnel option, corridor and drying method can be found in Attachment 4.

9.1 Settlement

The height of stored RTM varies by site, option and corridor. A preliminary settlement analysis should be conducted at each proposed storage site to understand the potential impacts, which would depend on the site-specific geotechnical conditions. Additional geotechnical analyses should be performed upon completion of supplemental site-specific geotechnical exploration and testing. Furthermore, at Bouldin Island and Lower Roberts Island, RTM stored long term is expected to sink by as much as 20 percent and that which has sunk would become unusable for future use, although this is likely to take a number of years and have negligible effect outside of the stockpile footprint.

10. Reusable Tunnel Material Usage and Disposal

At this time, the geotechnical and environmental properties of the anticipated RTM have been evaluated and deemed suitable for use in earthwork construction, subject to identified additional sampling and

testing and confirmatory testing during RTM generation. The following sections discuss potential beneficial uses of RTM.

10.1 Southern Forebay

Construction of a Southern Forebay is anticipated to require several million cubic yards of RTM, making it the single largest potential use of RTM on the project. As discussed previously, the volume of RTM generated at each of the launch shaft sites would depend on the final tunnel diameter and corridor. The calculations in Attachment 4 show the rate and timing at which RTM would be expected to be generated by each TBM and hence at each launch shaft site for each option, based on the current estimated construction schedule.

In all scenarios, the volume and timing of RTM generated at the Southern Forebay alone isn't sufficient for the Southern Forebay construction and therefore, import from other sources would be required to make up the deficit. Primarily the deficit would be obtained by transporting RTM from the Twin Cities Complex as there is potential for a direct rail link between the two. Transportation details are discussed in Section 11. The volume of RTM to be transported from the Twin Cities Complex to the Southern Forebay is summarized for each corridor and each option in Table 19.

Table 19. Dry Compacted RTM Volume Exported from Twin Cities Complex to Southern Forebay for Each Option and Corridor

Corridor	Option 1	Option 2	Option 3	Option 4
Central	1.5 M yd^3	2.2 M yd^3	1.8 M yd^3	0.6 M yd^3
Eastern	1.8 M yd^3	1.7 M yd^3	1.3 M yd^3	0.3 M yd^3

For the 26 ft ID option, in addition to the RTM imported from the Twin Cities Complex shown in the table above, a further 1.0 million cubic yards for the Central corridor and 33,500 cubic yard for the Eastern corridor of dry compacted RTM would be required for the Southern Forebay construction. It's possible this could be sourced from the launch shaft site on Bouldin Island or Lower Roberts Island respectively, but the RTM generated there would not be dried, and so special provisions would have to be made to process this RTM. Alternatively, this material could be imported from off site.

10.2 Shaft Pads

At this time, it is expected that shaft pads would be primarily built with soils borrowed from shallow excavation within the project, however, if RTM generation timing allows, pads may also be built from RTM. This would apply only to shaft pads constructed after the tunnel excavation has begun and would therefore represent only a small proportion of total shaft locations. The RTM volume anticipated for shaft pads would be negligible.

10.3 Intakes

At this time, no RTM is anticipated to be required at the intake structures.

10.4 Other Uses

At this time, it is anticipated that RTM would be used on the project to the greatest extent possible to reduce the need for imported fill. It is anticipated that surplus RTM would be stored at the launch shaft site where it was generated. However, launch shaft siting considered site access by rail to facilitate offsite transportation of RTM if needed.

It is anticipated that approximately 13 million cubic yards of suitable fill is required for levee maintenance within the Delta to upgrade the current levee system to comply with PL 84-99 Delta-Specific Geometry Standards (Arcadis, 2017). The majority of this fill is needed in the northwest and southeast portions of the Delta. Depending on project needs and timing, this fill could be made available to the Local Maintaining Agencies (LMA's) for levee maintenance and enhancements, subject to the environmental permitting requirements unique to those projects.

Other possible uses include:

- Fill material for construction of embankments or building pads to prevent flooding
- Fill material for habitat restoration projects
- Fill material for roadway projects
- Material for flood response
- Material to fill project-related borrow areas

An assessment of the suitability of RTM for these or any other application would be required to determine the feasibility taking into account transportation and environmental factors among others.

10.5 Disposal

If the RTM could not all be used for other purposes on the project and the surplus could not be stockpiled at the launch shaft site where it was generated, the RTM would need to be removed to a site(s) where it could be stockpiled, including Delta islands, aggregate suppliers, soil brokers or landfills.

11. Reusable Tunnel Material Transportation

Transportation of RTM would be minimized for traffic and air quality reasons. However, some of the RTM would be designated for use in the construction of the Southern Forebay. Similarly, it may also be necessary to transport RTM if a long-term storage location could not be found in the immediate vicinity of the launch shaft site where it was generated. Where RTM transportation is planned, shaft siting considered access to transportation by road, rail and barge. At this point, barge loading facilities are not included in the project and the discussion of RTM transport is limited to road and rail.

By road, it is estimated that with a semi end dump truck, 13 cubic yards of wet RTM and 14 cubic yards of dry RTM could be transported per truck trip. This is based on the expected density of the RTM and a weight limitation of 18 tons per truck. By rail, it is estimated that 1,200 cubic yards could be transported per trip based on 20 cars per train and a capacity of 60 cubic yards per car. This is based on volume limitations.

The following table shows the number of trips that would be required if dried RTM were to be removed from a site at the rate at which it would be generated per tunnel drive for the northern and main tunnel sections, based on the average excavation rate for each option over the course of one week based on a 5-day working week.

Table 20. Trips Required to Move Dry Excavated RTM at Average Excavation Rate for Each Option Per Tunnel Drive

	Option 1	Option 2	Option 3	Option 4
Average Excavation Rate (yd^3/week)	7,650	9,850	11,400	13,000
Road (trips/week)	545	700	815	950
Rail (trips/week)	7	9	10	12

For Options 1, 2 and 3, the southern tunnel section with a larger tunnel diameter would generate more RTM per week and require more trips. Option 4 has the same tunnel diameter for the northern, main and southern sections. At times of peak excavation, the number of trips required to meet the excavation rate would be double that shown in the table above.

For the additional tunnel connecting to Jones, which is only applicable for the 7,500 cfs option, 410 truck trips per week would be required to meet the average excavation rate and double this to meet the peak excavation rate. A total of 11,000 truck trips would be required to move all of the RTM generated from this tunnel to the Southern Forebay. Rail lines are not planned to connect to the launch shaft site for this tunnel.

11.1 Transporting Reusable Tunnel Material from Twin Cities to Southern Forebay

The range of volume of dry compacted RTM required to be transported from the Twin Cities Complex to the Southern Forebay varies from 0.3 to 2.2 million cubic yards, depending on the tunnel diameter and corridor. The volume is derived from the project-wide soil balance which accounts for the construction schedule and specifically, the timing of when RTM is generated and required. This would require between 700 and 1,600 rail trips or 53,400 to 130,500 truck trips for the Central Corridor and between 300 and 2,000 rail trips or 24,400 to 164,600 truck trips for the Eastern corridor.

For the 26 ft ID Option on the Central corridor, an additional 1.3 million cubic yards of imported dry excavated material would be required to supplement the available RTM. For the 26 ft ID Option on the Eastern corridor, an additional 0.1 million cubic yards of imported dry excavated material would be required to supplement available RTM. Imports to satisfy the Central corridor need for additional fill would result in 1,100 rail trips or 92,500 truck trips, whereas, imports to satisfy the Eastern corridor additional fill need would result in 100 rail trips or 3,000 truck trips.

Detailed calculations to show the number of trips by mode of transport required to move RTM to the Southern Forebay can be found in Attachment 4.

11.2 Transporting Reusable Tunnel Material Off Site

If any remaining RTM needed to be transported off site following the construction of the Southern Forebay and backfilling of borrow pits where needed, road or rail would be considered. The number of trips that would be required to remove remaining RTM from each launch shaft site for each corridor can be seen in the calculations in Attachment 4.

12. Conclusions

The following conclusions can be drawn from this evaluation:

- Depending on the tunnel diameter and chosen corridor, the volume of excavated RTM would range from 7.5 to 19.5 million cubic yards.
- Findings of the preliminary environmental assessment (DWR,2010) and the FY20-21 field investigation program (DCA, 2021) suggest there is no risk to human health, wildlife or the environment from extracting, handling, storing and reuse of RTM, provided standard procedures are followed.
- The use of soil conditioners in the tunneling process does not pose a risk to human health, wildlife or the environment provided standard procedures are followed.
- Following excavation, RTM would be tested in accordance with the requirements of the Central Valley Regional Water Quality Control Board and the Department of Toxic Substance Control for the presence of hazardous materials at concentrations exceeding regulatory threshold criteria, to confirm the interpretation of the environmental testing data.
- The extracting, handling, storing and reuse of soils may result in dust emissions that would impact air quality. An analysis of the potential impacts is needed to identify appropriate mitigation measures.
- Natural drying, assisted natural drying and mechanical drying of the RTM have been considered. The optimal solution would depend on the final tunnel diameter(s), rate of excavation, construction schedule and considerations of cost, environmental impact and availability of space at each of the launch shaft sites and would be determined by the contractor. At this time the following is recommended;
  - At the Twin Cities Complex launch shaft site, “Mechanical Drying” of RTM is recommended in order that the RTM is processed and made available for transportation to the Southern Forebay for use in embankment construction on a year round basis without being subject to fluctuating weather conditions.
  - At Bouldin Island launch shaft site on the Central corridor, the “Natural Drying” process is recommended as the RTM is expected to be stockpiled on site.
  - At Lower Roberts Island launch shaft site on the Eastern corridor, the “Natural Drying” process is recommended as the RTM is expected to be stockpiled on site.
  - At the Southern Forebay launch shaft site, “Mechanical Drying” of RTM is recommended in order that the RTM is processed and made available for use in embankment construction on a year-round basis without being subject to fluctuating weather conditions.
- For the sites where “Mechanical Drying” is employed, rotary drying with natural gas or propane powering the heat source is recommended as a more efficient and cost-effective solution of the two methods discussed in this TM. It should be noted that neither of the methods presented have been used in a tunnel construction application by the referenced manufacturers and the contractor should take all necessary steps to ensure the chosen system is suitable for the project which may be neither of the methods discussed in this TM.
- Settlement analysis and a study to understand the potential limitation on future land use should be conducted at each proposed RTM storage site to understand the potential impacts.
- The volume and timing of RTM that would be generated at the Southern Forebay would not be sufficient to meet the needs of the Southern Forebay construction. As such, RTM would need to be transported from elsewhere to make up the deficit. It is recommended that to the extent possible,

the additional RTM is primarily sourced from the Twin Cities Complex launch shaft site and transported by rail.

- The volume of RTM required to be transported from the Twin Cities Complex to the Southern Forebay for embankment construction would vary from 0.3 to 2.2 million cubic yards, depending on the tunnel diameter and corridor.

13. References

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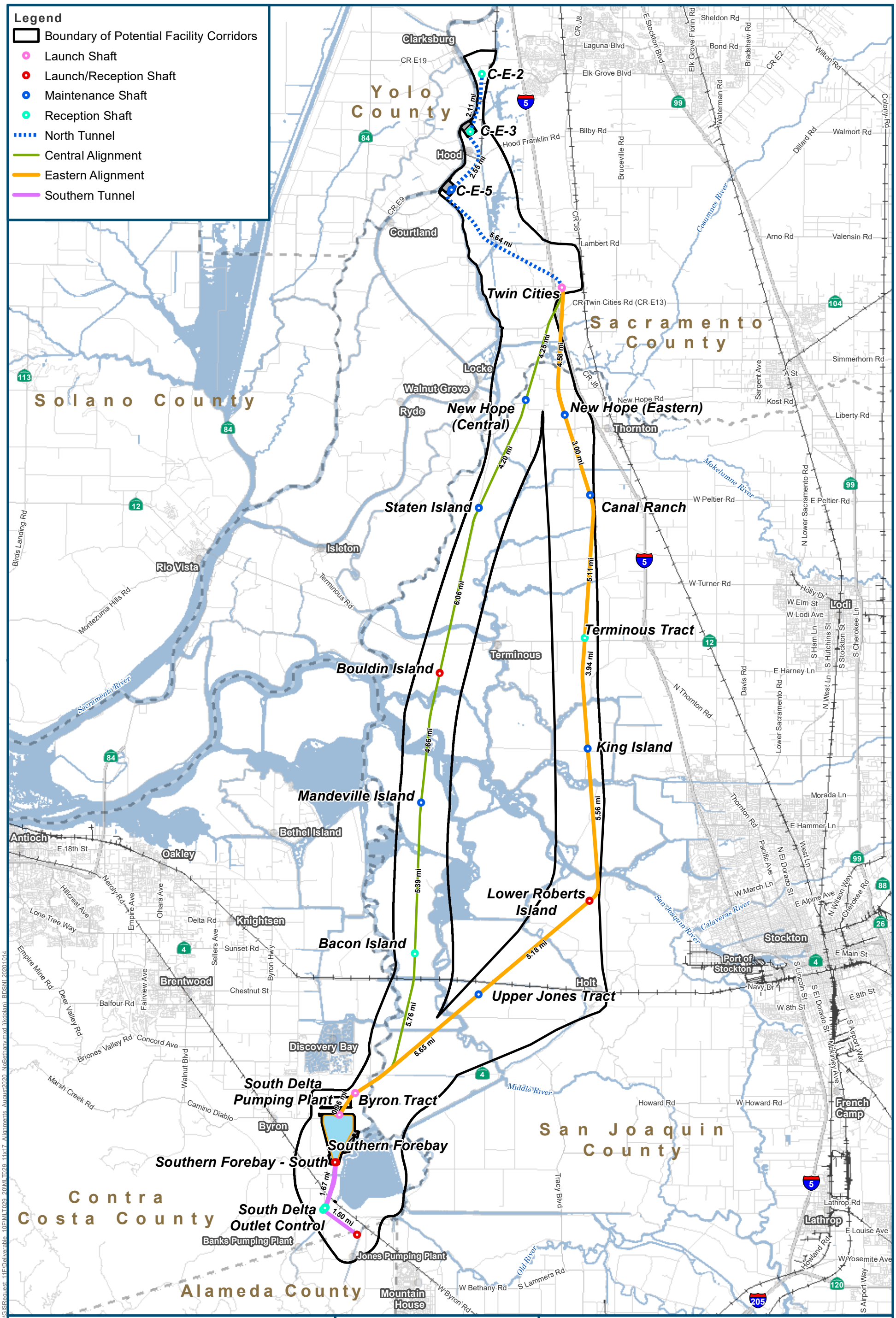
14. Document History and Quality Assurance

Reviewers listed have completed an internal quality review check and approval process for deliverable documents that is consistent with procedures and directives identified by the Engineering Design Manager (EDM) and the DCA.

Approval Names and Roles			
Prepared by	**Internal Quality Control review by**	**Consistency review by**	**Approved for submission by**
Shaun Firth / RTM Task Force Lead	Steve Dubnewych / EDM Tunnel & Shaft Lead	Gwen Buchholz / DCA Environmental Consultant Phil Ryan / EDM Design Manager	Terry Krause / EDM Project Manager

This interim document is considered preliminary and was prepared under the responsible charge of Shaun Firth, California Professional Engineering License C76019.

Attachment 1
Corridor Options



DCA DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

For Illustration Purposes Only

N

0 1.5 3 Miles

Alignments
August 2020

Data Source: DCA, DWR

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Attachment 2
Table of Inputs and Assumptions

CA Delta Conveyance Tunnel - RTM Calculations 14 Dec 2020

Inputs and Assumptions

Input		Value	Unit
Tunnel Lining Dimensions			
Option 1	Northern and Main tunnels lining ID	26.00	ft
	Southern tunnels lining ID	38.00	ft
	Northern and Main tunnels lining thickness	14.00	in
	Southern tunnels lining thickness	20.00	in
Option 2	Northern and Main tunnels lining ID	31.00	ft
	Southern tunnels lining ID	38.00	ft
	Northern and Main tunnels lining thickness	16.00	in
	Southern tunnels lining thickness	20.00	in
Option 3	Northern and Main tunnels lining ID	36.00	ft
	Southern tunnels lining ID	38.00	ft
	Northern and Main tunnels lining thickness	18.00	in
	Southern tunnels lining thickness	20.00	in
Option 4	Northern and Main tunnels lining ID	40.00	ft
	Southern tunnels lining ID	40.00	ft
	Northern and Main tunnels lining thickness	24.00	in
	Southern tunnels lining thickness	24.00	in
TBM Dimensions			
TBM tailcan thickness (All Options)		2.50	in
Cutterhead offset (All Options)		2.50	in
Tunnel Excavation Rates			
Start up advance rate (All Options)		30.00	ft / day
Option 1	Northern and Main tunnels average advance rate	50.00	ft / day
	Southern tunnels average advance rate	38.00	ft / day
Option 2	Northern and Main tunnels average advance rate	46.00	ft / day
	Southern tunnels average advance rate	38.00	ft / day
Option 3	Northern and Main tunnels average advance rate	40.00	ft / day
	Southern tunnels average advance rate	38.00	ft / day
Option 4	Northern and Main tunnels average advance rate	36.00	ft / day
	Southern tunnels average advance rate	36.00	ft / day
Est. percentage of excavation at peak rate (All Options)		16.67	%

TBM Utilization		
Tunnelling hours per day	20	hours
Tunnelling days per week	5	days / wk
Tunnelling weeks per year	51	wks / yr

Geotechnical Factors		
Unit weight of in-situ RTM	120.00	lb/ft3
Unit weight of wet excavated RTM	99.70	lb/ft3
Unit weight of dry excavated RTM	95.00	lb/ft3
Bulking factor	1.30	
Volume loss during drying	5.00	%
Volume of water extracted during drying	1.65	gal/ft3
Full compaction factor	0.80	

Drying RTM		
Average moisture content of excavated RTM	41.50	%
Desired optimum moisture content	22.00	%
Height of stockpile during drying	18.00	in
Working space / buffer for drying	20.00	%

Storing RTM		
Temporary stockpile working space/buffer	50.00	%
Temporary working space / buffer	20.00	%
Permanent working space / buffer	5.00	%
Max. height of temporary short term dry stockpiles	10.00	ft
Max. height of temporary short term wet stockpiles	10.00	ft
Max. height of temporary long term wet stockpiles	5.00	ft
Max. height of dry stockpile at Twin Cities	25.00	ft
Max. height of dry stockpile at Bouldin Island	8.00	ft
Max. height of dry stockpile at Lower Roberts Island	8.00	ft
Max. height of dry stockpile at Southern Forebay	15.00	ft

Transporting RTM		
Road capacity by volume based on one truck per trip	18	yd3 / trip
Road capacity by weight (semi-end dump trucks)	18	tons / trip
Road capacity by weight (bottom dump trucks)	20	tons / trip
Rail capacity based on 60yd3 per car, 20 cars per train	1,200	yd3 / trip

Alignment and Shaft Locations	
Shaft locations	As shown on dwg
Corridor options	As shown on dwg
Launch/reception shaft designation	As shown on dwg

Attachment 3
Determination of Geotechnical Factors

Project: Delta Conveyance
Subject: RTM Volume Reduction due to Drying
By: Myra Au/Andrew Finney
Checked: Dean Harris
Date: 04/21/2020 rev2

Assume

In-situ soil total unit weight
(avg total unit weight from depth 100 to 200ft) $\gamma_t := 120pcf$

In-situ soil water content (WC) $w_{in\_situ} := 0.31$

RTM moisture content (URS, 2014)
(conditioner and water added during tunneling) $w_{exc} := 0.415$

RTM optium moisture content (URS, 2014) $w_{opt} := 0.22$

RTM optimum dry unit weight (URS, 2014) $\gamma_{max} := 103pcf$

Bulking factor (no account for change in WC) $BF := 1.3$

Soil specific gravity $G_s := 2.7$

Unit weight of water $\gamma_w := 62.4pcf$

Soil Unit Weight Calculation

In-situ soil dry unit weight $\gamma_d := \frac{\gamma_t}{\left(1 + w_{in\_situ}\right)} = 91.6 \cdot pcf$

This is the weight of the solids in 1 cubic foot of in-situ soil. Now add water and bulk to get RTM properties

RTM total unit weight $\gamma_{t\_exc} := \frac{\gamma_d \cdot \left(1 + w_{exc}\right)}{BF} = 99.7 \cdot pcf$

RTM dry unit weight $\gamma_{d\_exc} := \frac{\gamma_{t\_exc}}{\left(1 + w_{exc}\right)} = 70.5 \cdot pcf$

RTM - Soil Phase Relationship (on the basis of $1ft^3$ total volume)

Total volume $Vol_{total} := 1ft^3$

Mass of soil solids $Mass_{exc\_solid} := \gamma_{d\_exc} \cdot 1ft^3 = 70.46 \cdot lbf$

Volume of soil solid $Vol_{exc\_solid} := \frac{Mass_{exc\_solid}}{G_s \cdot \gamma_w} = 0.42 \cdot ft^3$

Volume of water $Vol_{exc\_water} := \frac{\gamma_{d\_exc} \cdot w_{exc}}{\gamma_w} \cdot 1ft^3 = 0.47 \cdot ft^3$

Volume of air $Vol_{exc\_air} := Vol_{total} - Vol_{exc\_solid} - Vol_{exc\_water}$

$Vol_{exc\_air} = 0.11 \cdot ft^3$

Volume of void $Vol_{exc\_void} := 1ft^3 - Vol_{exc\_solid} = 0.58 \cdot ft^3$

RTM Dried to Optium Water Content - Soil Phase Relationship (on the basis of $1ft^3$ total volume)

RTM total unit weight (pcf) at optimum moisture content (after drying) $\gamma_{t\_exc\_opt} := \gamma_{d\_exc} \cdot (1 + w_{opt}) = 85.97 \cdot pcf$

Total volume (ft^3) $Vol_{total} := 1ft^3$

Mass of soil solids (lb) $Mass_{exc\_dry\_solid} := \gamma_{d\_exc} \cdot 1ft^3 = 70.46 \cdot lbf$

Volume of soil solid $Vol_{exc\_dry\_solid} := \frac{Mass_{exc\_dry\_solid}}{G_s \cdot \gamma_w} = 0.42 \cdot ft^3$

Volume of water $Vol_{exc\_dry\_water} := \frac{\gamma_{d\_exc} \cdot w_{opt}}{\gamma_w} \cdot 1ft^3 = 0.25 \cdot ft^3$

Volume of air $Vol_{exc\_dry\_air} := Vol_{total} - Vol_{exc\_dry\_solid} - Vol_{exc\_dry\_water}$

$Vol_{exc\_dry\_air} = 0.33 \cdot ft^3$

Volume of void $Vol_{exc\_dry\_void} := Vol_{total} - Vol_{exc\_dry\_solid} = 0.58 \cdot ft^3$

<u>Unit Volume of Water Reduction during Drying</u>
(From RTM to "dried" RTM)

$$Vol_{water\_red} := \frac{(Vol_{exc\_water} - Vol_{exc\_dry\_water})}{1 \cdot ft^3} = 1.65 \cdot \frac{gal}{ft^3}$$

<u>Percent Volume Reduction</u>
(As the RTM in the thermal dryer gets dried, more soil solids and water will fill the increased air void. Assume the total unit weight of the RTM after drying in the thermal dryer to be 95pcf)

On the basis of $1ft^3$ of soil volume in the thermal dryer after the RTM has been dried to optimum water content:

RTM total unit weight (pcf) $\gamma_{t\_dried} := 95 \cdot pcf$

Optimum water content $w_{opt} = 0.22$

RTM dry unit weight (pcf) $\gamma_{d\_dried} := \frac{\gamma_{t\_dried}}{1 + w_{opt}} = 77.87 \cdot pcf$

Mass of RTM soil solids $M_{d\_dried} := \gamma_{d\_dried} \cdot ft^3 = 77.87 \cdot lbf$

Volume of soil solids in RTM $V_{s\_dried} := \frac{M_{d\_dried}}{G_s \cdot \gamma_w} = 0.46 \cdot ft^3$

Mass of water in RTM $M_{w\_dried} := M_{d\_dried} \cdot w_{opt} = 17.13 \cdot lbf$

Volume of water in RTM $V_{w\_dried} := \frac{M_{w\_dried}}{\gamma_w} = 0.27 \cdot ft^3$

Volume of air in RTM $V_{a\_dried} := 1ft^3 - V_{w\_dried} - V_{s\_dried} = 0.26 \cdot ft^3$

$$Vol_{collapse} := \frac{\gamma_{t\_dried}}{\gamma_{t\_exc}} \cdot 100\% = 95 \cdot \%$$

So after drying the RTM occupys 95% of the former wet RTM volume.

<u>Percent Volume Reduction in place at 95% compaction</u>

$$\gamma_{d\_95\_compacted} := 0.95 \cdot \gamma_{max} = 97.8 \cdot pcf$$

$$\gamma_{t\_95\_compacted} := \gamma_{d\_95\_compacted} \cdot \left(1 + w_{opt}\right) = 119.38 \cdot pcf$$

$$SF_{inplace} := \frac{\gamma_{t\_dried}}{\gamma_{t\_95\_compacted}} = 0.80$$

Attachment 4.1
RTM Calculations – 3,000cfs, 26ft ID Tunnel

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D RTM Volumes

Column Inputs	Internal Diameter	Tunnelling days / week	Tunnelling weeks / year	TBM Cutterhead Area	Bulking factor	Volume reduction due to drying	Full compaction factor	TBM Cutterhead Area	Bulking factor	Volume reduction due to drying	Full compaction factor
Northern tunnels ID	26.0 ft	5 days	51 wks	74 yd2	1.30	5.00 %	0.80	74 yd2	1.30	5.00 %	0.80
Main tunnels ID	26.0 ft	5 days	51 wks	74 yd2				74 yd2			
Southern tunnels ID	38.0 ft	5 days	51 wks	155 yd2				155 yd2			

			Drive Options				RTM Volume / Tunnel Length				RTM Volume / Shaft				RTM Volume / Tunnel Drive	
Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	In-Situ RTM Volume / Tunnel Length	Wet Excavated RTM Volume / Tunnel Length	Dry Excavated RTM Volume / Tunnel Length	Dry Compacted RTM Volume / Tunnel Length	Wet In-situ RTM Volume / Shaft	Wet Excavated RTM Volume / Shaft	Dry Excavated RTM Volume / Shaft	Dry Compacted RTM Volume / Shaft	Dry Compacted RTM Volume / Tunnel Drive	Ave. Quarterly Excavated Dry Compacted RTM Volume / Tunnel Drive
CENTRAL		0.000 mi					- yd3	- yd3	- yd3	- yd3						
		0.000 mi		5.640 mi	2.8 yrs		- yd3	- yd3	- yd3	- yd3					728,064 yd3	64,438 yd3
	Intake No. 5 Shaft		R													
	Northern Tunnel	5.640 mi	↑				736,907 yd3	957,979 yd3	910,080 yd3	728,064 yd3						
	Twin Cities Shaft (2)		L			2					2,632,744 yd3	3,422,568 yd3	3,251,439 yd3	2,601,151 yd3		
	Main Tunnel	4.250 mi	↓				555,293 yd3	721,882 yd3	685,787 yd3	548,630 yd3						
	New Hope Shaft		M													
	Main Tunnel	4.200 mi	↓	14.510 mi	5.9 yrs		548,761 yd3	713,389 yd3	677,719 yd3	542,175 yd3					1,873,087 yd3	79,981 yd3
	Staten Island Shaft		M													
	Main Tunnel	6.060 mi	↓				791,783 yd3	1,029,318 yd3	977,852 yd3	782,282 yd3						
	Bouldin Island Shaft		L/R			1					1,313,106 yd3	1,707,037 yd3	1,621,686 yd3	1,297,348 yd3		
	Main Tunnel	4.660 mi	↓				608,863 yd3	791,522 yd3	751,946 yd3	601,557 yd3						
	Mandeville Island Shaft		M	10.050 mi	3.9 yrs										1,297,348 yd3	84,198 yd3
	Main Tunnel	5.390 mi	↓				704,243 yd3	915,516 yd3	869,740 yd3	695,792 yd3						
	Bacon Island Shaft		R													
	Main Tunnel	5.760 mi	↑				752,586 yd3	978,362 yd3	929,444 yd3	743,555 yd3						
	Byron Tract Shaft		M	6.720 mi	3.6 yrs										867,481 yd3	60,518 yd3
	Main Tunnel	0.960 mi	↑				125,431 yd3	163,060 yd3	154,907 yd3	123,926 yd3						
	Southern Forebay (N+S) Shafts (4)		L			2					1,790,122 yd3	2,327,159 yd3	2,210,801 yd3	1,768,641 yd3		
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.3 yrs		912,105 yd3	1,185,737 yd3	1,126,450 yd3	901,160 yd3					901,160 yd3	96,176 yd3
	CA Aqueduct Shaft (2)		R													
	Total	40.26 mi	3	40.26 mi		5	5,735,972 yd3	7,456,764 yd3	7,083,926 yd3	5,667,141 yd3	5,735,972 yd3	7,456,764 yd3	7,083,926 yd3	5,667,141 yd3	5,667,141 yd3	385,312 yd3

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	In-Situ RTM Volume / Tunnel Length	Wet Excavated RTM Volume / Tunnel Length	Dry Excavated RTM Volume / Tunnel Length	Dry Compacted RTM Volume / Tunnel Length	Wet In-situ RTM Volume / Shaft	Wet Excavated RTM Volume / Shaft	Dry Excavated RTM Volume / Shaft	Dry Compacted RTM Volume / Shaft	Dry Compacted RTM Volume / Tunnel Drive	Ave. Quarterly Excavated Dry Compacted RTM Volume / Tunnel Drive
EASTERN		0.000 mi					- yd3	- yd3	- yd3	- yd3						
		0.000 mi		5.640 mi	2.4 yrs		- yd3	- yd3	- yd3	- yd3					728,064 yd3	75,410 yd3
	Intake No. 5 Shaft		R													
	Northern Tunnel	5.640 mi	↑				736,907 yd3	957,979 yd3	910,080 yd3	728,064 yd3						
	Twin Cities Shaft (2)		L			2					2,394,948 yd3	3,113,432 yd3	2,957,761 yd3	2,366,209 yd3		
	Main Tunnel	4.580 mi	↓				598,410 yd3	777,933 yd3	739,037 yd3	591,229 yd3						
	New Hope Shaft		M													
	Main Tunnel	3.000 mi	↓	12.690 mi	5.4 yrs		391,972 yd3	509,563 yd3	484,085 yd3	387,268 yd3					1,638,144 yd3	76,227 yd3
	Canal Ranch		M													
	Main Tunnel	5.110 mi	↓				667,659 yd3	867,956 yd3	824,559 yd3	659,647 yd3						
	Terminous Tract Shaft		R													
	Main Tunnel	3.940 mi	↑				514,790 yd3	669,227 yd3	635,765 yd3	508,612 yd3						
	King Island Shaft		M	9.500 mi	4.1 yrs										1,226,349 yd3	74,355 yd3
	Main Tunnel	5.560 mi	↑				726,455 yd3	944,391 yd3	897,171 yd3	717,737 yd3						
	Lower Roberts Island Shaft		L/R			1					1,241,244 yd3	1,613,617 yd3	1,532,937 yd3	1,226,349 yd3		
	Main Tunnel	5.180 mi	↑				676,805 yd3	879,846 yd3	835,854 yd3	668,683 yd3						
	Upper Jones Tract Shaft		M													
	Main Tunnel	5.650 mi	↑	11.790 mi	5.6 yrs		738,214 yd3	959,678 yd3	911,694 yd3	729,355 yd3					1,521,964 yd3	67,515 yd3
	Byron Tract		M													
	Main Tunnel	0.960 mi	↑				125,431 yd3	163,060 yd3	154,907 yd3	123,926 yd3						
	Southern Forebay (N+S) Shaft (4)		L			2					2,452,555 yd3	3,188,321 yd3	3,028,905 yd3	2,423,124 yd3		
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.3 yrs		912,105 yd3	1,185,737 yd3	1,126,450 yd3	901,160 yd3					901,160 yd3	96,176 yd3
	CA Aqueduct Shaft (2)		R													
	Total	42.96 mi	3	42.96 mi		5	6,088,747 yd3	7,915,371 yd3	7,519,603 yd3	6,015,682 yd3	6,088,747 yd3	7,915,371 yd3	7,519,603 yd3	6,015,682 yd3	6,015,682 yd3	389,683 yd3

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D RTM Volumes

Column Inputs	Internal Diameter
Northern tunnels ID	26.0 ft
Main tunnels ID	26.0 ft
Southern tunnels ID	38.0 ft

Tunnelling days / week	Tunnelling weeks / year
5 days	51 wks
5 days	51 wks
5 days	51 wks

Drive Options

Quarterly Dry Compacted RTM Volume Generated by Tunnel Drive (m yd3)

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	Start Quart.	HIDE	Y1				Y2				Y3				Y4				Y5				Y6				Y7				Y8				Y9				Y10				Y11				Y12				Y13				Y14			
									1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
CENTRAL		0.000 mi																																																																
		0.000 mi		5.640 mi	2.8 yrs		23	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Intake No. 5 Shaft		R																																																													
	Northern Tunnel	5.640 mi	↑																																																													
	Twin Cities Shaft (2)		L			2																																																									
	Main Tunnel	4.250 mi	↓																																																												
	New Hope Shaft		M																																																												
	Main Tunnel	4.200 mi	↓	14.510 mi	5.9 yrs		17	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Staten Island Shaft		M																																																												
	Main Tunnel	6.060 mi	↓																																																												
	Bouldin Island Shaft		L/R			1																																																									
	Main Tunnel	4.660 mi	↓																																																												
	Mandeville Island Shaft		M	10.050 mi	3.9 yrs		22	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Main Tunnel	5.390 mi	↓																																																												
	Bacon Island Shaft		R																																																												
	Main Tunnel	5.760 mi	↑																																																												
	Byron Tract Shaft		M	6.720 mi	3.6 yrs		22	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Main Tunnel	0.960 mi	↑																																																												
	Southern Forebay (N+S) Shafts (4)		L			2																																																										
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.3 yrs		20	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	CA Aqueduct Shaft (2)		R																																																												
	Total	40.26 mi	3	40.26 mi		5			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.08	0.18	0.18	0.32	0.39	0.39	0.39	0.39	0.39	0.39	0.32	0.29	0.29	0.29	0.29	0.24	0.22	0.18	0.11	0.08	0.08	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	Start Quart.	HIDE	Y1				Y2				Y3				Y4				Y5				Y6				Y7				Y8				Y9				Y10				Y11				Y12				Y13				Y14			
									1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
EASTERN		0.000 mi																																																																
		0.000 mi		5.640 mi	2.4 yrs		23	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Intake No. 5 Shaft		R																																																													
	Northern Tunnel	5.640 mi	↑																																																													
	Twin Cities Shaft (2)		L			2																																																									
	Main Tunnel	4.580 mi	↓																																																												
	New Hope Shaft		M																																																												
	Main Tunnel	3.000 mi	↓	12.690 mi	5.4 yrs		17	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Canal Ranch		M																																																												
	Main Tunnel	5.110 mi	↓																																																												
	Terminous Tract Shaft		R																																																												
	Main Tunnel	3.940 mi	↑																																																												
	King Island Shaft		M	9.500 mi	4.1 yrs		22	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Main Tunnel	5.560 mi	↑																																																												
	Lower Roberts Island Shaft		L/R			1																																																										
	Main Tunnel	5.180 mi	↑																																																												
	Upper Jones Tract Shaft		M																																																												
	Main Tunnel	5.650 mi	↑	11.790 mi	5.6 yrs		22	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Byron Tract		M																																																												
	Main Tunnel	0.960 mi	↑																																																												
	Southern Forebay (N+S) Shaft (4)		L			2																																																										
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.3 yrs		20	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	CA Aqueduct Shaft (2)		R																																																												
	Total	42.96 mi	3	42.96 mi		5			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.08	0.17	0.17	0.31	0.39	0.39	0.39	0.39	0.39	0.39	0.33	0.29	0.29	0.27	0.22	0.22	0.22	0.22	0.22	0.14	0.07	0.07	0.07	0.07	0.07	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D RTM Volumes

Column Inputs	Internal Diameter
Northern tunnels ID	26.0 ft
Main tunnels ID	26.0 ft
Southern tunnels ID	38.0 ft

Tunnelling days / week	Tunnelling weeks / year
5 days	51 wks
5 days	51 wks
5 days	51 wks

Drive Options

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's
CENTRAL		0.000 mi				
		0.000 mi		5.640 mi	2.8 yrs	
	Intake No. 5 Shaft		R			
	Northern Tunnel	5.640 mi	↑			
	Twin Cities Shaft (2)		L			2
	Main Tunnel	4.250 mi	↓			
	New Hope Shaft		M			
	Main Tunnel	4.200 mi	↓	14.510 mi	5.9 yrs	
	Staten Island Shaft		M			
	Main Tunnel	6.060 mi	↓			
	Bouldin Island Shaft		L/R			1
	Main Tunnel	4.660 mi	↓			
	Mandeville Island Shaft		M	10.050 mi	3.9 yrs	
	Main Tunnel	5.390 mi	↓			
	Bacon Island Shaft		R			
	Main Tunnel	5.760 mi	↑			
	Byron Tract Shaft		M	6.720 mi	3.6 yrs	
	Main Tunnel	0.960 mi	↑			
	Southern Forebay (N+S) Shafts (4)		L			2
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.3 yrs	
	CA Aqueduct Shaft (2)		R			
	Total	40.26 mi	3	40.26 mi		5

Quarterly Dry Compacted RTM Volume Generated at Each Shaft (m yd3)

Start	Y1				Y2				Y3				Y4				Y5				Y6				Y7				Y8				Y9				Y10				Y11				Y12				Y13				Y14			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
23																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.08	0.08	0.08	0.08	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.10	0.08	0.08	0.08	0.08	0.08	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.10	0.06	0.06	0.06	0.06	0.06	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.08	0.18	0.18	0.32	0.39	0.39	0.39	0.39	0.39	0.39	0.32	0.29	0.29	0.29	0.29	0.24	0.22	0.18	0.11	0.08	0.08	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF Only	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.5	0.7	0.8	1.0	1.1	1.3	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
TC + SF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.4	0.6	0.8	1.1	1.4	1.7	2.0	2.3	2.6	2.9	3.1	3.3	3.5	3.7	3.9	4.0	4.1	4.2	4.3	4.3	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
All Shafts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.4	0.6	0.9	1.3	1.7	2.1	2.5	2.8	3.2	3.5	3.8	4.1	4.4	4.7	5.0	5.2	5.4	5.5	5.6	5.6	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's
EASTERN		0.000 mi				
		0.000 mi		5.640 mi	2.4 yrs	
	Intake No. 5 Shaft		R			
	Northern Tunnel	5.640 mi	↑			
	Twin Cities Shaft (2)		L			2
	Main Tunnel	4.580 mi	↓			
	New Hope Shaft		M			
	Main Tunnel	3.000 mi	↓	12.690 mi	5.4 yrs	
	Canal Ranch		M			
	Main Tunnel	5.110 mi	↓			
	Terminous Tract Shaft		R			
	Main Tunnel	3.940 mi	↑			
	King Island Shaft		M	9.500 mi	4.1 yrs	
	Main Tunnel	5.560 mi	↑			
	Lower Roberts Island Shaft		L/R			1
	Main Tunnel	5.180 mi	↑			
	Upper Jones Tract Shaft		M			
	Main Tunnel	5.650 mi	↑	11.790 mi	5.6 yrs	
	Byron Tract		M			
	Main Tunnel	0.960 mi	↑			
	Southern Forebay (N+S) Shaft (4)		L			2
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.3 yrs	
	CA Aqueduct Shaft (2)		R			
	Total	42.96 mi	3	42.96 mi		5

Start	Y1				Y2				Y3				Y4				Y5				Y6				Y7				Y8				Y9				Y10				Y11				Y12				Y13				Y14			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
23																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.08	0.08	0.08	0.08	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.13	0.08	0.08	0.08	0.08	0.08	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17																																																									
22																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22																																																									
20																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.08	0.17	0.17	0.31	0.39	0.39	0.39	0.39	0.39	0.39	0.33	0.29	0.29	0.27	0.22	0.22	0.22	0.22	0.22	0.14	0.07	0.07	0.07	0.07	0.07	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF Only	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.5	0.7	0.8	1.0	1.2	1.3	1.4	1.5	1.6	1.6	1.7	1.8	1.8	1.9	2.0	2.0	2.1	2.2	2.3	2.3	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
TC + SF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.4	0.6	0.8	1.1	1.4	1.8	2.1	2.4	2.7	3.0	3.2	3.4	3.6	3.7	3.9	4.0	4.2	4.3	4.4	4.5	4.6	4.6	4.7	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
All Shafts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.4	0.6	0.9	1.3	1.7	2.1	2.4	2.8	3.2	3.6	3.8	4.1	4.4	4.6	4.8	5.1	5.3	5.5	5.6	5.7	5.8	5.8	5.9	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D RTM Volumes

Column Inputs	Internal Diameter
Northern tunnels ID	26.0 ft
Main tunnels ID	26.0 ft
Southern tunnels ID	38.0 ft

Tunnelling days / week	Tunnelling weeks / year
5 days	51 wks
5 days	51 wks
5 days	51 wks

Working space / buffer
5 %

Working space / buffer
5 %

Full compaction factor	Working space / buffer
0.80	5 %

CENTRAL

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	Area required to store all RTM at shafts Wet Excavated: Volume / Shaft	Storage Height	Area	Area required to store all RTM at shafts Dry Excavated: Volume / Shaft	Storage Height	Area	Area required to store all RTM at shafts Dry Fully Compacted: Volume / Shaft	Storage Height	Area
			Drive Options												
		0.000 mi													
		0.000 mi		5.640 mi	2.8 yrs										
	Intake No. 5 Shaft		R												
	Northern Tunnel	5.640 mi	↑												
	Twin Cities Shaft (2)		L			2	3.4 m yd3	8 ft	278 acres	3.3 m yd3	15 ft	141 acres	2.6 m yd3	15 ft	113 acres
	Main Tunnel	4.250 mi	↓												
	New Hope Shaft		M												
	Main Tunnel	4.200 mi	↓	14.510 mi	5.9 yrs										
	Staten Island Shaft		M												
	Main Tunnel	6.060 mi	↓												
	Bouldin Island Shaft		L/R			1	1.7 m yd3	8 ft	139 acres	1.6 m yd3	8 ft	132 acres	1.3 m yd3	8 ft	106 acres
	Main Tunnel	4.660 mi	↓												
	Mandeville Island Shaft		M	10.050 mi	3.9 yrs										
	Main Tunnel	5.390 mi	↓												
	Bacon Island Shaft		R												
	Main Tunnel	5.760 mi	↑												
	Byron Tract Shaft		M	6.720 mi	3.6 yrs										
	Main Tunnel	0.960 mi	↑												
	Southern Forebay (N+S) Shafts (4)		L			2	2.3 m yd3	8 ft	189 acres	2.2 m yd3	15 ft	96 acres	1.8 m yd3	15 ft	77 acres
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.3 yrs										
	CA Aqueduct Shaft (2)		R												
	Total	40.26 mi	3	40.26 mi		5	7.5 m yd3		607 acres	7.1 m yd3		369 acres	5.7 m yd3		295 acres

EASTERN

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	Volume / Shaft	Storage Height	Area	Volume / Shaft	Storage Height	Area	Volume / Shaft	Storage Height	Area
		0.000 mi													
		0.000 mi		5.640 mi	2.4 yrs										
	Intake No. 5 Shaft		R												
	Northern Tunnel	5.640 mi	↑												
	Twin Cities Shaft (2)		L			2	3.1 m yd3	8 ft	253 acres	3.0 m yd3	15 ft	128 acres	2.4 m yd3	15 ft	103 acres
	Main Tunnel	4.580 mi	↓												
	New Hope Shaft		M												
	Main Tunnel	3.000 mi	↓	12.690 mi	5.4 yrs										
	Canal Ranch		M												
	Main Tunnel	5.110 mi	↓												
	Terminous Tract Shaft		R												
	Main Tunnel	3.940 mi	↑												
	King Island Shaft		M	9.500 mi	4.1 yrs										
	Main Tunnel	5.560 mi	↑												
	Lower Roberts Island Shaft		L/R			1	1.6 m yd3	8 ft	131 acres	1.5 m yd3	8 ft	125 acres	1.2 m yd3	8 ft	100 acres
	Main Tunnel	5.180 mi	↑												
	Upper Jones Tract Shaft		M												
	Main Tunnel	5.650 mi	↑	11.790 mi	5.6 yrs										
	Byron Tract		M												
	Main Tunnel	0.960 mi	↑												
	Southern Forebay (N+S) Shaft (4)		L			2	3.2 m yd3	8 ft	259 acres	3.0 m yd3	15 ft	131 acres	2.4 m yd3	15 ft	105 acres
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.3 yrs										
	CA Aqueduct Shaft (2)		R												
	Total	42.96 mi	3	42.96 mi		5	7.9 m yd3		644 acres	7.5 m yd3		384 acres	6.0 m yd3		308 acres

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D Stockpiles

Maximum allowable stockpile heights

Min. stockpile height at Twin Cities	10	ft	above grade
Max. stockpile height at Twin Cities	15	ft	above grade
Max. stockpile height at Bouldin Island	8	ft	above grade
Max. stockpile height at Lower Roberts	8	ft	above grade
Max. stockpile height at Southern Forebay	15	ft	above grade
Contingency	5	%	

Short term stockpiles (All RTM)

Central	Vol. of RTM to stockpile (yd3)	Area of temp. stockpile (acres)	Height of temp. stockpile (ft)
Twin Cities North	497,968	66	4.9
Twin Cities South	1,281,119	107	7.8
Bouldin Island	1,297,348	129	6.6
Southern Forebay North	867,481	115	4.9
Southern Forebay South	901,160	119	4.9

Eastern	Vol. of RTM to stockpile (yd3)	Area of temp. stockpile (acres)	Height of temp. stockpile (ft)
Twin Cities North	594,424	66	5.9
Twin Cities South	1,337,454	107	8.2
Lower Roberts	998,507	129	5.0
Southern Forebay North	1,521,964	147	6.8
Southern Forebay South	901,160	87	6.8

Notes
Twin Cities
Areas as shown on drawings
Bouldin Island and Lower Roberts
Same area used for short term and long term
see 'No Drying Annual Process' sheet.
Southern Forebay
Areas as shown on drawings

Long term stockpiles (Surplus RTM)

Central	Vol. of RTM to stockpile (yd3)	Area of perm. stockpile (acres)	Height of perm. stockpile (ft)
Twin Cities	378,686	16	15.0
Bouldin Island	1,037,879	129	5.0
Southern Forebay	-	234	0.0

Eastern	Vol. of RTM to stockpile (yd3)	Area of perm. stockpile (acres)	Height of perm. stockpile (ft)
Twin Cities	366,938	16	15.0
Lower Roberts	753,237	129	3.6
Southern Forebay	-	234	0.0

Notes
Twin Cities
Height limited to 15ft
Resulting area calculated
Bouldin Island and Lower Roberts
Same area used for short term and long term
see 'No Drying Annual Process' sheet.
Southern Forebay
Areas as shown on drawings

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Evaporation Calculation

California Irrigation Management Information System (CIMIS)

CIMIS Monthly Report

Rendered in ENGLISH Units.
April 2019 - March 2020
Printed on Wednesday, April 22, 2020

Holt - San Joaquin Valley - Station 248

Month Year	Total ETo (in)	Total Precip (in)	Avg Sol Rad (Ly/day)	Avg Vap Pres (mBars)	Avg Max Air Temp (°F)	Avg Min Air Temp (°F)	Avg Air Temp (°F)	Avg Max Rel Hum (%)	Avg Min Rel Hum (%)	Avg Rel Hum (%)	Avg Dew Point (°F)	Avg Wind Speed (mph)	Avg Soil Temp (°F)
Apr 2019	5.09	0.31	522 K	12.7 K	75.4 K	46.5	60.6 K	96	47	71 K	50.7 K	4.7 K	58.1
May 2019	5.86	1.88	570	12.9	76.3	47.6 K	61.6	95	46	69	51.0	4.9	60.5
Jun 2019	8.29 K	0.01	699	14.9 K	89.4 K	56.8 K	72.4 K	86	33	55 K	54.8 K	5.6 K	68.8
Jul 2019	8.35	0.00	680	15.5	90.4	57.2	73.3	85	34	56	56.3	5.5 K	69.2
Aug 2019	7.46	0.01	609	16.9 K	92.1 K	58.2 K	74.3 K	90	35	59 K	58.6 K	5.1 K	71.0
Sep 2019	5.60	0.12	503	15.1 K	86.6 K	55.6 K	70.2 K	89	35	60 K	55.4 K	5.3 K	67.7
Oct 2019	4.51	0.01	399 K	9.6 K	82.3 K	43.7 K	61.2 K	84	27	51 K	42.2 K	4.7 K	57.1 K
Nov 2019	2.31 K	0.57	252	9.1 K	72.3 K	38.3	52.8	95	38	67 K	41.6 K	3.9 K	50.8 K
Dec 2019	1.06	2.74	153	11.0 K	58.9	42.1	49.7 K	99	70	89 K	46.6 K	5.0 K	51.2
Tots/Avgs	48.53	5.6	487	13.1	80.4	49.4	64.0	91	41	64	50.8	5.0	61.6

Holt - San Joaquin Valley - Station 248

Month Year	Total ETo (in)	Total Precip (in)	Avg Sol Rad (Ly/day)	Avg Vap Pres (mBars)	Avg Max Air Temp (°F)	Avg Min Air Temp (°F)	Avg Air Temp (°F)	Avg Max Rel Hum (%)	Avg Min Rel Hum (%)	Avg Rel Hum (%)	Avg Dew Point (°F)	Avg Wind Speed (mph)	Avg Soil Temp (°F)
Jan 2020	1.26	0.98	188	10.4	58.4	38.2	47.5	100	72	92	45.3	4.1	49.9
Feb 2020	3.13	0.01	366 K	8.5	69.0 K	36.7	51.1	94	38	66	39.8	5.1 K	51.0
Mar 2020	3.58	1.19 K	404 K	10.1	66.0 K	41.4	53.0 K	96	50	74 K	44.5 K	5.0 K	55.5
Tots/Avgs	7.97	2.2	319	9.7	64.5	38.8	50.5	97	53	77	43.2	4.7	52.1

Flag Legend	
M - All Daily Values Missing	K - One or More Daily Values Flagged
J - One or More Daily Values Missing	L - Missing and Flagged Daily Values

Conversion Factors		
W/sq.m = Ly/day/2.065	inches * 25.4 = mm	(F-32) * 5/9 = c
	mBars * 0.1 = kPa	--

	Monthly evaporation	Monthly precipitation	Evaporation - precipitation	Consecutive 6mth adjusted evaporation
Apr	5.09 in	0.31 in	4.78 in	38.32 in
May	5.86 in	1.88 in	3.98 in	38.04 in
Jun	8.29 in	0.01 in	8.28 in	35.80 in
Jul	8.35 in	0.00 in	8.35 in	27.52 in
Aug	7.46 in	0.01 in	7.45 in	19.45 in
Sep	5.60 in	0.12 in	5.48 in	15.12 in
Oct	4.51 in	0.01 in	4.50 in	12.03 in
Nov	2.31 in	0.57 in	1.74 in	12.31 in
Dec	1.06 in	2.74 in	0.00 in	14.55 in
Jan	1.26 in	0.98 in	0.28 in	22.83 in
Feb	3.13 in	0.01 in	3.12 in	30.90 in
Mar	3.58 in	1.19 in	2.39 in	35.23 in
Apr	5.09 in	0.31 in	4.78 in	
May	5.86 in	1.88 in	3.98 in	
Jun	8.29 in	0.01 in	8.28 in	
Jul	8.35 in	0.00 in	8.35 in	
Aug	7.46 in	0.01 in	7.45 in	

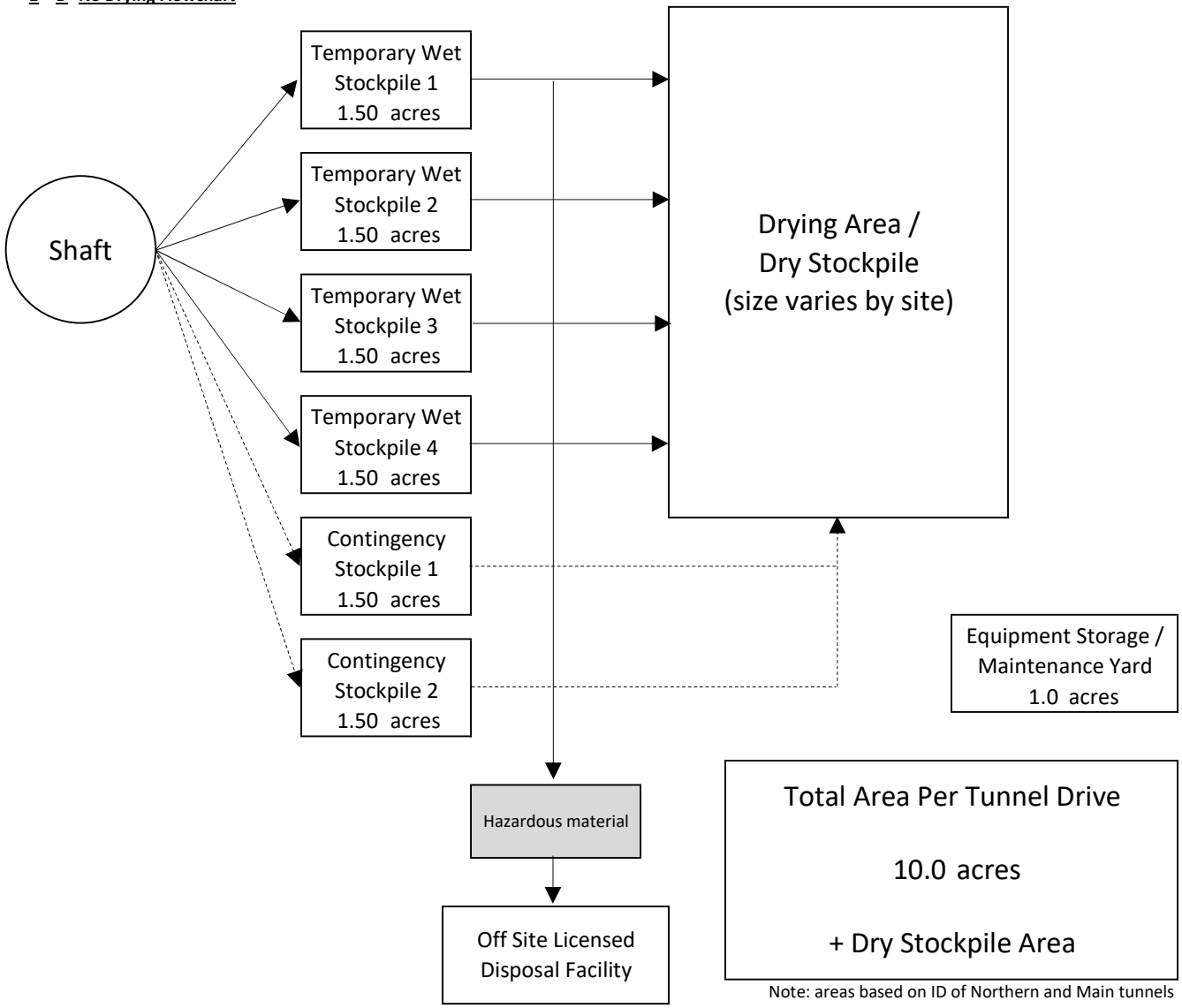
Max. continuous 6mth evaporation = 38.32 in
Average daily evaporation = 0.210 in
(Apr - Sept 2019)

Evaporation Rate

Vol. of water extracted during drying		1.65	gal/ft3	geotechnical calcs
Vol. of water extracted during drying	=	22.1%	of solids	conversion
Evaporation rate		0.210	in / day / area	from evaporation calc sheet
Evaporation rate	=	0.0175	ft / day / area	conversion
Evaporation rate	=	762.2	ft3 / day / acre	conversion
Height of drying stockpile		18.0	in	
Volume of 1 acre at 18 in high		65,340	ft3 / acre	
Volume of water to be removed from 1 acre		14,412	ft3 / acre	
Time required to dry 1 acre of RTM		18.91	days	regardless of area

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D No Drying Flowchart



Total Area Per Tunnel Drive

10.0 acres

+ Dry Stockpile Area

Note: areas based on ID of Northern and Main tunnels

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D No Drying Annual Process

Drying stockpile height per lift	18	in
Drying stockpile contingency	5	%
Tunnelling days / week	5	days / week
Tunnelling weeks / year	51	weeks / year
Wet season	7	months / year
Wet season	30	weeks / year

Season	Cell > / Area→ / Week↓	1 / 3.5	2 / 3.5	3 / 3.5	4 / 3.5	5 / 3.5	6 / 3.5	7 / 3.5	8 / 3.5	9 / 3.5	10 / 3.5	11 / 3.5	12 / 3.5	13 / 3.5	14 / 3.5	15 / 3.5	16 / 3.5	17 / 3.5	18 / 3.5	19 / 3.5	20 / 3.5	21 / 3.5	22 / 3.5	23 / 3.5	24 / 3.5	25 / 3.5	26 / 3.5	27 / 3.5	28 / 3.5	29 / 3.5	30 / 3.5	31 / 3.5	32 / 3.5	33 / 3.5	34 / 3.5	35 / 3.5	36 / 3.5	37 / 3.5	Spreading	Compacting
Wet	1	Hold	Hold	Hold	Fill	< wet season begins with 3 full cells from previous drying season																																	0	0
Wet	2	Hold	Hold	Hold	Hold	Fill																																	0	0
Wet	3	Hold	Hold	Hold	Hold	Hold	Fill																																0	0
Wet	4	Hold	Hold	Hold	Hold	Hold	Hold	Fill																															0	0
Wet	5	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																														0	0
Wet	6	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																													0	0
Wet	7	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																												0	0
Wet	8	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																											0	0
Wet	9	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																										0	0
Wet	10	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																									0	0
Wet	11	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																								0	0
Wet	12	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																							0	0
Wet	13	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																						0	0
Wet	14	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																					0	0
Wet	15	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																				0	0
Wet	16	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																			0	0
Wet	17	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																		0	0
Wet	18	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																	0	0
Wet	19	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																0	0
Wet	20	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill															0	0
Wet	21	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill														0	0
Wet	22	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill													0	0
Wet	23	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill												0	0
Wet	24	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill											0	0
Wet	25	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill										0	0
Wet	26	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill									0	0
Wet	27	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill								0	0
Wet	28	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill							0	0
Wet	29	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill						0	0
Wet	30	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill					0	0
Dry	31	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill + Spread				3	0
Dry	32	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry	Fill + Spread			3	0
Dry	33	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry	Dry	Fill + Spread		3	0
Dry	34	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry + Compact	Dry	Dry	Fill + Spread	3	3
Dry	35	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold		Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry + Compact	Dry	Dry		3	3
Dry	36	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold			Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold		Dry + Compact	Dry		3	3
Dry	37	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold				Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold			Dry + Compact		3	3
Dry	38	Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold					Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold					3	3
Dry	39		Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold						Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold					3	3
Dry	40			Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold							Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold					3	3
Dry	41				Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold								Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold					3	3
Dry	42					Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold									Dry + Compact	Dry	Dry	Spread	Hold	Hold					3	3
Dry	43						Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold										Dry + Compact	Dry	Dry	Spread	Hold					3	3
Dry	44							Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold											Dry + Compact	Dry	Dry	Spread					3	3
Dry	45								Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold												Dry + Compact	Dry	Dry					2	3
Dry	46									Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold													Dry + Compact	Dry					2	3
Dry	47										Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold														Dry + Compact					2	3
Dry	48											Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold																				2	2
Dry	49												Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread																				2	2
Dry	50	Fill												Dry + Compact	Dry	Dry		Dry + Compact	Dry	Dry																				0	2
Dry	51	Hold	Fill												Dry + Compact	Dry			Dry + Compact	Dry																				0	2
Dry	52	Hold	Hold	Fill												Dry + Compact				Dry + Compact																				0	2

Permanent stockpile

Shaft site	Stockpile area (acres)	Total vol. of RTM (yd3)	Final height of stockpile (ft)	Equivalent annual lift (in)
Bouldin Island	129	1,037,879	5.0	24
Lower Roberts	129	753,237	3.6	24

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D No Drying Areas

Excavation Rates	Main Tunnels		Southern Tunnels	
Tunnel lining ID	26	ft	38	ft
TBM cutterhead area	668	ft2	1,396	ft2
TBM advance rate (ave.)	50	ft / day	38	ft / day
TBM advance rate (peak)	100	ft / day	76	ft / day
Daily in-situ rate of excavation per tunnel (ave.)	1,237	yd3 / day	1,965	yd3 / day
Daily in-situ rate of excavation per tunnel (peak)	2,475	yd3 / day	3,931	yd3 / day
Bulking factor	1.30		1.30	
Daily excavated volume per tunnel (ave.)	1,608	yd3 / day	2,555	yd3 / day
Daily excavated volume per tunnel (peak)	3,217	yd3 / day	5,110	yd3 / day
Estimated duration of peak excavation	21	days	21	days
Volume loss due to drying	5	%	5	%
Equivalent daily dry excavated volume per tunnel (ave.)	1,528	yd3 / day	2,427	yd3 / day
Equivalent daily dry excavated volume per tunnel (peak.)	3,056	yd3 / day	4,855	yd3 / day

Temporary Wet Stockpile Area	Main Tunnels		Southern Tunnels		
No. of days storage	5	days	5	days	one week of excavation
Volume of RTM to stockpile at peak excavation rate	16,085	yd3	25,550	yd3	per stockpile
Height of stockpile	10	ft	10	ft	short term
Contingency	50	%	50	%	inc. allowance for conveyor pits
Area required at peak excavation rate	1.50	acres	2.38	acres	per stockpile
No. of temporary stockpiles	6.0		6.0		
Total area of temporary stockpiles	9.0	acres	14.3	acres	

Equipment Storage / Maintenance Yard

Area required for equipment storage / maintenance yard 1.0 acres

Drying Area / Dry Stockpile

Varies by tunnel drive and option

No Drying Area Summary

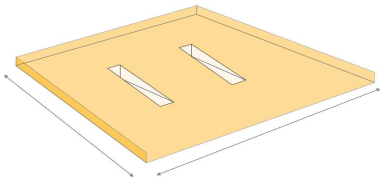
Alignment	Site	Tunnel Drive	Compacted RTM	Temporary Wet Stockpile 10 ft high	Equipment / Maintenance Yard	Total RTM Processing Area	Total RTM Processing Area
Central	Twin Cities	North	0.7 m yd3	9.0 acres	1 acres	10 acres	20 acres
		South	1.9 m yd3	9.0 acres	1 acres	10 acres	
	Bouldin Island	South	0.6 m yd3	9.0 acres	1 acres	10 acres	10 acres
	Southern Forebay	North	0.9 m yd3	9.0 acres	1 acres	10 acres	25 acres
		South	0.9 m yd3	14.3 acres	1 acres	15 acres	
Eastern	Twin Cities	North	0.7 m yd3	9.0 acres	1 acres	10 acres	20 acres
		South	1.6 m yd3	9.0 acres	1 acres	10 acres	
	Lower Roberts Island	North	1.2 m yd3	9.0 acres	1 acres	10 acres	10 acres
	Southern Forebay	North	1.5 m yd3	9.0 acres	1 acres	10 acres	25 acres
		South	0.9 m yd3	14.3 acres	1 acres	15 acres	

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D No Drying Equipment Main Tunnels

Temporary Wet Stockpile Filling

Volume of RTM to stockpile (peak)	16,085	yd3	per stockpile as for Natural Drying
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	23.1	hours / day	
Total hours at average excavation rate per day	11.6	hours / day	
Total hours for operation per year	2,947	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (peak)	16,085	yd3	per stockpile as for Natural Drying
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	10	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	23.1	hours / day	
Total hours at average excavation rate per day	11.6	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	2,947	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area / Dry Stockpile Moving

Daily excavated volume per tunnel (peak)	1,608	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	1	wheel loaders	
Total hours at average excavation rate per day	4.3	hours / day	
Total hours for operation per year	1,096	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Drying Area / Dry Stockpile Spreading

Volume of RTM to be spread per cell	8,042	yd3 / cell	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	day shift only
Average cycle time per shove	5	mins	assumed
Efficiency	80	%	assumed
Number of bulldozers per cell	2	bulldozers / cell	
Max. number of cells to spread in one week	3	cells	
Number of bulldozers required	6	bulldozers	
Number of cells to spread per year	52	cells / year	
Total hours for operation per year	2,947	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area per cell	3.5	acres	
Area per cell	16,889	yd2	
Speed	6.8	mph	
Speed	11,968	yd / hr	
Area/hr	27,925	yd2 / hr	
Working hours per day	10	hours	
Efficiency	50	%	assumed
Number of passes	2	passes	assumed
Time to compact one cell	2.4	hrs / cell	
Max. number of cells to compact in one week	3	cells / week	
Number of compactors required	1	compactors	
Number of cells to compact per year	52	cells / year	
Total hours for operation per year	126	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D No Drying Equipment Schedule Main Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average Excavation Rate: Total Hours / Year	Average Excavation Rate: Total Power / Year	Average Excavation Rate: Total Annual Operating Cost	Peak Excavation Rate: Quantity	Peak Excavation Rate: Total Capital Cost	Notes
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	2947 hrs	$ 105	$ 196,000	2947 hrs	477 MWh	$ 309,388	2	$ 392,000	Day and night shift, 12mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0 hrs	- MWh	$ -	0	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	2947 hrs	$ 105	$ 196,000	2947 hrs	477 MWh	$ 309,388	4	$ 784,000	Day shift only, 12mths
Wet Stockpile Moving	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	1096 hrs	$ 120	$ 180,000	1096 hrs	571 MWh	$ 131,462	1	$ 180,000	Day shift only, 12mths
Wet Stockpile Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	2947 hrs	$ 105	$ 196,000	2947 hrs	477 MWh	$ 309,388	6	$ 1,176,000	Day shift only, 12mths
Wet Stockpile Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	126 hrs	$ 55	$ 73,100	126 hrs	12 MWh	$ 6,919	1	$ 73,100	One pass over full wet storage area
								Total Electrical	- hrs	- MWh	$ -	0	$ -	
								Total Gas/Diesel	10,061 hrs	2,014 MWh	$ 1,066,544	14	$ 2,605,100	
								Total	10,061 hrs	2,014 MWh	$ 1,066,544	14	$ 2,605,100	

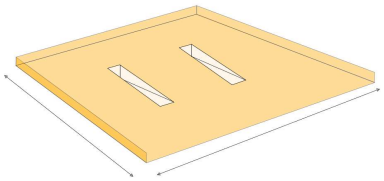
Equipment utilization 14%

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D No Drying Equipment Southern Tunnels

Temporary Wet Stockpile Filling

Volume of RTM to stockpile (peak)	25,550	yd3	per stockpile as for Natural Drying
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	36.7	hours / day	
Total hours at average excavation rate per day	18.4	hours / day	
Total hours for operation per year	4,681	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (peak)	25,550	yd3	per stockpile as for Natural Drying
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	10	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	36.7	hours / day	
Total hours at average excavation rate per day	18.4	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	4,681	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area / Dry Stockpile Moving

Daily excavated volume per tunnel (peak)	2,555	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	6.8	hours / day	
Total hours for operation per year	1,740	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Drying Area / Dry Stockpile Spreading

Volume of RTM to be spread per cell	8,042	yd3 / cell	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	day shift only
Average cycle time per shove	5	mins	assumed
Efficiency	80	%	assumed
Number of bulldozers per cell	2	bulldozers / cell	
Max. number of cells to spread in one week	3	cells	
Number of bulldozers required	6	bulldozers	
Number of cells to spread per year	52	cells / year	
Total hours for operation per year	2,947	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area per cell	3.5	acres	
Area per cell	16,889	yd2	
Speed	6.8	mph	
Speed	11,968	yd / hr	
Area/hr	27,925	yd2 / hr	
Working hours per day	10	hours	
Efficiency	50	%	assumed
Number of passes	2	passes	assumed
Time to compact one cell	2.4	hrs / cell	
Max. number of cells to compact in one week	3	cells / week	
Number of compactors required	1	compactors	
Number of cells to compact per year	52	cells / year	
Total hours for operation per year	126	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D No Drying Equipment Schedule Southern Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

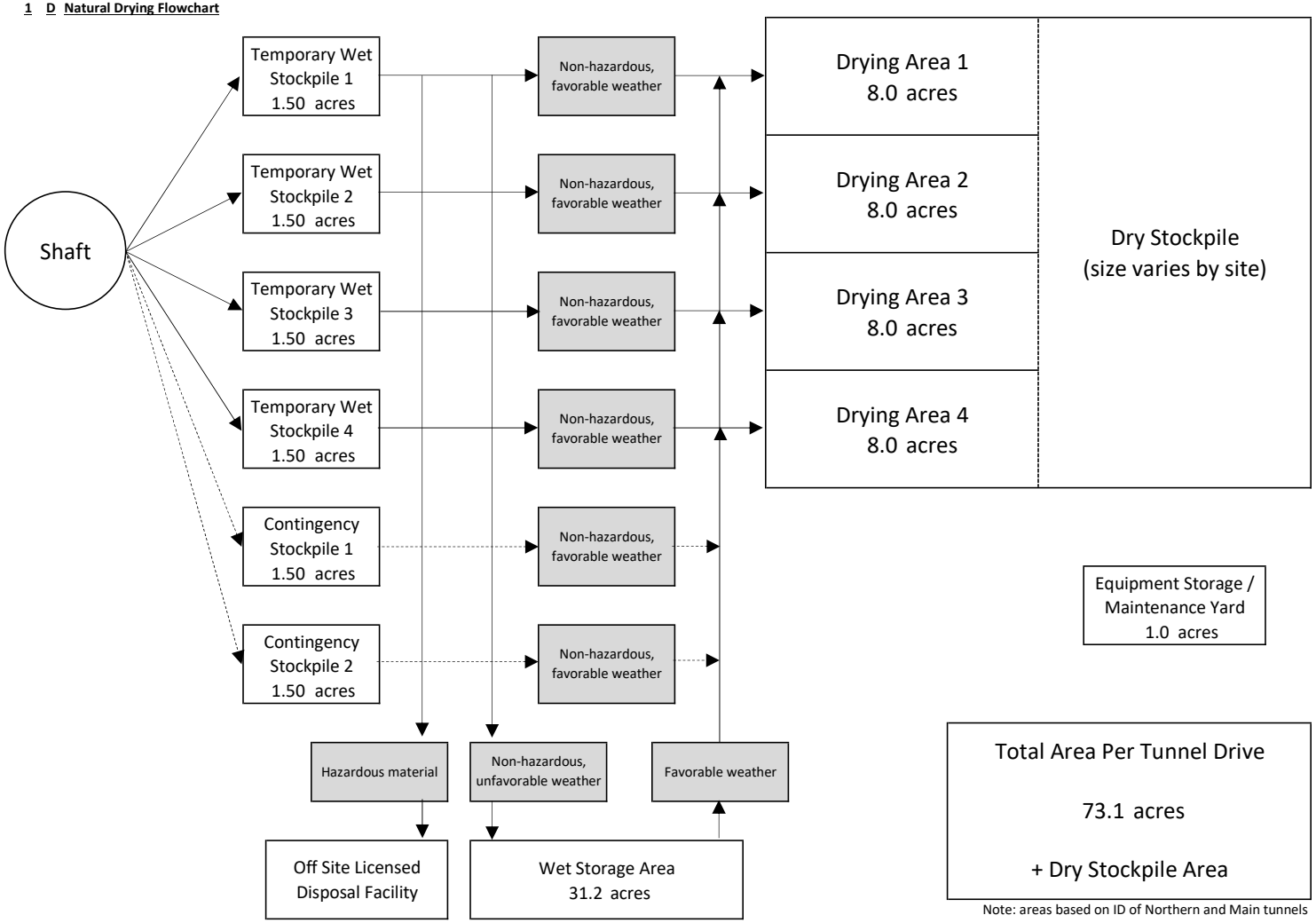
Equipment Schedule (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average Excavation Rate: Total Hours / Year	Average Excavation Rate: Total Power / Year	Average Excavation Rate: Total Annual Operating Cost	Peak Excavation Rate: Quantity	Peak Excavation Rate: Total Capital Cost	Notes
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4681 hrs	$ 105	$ 196,000	4681 hrs	757 MWh	$ 491,453	2	$ 392,000	Day and night shift, 12mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0 hrs	- MWh	$ -	0	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4681 hrs	$ 105	$ 196,000	4681 hrs	757 MWh	$ 491,453	4	$ 784,000	Day shift only, 12mths
Wet Stockpile Moving	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	1740 hrs	$ 120	$ 180,000	1740 hrs	907 MWh	$ 208,822	2	$ 360,000	Day shift only, 12mths
Wet Stockpile Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	2947 hrs	$ 105	$ 196,000	2947 hrs	477 MWh	$ 309,388	6	$ 1,176,000	Day shift only, 12mths
Wet Stockpile Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	126 hrs	$ 55	$ 73,100	126 hrs	12 MWh	$ 6,919	1	$ 73,100	One pass over full wet storage area
							Total Electrical		- hrs	- MWh	$ -	0	$ -	
							Total Gas/Diesel		14,174 hrs	2,911 MWh	$ 1,508,035	15	$ 2,785,100	
							Total		14,174 hrs	2,911 MWh	$ 1,508,035	15	$ 2,785,100	

Equipment utilization 19%

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D Natural Drying Flowchart



Equipment Storage / Maintenance Yard 1.0 acres

Total Area Per Tunnel Drive

73.1 acres

+ Dry Stockpile Area

Note: areas based on ID of Northern and Main tunnels

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D Natural Drying Areas

Excavation Rates	Main Tunnels		Southern Tunnels	
Tunnel lining ID	26	ft	38	ft
TBM cutterhead area	668	ft2	1,396	ft2
TBM advance rate (ave.)	50	ft / day	38	ft / day
TBM advance rate (peak)	100	ft / day	76	ft / day
Daily in-situ rate of excavation per tunnel (ave.)	1,237	yd3 / day	1,965	yd3 / day
Daily in-situ rate of excavation per tunnel (peak)	2,475	yd3 / day	3,931	yd3 / day
Bulking factor	1.30		1.30	
Daily excavated volume per tunnel (ave.)	1,608	yd3 / day	2,555	yd3 / day
Daily excavated volume per tunnel (peak)	3,217	yd3 / day	5,110	yd3 / day
Estimated duration of peak excavation	21	days	21	days
Volume loss due to drying	5	%	5	%
Equivalent daily dry excavated volume per tunnel (ave.)	1,528	yd3 / day	2,427	yd3 / day
Equivalent daily dry excavated volume per tunnel (peak.)	3,056	yd3 / day	4,855	yd3 / day

Temporary Wet Stockpile Area	Main Tunnels		Southern Tunnels		
No. of days storage	5	days	5	days	
Volume of RTM to stockpile at peak excavation rate	16,085	yd3	25,550	yd3	per stockpile
Height of stockpile	10	ft	10	ft	short term
Contingency	50	%	50	%	includes allowance for conveyor pits
Area required at peak excavation rate	1.50	acres	2.38	acres	per stockpile
No. of temporary stockpiles	6.0		6.0		
Total area of temporary stockpiles	9.0	acres	14.3	acres	

Drying Area	Main Tunnels		Southern Tunnels		
Volume of RTM to dry per stockpile	16,085	yd3	25,550	yd3	equivalent to 1 wk RTM at peak excavation
Contingency	20	%	20	%	
Height of stockpile	18.0	in	18.0	in	
Area required at peak excavation rate	8.0	acres	12.7	acres	per drying area
No. of drying areas	4.0		4.0		
Total area of drying areas	31.9	acres	50.7	acres	

Wet Storage Area	Main Tunnels		Southern Tunnels		
Period of wet weather	6	mths	6	mths	continuous storage
No. of days storage	130	days	130	days	based on working days
Volume of RTM to store at ave. excavation rate	209,676	yd3	333,063	yd3	
Height of stockpile	5.0	ft	5.0	ft	long term
Contingency	20	%	20	%	
Area required	31.2	acres	49.5	acres	

Equipment Storage / Maintenance Yard		
Area required for equipment storage / maintenance yard	1.0	acres

Permanent Stockpile		
Contingency	5	%

Natural Drying Area Summary

Alignment	Site	Tunnel Drive	Dry Partially Compacted RTM	Temporary Wet Stockpile 10 ft high	Drying Area 18 in high	Wet Storage 5 ft high	Equipment / Maintenance Yard	Total RTM Processing Area	Total RTM Processing Area	
Central	Twin Cities	North	0.7 m yd3	9.0 acres	32 acres	31 acres	1 acres	73 acres	146	acres
		South	1.9 m yd3	9.0 acres	32 acres	31 acres	1 acres	73 acres		
	Bouldin Island	South	1.3 m yd3	9.0 acres	32 acres	31 acres	1 acres	73 acres	73	acres
	Southern Forebay	North	0.9 m yd3	9.0 acres	32 acres	31 acres	1 acres	73 acres	189	acres
		South	0.9 m yd3	14.3 acres	51 acres	50 acres	1 acres	115 acres		
Eastern	Twin Cities	North	0.7 m yd3	9.0 acres	32 acres	31 acres	1 acres	73 acres	146	acres
		South	1.6 m yd3	9.0 acres	32 acres	31 acres	1 acres	73 acres		
	Lower Roberts Island	North	1.2 m yd3	9.0 acres	32 acres	31 acres	1 acres	73 acres	73	acres
	Southern Forebay	North	1.5 m yd3	9.0 acres	32 acres	31 acres	1 acres	73 acres	189	acres
		South	0.9 m yd3	14.3 acres	51 acres	50 acres	1 acres	115 acres		

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D Natural Drying Equipment Main Tunnels

Temporary Wet Stockpile Filling

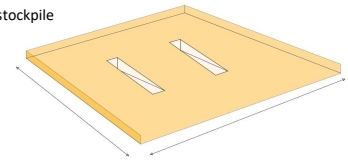
Volume of RTM to stockpile (peak)	16,085	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	23.1	hours / day	
Total hours at average excavation rate per day	11.6	hours / day	
Total hours for operation per year	2,947	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (peak)	16,085	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	10	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	23.1	hours / day	
Total hours at average excavation rate per day	11.6	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	2,947	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Spreading

Volume of RTM to be spread per day (peak)	1,608	yd3/day	per drying area
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	23.1	hours / day	
Total hours at average excavation rate per day	11.6	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	2,947	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Tilling

Drying Area	8.0	acres	per drying area
No. of drying areas	4.0		
Total drying area	31.9	acres	
Tilling rate per machine	14.50	acres/hr/tractor	includes 80% capacity
Passes per day	3	times	
Working hours per day	10	hours	
Min. number of tractors required	1	tractors	
Additional contingency	1	tractor	
No. of tractors required	2	tractors	
Total hours at average excavation rate per day	6.6	hours / day	
Total hours for operation per year	1,683	hours / year	

Example: John Deere 5090E (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area	31.9	acres	total drying area
Area	154,413	yd2	
Speed	6.8	mph	
Speed	11,968	yd/hr	
Area/hr	27,925	yd2/hr	
Efficiency	50	%	
Time to compact whole area	8	hrs	
Number of compactors required	1	compactors	to compact whole drying area in 1 day
Number of times to compact area per year	26	times/yr	assumed once a week for 6mths
Total hours for operation per year	216	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

Drying Area Piling

Volume of RTM to be piling per day (ave.)	1,528	yd3/day	dried volume, per drying area
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	22.0	hours / day	
Total hours for operation per year	5,598	hours / year	2 stockpiles emptied at any one time

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area to Dry Stockpile

Volume of RTM to be moved per day (ave.)	1,528	yd3/day	per drying area
Scraper capacity	24.00	yd3 / scraper	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of scrapers required	1	scrapers	
Total hours at average excavation rate per day	13.3	hours / day	
Total hours for operation per year	3,382	hours / year	2 stockpiles emptied at any one time

Example: Caterpillar 637K, Capacity = 24yd3 (see equipment schedule for details)

Wet Storage Stockpiling

Volume of RTM to be stockpiled per day	1,298	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	assuming bulldozers already on project site
Working hours per day	10	hours	
Average cycle time per shove	10	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours per day	18.7	hours / day	
Total hours for operation per year	2,378	hours / year	for 6mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

During peak excavation there will be 6 bulldozers operating in the various temporary stockpiles.
The wet stockpile will only be emptied when the excavation is below peak.
At average excavation there will be 3 bulldozers available for this operation.

Dry Stockpile Filling / Unloading

Bulldozers

Volume of RTM to be stockpiled per day per drying area (ave.)	1,528	yd3/day	per drying area
No. of drying areas to be emptied per day	2		
Volume of RTM to be stockpiled per day	3,056	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers	3	bulldozers	
Total hours at average excavation rate per day	22.0	hours / day	
Total hours for operation per year	5,598	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wheel Loaders

Daily excavated volume per tunnel (ave.)	1,528	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	1	wheel loaders	
Total hours at average excavation rate per day	8.2	hours / day	
Total hours for operation per year	2,081	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D Natural Drying Equipment Schedule Main Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average Excavation Rate: Total Hours / Year	Average Excavation Rate: Total Power / Year	Average Excavation Rate: Total Annual Operating Cost	Peak Excavation Rate: Quantity	Peak Excavation Rate: Total Capital Cost	Notes
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	2947 hrs	$ 105	$ 196,000	2947 hrs	477 MWh	$ 309,388	2	$ 392,000	Day and night shift, 12mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0 hrs	- MWh	$ -	0	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	2947 hrs	$ 105	$ 196,000	2947 hrs	477 MWh	$ 309,388	4	$ 784,000	Day shift only, 12mths
Drying Areas Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	2947 hrs	$ 105	$ 196,000	2947 hrs	477 MWh	$ 309,388	4	$ 784,000	Day shift only, 12mths
Drying Areas Tilling	Tractors	John Deere	5090E	90 hp	67 kW	1683 hrs	$ 30	$ 58,750	1683 hrs	113 MWh	$ 50,495	2	$ 117,500	Day shift only, 12mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	216 hrs	$ 55	$ 73,100	216 hrs	21 MWh	$ 11,861	1	$ 73,100	Once a week during wet months
Drying Areas Piling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	5598 hrs	$ 105	$ 196,000	5598 hrs	906 MWh	$ 587,837	4	$ 784,000	Day shift only, 12mths
Drying Area to Dry Stockpile	Scrapers	Caterpiller	637K	570 hp	425 kW	3382 hrs	$ 150	$ 905,000	3382 hrs	1,438 MWh	$ 507,359	2	$ 1,810,000	Day shift only, 12mths
Wet Storage Stockpiling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	2378 hrs	$ 105	$ 196,000	2378 hrs	385 MWh	$ 249,727	0	$ -	Day shift only, 6mths
Dry Stockpile Filling/Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	5598 hrs	$ 105	$ 196,000	5598 hrs	906 MWh	$ 587,837	3	$ 588,000	Day shift only, 12mths
Dry Stockpile Filling/Unloading	Wheel Loaders	Caterpiller	990K	699 hp	521 kW	2081 hrs	$ 120	$ 180,000	2081 hrs	1,085 MWh	$ 249,777	1	$ 180,000	Day shift only, 12mths
								Total Electrical	- hrs	- MWh	$ -	0	$ -	
								Total Gas/Diesel	29,778 hrs	6,284 MWh	$ 3,173,057	23	$ 5,512,600	
								Total	29,778 hrs	6,284 MWh	$ 3,173,057	23	$ 5,512,600	

Equipment utilization 25%

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D Natural Drying Equipment Southern Tunnels

Temporary Wet Stockpile Filling

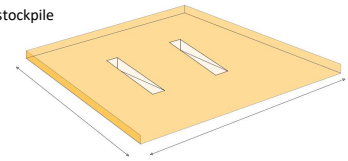
Volume of RTM to stockpile (peak)	25,550	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	36.7	hours / day	
Total hours at average excavation rate per day	18.4	hours / day	
Total hours for operation per year	4,681	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (peak)	25,550	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	10	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	36.7	hours / day	
Total hours at average excavation rate per day	18.4	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	4,681	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Spreading

Volume of RTM to be spread per day (peak)	2,555	yd3/day	per drying area
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	36.7	hours / day	
Total hours at average excavation rate per day	18.4	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	4,681	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Tilling

Drying Area	12.7	acres	per drying area
No. of drying areas	4.0		
Total drying area	50.7	acres	
Tilling rate per machine	14.50	acres/hr/tractor	includes 80% capacity
Passes per day	3	times	
Working hours per day	10	hours	
Min. number of tractors required	2	tractors	
Additional contingency	1	tractor	
No. of tractors required	3	tractors	
Total hours at average excavation rate per day	10.5	hours / day	
Total hours for operation per year	2,674	hours / year	

Example: John Deere 5090E (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area	50.7	acres	total drying area
Area	245,280	yd2	
Speed	6.8	mph	
Speed	11,968	yd/hr	
Area/hr	27,925	yd2/hr	
Efficiency	50	%	
Time to compact whole area	13	hrs	
Number of compactors required	2	compactors	to compact whole drying area in 1 day
Number of times to compact area per year	26	times/yr	assumed once a week for 6mths
Total hours for operation per year	343	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

Drying Area Piling

Volume of RTM to be piling per day (ave.)	2,427	yd3/day	dried volume, per drying area
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	34.9	hours / day	
Total hours for operation per year	8,893	hours / year	2 stockpiles emptied at any one time

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area to Dry Stockpile

Volume of RTM to be moved per day (ave.)	2,427	yd3/day	per drying area
Scraper capacity	24.00	yd3 / scraper	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of scrapers required	2	scrapers	
Total hours at average excavation rate per day	21.1	hours / day	
Total hours for operation per year	5,373	hours / year	2 stockpiles emptied at any one time

Example: Caterpillar 637K, Capacity = 24yd3 (see equipment schedule for details)

Wet Storage Stockpiling

Volume of RTM to be stockpiled per day	2,062	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	assuming bulldozers already on project site
Working hours per day	10	hours	
Average cycle time per shove	10	mins	
Efficiency	80	%	
Number of bulldozers required	3	bulldozers	
Total hours per day	29.6	hours / day	
Total hours for operation per year	3,778	hours / year	for 6mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

During peak excavation there will be 6 bulldozers operating in the various temporary stockpiles.
The wet stockpile will only be emptied when the excavation is below peak.
At average excavation there will be 3 bulldozers available for this operation.

Dry Stockpile Filling / Unloading

Bulldozers

Volume of RTM to be stockpiled per day per drying area (ave.)	2,427	yd3/day	per drying area
No. of drying areas to be emptied per day	2		
Volume of RTM to be stockpiled per day	4,855	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers	4	bulldozers	
Total hours at average excavation rate per day	34.9	hours / day	
Total hours for operation per year	8,893	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wheel Loaders

Daily excavated volume per tunnel (ave.)	2,427	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	13.0	hours / day	
Total hours for operation per year	3,306	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D Natural Drying Equipment Schedule Southern Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

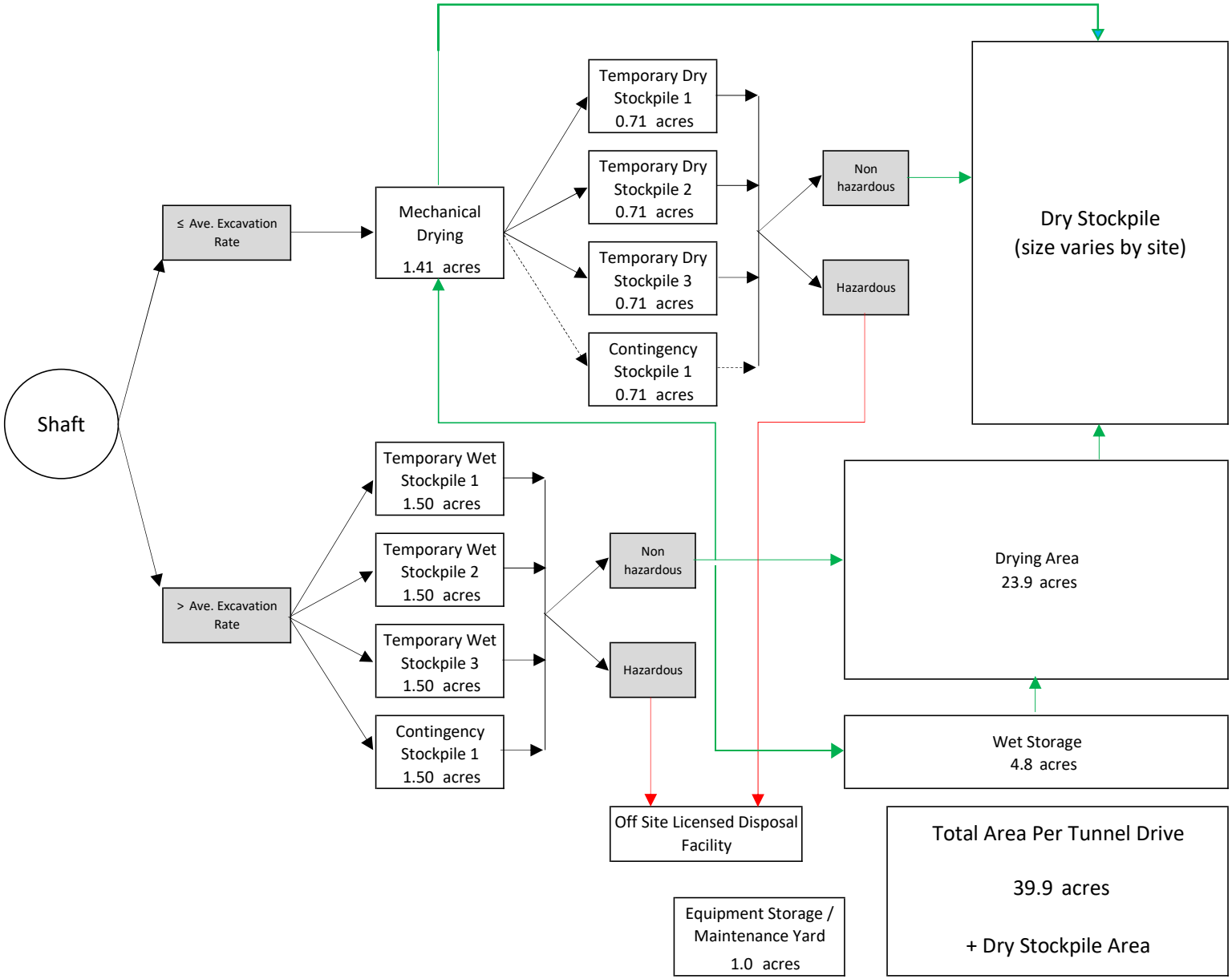
Equipment Schedule (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average Excavation Rate: Total Hours / Year	Average Excavation Rate: Total Power / Year	Average Excavation Rate: Total Annual Operating Cost	Peak Excavation Rate: Quantity	Peak Excavation Rate: Total Capital Cost	Notes
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4681 hrs	$ 105	$ 196,000	4681 hrs	757 MWh	$ 491,453	2	$ 392,000	Day and night shift, 12mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0 hrs	- MWh	$ -	0	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4681 hrs	$ 105	$ 196,000	4681 hrs	757 MWh	$ 491,453	4	$ 784,000	Day shift only, 12mths
Drying Areas Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4681 hrs	$ 105	$ 196,000	4681 hrs	757 MWh	$ 491,453	4	$ 784,000	Day shift only, 12mths
Drying Areas Tilling	Tractors	John Deere	5090E	90 hp	67 kW	2674 hrs	$ 30	$ 58,750	2674 hrs	179 MWh	$ 80,210	3	$ 176,250	Day shift only, 12mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	343 hrs	$ 55	$ 73,100	343 hrs	33 MWh	$ 18,840	2	$ 146,200	Once a week during wet months
Drying Areas Piling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	8893 hrs	$ 105	$ 196,000	8893 hrs	1,439 MWh	$ 933,760	4	$ 784,000	Day shift only, 12mths
Drying Area to Dry Stockpile	Scrapers	Caterpiller	637K	570 hp	425 kW	5373 hrs	$ 150	$ 905,000	5373 hrs	2,284 MWh	$ 805,924	4	$ 3,620,000	Day shift only, 12mths
Wet Storage Stockpiling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	3778 hrs	$ 105	$ 196,000	3778 hrs	611 MWh	$ 396,684	0	$ -	Day shift only, 6mths
Dry Stockpile Filling/Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	8893 hrs	$ 105	$ 196,000	8893 hrs	1,439 MWh	$ 933,760	4	$ 784,000	Day shift only, 12mths
Dry Stockpile Filling/Unloading	Wheel Loaders	Caterpiller	990K	699 hp	521 kW	3306 hrs	$ 120	$ 180,000	3306 hrs	1,723 MWh	$ 396,763	2	$ 360,000	Day shift only, 12mths
								Total Electrical	- hrs	- MWh	$ -	0	$ -	
								Total Gas/Diesel	47,301 hrs	9,982 MWh	$ 5,040,300	29	$ 7,830,450	
								Total	47,301 hrs	9,982 MWh	$ 5,040,300	29	$ 7,830,450	

Equipment utilization 32%

CA Delta Conveyance Tunnel - RTM Calculations

Option 1 D Mechanical Drying Flowchart



Note: areas based on ID of Northern and Main tunnels

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D Mechanical Drying Areas

Excavation rates	Main Tunnels		Southern Tunnels	
Tunnel lining ID	26	ft	38	ft
TBM cutterhead area	668	ft2	1,396	ft2
TBM advance rate (ave.)	50	ft / day	38	ft / day
TBM advance rate (peak)	100	ft / day	76	ft / day
Rate of in-situ material excavation per tunnel (ave.)	1,237	yd3 / day	1,965	yd3 / day
Rate of in-situ material excavation per tunnel (peak)	2,475	yd3 / day	3,931	yd3 / day
Bulking factor	1.30		1.30	
Excavated rate of material per tunnel drive (ave.)	1,608	yd3 / day	2,555	yd3 / day
Excavated rate of material per tunnel drive (peak)	3,217	yd3 / day	5,110	yd3 / day
Estimated duration of peak excavation	21	days	21	days
Volume loss due to drying	5	%	5	%
Equivalent daily dry excavated volume per tunnel (ave.)	1,528	yd3 / day	2,427	yd3 / day
Equivalent daily dry excavated volume per tunnel (peak.)	3,056	yd3 / day	4,855	yd3 / day

Mechanical Drying Area

Inputs

Unit weight of soil entering dryer	100	lb/ft3
Unit weight of soil entering dryer	2,692	lb/yd3
Unit weight of soil produced per day (ave.)	108	tons/hr
Working hours per day	20	hours
Working hours per year	5,100	hours

Option 1 - Thermal Drying

Equipment details (Note this is one possible option presented as an example)

Manufacturer	Komline-Sanderson				
Machine	K-S Paddle Dryer				
Model	16W-3200				
Capacity	70,000	lb/hr	=	520	yd3 / day
Length	16,822	mm	=	55.2	ft
Width	3,835	mm	=	12.6	ft
Height	4,273	mm	=	14.0	ft
Weight	102,058	kg	=	112.5	tons
Power for heat source	32	MMBtu/hr		9,378	kWh
Power for motors	250	hp		186	kW
Estimated capital cost	$ 4,500,000				

Option 2 - Rotary Drying

Equipment details (Note this is one possible option presented as an example)

Manufacturer	Vulcan Drying Systems					
Machine	Frac Sand Dryer					
Model	(Customized)					
Capacity	196,000	lb/hr	=	1,456	yd3 / day	
Length	22,860	mm	=	75.0	ft	assumed
Width	9,144	mm	=	30.0	ft	assumed
Height	6,096	mm	=	20.0	ft	assumed
Weight	90,718	kg	=	100.0	tons	assumed
Power for heat source	57	MMBtu/hr		16,705	kWh	
Power for motors	255	hp		190	kW	
Estimated capital cost	$ 400,000					

Assumptions

Clear space required around each dryer	3	ft
Efficiency / redundancy	85	%

Assumptions

Clear space required around each dryer	3	ft
Efficiency / redundancy	85	%

Option 1 - Thermal Drying	Main Tunnels		Southern Tunnels		per tunnel drive, average excavation rates
Min. quantity required	4		6		
Additional contingency	2		2		
Quantity required	6		8		
Total weight of equipment	675	tons	900	tons	
Area required	6,822	yd2	9,096	yd2	
Area required	1.41	acres	1.88	acres	

Option 2 - Rotary Drying	Main Tunnels		Southern Tunnels		per tunnel drive, average excavation rates
Min. quantity required	2		3		assumes all drying systems of same size
Additional contingency	1		1		- dryers can be custom made for desired quantity
Quantity required	3		4		
Total weight of equipment	300	tons	400	tons	
Area required	8,748	yd2	11,664	yd2	
Area required	1.81	acres	2.41	acres	

Temporary Dry Stockpile Area	Main Tunnels		Southern Tunnels		
No. of days storage	5	days	5	days	assuming 5 days of excavation at ave. rate in a 7 day cycle
Volume of RTM to stockpile at average excavation rate	7,640	yd3	12,136	yd3	
Height of stockpile	10	ft	10	ft	short term
Contingency	50	%	50	%	includes allowance for conveyor pits
Area required	0.71	acres	1.13	acres	per stockpile
No. of temporary stockpiles	4.0		4.0		3 active + 1 contingency
Total area of temporary stockpiles	2.8	acres	4.5	acres	

Temporary Wet Stockpile Area	Main Tunnels		Southern Tunnels		
No. of days storage	5	days	5	days	assuming 5 days of excavation at ave. rate in a 7 day cycle
Volume of RTM to stockpile at peak excavation rate	8,042	yd3	12,775	yd3	per stockpile = 1wks worth at average excavation rate
Height of stockpile	5	ft	5	ft	long term
Contingency	50	%	50	%	includes allowance for conveyor pits
Area required	1.50	acres	2.38	acres	
No. of temporary stockpiles	4.0		4.0		3wks of average excavation + 1wks contingency
Total area of temporary stockpiles	6.0	acres	9.5	acres	

(Temporary Wet Stockpile + Wet Storage + Drying Area = 13wks = 3mths)

Wet Storage Area	Main Tunnels		Southern Tunnels		
Volume of RTM to store	32,169	yd3	51,100	yd3	4wks of average excavation
Height of stockpile	5	ft	5	ft	long term
Contingency	20	%	20	%	
Area required	4.8	acres	7.6	acres	

(Temporary Wet Stockpile + Wet Storage + Drying Area = 13wks = 3mths)

Drying Area	Main Tunnels		Southern Tunnels		
Volume of RTM to dry at any one time	48,254	yd3	76,650	yd3	6wks of average excavation
Height of stockpile	18.0	in	18.0	in	
Contingency	20	%	20	%	
Area required	23.9	acres	38.0	acres	

(Temporary Wet Stockpile + Wet Storage + Drying Area = 13wks = 3mths)

Equipment Storage / Maintenance Yard

Area required for equipment storage / maintenance yard 1.0 acres

Dry Stockpile

Note the dry stockpile area is based on the requirements for Option 3 as shown on the drawings, except for Option 4 which requires a larger area.
Contingency 5 %

Mechanical Drying Area Summary

Alignment	Site	Tunnel Drive	Dry Partially Compacted RTM	Mechanical Drying Area	Temporary Dry Stockpile 10 ft high	Temporary Wet Stockpile 5 ft high	Wet Storage 5 ft high	Drying Area 18 in high	Equipment / Maintenance Yard	Total RTM Processing Area	Total RTM Processing Area
Central	Twin Cities	North	0.7 m yd3	1.8 acres	2.8 acres	6.0 acres	4.8 acres	23.9 acres	1 acres	40 acres	81 acres
		South	1.9 m yd3	1.8 acres	2.8 acres	6.0 acres	4.8 acres	23.9 acres	1 acres	40 acres	
	Bouldin Island	South	1.3 m yd3	1.8 acres	2.8 acres	6.0 acres	4.8 acres	23.9 acres	1 acres	40 acres	40 acres
	Southern Forebay	North	0.9 m yd3	1.8 acres	2.8 acres	6.0 acres	4.8 acres	23.9 acres	1 acres	40 acres	103 acres
		South	0.9 m yd3	2.4 acres	4.5 acres	9.5 acres	7.6 acres	38.0 acres	1 acres	63 acres	
Eastern	Twin Cities	North	0.7 m yd3	1.8 acres	2.8 acres	6.0 acres	4.8 acres	23.9 acres	1 acres	40 acres	81 acres
		South	1.6 m yd3	1.8 acres	2.8 acres	6.0 acres	4.8 acres	23.9 acres	1 acres	40 acres	
	Lower Roberts Island	North	1.2 m yd3	1.8 acres	2.8 acres	6.0 acres	4.8 acres	23.9 acres	1 acres	40 acres	40 acres
	Southern Forebay	North	1.5 m yd3	1.8 acres	2.8 acres	6.0 acres	4.8 acres	23.9 acres	1 acres	40 acres	103 acres
		South	0.9 m yd3	2.4 acres	4.5 acres	9.5 acres	7.6 acres	38.0 acres	1 acres	63 acres	

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Option 1 D Mechanical Drying Equipment Main Tunnels

Temporary Dry Stockpile Filling

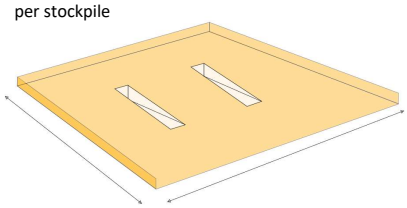
Volume of RTM to stockpile (ave.)	7,640	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	11.0	hours / day	
Total hours for operation per year	2,799	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Dry Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (ave.)	7,640	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	5	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	11.0	hours / day	
Total hours for operation per year	2,799	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Filling

Volume of RTM to be stockpiled per day (ave.)	1,608	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	11.6	hours / day	
Total hours for operation per year	737	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Volume of RTM to be stockpiled per day (ave.)	1,608	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	11.6	hours / day	
Total hours for operation per year	737	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wet Storage Filling/Emptying

Volume of RTM to be stockpiled per day (ave.)	1,608	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	11.6	hours / day	
Total hours for operation per year	227	hours / year	for 4wk operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Spreading

Volume of RTM to be spread per day (ave.)	1,608	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	11.6	hours / day	
Total hours for operation per year	737	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Tilling

Drying Area	23.9	acres	
No. of drying areas	1		
Total drying area	23.9	acres	
Tilling rate per machine	14.50	acres/hr/tractor	includes 80% capacity
Passes per day	3	times	
Working hours per day	10	hours	
Min. number of tractors required	1	tractors	
Additional contingency	1	tractor	
No. of tractors required	2	tractors	
Total hours at average excavation rate per day	5.0	hours / day	
Total hours for operation per year	316	hours / year	for 3mth operation

Example: John Deere 5090E (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area	23.9	acres	total drying area
Area	115,810	yd2	
Speed	6.8	mph	
Speed	11,968	yd/hr	
Area/hr	27,925	yd2/hr	
Efficiency	50	%	
Time to compact whole area	6	hrs	
Number of compactors required	1	compactors	to compact whole drying area in 1 day
Number of times to compact area per year	26	times/yr	assumed once a week for 6mths
Total hours for operation per year	162	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

Drying Area to Dry Stockpile

Volume of RTM to be moved per day (ave.)	1,528	yd3/day	dried volume
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	1	wheel loaders	
Total hours at average excavation rate per day	8.2	hours / day	
Total hours for operation per year	520	hours / year	for 3mth operation

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Dry Stockpile Filling / Unloading

Bulldozers

Volume of RTM to be stockpiled per day (ave.)	1,528	yd3/day	assume average excavation rate
No. of drying areas to be emptied per day	1		
Volume of RTM to be stockpiled per day	1,528	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers	2	bulldozers	
Total hours at average excavation rate per day	11.0	hours / day	
Total hours for operation per year	2,799	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wheel Loaders

Daily excavated volume per tunnel (ave.)	1,528	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	1	wheel loaders	
Total hours at average excavation rate per day	8.2	hours / day	
Total hours for operation per year	2,081	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Assume this will utilize the same equipment as for Drying Area to Dry Stockpile

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CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D Mechanical Drying Equipment Schedule Main Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule - Thermal Dryers (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average and Peak Excavation Rate: Quantity	Total Hours / Year	Total Power / Year	Total Annual Operating Cost	Total Capital Cost	Notes
Thermal Drying - heat source	Thermal Dryers	Komline-Sanderson	K-S Paddle Dryer	32 MMBtu	9378 kW	30600 hrs	$ 7.76	$ 4,500,000	6	30600 hrs	979 MMBtu	$ 7,598,592	$ 27,000,000	Day and night shift, 12mths
Thermal Drying - motors	Thermal Dryers	Komline-Sanderson	K-S Paddle Dryer	250 hp	186 kW	30600 hrs	$ 120.00		6	30600 hrs	5,705 MWh	$ 684,552		Day and night shift, 12mths
Temporary Dry Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	2799 hrs	$ 105	$ 196,000	1	2799 hrs	453 MWh	$ 293,918	$ 196,000	Day and night shift, 12mths
Temporary Dry Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Dry Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	2799 hrs	$ 105	$ 196,000	2	2799 hrs	453 MWh	$ 293,918	$ 392,000	Day shift only, 12mths
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	737 hrs	$ 105	$ 196,000	1	737 hrs	119 MWh	$ 77,347	$ 196,000	Day and night shift, 3mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	737 hrs	$ 105	$ 196,000	1	737 hrs	119 MWh	$ 77,347	$ 196,000	Day and night shift, 3mths
Wet Storage Filling/Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	227 hrs	$ 105	$ 196,000	1	227 hrs	37 MWh	$ 23,799	$ 196,000	Day and night shift, 4 wks
Drying Area Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	737 hrs	$ 105	$ 196,000	2	737 hrs	119 MWh	$ 77,347	$ 392,000	Day shift only, 3mths
Drying Area Tilling	Tractors	John Deere	5090E	90 hp	67 kW	316 hrs	$ 30	$ 58,750	2	316 hrs	21 MWh	$ 9,468	$ 117,500	Day shift only, 3mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	162 hrs	$ 55	$ 73,100	1	162 hrs	16 MWh	$ 8,896	$ 73,100	Once a week during wet months
Drying Area to Dry Stockpile	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	520 hrs	$ 120	$ 180,000	1	520 hrs	271 MWh	$ 62,444	$ 180,000	Day shift only, 3mths
Dry Stockpile Filling / Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	2799 hrs	$ 105	$ 196,000	2	2799 hrs	453 MWh	$ 293,918	$ 392,000	Day shift only, 12mths
Dry Stockpile Filling / Unloading	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	2081 hrs	$ 120	$ 180,000	1	2081 hrs	1,085 MWh	$ 249,777	$ 180,000	Day shift only, 12mths

Equipment utilization 55%

Total Natural Gas	6	30,600 hrs	979 MMBtu	$ 7,598,592	
Total Electrical	6	30,600 hrs	5,705 MWh	$ 684,552	$ 27,000,000
Total Gas/Diesel	15	13,913 hrs	3,146 MWh	$ 1,468,180	$ 2,510,600
Total	27	75,113 hrs	8,851 MWh	$ 9,751,325	$ 29,510,600

Equipment Schedule - Rotary Dryers (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average and Peak Excavation Rate: Quantity	Total Hours / Year	Total Power / Year	Total Annual Operating Cost	Total Capital Cost	Notes
Rotary Drying - heat source	Rotary Dryers	Vulcan	Frac Sand Dryer	57 MMBtu	16705 kW	15300 hrs	$ 7.76	$ 400,000	3	15300 hrs	872 MMBtu	$ 6,767,496	$ 1,200,000	Day and night shift, 12mths
Rotary Drying - motors	Rotary Dryers	Vulcan	Frac Sand Dryer	255 hp	190 kW	15300 hrs	$ 120.00		3	15300 hrs	2,909 MWh	$ 349,122		Day and night shift, 12mths
Temporary Dry Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	2799 hrs	$ 105	$ 196,000	1	2799 hrs	453 MWh	$ 293,918	$ 196,000	Day and night shift, 12mths
Temporary Dry Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Dry Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	2799 hrs	$ 105	$ 196,000	2	2799 hrs	453 MWh	$ 293,918	$ 392,000	Day shift only, 12mths
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	737 hrs	$ 105	$ 196,000	1	737 hrs	119 MWh	$ 77,347	$ 196,000	Day and night shift, 3mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	737 hrs	$ 105	$ 196,000	1	737 hrs	119 MWh	$ 77,347	$ 196,000	Day and night shift, 3mths
Wet Storage Filling/Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	227 hrs	$ 105	$ 196,000	1	227 hrs	37 MWh	$ 23,799	$ 196,000	Day and night shift, 4 wks
Drying Area Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	737 hrs	$ 105	$ 196,000	2	737 hrs	119 MWh	$ 77,347	$ 392,000	Day shift only, 3mths
Drying Area Tilling	Tractors	John Deere	5090E	90 hp	67 kW	316 hrs	$ 30	$ 58,750	2	316 hrs	21 MWh	$ 9,468	$ 117,500	Day shift only, 3mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	162 hrs	$ 55	$ 73,100	1	162 hrs	16 MWh	$ 8,896	$ 73,100	Once a week during wet months
Drying Area to Dry Stockpile	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	520 hrs	$ 120	$ 180,000	1	520 hrs	271 MWh	$ 62,444	$ 180,000	Day shift only, 3mths
Dry Stockpile Filling / Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	2799 hrs	$ 105	$ 196,000	2	2799 hrs	453 MWh	$ 293,918	$ 392,000	Day shift only, 12mths
Dry Stockpile Filling / Unloading	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	2081 hrs	$ 120	$ 180,000	1	2081 hrs	1,085 MWh	$ 249,777	$ 180,000	Day shift only, 12mths

Equipment utilization 42%

Total Natural Gas	3	15,300 hrs	872 MMBtu	$ 6,767,496	
Total Electrical	3	15,300 hrs	2,909 MWh	$ 349,122	$ 1,200,000
Total Gas/Diesel	15	13,913 hrs	3,146 MWh	$ 1,468,180	$ 2,510,600
Total	21	44,513 hrs	6,056 MWh	$ 8,584,798	$ 3,710,600

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D Mechanical Drying Equipment Southern Tunnels

Temporary Dry Stockpile Filling

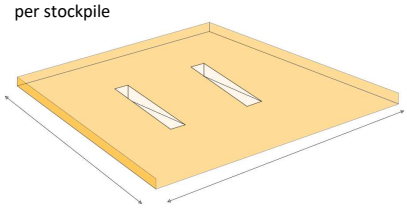
Volume of RTM to stockpile (ave.)	12,136	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	17.4	hours / day	
Total hours for operation per year	4,446	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Dry Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (ave.)	12,136	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	5	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	17.4	hours / day	
Total hours for operation per year	4,446	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Filling

Volume of RTM to be stockpiled per day (ave.)	2,555	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	18.4	hours / day	
Total hours for operation per year	1,170	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Volume of RTM to be stockpiled per day (ave.)	2,555	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	18.4	hours / day	
Total hours for operation per year	1,170	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wet Storage Filling/Emptying

Volume of RTM to be stockpiled per day (ave.)	2,555	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	18.4	hours / day	
Total hours for operation per year	360	hours / year	for 4wk operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Spreading

Volume of RTM to be spread per day (ave.)	2,555	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	18.4	hours / day	
Total hours for operation per year	1,170	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Tilling

Drying Area	38.0	acres	
No. of drying areas	1		
Total drying area	38.0	acres	
Tilling rate per machine	14.50	acres/hr/tractor	includes 80% capacity
Passes per day	3	times	
Working hours per day	10	hours	
Min. number of tractors required	1	tractors	
Additional contingency	1	tractor	
No. of tractors required	2	tractors	
Total hours at average excavation rate per day	7.9	hours / day	
Total hours for operation per year	501	hours / year	for 3mth operation

Example: John Deere 5090E (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area	38.0	acres	total drying area
Area	183,960	yd2	
Speed	6.8	mph	
Speed	11,968	yd/hr	
Area/hr	27,925	yd2/hr	
Efficiency	50	%	
Time to compact whole area	10	hrs	
Number of compactors required	1	compactors	to compact whole drying area in 1 day
Number of times to compact area per year	26	times/yr	assumed once a week for 6mths
Total hours for operation per year	257	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

Drying Area to Dry Stockpile

Volume of RTM to be moved per day (ave.)	2,427	yd3/day	dried volume
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	13.0	hours / day	
Total hours for operation per year	827	hours / year	for 3mth operation

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Dry Stockpile Filling / Unloading

Bulldozers

Volume of RTM to be stockpiled per day (ave.)	2,427	yd3/day	assume average excavation rate
No. of drying areas to be emptied per day	1		
Volume of RTM to be stockpiled per day	2,427	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers	2	bulldozers	
Total hours at average excavation rate per day	17.4	hours / day	
Total hours for operation per year	4,446	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wheel Loaders

Daily excavated volume per tunnel (ave.)	2,427	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	13.0	hours / day	
Total hours for operation per year	3,306	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Assume this will utilize the same equipment as for Drying Area to Dry Stockpile

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CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D Mechanical Drying Equipment Schedule Southern Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule - Thermal Dryers (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average and Peak Excavation Rate: Quantity	Total Hours / Year	Total Power / Year	Total Annual Operating Cost	Total Capital Cost	Notes
Thermal Drying - heat source	Thermal Dryers	Komline-Sanderson	K-S Paddle Dryer	32 MMBtu	9378 kW	40800 hrs	$ 7.76	$ 4,500,000	6	40800 hrs	1,306 MMBtu	$ 10,131,456	$ 27,000,000	Day and night shift, 12mths
Thermal Drying - motors	Thermal Dryers	Komline-Sanderson	K-S Paddle Dryer	250 hp	186 kW	40800 hrs	$ 120.00		6	40800 hrs	7,606 MWh	$ 912,737		Day and night shift, 12mths
Temporary Dry Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4446 hrs	$ 105	$ 196,000	1	4446 hrs	720 MWh	$ 466,880	$ 196,000	Day and night shift, 12mths
Temporary Dry Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Dry Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4446 hrs	$ 105	$ 196,000	2	4446 hrs	720 MWh	$ 466,880	$ 392,000	Day shift only, 12mths
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1170 hrs	$ 105	$ 196,000	1	1170 hrs	189 MWh	$ 122,863	$ 196,000	Day and night shift, 3mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1170 hrs	$ 105	$ 196,000	1	1170 hrs	189 MWh	$ 122,863	$ 196,000	Day and night shift, 3mths
Wet Storage Filling/Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	360 hrs	$ 105	$ 196,000	1	360 hrs	58 MWh	$ 37,804	$ 196,000	Day and night shift, 4 wks
Drying Area Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1170 hrs	$ 105	$ 196,000	2	1170 hrs	189 MWh	$ 122,863	$ 392,000	Day shift only, 3mths
Drying Area Tilling	Tractors	John Deere	5090E	90 hp	67 kW	501 hrs	$ 30	$ 58,750	2	501 hrs	34 MWh	$ 15,039	$ 117,500	Day shift only, 3mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	257 hrs	$ 55	$ 73,100	1	257 hrs	25 MWh	$ 14,130	$ 73,100	Once a week during wet months
Drying Area to Dry Stockpile	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	827 hrs	$ 120	$ 180,000	2	827 hrs	431 MWh	$ 99,191	$ 360,000	Day shift only, 3mths
Dry Stockpile Filling / Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4446 hrs	$ 105	$ 196,000	2	4446 hrs	720 MWh	$ 466,880	$ 392,000	Day shift only, 12mths
Dry Stockpile Filling / Unloading	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	3306 hrs	$ 120	$ 180,000	2	3306 hrs	1,723 MWh	$ 396,763	$ 360,000	Day shift only, 12mths

Equipment utilization 70%

Total Natural Gas	6	40,800 hrs	1,306 MMBtu	$ 10,131,456	
Total Electrical	6	40,800 hrs	7,606 MWh	$ 912,737	$ 27,000,000
Total Gas/Diesel	17	22,101 hrs	4,998 MWh	$ 2,332,157	$ 2,870,600
Total	29	103,701 hrs	12,604 MWh	$ 13,376,350	$ 29,870,600

Equipment Schedule - Rotary Dryers (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average and Peak Excavation Rate: Quantity	Total Hours / Year	Total Power / Year	Total Annual Operating Cost	Total Capital Cost	Notes
Rotary Drying - heat source	Rotary Dryers	Vulcan	Frac Sand Dryer	57 MMBtu	16705 kW	20400 hrs	$ 7.76	$ 400,000	3	20400 hrs	1,163 MMBtu	$ 9,023,328	$ 1,200,000	Day and night shift, 12mths
Rotary Drying - motors	Rotary Dryers	Vulcan	Frac Sand Dryer	255 hp	190 kW	20400 hrs	$ 120.00		3	20400 hrs	3,879 MWh	$ 465,496		Day and night shift, 12mths
Temporary Dry Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4446 hrs	$ 105	$ 196,000	1	4446 hrs	720 MWh	$ 466,880	$ 196,000	Day and night shift, 12mths
Temporary Dry Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Dry Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4446 hrs	$ 105	$ 196,000	2	4446 hrs	720 MWh	$ 466,880	$ 392,000	Day shift only, 12mths
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1170 hrs	$ 105	$ 196,000	1	1170 hrs	189 MWh	$ 122,863	$ 196,000	Day and night shift, 3mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1170 hrs	$ 105	$ 196,000	1	1170 hrs	189 MWh	$ 122,863	$ 196,000	Day and night shift, 3mths
Wet Storage Filling/Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	360 hrs	$ 105	$ 196,000	1	360 hrs	58 MWh	$ 37,804	$ 196,000	Day and night shift, 4 wks
Drying Area Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1170 hrs	$ 105	$ 196,000	2	1170 hrs	189 MWh	$ 122,863	$ 392,000	Day shift only, 3mths
Drying Area Tilling	Tractors	John Deere	5090E	90 hp	67 kW	501 hrs	$ 30	$ 58,750	2	501 hrs	34 MWh	$ 15,039	$ 117,500	Day shift only, 3mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	257 hrs	$ 55	$ 73,100	1	257 hrs	25 MWh	$ 14,130	$ 73,100	Once a week during wet months
Drying Area to Dry Stockpile	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	827 hrs	$ 120	$ 180,000	2	827 hrs	431 MWh	$ 99,191	$ 360,000	Day shift only, 3mths
Dry Stockpile Filling / Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4446 hrs	$ 105	$ 196,000	2	4446 hrs	720 MWh	$ 466,880	$ 392,000	Day shift only, 12mths
Dry Stockpile Filling / Unloading	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	3306 hrs	$ 120	$ 180,000	2	3306 hrs	1,723 MWh	$ 396,763	$ 360,000	Day shift only, 12mths

Equipment utilization 54%

Total Natural Gas	3	20,400 hrs	1,163 MMBtu	$ 9,023,328	
Total Electrical	3	20,400 hrs	3,879 MWh	$ 465,496	$ 1,200,000
Total Gas/Diesel	17	22,101 hrs	4,998 MWh	$ 2,332,157	$ 2,870,600
Total	23	62,901 hrs	8,877 MWh	$ 11,820,981	$ 4,070,600

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 1 D Transportation Calculations

Unit weight of RTM

Unit weight of in-situ RTM	120.00	lb/ft3	1.62	tons/yd3
Unit weight of wet excavated RTM	99.70	lb/ft3	1.35	tons/yd3
Unit weight of dry excavated RTM	95.00	lb/ft3	1.28	tons/yd3

Transportation Capacity

Road by weight (semi-end dump trucks)	18	tons / trip	semi end dump truck
Road by weight (bottom dump trucks)	20	tons / trip	bottom dump truck
Road by volume	18	yd3 / trip	based on one truck per trip
Rail by volume	1200	yd3 / trip	based on 60yd3 / car, 20 cars / train

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Trips required to move Wet Excavated RTM at average excavation rate - Main tunnels

Average excavation rate	1,608	yd3 / day	8,042	yd3 / week
Average excavation rate	2,165	tons / day	10,825	tons / week
Road (by weight)	121	trips / day	602	trips / week
Road (by volume)	90	trips / day	447	trips / week
Rail	2	trips / day	7	trips / week

Trips required to move Dry Excavated RTM at average excavation rate - Main tunnels

Average excavation rate	1,528	yd3 / day	7,640	yd3 / week
Average excavation rate	1,960	tons / day	9,799	tons / week
Road (by weight)	109	trips / day	545	trips / week
Road (by volume)	85	trips / day	425	trips / week
Rail	2	trips / day	7	trips / week

Trips required to move Dry Excavated RTM from Twin Cities to Southern Forebay

	Vol. to transport to SF	Weight to transport to SF	Road Trips	Rail Trips	Total Weeks
Central Alignment	1.8 m yd3	2.3 m tons	127,500	1,500	234
Eastern Alignment	2.3 m yd3	3.0 m tons	164,500	2,000	302

Attachment 4.2
RTM Calculations – 4,500cfs, 31ft ID Tunnel

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B RTM Volumes

Column Inputs	Internal Diameter	Tunnelling days / week	Tunnelling weeks / year	TBM Cutterhead Area	Bulking factor	Volume reduction due to drying	Full compaction factor	TBM Cutterhead Area	Bulking factor	Volume reduction due to drying	Full compaction factor
Northern tunnels ID	31.0 ft	5 days	51 wks	104 yd2	1.30	5.00 %	0.80	104 yd2	1.30	5.00 %	0.80
Main tunnels ID	31.0 ft	5 days	51 wks	104 yd2				104 yd2			
Southern tunnels ID	38.0 ft	5 days	51 wks	155 yd2				155 yd2			

			Drive Options				RTM Volume / Tunnel Length				RTM Volume / Shaft				RTM Volume / Tunnel Drive	
Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	In-Situ RTM Volume / Tunnel Length	Wet Excavated RTM Volume / Tunnel Length	Dry Excavated RTM Volume / Tunnel Length	Dry Compacted RTM Volume / Tunnel Length	Wet In-situ RTM Volume / Shaft	Wet Excavated RTM Volume / Shaft	Dry Excavated RTM Volume / Shaft	Dry Compacted RTM Volume / Shaft	Dry Compacted RTM Volume / Tunnel Drive	Ave. Quarterly Excavated Dry Compacted RTM Volume / Tunnel Drive
CENTRAL		0.000 mi					- yd3	- yd3	- yd3	- yd3						
	Intake No. 3 Shaft		R													
	Northern Tunnel	2.550 mi	↑	8.190 mi	3.9 yrs		466,164 yd3	606,013 yd3	575,712 yd3	460,570 yd3					1,479,241 yd3	95,057 yd3
	Intake No. 5 Shaft		M													
	Northern Tunnel	5.640 mi	↑				1,031,044 yd3	1,340,358 yd3	1,273,340 yd3	1,018,672 yd3						
	Twin Cities Shaft (2)		L			2					4,149,771 yd3	5,394,702 yd3	5,124,967 yd3	4,099,973 yd3		
	Main Tunnel	4.250 mi	↓				776,939 yd3	1,010,021 yd3	959,520 yd3	767,616 yd3						
	New Hope Shaft		M													
	Main Tunnel	4.200 mi	↓	14.510 mi	6.5 yrs		767,799 yd3	998,139 yd3	948,232 yd3	758,585 yd3					2,620,732 yd3	101,374 yd3
	Staten Island Shaft		M													
	Main Tunnel	6.060 mi	↓				1,107,824 yd3	1,440,171 yd3	1,368,163 yd3	1,094,530 yd3						
	Bouldin Island Shaft		L/R			1					1,837,233 yd3	2,388,403 yd3	2,268,983 yd3	1,815,186 yd3		
	Main Tunnel	4.660 mi	↓				851,891 yd3	1,107,459 yd3	1,052,086 yd3	841,669 yd3						
	Mandeville Island Shaft		M	10.050 mi	4.2 yrs										1,815,186 yd3	107,208 yd3
	Main Tunnel	5.390 mi	↓				985,342 yd3	1,280,945 yd3	1,216,897 yd3	973,518 yd3						
	Bacon Island Shaft		R													
	Main Tunnel	5.760 mi	↑				1,052,981 yd3	1,368,876 yd3	1,300,432 yd3	1,040,346 yd3						
	Byron Tract Shaft		M	6.720 mi	4.0 yrs										1,213,737 yd3	76,805 yd3
	Main Tunnel	0.960 mi	↑				175,497 yd3	228,146 yd3	216,739 yd3	173,391 yd3						
	Southern Forebay (N+S) Shafts (4)		L			2					2,140,584 yd3	2,782,759 yd3	2,643,621 yd3	2,114,897 yd3		
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.5 yrs		912,105 yd3	1,185,737 yd3	1,126,450 yd3	901,160 yd3					901,160 yd3	88,898 yd3
	CA Aqueduct Shaft (2)		R													
	Total	42.81 mi	3	42.81 mi		5	8,127,588 yd3	10,565,864 yd3	10,037,571 yd3	8,030,057 yd3	8,127,588 yd3	10,565,864 yd3	10,037,571 yd3	8,030,057 yd3	8,030,057 yd3	469,342 yd3

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	In-Situ RTM Volume / Tunnel Length	Wet Excavated RTM Volume / Tunnel Length	Dry Excavated RTM Volume / Tunnel Length	Dry Compacted RTM Volume / Tunnel Length	Wet In-situ RTM Volume / Shaft	Wet Excavated RTM Volume / Shaft	Dry Excavated RTM Volume / Shaft	Dry Compacted RTM Volume / Shaft	Dry Compacted RTM Volume / Tunnel Drive	Ave. Quarterly Excavated Dry Compacted RTM Volume / Tunnel Drive
EASTERN		0.000 mi					- yd3	- yd3	- yd3	- yd3						
	Intake No. 3 Shaft		R													
	Northern Tunnel	2.550 mi	↑	8.190 mi	3.9 yrs		466,164 yd3	606,013 yd3	575,712 yd3	460,570 yd3					1,479,241 yd3	95,057 yd3
	Intake No. 5 Shaft		M													
	Northern Tunnel	5.640 mi	↑				1,031,044 yd3	1,340,358 yd3	1,273,340 yd3	1,018,672 yd3						
	Twin Cities Shaft (2)		L			2					3,817,058 yd3	4,962,175 yd3	4,714,066 yd3	3,771,253 yd3		
	Main Tunnel	4.580 mi	↓				837,266 yd3	1,088,446 yd3	1,034,024 yd3	827,219 yd3						
	New Hope Shaft		M													
	Main Tunnel	3.000 mi	↓	12.690 mi	5.9 yrs		548,428 yd3	712,956 yd3	677,308 yd3	541,847 yd3					2,292,012 yd3	96,693 yd3
	Canal Ranch		M													
	Main Tunnel	5.110 mi	↓				934,155 yd3	1,214,402 yd3	1,153,682 yd3	922,946 yd3						
	Terminous Tract Shaft		R													
	Main Tunnel	3.940 mi	↑				720,269 yd3	936,349 yd3	889,532 yd3	711,625 yd3						
	King Island Shaft		M	9.500 mi	4.5 yrs										1,715,848 yd3	94,548 yd3
	Main Tunnel	5.560 mi	↑				1,016,420 yd3	1,321,345 yd3	1,255,278 yd3	1,004,223 yd3						
	Lower Roberts Island Shaft		L/R			1					1,736,688 yd3	2,257,695 yd3	2,144,810 yd3	1,715,848 yd3		
	Main Tunnel	5.180 mi	↑				946,952 yd3	1,231,038 yd3	1,169,486 yd3	935,589 yd3						
	Upper Jones Tract Shaft		M													
	Main Tunnel	5.650 mi	↑	11.790 mi	6.2 yrs		1,032,872 yd3	1,342,734 yd3	1,275,597 yd3	1,020,478 yd3					2,129,458 yd3	85,412 yd3
	Byron Tract		M													
	Main Tunnel	0.960 mi	↑				175,497 yd3	228,146 yd3	216,739 yd3	173,391 yd3						
	Southern Forebay (N+S) Shaft (4)		L			2					3,067,427 yd3	3,987,655 yd3	3,788,272 yd3	3,030,618 yd3		
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.5 yrs		912,105 yd3	1,185,737 yd3	1,126,450 yd3	901,160 yd3					901,160 yd3	88,898 yd3
	CA Aqueduct Shaft (2)		R													
	Total	45.51 mi	3	45.51 mi		5	8,621,173 yd3	11,207,524 yd3	10,647,148 yd3	8,517,719 yd3	8,621,173 yd3	11,207,524 yd3	10,647,148 yd3	8,517,719 yd3	8,517,719 yd3	460,608 yd3

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B RTM Volumes

Column Inputs	Internal Diameter
Northern tunnels ID	31.0 ft
Main tunnels ID	31.0 ft
Southern tunnels ID	38.0 ft

Tunnelling days / week	Tunnelling weeks / year
5 days	51 wks
5 days	51 wks
5 days	51 wks

Drive Options

Quarterly Dry Compacted RTM Volume Generated by Tunnel Drive (m yd3)

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	Start Quart.	HIDE
CENTRAL		0.000 mi						
	Intake No. 3 Shaft		R					
	Northern Tunnel	2.550 mi	↑	8.190 mi	3.9 yrs		20	0
	Intake No. 5 Shaft		M					
	Northern Tunnel	5.640 mi	↑					
	Twin Cities Shaft (2)		L			2		
	Main Tunnel	4.250 mi	↓					
	New Hope Shaft		M					
	Main Tunnel	4.200 mi	↓	14.510 mi	6.5 yrs		17	0
	Staten Island Shaft		M					
	Main Tunnel	6.060 mi	↓					
	Bouldin Island Shaft		L/R			1		
	Main Tunnel	4.660 mi	↓					
	Mandeville Island Shaft		M	10.050 mi	4.2 yrs		22	0
	Main Tunnel	5.390 mi	↓					
	Bacon Island Shaft		R					
	Main Tunnel	5.760 mi	↑					
	Byron Tract Shaft		M	6.720 mi	4.0 yrs		24	0
	Main Tunnel	0.960 mi	↑					
	Southern Forebay (N+S) Shafts (4)		L			2		
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.5 yrs		23	0
	CA Aqueduct Shaft (2)		R					
	Total	42.81 mi	3	42.81 mi		5		

Start Quart.	Y1				Y2				Y3				Y4			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Start Quart.	Y5				Y6				Y7				Y8			
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
20	0.00	0.00	0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
17	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
22	0.00	0.00	0.00	0.00	0.00	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
23	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
	0.10	0.10	0.10	0.20	0.20	0.30	0.39	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47

Start Quart.	Y9				Y10				Y11				Y12			
	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
20	0.10	0.10	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.00	0.00	0.00	0.00	0.00	0.00
22	0.11	0.11	0.11	0.11	0.11	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.08	0.08	0.08	0.08	0.08	0.08	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.39	0.38	0.34	0.29	0.29	0.28	0.16	0.10	0.10	0.09	0.00	0.00	0.00	0.00	0.00	0.00

Start Quart.	Y13				Y14			
	49	50	51	52	53	54	55	56
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	Start Quart.	HIDE
EASTERN		0.000 mi						
	Intake No. 3 Shaft		R					
	Northern Tunnel	2.550 mi	↑	8.190 mi	3.9 yrs		20	0
	Intake No. 5 Shaft		M					
	Northern Tunnel	5.640 mi	↑					
	Twin Cities Shaft (2)		L			2		
	Main Tunnel	4.580 mi	↓					
	New Hope Shaft		M					
	Main Tunnel	3.000 mi	↓	12.690 mi	5.9 yrs		17	0
	Canal Ranch		M					
	Main Tunnel	5.110 mi	↓					
	Terminous Tract Shaft		R					
	Main Tunnel	3.940 mi	↑					
	King Island Shaft		M	9.500 mi	4.5 yrs		22	0
	Main Tunnel	5.560 mi	↑					
	Lower Roberts Island Shaft		L/R			1		
	Main Tunnel	5.180 mi	↑					
	Upper Jones Tract Shaft		M					
	Main Tunnel	5.650 mi	↑	11.790 mi	6.2 yrs		24	0
	Byron Tract		M					
	Main Tunnel	0.960 mi	↑					
	Southern Forebay (N+S) Shaft (4)		L			2		
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.5 yrs		23	0
	CA Aqueduct Shaft (2)		R					
	Total	45.51 mi	3	45.51 mi		5		

Start Quart.	Y1				Y2				Y3				Y4			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Start Quart.	Y5				Y6				Y7				Y8			
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
20	0.00	0.00	0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
17	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
22	0.00	0.00	0.00	0.00	0.00	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
24	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
23	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
	0.10	0.10	0.10	0.19	0.19	0.29	0.38	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46

Start Quart.	Y9				Y10				Y11				Y12			
	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
20	0.10	0.10	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.08
23	0.09	0.09	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.38	0.37	0.33	0.28	0.28	0.28	0.28	0.17	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.08

Start Quart.	Y13				Y14			
	49	50	51	52	53	54	55	56
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B RTM Volumes

Column Inputs	Internal Diameter
Northern tunnels ID	31.0 ft
Main tunnels ID	31.0 ft
Southern tunnels ID	38.0 ft

Tunnelling days / week	Tunnelling weeks / year
5 days	51 wks
5 days	51 wks
5 days	51 wks

Drive Options

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's
CENTRAL		0.000 mi				
	Intake No. 3 Shaft		R			
	Northern Tunnel	2.550 mi	↑	8.190 mi	3.9 yrs	
	Intake No. 5 Shaft		M			
	Northern Tunnel	5.640 mi	↑			
	Twin Cities Shaft (2)		L			2
	Main Tunnel	4.250 mi	↓			
	New Hope Shaft		M			
	Main Tunnel	4.200 mi	↓	14.510 mi	6.5 yrs	
	Staten Island Shaft		M			
	Main Tunnel	6.060 mi	↓			
	Bouldin Island Shaft		L/R			1
	Main Tunnel	4.660 mi	↓			
	Mandeville Island Shaft		M	10.050 mi	4.2 yrs	
	Main Tunnel	5.390 mi	↓			
	Bacon Island Shaft		R			
	Main Tunnel	5.760 mi	↑			
	Byron Tract Shaft		M	6.720 mi	4.0 yrs	
	Main Tunnel	0.960 mi	↑			
	Southern Forebay (N+S) Shafts (4)		L			2
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.5 yrs	
	CA Aqueduct Shaft (2)		R			
	Total	42.81 mi	3	42.81 mi		5

Quarterly Dry Compacted RTM Volume Generated at Each Shaft (m yd3)

Start	Y1				Y2				Y3				Y4				Y5				Y6				Y7				Y8				Y9				Y10				Y11				Y12				Y13				Y14			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
20																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.15	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22																																																									
24																																																									
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.09	0.08	0.08	0.08	0.08	0.08	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.20	0.20	0.30	0.39	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.39	0.38	0.34	0.29	0.29	0.28	0.16	0.10	0.10	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF Only	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.4	0.6	0.8	0.9	1.1	1.2	1.4	1.6	1.7	1.7	1.8	1.9	2.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
TC + SF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.5	1.9	2.3	2.6	3.0	3.4	3.7	4.1	4.4	4.7	5.0	5.2	5.4	5.6	5.8	5.9	6.0	6.1	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
All Shafts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.4	1.9	2.3	2.8	3.3	3.7	4.2	4.7	5.1	5.6	6.0	6.4	6.7	7.0	7.3	7.6	7.7	7.8	7.9	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's
EASTERN		0.000 mi				
	Intake No. 3 Shaft		R			
	Northern Tunnel	2.550 mi	↑	8.190 mi	3.9 yrs	
	Intake No. 5 Shaft		M			
	Northern Tunnel	5.640 mi	↑			
	Twin Cities Shaft (2)		L			2
	Main Tunnel	4.580 mi	↓			
	New Hope Shaft		M			
	Main Tunnel	3.000 mi	↓	12.690 mi	5.9 yrs	
	Canal Ranch		M			
	Main Tunnel	5.110 mi	↓			
	Terminous Tract Shaft		R			
	Main Tunnel	3.940 mi	↑			
	King Island Shaft		M	9.500 mi	4.5 yrs	
	Main Tunnel	5.560 mi	↑			
	Lower Roberts Island Shaft		L/R			1
	Main Tunnel	5.180 mi	↑			
	Upper Jones Tract Shaft		M			
	Main Tunnel	5.650 mi	↑	11.790 mi	6.2 yrs	
	Byron Tract		M			
	Main Tunnel	0.960 mi	↑			
	Southern Forebay (N+S) Shaft (4)		L			2
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.5 yrs	
	CA Aqueduct Shaft (2)		R			
	Total	45.51 mi	3	45.51 mi		5

Start	Y1				Y2				Y3				Y4				Y5				Y6				Y7				Y8				Y9				Y10				Y11				Y12				Y13				Y14			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
20																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.15	0.10	0.10	0.10	0.10	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22																																																									
24																																																									
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.19	0.19	0.29	0.38	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.38	0.37	0.33	0.28	0.28	0.28	0.28	0.17	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF Only	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.4	0.6	0.8	1.0	1.1	1.3	1.5	1.7	1.8	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
TC + SF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.5	0.7	0.9	1.1	1.5	1.9	2.2	2.6	3.0	3.3	3.7	4.1	4.4	4.7	5.0	5.2	5.4	5.6	5.8	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.6	6.7	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
All Shafts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.3	1.8	2.3	2.7	3.2	3.6	4.1	4.6	5.0	5.5	5.9	6.2	6.6	6.8	7.1	7.4	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.4	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B RTM Volumes

Column Inputs	Internal Diameter	Tunnelling days / week	Tunnelling weeks / year	Working space / buffer	Working space / buffer	Full compaction factor	Working space / buffer
Northern tunnels ID	31.0 ft	5 days	51 wks	5 %	5 %	0.80	5 %
Main tunnels ID	31.0 ft	5 days	51 wks				
Southern tunnels ID	38.0 ft	5 days	51 wks				

			Drive Options				Area required to store all RTM at shafts Wet Excavated			Area required to store all RTM at shafts Dry Excavated			Area required to store all RTM at shafts Dry Fully Compacted		
Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	Volume / Shaft	Storage Height	Area	Volume / Shaft	Storage Height	Area	Volume / Shaft	Storage Height	Area
CENTRAL		0.000 mi													
	Intake No. 3 Shaft		R												
	Northern Tunnel	2.550 mi	↑	8.190 mi	3.9 yrs										
	Intake No. 5 Shaft		M												
	Northern Tunnel	5.640 mi	↑												
	Twin Cities Shaft (2)		L			2	5.4 m yd3	8 ft	439 acres	5.1 m yd3	15 ft	222 acres	4.1 m yd3	15 ft	178 acres
	Main Tunnel	4.250 mi	↓												
	New Hope Shaft		M												
	Main Tunnel	4.200 mi	↓	14.510 mi	6.5 yrs										
	Staten Island Shaft		M												
	Main Tunnel	6.060 mi	↓												
	Bouldin Island Shaft		L/R			1	2.4 m yd3	8 ft	194 acres	2.3 m yd3	8 ft	185 acres	1.8 m yd3	8 ft	148 acres
	Main Tunnel	4.660 mi	↓												
	Mandeville Island Shaft		M	10.050 mi	4.2 yrs										
	Main Tunnel	5.390 mi	↓												
	Bacon Island Shaft		R												
	Main Tunnel	5.760 mi	↑												
	Byron Tract Shaft		M	6.720 mi	4.0 yrs										
	Main Tunnel	0.960 mi	↑												
	Southern Forebay (N+S) Shafts (4)		L			2	2.8 m yd3	8 ft	226 acres	2.6 m yd3	15 ft	115 acres	2.1 m yd3	15 ft	92 acres
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.5 yrs										
	CA Aqueduct Shaft (2)		R												
	Total	42.81 mi	3	42.81 mi		5	10.6 m yd3		860 acres	10.0 m yd3		522 acres	8.0 m yd3		417 acres

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	Volume / Shaft	Storage Height	Area	Volume / Shaft	Storage Height	Area	Volume / Shaft	Storage Height	Area
EASTERN		0.000 mi													
	Intake No. 3 Shaft		R												
	Northern Tunnel	2.550 mi	↑	8.190 mi	3.9 yrs										
	Intake No. 5 Shaft		M												
	Northern Tunnel	5.640 mi	↑												
	Twin Cities Shaft (2)		L			2	5.0 m yd3	8 ft	404 acres	4.7 m yd3	15 ft	205 acres	3.8 m yd3	15 ft	164 acres
	Main Tunnel	4.580 mi	↓												
	New Hope Shaft		M												
	Main Tunnel	3.000 mi	↓	12.690 mi	5.9 yrs										
	Canal Ranch		M												
	Main Tunnel	5.110 mi	↓												
	Terminous Tract Shaft		R												
	Main Tunnel	3.940 mi	↑												
	King Island Shaft		M	9.500 mi	4.5 yrs										
	Main Tunnel	5.560 mi	↑												
	Lower Roberts Island Shaft		L/R			1	2.3 m yd3	8 ft	184 acres	2.1 m yd3	8 ft	174 acres	1.7 m yd3	8 ft	140 acres
	Main Tunnel	5.180 mi	↑												
	Upper Jones Tract Shaft		M												
	Main Tunnel	5.650 mi	↑	11.790 mi	6.2 yrs										
	Byron Tract		M												
	Main Tunnel	0.960 mi	↑												
	Southern Forebay (N+S) Shaft (4)		L			2	4.0 m yd3	8 ft	324 acres	3.8 m yd3	15 ft	164 acres	3.0 m yd3	15 ft	131 acres
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.5 yrs										
	CA Aqueduct Shaft (2)		R												
	Total	45.51 mi	3	45.51 mi		5	11.2 m yd3		912 acres	10.6 m yd3		543 acres	8.5 m yd3		435 acres

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B Stockpiles

Maximum allowable stockpile heights

Min. stockpile height at Twin Cities	10	ft	above grade
Max. stockpile height at Twin Cities	15	ft	above grade
Max. stockpile height at Bouldin Island	8	ft	above grade
Max. stockpile height at Lower Roberts	8	ft	above grade
Max. stockpile height at Southern Forebay	15	ft	above grade
Contingency	5	%	

Short term stockpiles (All RTM)

Central	Vol. of RTM to stockpile (yd3)	Area of temp. stockpile (acres)	Height of temp. stockpile (ft)
Twin Cities North	1,182,647	66	11.7
Twin Cities South	2,095,263	107	12.8
Bouldin Island	1,815,186	166	7.1
Southern Forebay North	1,213,737	134	5.9
Southern Forebay South	901,160	100	5.9

Eastern	Vol. of RTM to stockpile (yd3)	Area of temp. stockpile (acres)	Height of temp. stockpile (ft)
Twin Cities North	1,308,879	66	12.9
Twin Cities South	2,028,044	107	12.4
Lower Roberts	1,488,006	166	5.8
Southern Forebay North	2,129,458	164	8.5
Southern Forebay South	901,160	70	8.5

Notes

Twin Cities

Areas as shown on drawings

Bouldin Island and Lower Roberts

Same area used for short term and long term

see 'No Drying Annual Process' sheet.

Southern Forebay

Areas as shown on drawings

Long term stockpiles (Surplus RTM)

Central	Vol. of RTM to stockpile (yd3)	Area of perm. stockpile (acres)	Height of perm. stockpile (ft)
Twin Cities	1,083,391	47	15.0
Bouldin Island	1,452,149	166	5.4
Southern Forebay	-	234	0.0

Eastern	Vol. of RTM to stockpile (yd3)	Area of perm. stockpile (acres)	Height of perm. stockpile (ft)
Twin Cities	1,832,404	80	15.0
Lower Roberts	1,144,836	166	4.3
Southern Forebay	397,963	234	1.1

Notes

Twin Cities

Height limited to 15ft

Resulting area calculated

Bouldin Island and Lower Roberts

Same area used for short term and long term

see 'No Drying Annual Process' sheet.

Southern Forebay

Areas as shown on drawings

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Evaporation Calculation

California Irrigation Management Information System (CIMIS)

CIMIS Monthly Report

Rendered in ENGLISH Units.
April 2019 - March 2020
Printed on Wednesday, April 22, 2020

Holt - San Joaquin Valley - Station 248

Month Year	Total ETo (in)	Total Precip (in)	Avg Sol Rad (Ly/day)	Avg Vap Pres (mBars)	Avg Max Air Temp (°F)	Avg Min Air Temp (°F)	Avg Air Temp (°F)	Avg Max Rel Hum (%)	Avg Min Rel Hum (%)	Avg Rel Hum (%)	Avg Dew Point (°F)	Avg Wind Speed (mph)	Avg Soil Temp (°F)
Apr 2019	5.09	0.31	522 K	12.7 K	75.4 K	46.5	60.6 K	96	47	71 K	50.7 K	4.7 K	58.1
May 2019	5.86	1.88	570	12.9	76.3	47.6 K	61.6	95	46	69	51.0	4.9	60.5
Jun 2019	8.29 K	0.01	699	14.9 K	89.4 K	56.8 K	72.4 K	86	33	55 K	54.8 K	5.6 K	68.8
Jul 2019	8.35	0.00	680	15.5	90.4	57.2	73.3	85	34	56	56.3	5.5 K	69.2
Aug 2019	7.46	0.01	609	16.9 K	92.1 K	58.2 K	74.3 K	90	35	59 K	58.6 K	5.1 K	71.0
Sep 2019	5.60	0.12	503	15.1 K	86.6 K	55.6 K	70.2 K	89	35	60 K	55.4 K	5.3 K	67.7
Oct 2019	4.51	0.01	399 K	9.6 K	82.3 K	43.7 K	61.2 K	84	27	51 K	42.2 K	4.7 K	57.1 K
Nov 2019	2.31 K	0.57	252	9.1 K	72.3 K	38.3	52.8	95	38	67 K	41.6 K	3.9 K	50.8 K
Dec 2019	1.06	2.74	153	11.0 K	58.9	42.1	49.7 K	99	70	89 K	46.6 K	5.0 K	51.2
Tots/Avgs	48.53	5.6	487	13.1	80.4	49.4	64.0	91	41	64	50.8	5.0	61.6

Holt - San Joaquin Valley - Station 248

Month Year	Total ETo (in)	Total Precip (in)	Avg Sol Rad (Ly/day)	Avg Vap Pres (mBars)	Avg Max Air Temp (°F)	Avg Min Air Temp (°F)	Avg Air Temp (°F)	Avg Max Rel Hum (%)	Avg Min Rel Hum (%)	Avg Rel Hum (%)	Avg Dew Point (°F)	Avg Wind Speed (mph)	Avg Soil Temp (°F)
Jan 2020	1.26	0.98	188	10.4	58.4	38.2	47.5	100	72	92	45.3	4.1	49.9
Feb 2020	3.13	0.01	366 K	8.5	69.0 K	36.7	51.1	94	38	66	39.8	5.1 K	51.0
Mar 2020	3.58	1.19 K	404 K	10.1	66.0 K	41.4	53.0 K	96	50	74 K	44.5 K	5.0 K	55.5
Tots/Avgs	7.97	2.2	319	9.7	64.5	38.8	50.5	97	53	77	43.2	4.7	52.1

Flag Legend	
M - All Daily Values Missing	K - One or More Daily Values Flagged
J - One or More Daily Values Missing	L - Missing and Flagged Daily Values

Conversion Factors		
W/sq.m = Ly/day/2.065	inches * 25.4 = mm	(F-32) * 5/9 = c
	mBars * 0.1 = kPa	--

	Monthly evaporation	Monthly precipitation	Evaporation - precipitation	Consecutive 6mth adjusted evaporation
Apr	5.09 in	0.31 in	4.78 in	38.32 in
May	5.86 in	1.88 in	3.98 in	38.04 in
Jun	8.29 in	0.01 in	8.28 in	35.80 in
Jul	8.35 in	0.00 in	8.35 in	27.52 in
Aug	7.46 in	0.01 in	7.45 in	19.45 in
Sep	5.60 in	0.12 in	5.48 in	15.12 in
Oct	4.51 in	0.01 in	4.50 in	12.03 in
Nov	2.31 in	0.57 in	1.74 in	12.31 in
Dec	1.06 in	2.74 in	0.00 in	14.55 in
Jan	1.26 in	0.98 in	0.28 in	22.83 in
Feb	3.13 in	0.01 in	3.12 in	30.90 in
Mar	3.58 in	1.19 in	2.39 in	35.23 in
Apr	5.09 in	0.31 in	4.78 in	
May	5.86 in	1.88 in	3.98 in	
Jun	8.29 in	0.01 in	8.28 in	
Jul	8.35 in	0.00 in	8.35 in	
Aug	7.46 in	0.01 in	7.45 in	

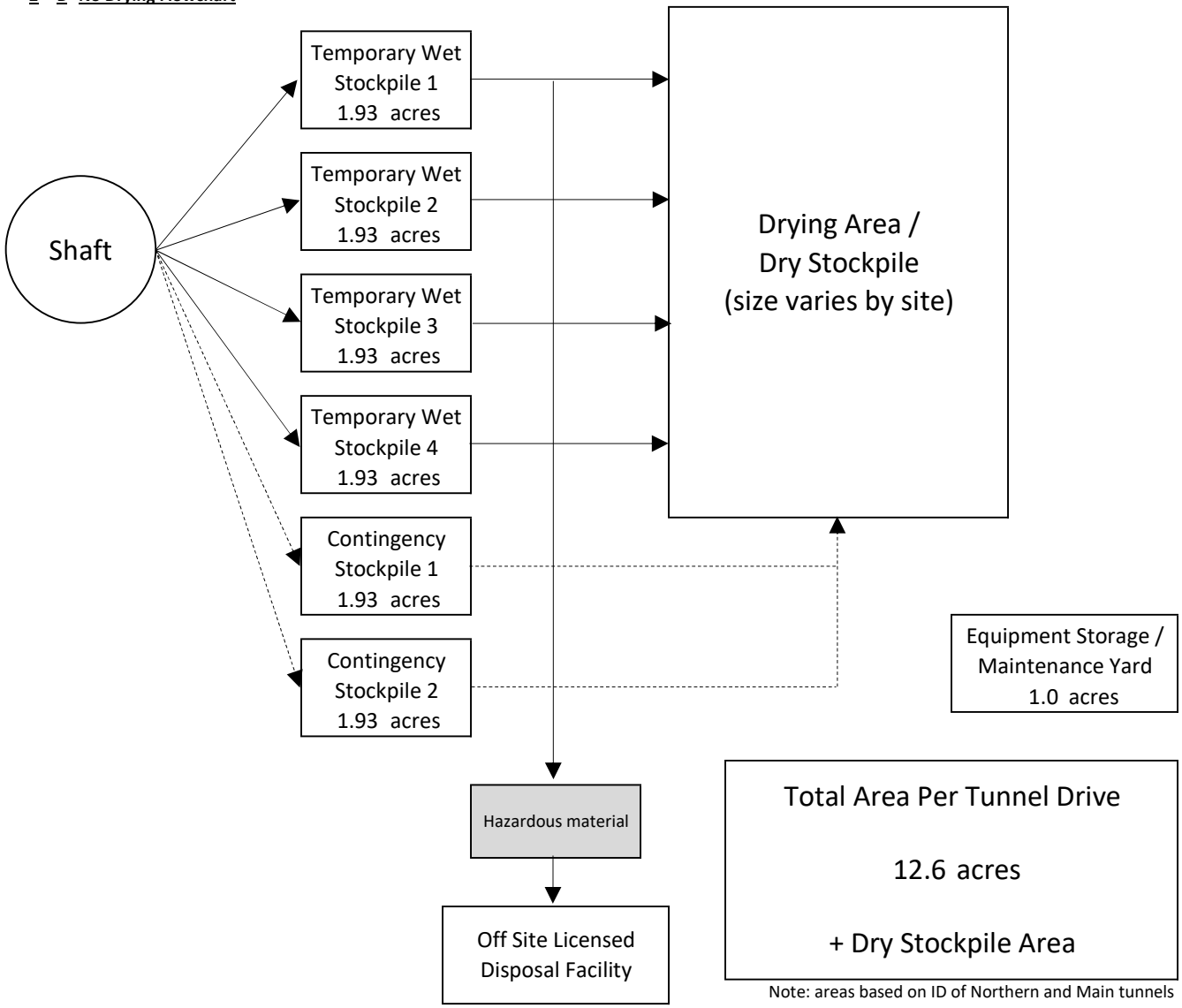
Max. continuous 6mth evaporation = 38.32 in
Average daily evaporation = 0.210 in
(Apr - Sept 2019)

Evaporation Rate

Vol. of water extracted during drying		1.65	gal/ft3	geotechnical calcs
Vol. of water extracted during drying	=	22.1%	of solids	conversion
Evaporation rate		0.210	in / day / area	from evaporation calc sheet
Evaporation rate	=	0.0175	ft / day / area	conversion
Evaporation rate	=	762.2	ft3 / day / acre	conversion
Height of drying stockpile		18.0	in	
Volume of 1 acre at 18 in high		65,340	ft3 / acre	
Volume of water to be removed from 1 acre		14,412	ft3 / acre	
Time required to dry 1 acre of RTM		18.91	days	regardless of area

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B No Drying Flowchart



Total Area Per Tunnel Drive

12.6 acres

+ Dry Stockpile Area

Note: areas based on ID of Northern and Main tunnels

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B No Drying Annual Process

Drying stockpile height per lift	18	in
Drying stockpile contingency	5	%
Tunnelling days / week	5	days / week
Tunnelling weeks / year	51	weeks / year
Wet season	7	months / year
Wet season	30	weeks / year

Season	Cell > / Area→ / Week↓	1 / 4.5	2 / 4.5	3 / 4.5	4 / 4.5	5 / 4.5	6 / 4.5	7 / 4.5	8 / 4.5	9 / 4.5	10 / 4.5	11 / 4.5	12 / 4.5	13 / 4.5	14 / 4.5	15 / 4.5	16 / 4.5	17 / 4.5	18 / 4.5	19 / 4.5	20 / 4.5	21 / 4.5	22 / 4.5	23 / 4.5	24 / 4.5	25 / 4.5	26 / 4.5	27 / 4.5	28 / 4.5	29 / 4.5	30 / 4.5	31 / 4.5	32 / 4.5	33 / 4.5	34 / 4.5	35 / 4.5	36 / 4.5	37 / 4.5	Spreading	Compacting
Wet	1	Hold	Hold	Hold	Fill	< wet season begins with 3 full cells from previous drying season																																	0	0
Wet	2	Hold	Hold	Hold	Hold	Fill																																	0	0
Wet	3	Hold	Hold	Hold	Hold	Hold	Fill																																0	0
Wet	4	Hold	Hold	Hold	Hold	Hold	Hold	Fill																															0	0
Wet	5	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																														0	0
Wet	6	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																													0	0
Wet	7	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																												0	0
Wet	8	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																											0	0
Wet	9	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																										0	0
Wet	10	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																									0	0
Wet	11	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																								0	0
Wet	12	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																							0	0
Wet	13	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																						0	0
Wet	14	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																					0	0
Wet	15	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																				0	0
Wet	16	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																			0	0
Wet	17	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																		0	0
Wet	18	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																	0	0
Wet	19	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																0	0
Wet	20	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill															0	0
Wet	21	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill														0	0
Wet	22	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill													0	0
Wet	23	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill												0	0
Wet	24	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill											0	0
Wet	25	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill										0	0
Wet	26	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill									0	0
Wet	27	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill								0	0
Wet	28	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill							0	0
Wet	29	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill						0	0
Wet	30	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill					0	0
Dry	31	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill + Spread				3	0
Dry	32	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry	Fill + Spread			3	0
Dry	33	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry	Dry	Fill + Spread		3	0
Dry	34	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry + Compact	Dry	Dry	Fill + Spread	3	3
Dry	35	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold		Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry + Compact	Dry	Dry		3	3
Dry	36	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold			Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold		Dry + Compact	Dry		3	3
Dry	37	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold				Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold			Dry + Compact		3	3
Dry	38	Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold					Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold					3	3
Dry	39		Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold						Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold					3	3
Dry	40			Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold							Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold					3	3
Dry	41				Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold								Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold					3	3
Dry	42					Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold									Dry + Compact	Dry	Dry	Spread	Hold	Hold					3	3
Dry	43						Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold										Dry + Compact	Dry	Dry	Spread	Hold					3	3
Dry	44							Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold											Dry + Compact	Dry	Dry	Spread					3	3
Dry	45								Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold												Dry + Compact	Dry	Dry					2	3
Dry	46									Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold													Dry + Compact	Dry					2	3
Dry	47										Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold														Dry + Compact					2	3
Dry	48											Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold																				2	2
Dry	49												Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread																				2	2
Dry	50	Fill												Dry + Compact	Dry	Dry		Dry + Compact	Dry	Dry																				0	2
Dry	51	Hold	Fill												Dry + Compact	Dry			Dry + Compact	Dry																				0	2
Dry	52	Hold	Hold	Fill												Dry + Compact				Dry + Compact																				0	2

Permanent stockpile

Shaft site	Stockpile area (acres)	Total vol. of RTM (yd3)	Final height of stockpile (ft)	Equivalent annual lift (in)
Bouldin Island	166	1,452,149	5.4	24
Lower Roberts	166	1,144,836	4.3	24

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B No Drying Areas

Excavation Rates	Main Tunnels		Southern Tunnels	
Tunnel lining ID	31	ft	38	ft
TBM cutterhead area	935	ft2	1,396	ft2
TBM advance rate (ave.)	46	ft / day	38	ft / day
TBM advance rate (peak)	92	ft / day	76	ft / day
Daily in-situ rate of excavation per tunnel (ave.)	1,593	yd3 / day	1,965	yd3 / day
Daily in-situ rate of excavation per tunnel (peak)	3,185	yd3 / day	3,931	yd3 / day
Bulking factor	1.30		1.30	
Daily excavated volume per tunnel (ave.)	2,070	yd3 / day	2,555	yd3 / day
Daily excavated volume per tunnel (peak)	4,141	yd3 / day	5,110	yd3 / day
Estimated duration of peak excavation	21	days	21	days
Volume loss due to drying	5	%	5	%
Equivalent daily dry excavated volume per tunnel (ave.)	1,967	yd3 / day	2,427	yd3 / day
Equivalent daily dry excavated volume per tunnel (peak.)	3,934	yd3 / day	4,855	yd3 / day

Temporary Wet Stockpile Area	Main Tunnels		Southern Tunnels		
No. of days storage	5	days	5	days	one week of excavation
Volume of RTM to stockpile at peak excavation rate	20,705	yd3	25,550	yd3	per stockpile
Height of stockpile	10	ft	10	ft	short term
Contingency	50	%	50	%	inc. allowance for conveyor pits
Area required at peak excavation rate	1.93	acres	2.38	acres	per stockpile
No. of temporary stockpiles	6.0		6.0		
Total area of temporary stockpiles	11.6	acres	14.3	acres	

Equipment Storage / Maintenance Yard

Area required for equipment storage / maintenance yard 1.0 acres

Drying Area / Dry Stockpile

Varies by tunnel drive and option

No Drying Area Summary

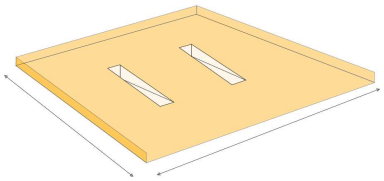
Alignment	Site	Tunnel Drive	Compacted RTM	Temporary Wet Stockpile 10 ft high	Equipment / Maintenance Yard	Total RTM Processing Area	Total RTM Processing Area
Central	Twin Cities	North	1.5 m yd3	11.6 acres	1 acres	13 acres	25 acres
		South	2.6 m yd3	11.6 acres	1 acres	13 acres	
	Bouldin Island	South	0.8 m yd3	11.6 acres	1 acres	13 acres	13 acres
	Southern Forebay	North	1.2 m yd3	11.6 acres	1 acres	13 acres	28 acres
		South	0.9 m yd3	14.3 acres	1 acres	15 acres	
Eastern	Twin Cities	North	1.5 m yd3	11.6 acres	1 acres	13 acres	25 acres
		South	2.3 m yd3	11.6 acres	1 acres	13 acres	
	Lower Roberts Island	North	1.7 m yd3	11.6 acres	1 acres	13 acres	13 acres
	Southern Forebay	North	2.1 m yd3	11.6 acres	1 acres	13 acres	28 acres
		South	0.9 m yd3	14.3 acres	1 acres	15 acres	

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B No Drying Equipment Main Tunnels

Temporary Wet Stockpile Filling

Volume of RTM to stockpile (peak)	20,705	yd3	per stockpile as for Natural Drying
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	29.7	hours / day	
Total hours at average excavation rate per day	14.9	hours / day	
Total hours for operation per year	3,793	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (peak)	20,705	yd3	per stockpile as for Natural Drying
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	10	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	29.7	hours / day	
Total hours at average excavation rate per day	14.9	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	3,793	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area / Dry Stockpile Moving

Daily excavated volume per tunnel (peak)	2,070	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	5.5	hours / day	
Total hours for operation per year	1,410	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Drying Area / Dry Stockpile Spreading

Volume of RTM to be spread per cell	10,352	yd3 / cell	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	day shift only
Average cycle time per shove	5	mins	assumed
Efficiency	80	%	assumed
Number of bulldozers per cell	2	bulldozers / cell	
Max. number of cells to spread in one week	3	cells	
Number of bulldozers required	6	bulldozers	
Number of cells to spread per year	52	cells / year	
Total hours for operation per year	3,793	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area per cell	4.5	acres	
Area per cell	21,740	yd2	
Speed	6.8	mph	
Speed	11,968	yd / hr	
Area/hr	27,925	yd2 / hr	
Working hours per day	10	hours	
Efficiency	50	%	assumed
Number of passes	2	passes	assumed
Time to compact one cell	3.1	hrs / cell	
Max. number of cells to compact in one week	3	cells / week	
Number of compactors required	1	compactors	
Number of cells to compact per year	52	cells / year	
Total hours for operation per year	162	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B No Drying Equipment Schedule Main Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average Excavation Rate: Total Hours / Year	Average Excavation Rate: Total Power / Year	Average Excavation Rate: Total Annual Operating Cost	Peak Excavation Rate: Quantity	Peak Excavation Rate: Total Capital Cost	Notes
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	3793 hrs	$ 105	$ 196,000	3793 hrs	614 MWh	$ 398,250	2	$ 392,000	Day and night shift, 12mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0 hrs	- MWh	$ -	0	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	3793 hrs	$ 105	$ 196,000	3793 hrs	614 MWh	$ 398,250	4	$ 784,000	Day shift only, 12mths
Wet Stockpile Moving	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	1410 hrs	$ 120	$ 180,000	1410 hrs	735 MWh	$ 169,220	2	$ 360,000	Day shift only, 12mths
Wet Stockpile Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	3793 hrs	$ 105	$ 196,000	3793 hrs	614 MWh	$ 398,250	6	$ 1,176,000	Day shift only, 12mths
Wet Stockpile Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	162 hrs	$ 55	$ 73,100	162 hrs	16 MWh	$ 8,906	1	$ 73,100	One pass over full wet storage area
								Total Electrical	- hrs	- MWh	$ -	0	$ -	
								Total Gas/Diesel	12,951 hrs	2,592 MWh	$ 1,372,876	15	$ 2,785,100	
								Total	12,951 hrs	2,592 MWh	$ 1,372,876	15	$ 2,785,100	

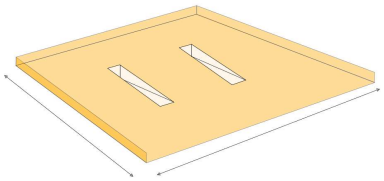
Equipment utilization 17%

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B No Drying Equipment Southern Tunnels

Temporary Wet Stockpile Filling

Volume of RTM to stockpile (peak)	25,550	yd3	per stockpile as for Natural Drying
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	36.7	hours / day	
Total hours at average excavation rate per day	18.4	hours / day	
Total hours for operation per year	4,681	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (peak)	25,550	yd3	per stockpile as for Natural Drying
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	10	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	36.7	hours / day	
Total hours at average excavation rate per day	18.4	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	4,681	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area / Dry Stockpile Moving

Daily excavated volume per tunnel (peak)	2,555	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	6.8	hours / day	
Total hours for operation per year	1,740	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Drying Area / Dry Stockpile Spreading

Volume of RTM to be spread per cell	10,352	yd3 / cell	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	day shift only
Average cycle time per shove	5	mins	assumed
Efficiency	80	%	assumed
Number of bulldozers per cell	2	bulldozers / cell	
Max. number of cells to spread in one week	3	cells	
Number of bulldozers required	6	bulldozers	
Number of cells to spread per year	52	cells / year	
Total hours for operation per year	3,793	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area per cell	4.5	acres	
Area per cell	21,740	yd2	
Speed	6.8	mph	
Speed	11,968	yd / hr	
Area/hr	27,925	yd2 / hr	
Working hours per day	10	hours	
Efficiency	50	%	assumed
Number of passes	2	passes	assumed
Time to compact one cell	3.1	hrs / cell	
Max. number of cells to compact in one week	3	cells / week	
Number of compactors required	1	compactors	
Number of cells to compact per year	52	cells / year	
Total hours for operation per year	162	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B No Drying Equipment Schedule Southern Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

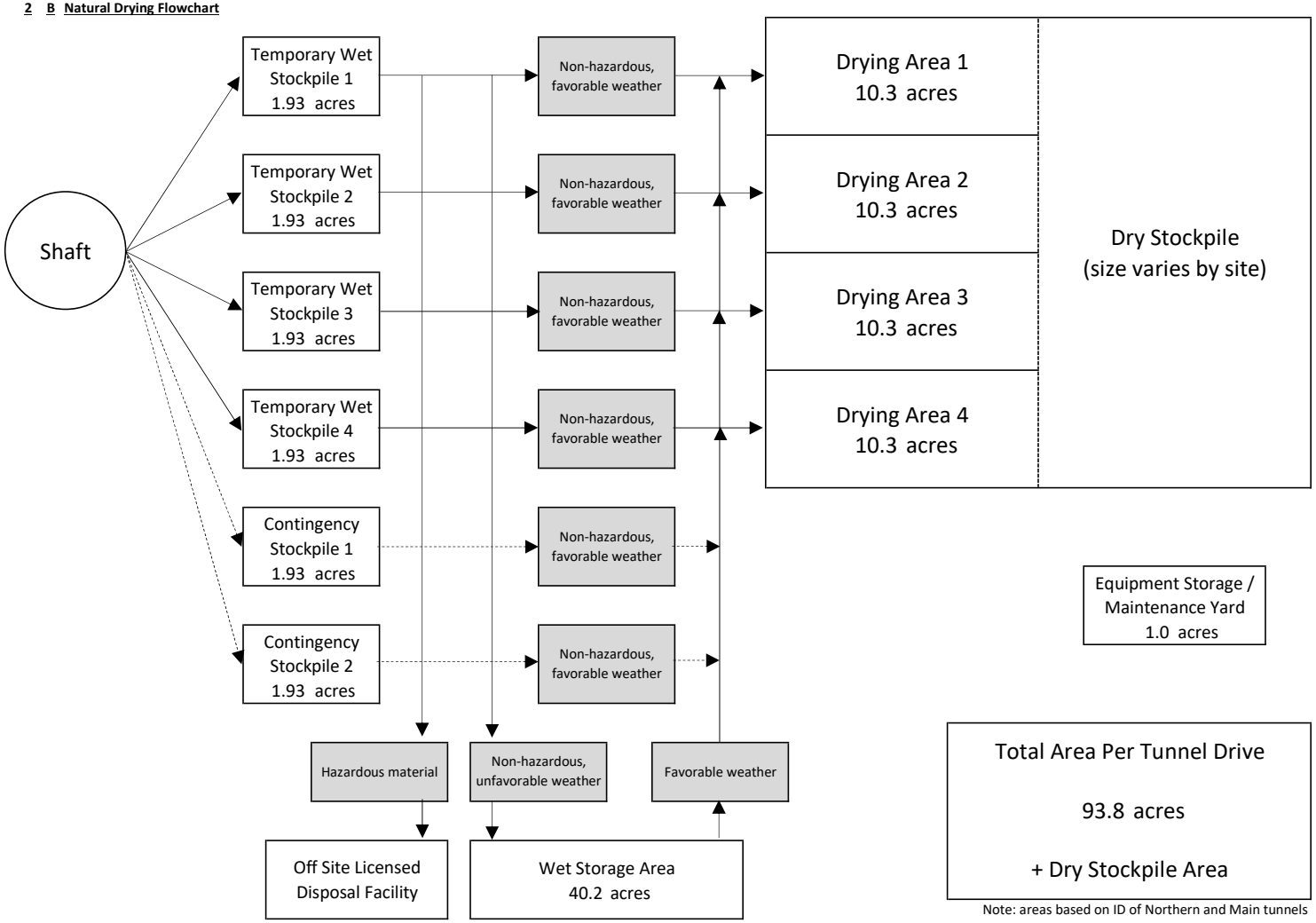
Equipment Schedule (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average Excavation Rate: Total Hours / Year	Average Excavation Rate: Total Power / Year	Average Excavation Rate: Total Annual Operating Cost	Peak Excavation Rate: Quantity	Peak Excavation Rate: Total Capital Cost	Notes
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4681 hrs	$ 105	$ 196,000	4681 hrs	757 MWh	$ 491,453	2	$ 392,000	Day and night shift, 12mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0 hrs	- MWh	$ -	0	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4681 hrs	$ 105	$ 196,000	4681 hrs	757 MWh	$ 491,453	4	$ 784,000	Day shift only, 12mths
Wet Stockpile Moving	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	1740 hrs	$ 120	$ 180,000	1740 hrs	907 MWh	$ 208,822	2	$ 360,000	Day shift only, 12mths
Wet Stockpile Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	3793 hrs	$ 105	$ 196,000	3793 hrs	614 MWh	$ 398,250	6	$ 1,176,000	Day shift only, 12mths
Wet Stockpile Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	162 hrs	$ 55	$ 73,100	162 hrs	16 MWh	$ 8,906	1	$ 73,100	One pass over full wet storage area
								Total Electrical	- hrs	- MWh	$ -	0	$ -	
								Total Gas/Diesel	15,056 hrs	3,051 MWh	$ 1,598,884	15	$ 2,785,100	
								Total	15,056 hrs	3,051 MWh	$ 1,598,884	15	$ 2,785,100	

Equipment utilization 20%

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B Natural Drying Flowchart



Equipment Storage / Maintenance Yard 1.0 acres

Total Area Per Tunnel Drive

93.8 acres

+ Dry Stockpile Area

Note: areas based on ID of Northern and Main tunnels

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B Natural Drying Areas

Excavation Rates	Main Tunnels		Southern Tunnels	
Tunnel lining ID	31	ft	38	ft
TBM cutterhead area	935	ft2	1,396	ft2
TBM advance rate (ave.)	46	ft / day	38	ft / day
TBM advance rate (peak)	92	ft / day	76	ft / day
Daily in-situ rate of excavation per tunnel (ave.)	1,593	yd3 / day	1,965	yd3 / day
Daily in-situ rate of excavation per tunnel (peak)	3,185	yd3 / day	3,931	yd3 / day
Bulking factor	1.30		1.30	
Daily excavated volume per tunnel (ave.)	2,070	yd3 / day	2,555	yd3 / day
Daily excavated volume per tunnel (peak)	4,141	yd3 / day	5,110	yd3 / day
Estimated duration of peak excavation	21	days	21	days
Volume loss due to drying	5	%	5	%
Equivalent daily dry excavated volume per tunnel (ave.)	1,967	yd3 / day	2,427	yd3 / day
Equivalent daily dry excavated volume per tunnel (peak.)	3,934	yd3 / day	4,855	yd3 / day

Temporary Wet Stockpile Area	Main Tunnels		Southern Tunnels		
No. of days storage	5	days	5	days	
Volume of RTM to stockpile at peak excavation rate	20,705	yd3	25,550	yd3	per stockpile
Height of stockpile	10	ft	10	ft	short term
Contingency	50	%	50	%	includes allowance for conveyor pits
Area required at peak excavation rate	1.93	acres	2.38	acres	per stockpile
No. of temporary stockpiles	6.0		6.0		
Total area of temporary stockpiles	11.6	acres	14.3	acres	

Drying Area	Main Tunnels		Southern Tunnels		
Volume of RTM to dry per stockpile	20,705	yd3	25,550	yd3	equivalent to 1 wk RTM at peak excavation
Contingency	20	%	20	%	
Height of stockpile	18.0	in	18.0	in	
Area required at peak excavation rate	10.3	acres	12.7	acres	per drying area
No. of drying areas	4.0		4.0		
Total area of drying areas	41.1	acres	50.7	acres	

Wet Storage Area	Main Tunnels		Southern Tunnels		
Period of wet weather	6	mths	6	mths	continuous storage
No. of days storage	130	days	130	days	based on working days
Volume of RTM to store at ave. excavation rate	269,898	yd3	333,063	yd3	
Height of stockpile	5.0	ft	5.0	ft	long term
Contingency	20	%	20	%	
Area required	40.2	acres	49.5	acres	

Equipment Storage / Maintenance Yard		
Area required for equipment storage / maintenance yard	1.0	acres

Permanent Stockpile		
Contingency	5	%

Natural Drying Area Summary

Alignment	Site	Tunnel Drive	Dry Partially Compacted RTM	Temporary Wet Stockpile 10 ft high	Drying Area 18 in high	Wet Storage 5 ft high	Equipment / Maintenance Yard	Total RTM Processing Area	Total RTM Processing Area	
Central	Twin Cities	North	1.5 m yd3	11.6 acres	41 acres	40 acres	1 acres	94 acres	188	acres
		South	2.6 m yd3	11.6 acres	41 acres	40 acres	1 acres	94 acres		
	Bouldin Island	South	1.8 m yd3	11.6 acres	41 acres	40 acres	1 acres	94 acres	94	acres
	Southern Forebay	North	1.2 m yd3	11.6 acres	41 acres	40 acres	1 acres	94 acres	209	acres
		South	0.9 m yd3	14.3 acres	51 acres	50 acres	1 acres	115 acres		
Eastern	Twin Cities	North	1.5 m yd3	11.6 acres	41 acres	40 acres	1 acres	94 acres	188	acres
		South	2.3 m yd3	11.6 acres	41 acres	40 acres	1 acres	94 acres		
	Lower Roberts Island	North	1.7 m yd3	11.6 acres	41 acres	40 acres	1 acres	94 acres	94	acres
	Southern Forebay	North	2.1 m yd3	11.6 acres	41 acres	40 acres	1 acres	94 acres	209	acres
		South	0.9 m yd3	14.3 acres	51 acres	50 acres	1 acres	115 acres		

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B Natural Drying Equipment Main Tunnels

Temporary Wet Stockpile Filling

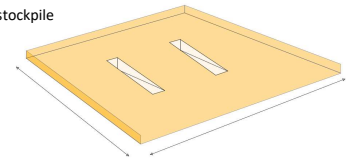
Volume of RTM to stockpile (peak)	20,705	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	29.7	hours / day	
Total hours at average excavation rate per day	14.9	hours / day	
Total hours for operation per year	3,793	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (peak)	20,705	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	10	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	29.7	hours / day	
Total hours at average excavation rate per day	14.9	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	3,793	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Spreading

Volume of RTM to be spread per day (peak)	2,070	yd3/day	per drying area
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	29.7	hours / day	
Total hours at average excavation rate per day	14.9	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	3,793	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Tilling

Drying Area	10.3	acres	per drying area
No. of drying areas	4.0		
Total drying area	41.1	acres	
Tilling rate per machine	14.50	acres/hr/tractor	includes 80% capacity
Passes per day	3	times	
Working hours per day	10	hours	
Min. number of tractors required	1	tractors	
Additional contingency	1	tractor	
No. of tractors required	2	tractors	
Total hours at average excavation rate per day	8.5	hours / day	
Total hours for operation per year	2,167	hours / year	

Example: John Deere 5090E (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area	41.1	acres	total drying area
Area	198,764	yd2	
Speed	6.8	mph	
Speed	11,968	yd/hr	
Area/hr	27,925	yd2/hr	
Efficiency	50	%	
Time to compact whole area	11	hrs	
Number of compactors required	2	compactors	to compact whole drying area in 1 day
Number of times to compact area per year	26	times/yr	assumed once a week for 6mths
Total hours for operation per year	278	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

Drying Area Piling

Volume of RTM to be piling per day (ave.)	1,967	yd3/day	dried volume, per drying area
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	28.3	hours / day	
Total hours for operation per year	7,206	hours / year	2 stockpiles emptied at any one time

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area to Dry Stockpile

Volume of RTM to be moved per day (ave.)	1,967	yd3/day	per drying area
Scraper capacity	24.00	yd3 / scraper	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of scrapers required	1	scrapers	
Total hours at average excavation rate per day	17.1	hours / day	
Total hours for operation per year	4,354	hours / year	2 stockpiles emptied at any one time

Example: Caterpillar 637K, Capacity = 24yd3 (see equipment schedule for details)

Wet Storage Stockpiling

Volume of RTM to be stockpiled per day	1,671	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	assuming bulldozers already on project site
Working hours per day	10	hours	
Average cycle time per shove	10	mins	
Efficiency	80	%	
Number of bulldozers required	3	bulldozers	
Total hours per day	24.0	hours / day	
Total hours for operation per year	3,061	hours / year	for 6mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

During peak excavation there will be 6 bulldozers operating in the various temporary stockpiles.
The wet stockpile will only be emptied when the excavation is below peak.
At average excavation there will be 3 bulldozers available for this operation.

Dry Stockpile Filling / Unloading

Bulldozers

Volume of RTM to be stockpiled per day per drying area (ave.)	1,967	yd3/day	per drying area
No. of drying areas to be emptied per day	2		
Volume of RTM to be stockpiled per day	3,934	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers	3	bulldozers	
Total hours at average excavation rate per day	28.3	hours / day	
Total hours for operation per year	7,206	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wheel Loaders

Daily excavated volume per tunnel (ave.)	1,967	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	10.5	hours / day	
Total hours for operation per year	2,679	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B Natural Drying Equipment Schedule Main Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average Excavation Rate: Total Hours / Year	Average Excavation Rate: Total Power / Year	Average Excavation Rate: Total Annual Operating Cost	Peak Excavation Rate: Quantity	Peak Excavation Rate: Total Capital Cost	Notes
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	3793 hrs	$ 105	$ 196,000	3793 hrs	614 MWh	$ 398,250	2	$ 392,000	Day and night shift, 12mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0 hrs	- MWh	$ -	0	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	3793 hrs	$ 105	$ 196,000	3793 hrs	614 MWh	$ 398,250	4	$ 784,000	Day shift only, 12mths
Drying Areas Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	3793 hrs	$ 105	$ 196,000	3793 hrs	614 MWh	$ 398,250	4	$ 784,000	Day shift only, 12mths
Drying Areas Tilling	Tractors	John Deere	5090E	90 hp	67 kW	2167 hrs	$ 30	$ 58,750	2167 hrs	145 MWh	$ 64,999	2	$ 117,500	Day shift only, 12mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	278 hrs	$ 55	$ 73,100	278 hrs	27 MWh	$ 15,267	2	$ 146,200	Once a week during wet months
Drying Areas Piling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	7206 hrs	$ 105	$ 196,000	7206 hrs	1,166 MWh	$ 756,675	4	$ 784,000	Day shift only, 12mths
Drying Area to Dry Stockpile	Scrapers	Caterpiller	637K	570 hp	425 kW	4354 hrs	$ 150	$ 905,000	4354 hrs	1,851 MWh	$ 653,083	2	$ 1,810,000	Day shift only, 12mths
Wet Storage Stockpiling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	3061 hrs	$ 105	$ 196,000	3061 hrs	495 MWh	$ 321,453	0	$ -	Day shift only, 6mths
Dry Stockpile Filling/Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	7206 hrs	$ 105	$ 196,000	7206 hrs	1,166 MWh	$ 756,675	3	$ 588,000	Day shift only, 12mths
Dry Stockpile Filling/Unloading	Wheel Loaders	Caterpiller	990K	699 hp	521 kW	2679 hrs	$ 120	$ 180,000	2679 hrs	1,397 MWh	$ 321,518	2	$ 360,000	Day shift only, 12mths
								Total Electrical	- hrs	- MWh	$ -	0	$ -	
								Total Gas/Diesel	38,330 hrs	8,089 MWh	$ 4,084,419	25	$ 5,765,700	
								Total	38,330 hrs	8,089 MWh	$ 4,084,419	25	$ 5,765,700	

Equipment utilization 30%

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B Natural Drying Equipment Southern Tunnels

Temporary Wet Stockpile Filling

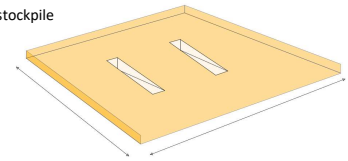
Volume of RTM to stockpile (peak)	25,550	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	36.7	hours / day	
Total hours at average excavation rate per day	18.4	hours / day	
Total hours for operation per year	4,681	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (peak)	25,550	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	10	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	36.7	hours / day	
Total hours at average excavation rate per day	18.4	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	4,681	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Spreading

Volume of RTM to be spread per day (peak)	2,555	yd3/day	per drying area
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	36.7	hours / day	
Total hours at average excavation rate per day	18.4	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	4,681	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Tilling

Drying Area	12.7	acres	per drying area
No. of drying areas	4.0		
Total drying area	50.7	acres	
Tilling rate per machine	14.50	acres/hr/tractor	includes 80% capacity
Passes per day	3	times	
Working hours per day	10	hours	
Min. number of tractors required	2	tractors	
Additional contingency	1	tractor	
No. of tractors required	3	tractors	
Total hours at average excavation rate per day	10.5	hours / day	
Total hours for operation per year	2,674	hours / year	

Example: John Deere 5090E (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area	50.7	acres	total drying area
Area	245,280	yd2	
Speed	6.8	mph	
Speed	11,968	yd/hr	
Area/hr	27,925	yd2/hr	
Efficiency	50	%	
Time to compact whole area	13	hrs	
Number of compactors required	2	compactors	to compact whole drying area in 1 day
Number of times to compact area per year	26	times/yr	assumed once a week for 6mths
Total hours for operation per year	343	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

Drying Area Piling

Volume of RTM to be piling per day (ave.)	2,427	yd3/day	dried volume, per drying area
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	34.9	hours / day	
Total hours for operation per year	8,893	hours / year	2 stockpiles emptied at any one time

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area to Dry Stockpile

Volume of RTM to be moved per day (ave.)	2,427	yd3/day	per drying area
Scraper capacity	24.00	yd3 / scraper	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of scrapers required	2	scrapers	
Total hours at average excavation rate per day	21.1	hours / day	
Total hours for operation per year	5,373	hours / year	2 stockpiles emptied at any one time

Example: Caterpillar 637K, Capacity = 24yd3 (see equipment schedule for details)

Wet Storage Stockpiling

Volume of RTM to be stockpiled per day	2,062	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	assuming bulldozers already on project site
Working hours per day	10	hours	
Average cycle time per shove	10	mins	
Efficiency	80	%	
Number of bulldozers required	3	bulldozers	
Total hours per day	29.6	hours / day	
Total hours for operation per year	3,778	hours / year	for 6mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

During peak excavation there will be 6 bulldozers operating in the various temporary stockpiles.
The wet stockpile will only be emptied when the excavation is below peak.
At average excavation there will be 3 bulldozers available for this operation.

Dry Stockpile Filling / Unloading

Bulldozers

Volume of RTM to be stockpiled per day per drying area (ave.)	2,427	yd3/day	per drying area
No. of drying areas to be emptied per day	2		
Volume of RTM to be stockpiled per day	4,855	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers	4	bulldozers	
Total hours at average excavation rate per day	34.9	hours / day	
Total hours for operation per year	8,893	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wheel Loaders

Daily excavated volume per tunnel (ave.)	2,427	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	13.0	hours / day	
Total hours for operation per year	3,306	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

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Option 2 B Natural Drying Equipment Schedule Southern Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

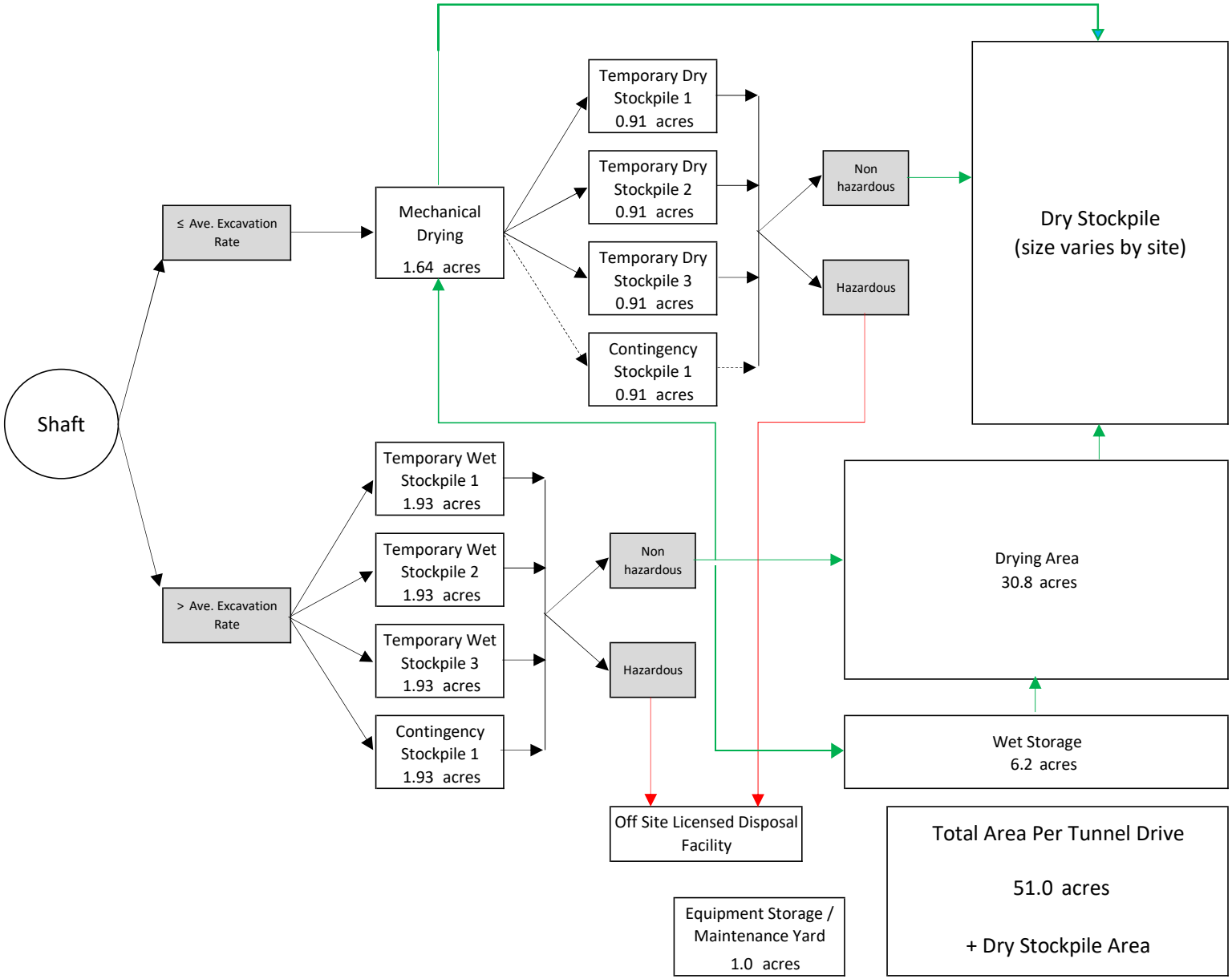
Equipment Schedule (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average Excavation Rate: Total Hours / Year	Average Excavation Rate: Total Power / Year	Average Excavation Rate: Total Annual Operating Cost	Peak Excavation Rate: Quantity	Peak Excavation Rate: Total Capital Cost	Notes
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4681 hrs	$ 105	$ 196,000	4681 hrs	757 MWh	$ 491,453	2	$ 392,000	Day and night shift, 12mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0 hrs	- MWh	$ -	0	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4681 hrs	$ 105	$ 196,000	4681 hrs	757 MWh	$ 491,453	4	$ 784,000	Day shift only, 12mths
Drying Areas Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4681 hrs	$ 105	$ 196,000	4681 hrs	757 MWh	$ 491,453	4	$ 784,000	Day shift only, 12mths
Drying Areas Tilling	Tractors	John Deere	5090E	90 hp	67 kW	2674 hrs	$ 30	$ 58,750	2674 hrs	179 MWh	$ 80,210	3	$ 176,250	Day shift only, 12mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	343 hrs	$ 55	$ 73,100	343 hrs	33 MWh	$ 18,840	2	$ 146,200	Once a week during wet months
Drying Areas Piling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	8893 hrs	$ 105	$ 196,000	8893 hrs	1,439 MWh	$ 933,760	4	$ 784,000	Day shift only, 12mths
Drying Area to Dry Stockpile	Scrapers	Caterpiller	637K	570 hp	425 kW	5373 hrs	$ 150	$ 905,000	5373 hrs	2,284 MWh	$ 805,924	4	$ 3,620,000	Day shift only, 12mths
Wet Storage Stockpiling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	3778 hrs	$ 105	$ 196,000	3778 hrs	611 MWh	$ 396,684	0	$ -	Day shift only, 6mths
Dry Stockpile Filling/Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	8893 hrs	$ 105	$ 196,000	8893 hrs	1,439 MWh	$ 933,760	4	$ 784,000	Day shift only, 12mths
Dry Stockpile Filling/Unloading	Wheel Loaders	Caterpiller	990K	699 hp	521 kW	3306 hrs	$ 120	$ 180,000	3306 hrs	1,723 MWh	$ 396,763	2	$ 360,000	Day shift only, 12mths
								Total Electrical	- hrs	- MWh	$ -	0	$ -	
								Total Gas/Diesel	47,301 hrs	9,982 MWh	$ 5,040,300	29	$ 7,830,450	
								Total	47,301 hrs	9,982 MWh	$ 5,040,300	29	$ 7,830,450	

Equipment utilization 32%

CA Delta Conveyance Tunnel - RTM Calculations

Option 2 B Mechanical Drying Flowchart



Note: areas based on ID of Northern and Main tunnels

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B Mechanical Drying Areas

Excavation rates	Main Tunnels		Southern Tunnels	
Tunnel lining ID	31	ft	38	ft
TBM cutterhead area	935	ft2	1,396	ft2
TBM advance rate (ave.)	46	ft / day	38	ft / day
TBM advance rate (peak)	92	ft / day	76	ft / day
Rate of in-situ material excavation per tunnel (ave.)	1,593	yd3 / day	1,965	yd3 / day
Rate of in-situ material excavation per tunnel (peak)	3,185	yd3 / day	3,931	yd3 / day
Bulking factor	1.30		1.30	
Excavated rate of material per tunnel drive (ave.)	2,070	yd3 / day	2,555	yd3 / day
Excavated rate of material per tunnel drive (peak)	4,141	yd3 / day	5,110	yd3 / day
Estimated duration of peak excavation	21	days	21	days
Volume loss due to drying	5	%	5	%
Equivalent daily dry excavated volume per tunnel (ave.)	1,967	yd3 / day	2,427	yd3 / day
Equivalent daily dry excavated volume per tunnel (peak.)	3,934	yd3 / day	4,855	yd3 / day

Mechanical Drying Area

Inputs

Unit weight of soil entering dryer	100	lb/ft3
Unit weight of soil entering dryer	2,692	lb/yd3
Unit weight of soil produced per day (ave.)	139	tons/hr
Working hours per day	20	hours
Working hours per year	5,100	hours

Option 1 - Thermal Drying

Equipment details (Note this is one possible option presented as an example)

Manufacturer	Komline-Sanderson				
Machine	K-S Paddle Dryer				
Model	16W-3200				
Capacity	70,000	lb/hr	=	520	yd3 / day
Length	16,822	mm	=	55.2	ft
Width	3,835	mm	=	12.6	ft
Height	4,273	mm	=	14.0	ft
Weight	102,058	kg	=	112.5	tons
Power for heat source	32	MMBtu/hr		9,378	kWh
Power for motors	250	hp		186	kW
Estimated capital cost	$ 4,500,000				

Option 2 - Rotary Drying

Equipment details (Note this is one possible option presented as an example)

Manufacturer	Vulcan Drying Systems					
Machine	Frac Sand Dryer					
Model	(Customized)					
Capacity	196,000	lb/hr	=	1,456	yd3 / day	
Length	22,860	mm	=	75.0	ft	assumed
Width	9,144	mm	=	30.0	ft	assumed
Height	6,096	mm	=	20.0	ft	assumed
Weight	90,718	kg	=	100.0	tons	assumed
Power for heat source	57	MMBtu/hr		16,705	kWh	
Power for motors	255	hp		190	kW	
Estimated capital cost	$ 400,000					

Assumptions

Clear space required around each dryer	3	ft
Efficiency / redundancy	85	%

Assumptions

Clear space required around each dryer	3	ft
Efficiency / redundancy	85	%

Option 1 - Thermal Drying	Main Tunnels		Southern Tunnels		per tunnel drive, average excavation rates
Min. quantity required	5		6		
Additional contingency	2		2		
Quantity required	7		8		
Total weight of equipment	788	tons	900	tons	
Area required	7,959	yd2	9,096	yd2	
Area required	1.64	acres	1.88	acres	

Option 2 - Rotary Drying	Main Tunnels		Southern Tunnels		per tunnel drive, average excavation rates
Min. quantity required	2		3		assumes all drying systems of same size
Additional contingency	1		1		- dryers can be custom made for desired quantity
Quantity required	3		4		
Total weight of equipment	300	tons	400	tons	
Area required	8,748	yd2	11,664	yd2	
Area required	1.81	acres	2.41	acres	

Temporary Dry Stockpile Area	Main Tunnels		Southern Tunnels		
No. of days storage	5	days	5	days	assuming 5 days of excavation at ave. rate in a 7 day cycle
Volume of RTM to stockpile at average excavation rate	9,835	yd3	12,136	yd3	
Height of stockpile	10	ft	10	ft	short term
Contingency	50	%	50	%	includes allowance for conveyor pits
Area required	0.91	acres	1.13	acres	per stockpile
No. of temporary stockpiles	4.0		4.0		3 active + 1 contingency
Total area of temporary stockpiles	3.7	acres	4.5	acres	

Temporary Wet Stockpile Area	Main Tunnels		Southern Tunnels		
No. of days storage	5	days	5	days	assuming 5 days of excavation at ave. rate in a 7 day cycle
Volume of RTM to stockpile at peak excavation rate	10,352	yd3	12,775	yd3	per stockpile = 1wks worth at average excavation rate
Height of stockpile	5	ft	5	ft	long term
Contingency	50	%	50	%	includes allowance for conveyor pits
Area required	1.93	acres	2.38	acres	
No. of temporary stockpiles	4.0		4.0		3wks of average excavation + 1wks contingency
Total area of temporary stockpiles	7.7	acres	9.5	acres	

(Temporary Wet Stockpile + Wet Storage + Drying Area = 13wks = 3mths)

Wet Storage Area	Main Tunnels		Southern Tunnels		
Volume of RTM to store	41,409	yd3	51,100	yd3	4wks of average excavation
Height of stockpile	5	ft	5	ft	long term
Contingency	20	%	20	%	
Area required	6.2	acres	7.6	acres	

(Temporary Wet Stockpile + Wet Storage + Drying Area = 13wks = 3mths)

Drying Area	Main Tunnels		Southern Tunnels		
Volume of RTM to dry at any one time	62,114	yd3	76,650	yd3	6wks of average excavation
Height of stockpile	18.0	in	18.0	in	
Contingency	20	%	20	%	
Area required	30.8	acres	38.0	acres	

(Temporary Wet Stockpile + Wet Storage + Drying Area = 13wks = 3mths)

Equipment Storage / Maintenance Yard

Area required for equipment storage / maintenance yard 1.0 acres

Dry Stockpile

Note the dry stockpile area is based on the requirements for Option 3 as shown on the drawings, except for Option 4 which requires a larger area.
Contingency 5 %

Mechanical Drying Area Summary

Alignment	Site	Tunnel Drive	Dry Partially Compacted RTM	Mechanical Drying Area	Temporary Dry Stockpile 10 ft high	Temporary Wet Stockpile 5 ft high	Wet Storage 5 ft high	Drying Area 18 in high	Equipment / Maintenance Yard	Total RTM Processing Area	Total RTM Processing Area
Central	Twin Cities	North	1.5 m yd3	1.8 acres	3.7 acres	7.7 acres	6.2 acres	30.8 acres	1 acres	51 acres	102 acres
		South	2.6 m yd3	1.8 acres	3.7 acres	7.7 acres	6.2 acres	30.8 acres	1 acres	51 acres	
	Bouldin Island	South	1.8 m yd3	1.8 acres	3.7 acres	7.7 acres	6.2 acres	30.8 acres	1 acres	51 acres	51 acres
	Southern Forebay	North	1.2 m yd3	1.8 acres	3.7 acres	7.7 acres	6.2 acres	30.8 acres	1 acres	51 acres	114 acres
		South	0.9 m yd3	2.4 acres	4.5 acres	9.5 acres	7.6 acres	38.0 acres	1 acres	63 acres	
Eastern	Twin Cities	North	1.5 m yd3	1.8 acres	3.7 acres	7.7 acres	6.2 acres	30.8 acres	1 acres	51 acres	102 acres
		South	2.3 m yd3	1.8 acres	3.7 acres	7.7 acres	6.2 acres	30.8 acres	1 acres	51 acres	
	Lower Roberts Island	North	1.7 m yd3	1.8 acres	3.7 acres	7.7 acres	6.2 acres	30.8 acres	1 acres	51 acres	51 acres
	Southern Forebay	North	2.1 m yd3	1.8 acres	3.7 acres	7.7 acres	6.2 acres	30.8 acres	1 acres	51 acres	114 acres
		South	0.9 m yd3	2.4 acres	4.5 acres	9.5 acres	7.6 acres	38.0 acres	1 acres	63 acres	

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Option 2 B Mechanical Drying Equipment Main Tunnels

Temporary Dry Stockpile Filling

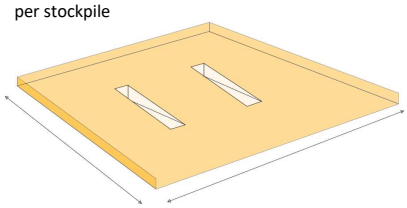
Volume of RTM to stockpile (ave.)	9,835	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	14.1	hours / day	
Total hours for operation per year	3,603	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Dry Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (ave.)	9,835	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	5	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	14.1	hours / day	
Total hours for operation per year	3,603	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Filling

Volume of RTM to be stockpiled per day (ave.)	2,070	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	14.9	hours / day	
Total hours for operation per year	948	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Volume of RTM to be stockpiled per day (ave.)	2,070	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	14.9	hours / day	
Total hours for operation per year	948	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wet Storage Filling/Emptying

Volume of RTM to be stockpiled per day (ave.)	2,070	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	14.9	hours / day	
Total hours for operation per year	292	hours / year	for 4wk operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Spreading

Volume of RTM to be spread per day (ave.)	2,070	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	14.9	hours / day	
Total hours for operation per year	948	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Tilling

Drying Area	30.8	acres	
No. of drying areas	1		
Total drying area	30.8	acres	
Tilling rate per machine	14.50	acres/hr/tractor	includes 80% capacity
Passes per day	3	times	
Working hours per day	10	hours	
Min. number of tractors required	1	tractors	
Additional contingency	1	tractor	
No. of tractors required	2	tractors	
Total hours at average excavation rate per day	6.4	hours / day	
Total hours for operation per year	406	hours / year	for 3mth operation

Example: John Deere 5090E (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area	30.8	acres	total drying area
Area	149,073	yd2	
Speed	6.8	mph	
Speed	11,968	yd/hr	
Area/hr	27,925	yd2/hr	
Efficiency	50	%	
Time to compact whole area	8	hrs	
Number of compactors required	1	compactors	to compact whole drying area in 1 day
Number of times to compact area per year	26	times/yr	assumed once a week for 6mths
Total hours for operation per year	208	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

Drying Area to Dry Stockpile

Volume of RTM to be moved per day (ave.)	1,967	yd3/day	dried volume
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	10.5	hours / day	
Total hours for operation per year	670	hours / year	for 3mth operation

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Dry Stockpile Filling / Unloading

Bulldozers

Volume of RTM to be stockpiled per day (ave.)	1,967	yd3/day	assume average excavation rate
No. of drying areas to be emptied per day	1		
Volume of RTM to be stockpiled per day	1,967	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers	2	bulldozers	
Total hours at average excavation rate per day	14.1	hours / day	
Total hours for operation per year	3,603	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wheel Loaders

Daily excavated volume per tunnel (ave.)	1,967	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	10.5	hours / day	
Total hours for operation per year	2,679	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Assume this will utilize the same equipment as for Drying Area to Dry Stockpile

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CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B Mechanical Drying Equipment Schedule Main Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule - Thermal Dryers (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average and Peak Excavation Rate: Quantity	Total Hours / Year	Total Power / Year	Total Annual Operating Cost	Total Capital Cost	Notes
Thermal Drying - heat source	Thermal Dryers	Komline-Sanderson	K-S Paddle Dryer	32 MMBtu	9378 kW	35700 hrs	$ 7.76	$ 4,500,000	7	35700 hrs	1,142 MMBtu	$ 8,865,024	$ 31,500,000	Day and night shift, 12mths
Thermal Drying - motors	Thermal Dryers	Komline-Sanderson	K-S Paddle Dryer	250 hp	186 kW	35700 hrs	$ 120.00		7	35700 hrs	6,655 MWh	$ 798,645		Day and night shift, 12mths
Temporary Dry Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	3603 hrs	$ 105	$ 196,000	1	3603 hrs	583 MWh	$ 378,337	$ 196,000	Day and night shift, 12mths
Temporary Dry Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Dry Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	3603 hrs	$ 105	$ 196,000	2	3603 hrs	583 MWh	$ 378,337	$ 392,000	Day shift only, 12mths
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	948 hrs	$ 105	$ 196,000	1	948 hrs	153 MWh	$ 99,562	$ 196,000	Day and night shift, 3mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	948 hrs	$ 105	$ 196,000	1	948 hrs	153 MWh	$ 99,562	$ 196,000	Day and night shift, 3mths
Wet Storage Filling/Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	292 hrs	$ 105	$ 196,000	1	292 hrs	47 MWh	$ 30,635	$ 196,000	Day and night shift, 4 wks
Drying Area Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	948 hrs	$ 105	$ 196,000	2	948 hrs	153 MWh	$ 99,562	$ 392,000	Day shift only, 3mths
Drying Area Tilling	Tractors	John Deere	5090E	90 hp	67 kW	406 hrs	$ 30	$ 58,750	2	406 hrs	27 MWh	$ 12,187	$ 117,500	Day shift only, 3mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	208 hrs	$ 55	$ 73,100	1	208 hrs	20 MWh	$ 11,451	$ 73,100	Once a week during wet months
Drying Area to Dry Stockpile	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	670 hrs	$ 120	$ 180,000	2	670 hrs	349 MWh	$ 80,379	$ 360,000	Day shift only, 3mths
Dry Stockpile Filling / Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	3603 hrs	$ 105	$ 196,000	2	3603 hrs	583 MWh	$ 378,337	$ 392,000	Day shift only, 12mths
Dry Stockpile Filling / Unloading	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	2679 hrs	$ 120	$ 180,000	2	2679 hrs	1,397 MWh	$ 321,518	$ 360,000	Day shift only, 12mths

Equipment utilization 56%

Total Natural Gas	7	35,700 hrs	1,142 MMBtu	$ 8,865,024	
Total Electrical	7	35,700 hrs	6,655 MWh	$ 798,645	$ 31,500,000
Total Gas/Diesel	17	17,910 hrs	4,050 MWh	$ 1,889,869	$ 2,870,600
Total	31	89,310 hrs	10,705 MWh	$ 11,553,538	$ 34,370,600

Equipment Schedule - Rotary Dryers (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average and Peak Excavation Rate: Quantity	Total Hours / Year	Total Power / Year	Total Annual Operating Cost	Total Capital Cost	Notes
Rotary Drying - heat source	Rotary Dryers	Vulcan	Frac Sand Dryer	57 MMBtu	16705 kW	15300 hrs	$ 7.76	$ 400,000	3	15300 hrs	872 MMBtu	$ 6,767,496	$ 1,200,000	Day and night shift, 12mths
Rotary Drying - motors	Rotary Dryers	Vulcan	Frac Sand Dryer	255 hp	190 kW	15300 hrs	$ 120.00		3	15300 hrs	2,909 MWh	$ 349,122		Day and night shift, 12mths
Temporary Dry Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	3603 hrs	$ 105	$ 196,000	1	3603 hrs	583 MWh	$ 378,337	$ 196,000	Day and night shift, 12mths
Temporary Dry Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Dry Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	3603 hrs	$ 105	$ 196,000	2	3603 hrs	583 MWh	$ 378,337	$ 392,000	Day shift only, 12mths
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	948 hrs	$ 105	$ 196,000	1	948 hrs	153 MWh	$ 99,562	$ 196,000	Day and night shift, 3mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	948 hrs	$ 105	$ 196,000	1	948 hrs	153 MWh	$ 99,562	$ 196,000	Day and night shift, 3mths
Wet Storage Filling/Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	292 hrs	$ 105	$ 196,000	1	292 hrs	47 MWh	$ 30,635	$ 196,000	Day and night shift, 4 wks
Drying Area Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	948 hrs	$ 105	$ 196,000	2	948 hrs	153 MWh	$ 99,562	$ 392,000	Day shift only, 3mths
Drying Area Tilling	Tractors	John Deere	5090E	90 hp	67 kW	406 hrs	$ 30	$ 58,750	2	406 hrs	27 MWh	$ 12,187	$ 117,500	Day shift only, 3mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	208 hrs	$ 55	$ 73,100	1	208 hrs	20 MWh	$ 11,451	$ 73,100	Once a week during wet months
Drying Area to Dry Stockpile	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	670 hrs	$ 120	$ 180,000	2	670 hrs	349 MWh	$ 80,379	$ 360,000	Day shift only, 3mths
Dry Stockpile Filling / Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	3603 hrs	$ 105	$ 196,000	2	3603 hrs	583 MWh	$ 378,337	$ 392,000	Day shift only, 12mths
Dry Stockpile Filling / Unloading	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	2679 hrs	$ 120	$ 180,000	2	2679 hrs	1,397 MWh	$ 321,518	$ 360,000	Day shift only, 12mths

Equipment utilization 41%

Total Natural Gas	3	15,300 hrs	872 MMBtu	$ 6,767,496	
Total Electrical	3	15,300 hrs	2,909 MWh	$ 349,122	$ 1,200,000
Total Gas/Diesel	17	17,910 hrs	4,050 MWh	$ 1,889,869	$ 2,870,600
Total	23	48,510 hrs	6,959 MWh	$ 9,006,487	$ 4,070,600

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B Mechanical Drying Equipment Southern Tunnels

Temporary Dry Stockpile Filling

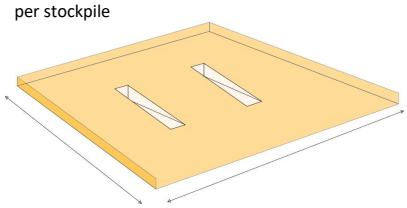
Volume of RTM to stockpile (ave.)	12,136	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	17.4	hours / day	
Total hours for operation per year	4,446	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Dry Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (ave.)	12,136	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	5	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	17.4	hours / day	
Total hours for operation per year	4,446	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Filling

Volume of RTM to be stockpiled per day (ave.)	2,555	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	18.4	hours / day	
Total hours for operation per year	1,170	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Volume of RTM to be stockpiled per day (ave.)	2,555	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	18.4	hours / day	
Total hours for operation per year	1,170	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wet Storage Filling/Emptying

Volume of RTM to be stockpiled per day (ave.)	2,555	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	18.4	hours / day	
Total hours for operation per year	360	hours / year	for 4wk operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Spreading

Volume of RTM to be spread per day (ave.)	2,555	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	18.4	hours / day	
Total hours for operation per year	1,170	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Tilling

Drying Area	38.0	acres	
No. of drying areas	1		
Total drying area	38.0	acres	
Tilling rate per machine	14.50	acres/hr/tractor	includes 80% capacity
Passes per day	3	times	
Working hours per day	10	hours	
Min. number of tractors required	1	tractors	
Additional contingency	1	tractor	
No. of tractors required	2	tractors	
Total hours at average excavation rate per day	7.9	hours / day	
Total hours for operation per year	501	hours / year	for 3mth operation

Example: John Deere 5090E (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area	38.0	acres	total drying area
Area	183,960	yd2	
Speed	6.8	mph	
Speed	11,968	yd/hr	
Area/hr	27,925	yd2/hr	
Efficiency	50	%	
Time to compact whole area	10	hrs	
Number of compactors required	1	compactors	to compact whole drying area in 1 day
Number of times to compact area per year	26	times/yr	assumed once a week for 6mths
Total hours for operation per year	257	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

Drying Area to Dry Stockpile

Volume of RTM to be moved per day (ave.)	2,427	yd3/day	dried volume
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	13.0	hours / day	
Total hours for operation per year	827	hours / year	for 3mth operation

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Dry Stockpile Filling / Unloading

Bulldozers

Volume of RTM to be stockpiled per day (ave.)	2,427	yd3/day	assume average excavation rate
No. of drying areas to be emptied per day	1		
Volume of RTM to be stockpiled per day	2,427	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers	2	bulldozers	
Total hours at average excavation rate per day	17.4	hours / day	
Total hours for operation per year	4,446	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wheel Loaders

Daily excavated volume per tunnel (ave.)	2,427	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	13.0	hours / day	
Total hours for operation per year	3,306	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Assume this will utilize the same equipment as for Drying Area to Dry Stockpile

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CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B Mechanical Drying Equipment Schedule Southern Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule - Thermal Dryers (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average and Peak Excavation Rate: Quantity	Total Hours / Year	Total Power / Year	Total Annual Operating Cost	Total Capital Cost	Notes
Thermal Drying - heat source	Thermal Dryers	Komline-Sanderson	K-S Paddle Dryer	32 MMBtu	9378 kW	40800 hrs	$ 7.76	$ 4,500,000	7	40800 hrs	1,306 MMBtu	$ 10,131,456	$ 31,500,000	Day and night shift, 12mths
Thermal Drying - motors	Thermal Dryers	Komline-Sanderson	K-S Paddle Dryer	250 hp	186 kW	40800 hrs	$ 120.00		7	40800 hrs	7,606 MWh	$ 912,737		Day and night shift, 12mths
Temporary Dry Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4446 hrs	$ 105	$ 196,000	1	4446 hrs	720 MWh	$ 466,880	$ 196,000	Day and night shift, 12mths
Temporary Dry Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Dry Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4446 hrs	$ 105	$ 196,000	2	4446 hrs	720 MWh	$ 466,880	$ 392,000	Day shift only, 12mths
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1170 hrs	$ 105	$ 196,000	1	1170 hrs	189 MWh	$ 122,863	$ 196,000	Day and night shift, 3mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1170 hrs	$ 105	$ 196,000	1	1170 hrs	189 MWh	$ 122,863	$ 196,000	Day and night shift, 3mths
Wet Storage Filling/Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	360 hrs	$ 105	$ 196,000	1	360 hrs	58 MWh	$ 37,804	$ 196,000	Day and night shift, 4 wks
Drying Area Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1170 hrs	$ 105	$ 196,000	2	1170 hrs	189 MWh	$ 122,863	$ 392,000	Day shift only, 3mths
Drying Area Tilling	Tractors	John Deere	5090E	90 hp	67 kW	501 hrs	$ 30	$ 58,750	2	501 hrs	34 MWh	$ 15,039	$ 117,500	Day shift only, 3mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	257 hrs	$ 55	$ 73,100	1	257 hrs	25 MWh	$ 14,130	$ 73,100	Once a week during wet months
Drying Area to Dry Stockpile	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	827 hrs	$ 120	$ 180,000	2	827 hrs	431 MWh	$ 99,191	$ 360,000	Day shift only, 3mths
Dry Stockpile Filling / Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4446 hrs	$ 105	$ 196,000	2	4446 hrs	720 MWh	$ 466,880	$ 392,000	Day shift only, 12mths
Dry Stockpile Filling / Unloading	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	3306 hrs	$ 120	$ 180,000	2	3306 hrs	1,723 MWh	$ 396,763	$ 360,000	Day shift only, 12mths

Equipment utilization 66%

Total Natural Gas	7	40,800 hrs	1,306 MMBtu	$ 10,131,456	
Total Electrical	7	40,800 hrs	7,606 MWh	$ 912,737	$ 31,500,000
Total Gas/Diesel	17	22,101 hrs	4,998 MWh	$ 2,332,157	$ 2,870,600
Total	31	103,701 hrs	12,604 MWh	$ 13,376,350	$ 34,370,600

Equipment Schedule - Rotary Dryers (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average and Peak Excavation Rate: Quantity	Total Hours / Year	Total Power / Year	Total Annual Operating Cost	Total Capital Cost	Notes
Rotary Drying - heat source	Rotary Dryers	Vulcan	Frac Sand Dryer	57 MMBtu	16705 kW	20400 hrs	$ 7.76	$ 400,000	3	20400 hrs	1,163 MMBtu	$ 9,023,328	$ 1,200,000	Day and night shift, 12mths
Rotary Drying - motors	Rotary Dryers	Vulcan	Frac Sand Dryer	255 hp	190 kW	20400 hrs	$ 120.00		3	20400 hrs	3,879 MWh	$ 465,496		Day and night shift, 12mths
Temporary Dry Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4446 hrs	$ 105	$ 196,000	1	4446 hrs	720 MWh	$ 466,880	$ 196,000	Day and night shift, 12mths
Temporary Dry Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Dry Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4446 hrs	$ 105	$ 196,000	2	4446 hrs	720 MWh	$ 466,880	$ 392,000	Day shift only, 12mths
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1170 hrs	$ 105	$ 196,000	1	1170 hrs	189 MWh	$ 122,863	$ 196,000	Day and night shift, 3mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1170 hrs	$ 105	$ 196,000	1	1170 hrs	189 MWh	$ 122,863	$ 196,000	Day and night shift, 3mths
Wet Storage Filling/Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	360 hrs	$ 105	$ 196,000	1	360 hrs	58 MWh	$ 37,804	$ 196,000	Day and night shift, 4 wks
Drying Area Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1170 hrs	$ 105	$ 196,000	2	1170 hrs	189 MWh	$ 122,863	$ 392,000	Day shift only, 3mths
Drying Area Tilling	Tractors	John Deere	5090E	90 hp	67 kW	501 hrs	$ 30	$ 58,750	2	501 hrs	34 MWh	$ 15,039	$ 117,500	Day shift only, 3mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	257 hrs	$ 55	$ 73,100	1	257 hrs	25 MWh	$ 14,130	$ 73,100	Once a week during wet months
Drying Area to Dry Stockpile	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	827 hrs	$ 120	$ 180,000	2	827 hrs	431 MWh	$ 99,191	$ 360,000	Day shift only, 3mths
Dry Stockpile Filling / Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4446 hrs	$ 105	$ 196,000	2	4446 hrs	720 MWh	$ 466,880	$ 392,000	Day shift only, 12mths
Dry Stockpile Filling / Unloading	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	3306 hrs	$ 120	$ 180,000	2	3306 hrs	1,723 MWh	$ 396,763	$ 360,000	Day shift only, 12mths

Equipment utilization 54%

Total Natural Gas	3	20,400 hrs	1,163 MMBtu	$ 9,023,328	
Total Electrical	3	20,400 hrs	3,879 MWh	$ 465,496	$ 1,200,000
Total Gas/Diesel	17	22,101 hrs	4,998 MWh	$ 2,332,157	$ 2,870,600
Total	23	62,901 hrs	8,877 MWh	$ 11,820,981	$ 4,070,600

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 2 B Transportation Calculations

Unit weight of RTM

Unit weight of in-situ RTM	120.00	lb/ft3	1.62	tons/yd3
Unit weight of wet excavated RTM	99.70	lb/ft3	1.35	tons/yd3
Unit weight of dry excavated RTM	95.00	lb/ft3	1.28	tons/yd3

Transportation Capacity

Road by weight (semi-end dump trucks)	18	tons / trip	semi end dump truck
Road by weight (bottom dump trucks)	20	tons / trip	bottom dump truck
Road by volume	18	yd3 / trip	based on one truck per trip
Rail by volume	1200	yd3 / trip	based on 60yd3 / car, 20 cars / train

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Trips required to move Wet Excavated RTM at average excavation rate - Main tunnels

Average excavation rate	2,070	yd3 / day	10,352	yd3 / week
Average excavation rate	2,787	tons / day	13,934	tons / week
Road (by weight)	155	trips / day	775	trips / week
Road (by volume)	116	trips / day	576	trips / week
Rail	2	trips / day	9	trips / week

Trips required to move Dry Excavated RTM at average excavation rate - Main tunnels

Average excavation rate	1,967	yd3 / day	9,835	yd3 / week
Average excavation rate	2,523	tons / day	12,613	tons / week
Road (by weight)	141	trips / day	701	trips / week
Road (by volume)	110	trips / day	547	trips / week
Rail	2	trips / day	9	trips / week

Trips required to move Dry Excavated RTM from Twin Cities to Southern Forebay

	Vol. to transport to SF	Weight to transport to SF	Road Trips	Rail Trips	Total Weeks
Central Alignment	2.8 m yd3	3.6 m tons	198,200	2,400	283
Eastern Alignment	2.2 m yd3	2.8 m tons	156,200	1,900	223

Attachment 4.3
RTM Calculations – 6,000cfs, 36ft ID Tunnel

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B RTM Volumes

Column Inputs	Internal Diameter	Tunnelling days / week	Tunnelling weeks / year	TBM Cutterhead Area	Bulking factor	Volume reduction due to drying	Full compaction factor	TBM Cutterhead Area	Bulking factor	Volume reduction due to drying	Full compaction factor
Northern tunnels ID	36.0 ft	5 days	51 wks	138 yd2	1.30	5.00 %	0.80	138 yd2	1.30	5.00 %	0.80
Main tunnels ID	36.0 ft	5 days	51 wks	138 yd2				138 yd2			
Southern tunnels ID	38.0 ft	5 days	51 wks	155 yd2				155 yd2			

Option	Element	Tunnel Length	Drive Options: Tunnel Drive	Drive Length	Drive Duration	TBM's	RTM Volume / Tunnel Length: In-Situ RTM Volume / Tunnel Length	Wet Excavated RTM Volume / Tunnel Length	Dry Excavated RTM Volume / Tunnel Length	Dry Compacted RTM Volume / Tunnel Length	RTM Volume / Shaft: Wet In-situ RTM Volume / Shaft	Wet Excavated RTM Volume / Shaft	Dry Excavated RTM Volume / Shaft	Dry Compacted RTM Volume / Shaft	RTM Volume / Tunnel Drive: Dry Compacted RTM Volume / Tunnel Drive	Ave. Quarterly Excavated Dry Compacted RTM Volume / Tunnel Drive
CENTRAL		0.000 mi					- yd3	- yd3	- yd3	- yd3						
	Intake No. 3 Shaft		R													
	Northern Tunnel	2.550 mi	↑	8.190 mi	4.1 yrs		621,432 yd3	807,861 yd3	767,468 yd3	613,975 yd3					1,971,942 yd3	118,929 yd3
	Intake No. 5 Shaft		M													
	Northern Tunnel	5.640 mi	↑				1,374,461 yd3	1,786,799 yd3	1,697,459 yd3	1,357,968 yd3						
	Twin Cities Shaft (2)		L			2					5,531,962 yd3	7,191,551 yd3	6,831,973 yd3	5,465,579 yd3		
	Main Tunnel	4.250 mi	↓				1,035,720 yd3	1,346,436 yd3	1,279,114 yd3	1,023,291 yd3						
	New Hope Shaft		M													
	Main Tunnel	4.200 mi	↓	14.510 mi	6.9 yrs		1,023,535 yd3	1,330,595 yd3	1,264,066 yd3	1,011,252 yd3					3,493,636 yd3	126,707 yd3
	Staten Island Shaft		M													
	Main Tunnel	6.060 mi	↓				1,476,815 yd3	1,919,859 yd3	1,823,866 yd3	1,459,093 yd3						
	Bouldin Island Shaft		L/R			1					2,449,173 yd3	3,183,924 yd3	3,024,728 yd3	2,419,783 yd3		
	Main Tunnel	4.660 mi	↓				1,135,636 yd3	1,476,327 yd3	1,402,511 yd3	1,122,009 yd3						
	Mandeville Island Shaft		M	10.050 mi	4.5 yrs										2,419,783 yd3	134,391 yd3
	Main Tunnel	5.390 mi	↓				1,313,536 yd3	1,707,597 yd3	1,622,217 yd3	1,297,774 yd3						
	Bacon Island Shaft		R													
	Main Tunnel	5.760 mi	↑				1,403,705 yd3	1,824,816 yd3	1,733,576 yd3	1,386,860 yd3						
	Byron Tract Shaft		M	6.720 mi	4.2 yrs										1,618,004 yd3	95,934 yd3
	Main Tunnel	0.960 mi	↑				233,951 yd3	304,136 yd3	288,929 yd3	231,143 yd3						
	Southern Forebay (N+S) Shafts (4)		L			2					2,549,761 yd3	3,314,690 yd3	3,148,955 yd3	2,519,164 yd3		
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.5 yrs		912,105 yd3	1,185,737 yd3	1,126,450 yd3	901,160 yd3					901,160 yd3	88,898 yd3
	CA Aqueduct Shaft (2)		R													
	Total	42.81 mi	3	42.81 mi		5	10,530,896 yd3	13,690,165 yd3	13,005,657 yd3	10,404,525 yd3	10,530,896 yd3	13,690,165 yd3	13,005,657 yd3	10,404,525 yd3	10,404,525 yd3	564,860 yd3

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	In-Situ RTM Volume / Tunnel Length	Wet Excavated RTM Volume / Tunnel Length	Dry Excavated RTM Volume / Tunnel Length	Dry Compacted RTM Volume / Tunnel Length	Wet In-situ RTM Volume / Shaft	Wet Excavated RTM Volume / Shaft	Dry Excavated RTM Volume / Shaft	Dry Compacted RTM Volume / Shaft	Dry Compacted RTM Volume / Tunnel Drive	Ave. Quarterly Excavated Dry Compacted RTM Volume / Tunnel Drive
EASTERN		0.000 mi					- yd3	- yd3	- yd3	- yd3						
	Intake No. 3 Shaft		R													
	Northern Tunnel	2.550 mi	↑	8.190 mi	4.1 yrs		621,432 yd3	807,861 yd3	767,468 yd3	613,975 yd3					1,971,942 yd3	118,929 yd3
	Intake No. 5 Shaft		M													
	Northern Tunnel	5.640 mi	↑				1,374,461 yd3	1,786,799 yd3	1,697,459 yd3	1,357,968 yd3						
	Twin Cities Shaft (2)		L			2					5,088,430 yd3	6,614,959 yd3	6,284,211 yd3	5,027,369 yd3		
	Main Tunnel	4.580 mi	↓				1,116,140 yd3	1,450,982 yd3	1,378,433 yd3	1,102,747 yd3						
	New Hope Shaft		M													
	Main Tunnel	3.000 mi	↓	12.690 mi	6.3 yrs		731,096 yd3	950,425 yd3	902,904 yd3	722,323 yd3					3,055,427 yd3	120,905 yd3
	Canal Ranch		M													
	Main Tunnel	5.110 mi	↓				1,245,301 yd3	1,618,891 yd3	1,537,946 yd3	1,230,357 yd3						
	Terminous Tract Shaft		R													
	Main Tunnel	3.940 mi	↑				960,173 yd3	1,248,225 yd3	1,185,814 yd3	948,651 yd3						
	King Island Shaft		M	9.500 mi	4.8 yrs										2,287,357 yd3	118,457 yd3
	Main Tunnel	5.560 mi	↑				1,354,965 yd3	1,761,455 yd3	1,673,382 yd3	1,338,706 yd3						
	Lower Roberts Island Shaft		L/R			1					2,315,138 yd3	3,009,680 yd3	2,859,196 yd3	2,287,357 yd3		
	Main Tunnel	5.180 mi	↑				1,262,360 yd3	1,641,068 yd3	1,559,014 yd3	1,247,211 yd3						
	Upper Jones Tract Shaft		M													
	Main Tunnel	5.650 mi	↑	11.790 mi	6.7 yrs		1,376,898 yd3	1,789,967 yd3	1,700,469 yd3	1,360,375 yd3					2,838,730 yd3	106,511 yd3
	Byron Tract		M													
	Main Tunnel	0.960 mi	↑				233,951 yd3	304,136 yd3	288,929 yd3	231,143 yd3						
	Southern Forebay (N+S) Shaft (4)		L			2					3,785,314 yd3	4,920,908 yd3	4,674,863 yd3	3,739,890 yd3		
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.5 yrs		912,105 yd3	1,185,737 yd3	1,126,450 yd3	901,160 yd3					901,160 yd3	88,898 yd3
	CA Aqueduct Shaft (2)		R													
	Total	45.51 mi	3	45.51 mi		5	11,188,883 yd3	14,545,547 yd3	13,818,270 yd3	11,054,616 yd3	11,188,883 yd3	14,545,547 yd3	13,818,270 yd3	11,054,616 yd3	11,054,616 yd3	553,700 yd3

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B RTM Volumes

Column Inputs	Internal Diameter
Northern tunnels ID	36.0 ft
Main tunnels ID	36.0 ft
Southern tunnels ID	38.0 ft

Tunnelling days / week	Tunnelling weeks / year
5 days	51 wks
5 days	51 wks
5 days	51 wks

Drive Options

Quarterly Dry Compacted RTM Volume Generated by Tunnel Drive (m yd3)

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	Start Quart.	HIDE	Y1				Y2				Y3				Y4				Y5				Y6				Y7				Y8				Y9				Y10				Y11				Y12				Y13				Y14			
									1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
CENTRAL		0.000 mi																																																																
	Intake No. 3 Shaft		R																																																														
	Northern Tunnel	2.550 mi	↑	8.190 mi	4.1 yrs		20	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Intake No. 5 Shaft		M																																																													
	Northern Tunnel	5.640 mi	↑																																																													
	Twin Cities Shaft (2)		L			2																																																									
	Main Tunnel	4.250 mi	↓																																																													
	New Hope Shaft		M																																																												
	Main Tunnel	4.200 mi	↓	14.510 mi	6.9 yrs		17	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Staten Island Shaft		M																																																												
	Main Tunnel	6.060 mi	↓																																																													
	Bouldin Island Shaft		L/R			1																																																										
	Main Tunnel	4.660 mi	↓																																																													
	Mandeville Island Shaft		M	10.050 mi	4.5 yrs		22	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Main Tunnel	5.390 mi	↓																																																													
	Bacon Island Shaft		R																																																												
	Main Tunnel	5.760 mi	↑																																																													
	Byron Tract Shaft		M	6.720 mi	4.2 yrs		24	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Main Tunnel	0.960 mi	↑																																																													
	Southern Forebay (N+S) Shafts (4)		L			2																																																										
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.5 yrs		23	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	CA Aqueduct Shaft (2)		R																																																													
	Total	42.81 mi	3	42.81 mi		5			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.13	0.13	0.25	0.25	0.38	0.47	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.49	0.48	0.48	0.43	0.36	0.36	0.36	0.21	0.13	0.13	0.13	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	Start Quart.	HIDE	Y1				Y2				Y3				Y4				Y5				Y6				Y7				Y8				Y9				Y10				Y11				Y12				Y13				Y14			
									1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
EASTERN		0.000 mi																																																														
	Intake No. 3 Shaft		R																																																													
	Northern Tunnel	2.550 mi	↑	8.190 mi	4.1 yrs		20	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Intake No. 5 Shaft		M																																																													
	Northern Tunnel	5.640 mi	↑																																																													
	Twin Cities Shaft (2)		L			2																																																									
	Main Tunnel	4.580 mi	↓																																																													
	New Hope Shaft		M																																																												
	Main Tunnel	3.000 mi	↓	12.690 mi	6.3 yrs		17	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Canal Ranch		M																																																													
	Main Tunnel	5.110 mi	↓																																																													
	Terminous Tract Shaft		R																																																												
	Main Tunnel	3.940 mi	↑																																																													
	King Island Shaft		M	9.500 mi	4.8 yrs		22	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Main Tunnel	5.560 mi	↑																																																													
	Lower Roberts Island Shaft		L/R			1																																																										
	Main Tunnel	5.180 mi	↑																																																													
	Upper Jones Tract Shaft		M																																																												
	Main Tunnel	5.650 mi	↑	11.790 mi	6.7 yrs		24	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.07	0.00	0.00	0.00	0.00	0.00	0.00
	Byron Tract		M																																																													
	Main Tunnel	0.960 mi	↑																																																													
	Southern Forebay (N+S) Shaft (4)		L			2																																																									
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.5 yrs		23	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	CA Aqueduct Shaft (2)		R																																																													
	Total	45.51 mi	3	45.51 mi		5			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.12	0.24	0.24	0.36	0.45	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.48	0.46	0.46	0.41	0.35	0.35	0.35	0.26	0.14	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.07	0.00	0.00	0.00	0.00	0.00	0.00

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B RTM Volumes

Column Inputs	Internal Diameter
Northern tunnels ID	36.0 ft
Main tunnels ID	36.0 ft
Southern tunnels ID	38.0 ft

Tunnelling days / week	Tunnelling weeks / year
5 days	51 wks
5 days	51 wks
5 days	51 wks

Drive Options

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's
CENTRAL		0.000 mi				
	Intake No. 3 Shaft		R			
	Northern Tunnel	2.550 mi	↑	8.190 mi	4.1 yrs	
	Intake No. 5 Shaft		M			
	Northern Tunnel	5.640 mi	↑			
	Twin Cities Shaft (2)		L			2
	Main Tunnel	4.250 mi	↓			
	New Hope Shaft		M			
	Main Tunnel	4.200 mi	↓	14.510 mi	6.9 yrs	
	Staten Island Shaft		M			
	Main Tunnel	6.060 mi	↓			
	Bouldin Island Shaft		L/R			1
	Main Tunnel	4.660 mi	↓			
	Mandeville Island Shaft		M	10.050 mi	4.5 yrs	
	Main Tunnel	5.390 mi	↓			
	Bacon Island Shaft		R			
	Main Tunnel	5.760 mi	↑			
	Byron Tract Shaft		M	6.720 mi	4.2 yrs	
	Main Tunnel	0.960 mi	↑			
	Southern Forebay (N+S) Shafts (4)		L			2
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.5 yrs	
	CA Aqueduct Shaft (2)		R			
	Total	42.81 mi	3	42.81 mi		5

Quarterly Dry Compacted RTM Volume Generated at Each Shaft (m yd3)

Start	Y1				Y2				Y3				Y4				Y5				Y6				Y7				Y8				Y9				Y10				Y11				Y12				Y13				Y14			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
20																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.13	0.13	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.20	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22																																																									
24																																																									
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.13	0.13	0.25	0.25	0.38	0.47	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.49	0.48	0.48	0.43	0.36	0.36	0.36	0.21	0.13	0.13	0.13	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF Only	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.5	0.6	0.8	1.0	1.2	1.4	1.6	1.8	1.9	2.0	2.1	2.1	2.2	2.3	2.4	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
TC + SF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.4	0.6	0.9	1.1	1.5	1.9	2.3	2.7	3.2	3.6	4.0	4.5	4.9	5.3	5.7	6.0	6.4	6.7	6.9	7.1	7.3	7.5	7.7	7.8	7.9	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
All Shafts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.4	0.6	0.9	1.3	1.7	2.3	2.9	3.4	4.0	4.5	5.1	5.7	6.2	6.8	7.3	7.8	8.2	8.7	9.0	9.4	9.7	10.0	10.1	10.2	10.3	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's
EASTERN		0.000 mi				
	Intake No. 3 Shaft		R			
	Northern Tunnel	2.550 mi	↑	8.190 mi	4.1 yrs	
	Intake No. 5 Shaft		M			
	Northern Tunnel	5.640 mi	↑			
	Twin Cities Shaft (2)		L			2
	Main Tunnel	4.580 mi	↓			
	New Hope Shaft		M			
	Main Tunnel	3.000 mi	↓	12.690 mi	6.3 yrs	
	Canal Ranch		M			
	Main Tunnel	5.110 mi	↓			
	Terminous Tract Shaft		R			
	Main Tunnel	3.940 mi	↑			
	King Island Shaft		M	9.500 mi	4.8 yrs	
	Main Tunnel	5.560 mi	↑			
	Lower Roberts Island Shaft		L/R			1
	Main Tunnel	5.180 mi	↑			
	Upper Jones Tract Shaft		M			
	Main Tunnel	5.650 mi	↑	11.790 mi	6.7 yrs	
	Byron Tract		M			
	Main Tunnel	0.960 mi	↑			
	Southern Forebay (N+S) Shaft (4)		L			2
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.5 yrs	
	CA Aqueduct Shaft (2)		R			
	Total	45.51 mi	3	45.51 mi		5

Start	Y1				Y2				Y3				Y4				Y5				Y6				Y7				Y8				Y9				Y10				Y11				Y12				Y13				Y14			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
20																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.12	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.19	0.12	0.12	0.12	0.12	0.12	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22																																																									
24																																																									
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.07	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.12	0.24	0.24	0.36	0.45	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.48	0.46	0.46	0.41	0.35	0.35	0.35	0.35	0.26	0.14	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.07	0.00	0.00	0.00	0.00	0.00	0.00
SF Only	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.5	0.7	0.9	1.1	1.3	1.5	1.7	1.8	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.4	3.5	3.6	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
TC + SF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.8	1.1	1.4	1.8	2.3	2.7	3.2	3.6	4.0	4.5	4.9	5.3	5.7	6.0	6.4	6.7	6.9	7.1	7.4	7.6	7.8	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.8	8.8	8.8	8.8	8.8	8.8
All Shafts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.8	1.2	1.6	2.2	2.8	3.3	3.9	4.4	5.0	5.5	6.1	6.6	7.1	7.6	8.0	8.5	8.8	9.1	9.5	9.8	10.1	10.2	10.3	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.1	11.1	11.1	11.1	11.1	11.1

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B RTM Volumes

Column Inputs	Internal Diameter	Tunnelling days / week	Tunnelling weeks / year	Working space / buffer	Working space / buffer	Full compaction factor	Working space / buffer
Northern tunnels ID	36.0 ft	5 days	51 wks	5 %	5 %	0.80	5 %
Main tunnels ID	36.0 ft	5 days	51 wks				
Southern tunnels ID	38.0 ft	5 days	51 wks				

			Drive Options				Area required to store all RTM at shafts Wet Excavated			Area required to store all RTM at shafts Dry Excavated			Area required to store all RTM at shafts Dry Fully Compacted		
Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	Volume / Shaft	Storage Height	Area	Volume / Shaft	Storage Height	Area	Volume / Shaft	Storage Height	Area
CENTRAL		0.000 mi													
	Intake No. 3 Shaft		R												
	Northern Tunnel	2.550 mi	↑	8.190 mi	4.1 yrs										
	Intake No. 5 Shaft		M												
	Northern Tunnel	5.640 mi	↑												
	Twin Cities Shaft (2)		L			2	7.2 m yd3	8 ft	585 acres	6.8 m yd3	15 ft	296 acres	5.5 m yd3	15 ft	237 acres
	Main Tunnel	4.250 mi	↓												
	New Hope Shaft		M												
	Main Tunnel	4.200 mi	↓	14.510 mi	6.9 yrs										
	Staten Island Shaft		M												
	Main Tunnel	6.060 mi	↓												
	Bouldin Island Shaft		L/R			1	3.2 m yd3	8 ft	259 acres	3.0 m yd3	8 ft	246 acres	2.4 m yd3	8 ft	197 acres
	Main Tunnel	4.660 mi	↓												
	Mandeville Island Shaft		M	10.050 mi	4.5 yrs										
	Main Tunnel	5.390 mi	↓												
	Bacon Island Shaft		R												
	Main Tunnel	5.760 mi	↑												
	Byron Tract Shaft		M	6.720 mi	4.2 yrs										
	Main Tunnel	0.960 mi	↑												
	Southern Forebay (N+S) Shafts (4)		L			2	3.3 m yd3	8 ft	270 acres	3.1 m yd3	15 ft	137 acres	2.5 m yd3	15 ft	109 acres
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.5 yrs										
	CA Aqueduct Shaft (2)		R												
	Total	42.81 mi	3	42.81 mi		5	13.7 m yd3		1114 acres	13.0 m yd3		679 acres	10.4 m yd3		543 acres

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	Volume / Shaft	Storage Height	Area	Volume / Shaft	Storage Height	Area	Volume / Shaft	Storage Height	Area
EASTERN		0.000 mi													
	Intake No. 3 Shaft		R												
	Northern Tunnel	2.550 mi	↑	8.190 mi	4.1 yrs										
	Intake No. 5 Shaft		M												
	Northern Tunnel	5.640 mi	↑												
	Twin Cities Shaft (2)		L			2	6.6 m yd3	8 ft	538 acres	6.3 m yd3	15 ft	273 acres	5.0 m yd3	15 ft	218 acres
	Main Tunnel	4.580 mi	↓												
	New Hope Shaft		M												
	Main Tunnel	3.000 mi	↓	12.690 mi	6.3 yrs										
	Canal Ranch		M												
	Main Tunnel	5.110 mi	↓												
	Terminous Tract Shaft		R												
	Main Tunnel	3.940 mi	↑												
	King Island Shaft		M	9.500 mi	4.8 yrs										
	Main Tunnel	5.560 mi	↑												
	Lower Roberts Island Shaft		L/R			1	3.0 m yd3	8 ft	245 acres	2.9 m yd3	8 ft	233 acres	2.3 m yd3	8 ft	186 acres
	Main Tunnel	5.180 mi	↑												
	Upper Jones Tract Shaft		M												
	Main Tunnel	5.650 mi	↑	11.790 mi	6.7 yrs										
	Byron Tract		M												
	Main Tunnel	0.960 mi	↑												
	Southern Forebay (N+S) Shaft (4)		L			2	4.9 m yd3	8 ft	400 acres	4.7 m yd3	15 ft	203 acres	3.7 m yd3	15 ft	162 acres
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.5 yrs										
	CA Aqueduct Shaft (2)		R												
	Total	45.51 mi	3	45.51 mi		5	14.5 m yd3		1183 acres	13.8 m yd3		708 acres	11.1 m yd3		566 acres

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B Stockpiles

Maximum allowable stockpile heights

Min. stockpile height at Twin Cities	10	ft	above grade
Max. stockpile height at Twin Cities	15	ft	above grade
Max. stockpile height at Bouldin Island	8	ft	above grade
Max. stockpile height at Lower Roberts	8	ft	above grade
Max. stockpile height at Southern Forebay	15	ft	above grade
Contingency	5	%	

Short term stockpiles (All RTM)

Central	Vol. of RTM to stockpile (yd3)	Area of temp. stockpile (acres)	Height of temp. stockpile (ft)
Twin Cities North	1,675,347	66	16.6
Twin Cities South	2,968,167	107	18.1
Bouldin Island	2,419,783	193	8.2
Southern Forebay North	1,618,004	150	7.0
Southern Forebay South	901,160	84	7.0

Eastern	Vol. of RTM to stockpile (yd3)	Area of temp. stockpile (acres)	Height of temp. stockpile (ft)
Twin Cities North	1,801,580	66	17.8
Twin Cities South	2,791,459	107	17.0
Lower Roberts	2,059,514	193	7.0
Southern Forebay North	2,838,730	178	10.4
Southern Forebay South	901,160	56	10.4

Notes

Twin Cities

Areas as shown on drawings

Bouldin Island and Lower Roberts

Same area used for short term and long term

see 'No Drying Annual Process' sheet.

Southern Forebay

Areas as shown on drawings

Long term stockpiles (Surplus RTM)

Central	Vol. of RTM to stockpile (yd3)	Area of perm. stockpile (acres)	Height of perm. stockpile (ft)
Twin Cities	2,833,050	123	15.0
Bouldin Island	1,935,826	193	6.2
Southern Forebay	-	234	0.0

Eastern	Vol. of RTM to stockpile (yd3)	Area of perm. stockpile (acres)	Height of perm. stockpile (ft)
Twin Cities	3,481,695	151	15.0
Lower Roberts	1,602,043	193	5.2
Southern Forebay	678,597	234	1.9

Notes

Twin Cities

Height limited to 15ft

Resulting area calculated

Bouldin Island and Lower Roberts

Same area used for short term and long term

see 'No Drying Annual Process' sheet.

Southern Forebay

Areas as shown on drawings

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Evaporation Calculation

California Irrigation Management Information System (CIMIS)

CIMIS Monthly Report

Rendered in ENGLISH Units.
April 2019 - March 2020
Printed on Wednesday, April 22, 2020

Holt - San Joaquin Valley - Station 248

Month Year	Total ETo (in)	Total Precip (in)	Avg Sol Rad (Ly/day)	Avg Vap Pres (mBars)	Avg Max Air Temp (°F)	Avg Min Air Temp (°F)	Avg Air Temp (°F)	Avg Max Rel Hum (%)	Avg Min Rel Hum (%)	Avg Rel Hum (%)	Avg Dew Point (°F)	Avg Wind Speed (mph)	Avg Soil Temp (°F)
Apr 2019	5.09	0.31	522 K	12.7 K	75.4 K	46.5	60.6 K	96	47	71 K	50.7 K	4.7 K	58.1
May 2019	5.86	1.88	570	12.9	76.3	47.6 K	61.6	95	46	69	51.0	4.9	60.5
Jun 2019	8.29 K	0.01	699	14.9 K	89.4 K	56.8 K	72.4 K	86	33	55 K	54.8 K	5.6 K	68.8
Jul 2019	8.35	0.00	680	15.5	90.4	57.2	73.3	85	34	56	56.3	5.5 K	69.2
Aug 2019	7.46	0.01	609	16.9 K	92.1 K	58.2 K	74.3 K	90	35	59 K	58.6 K	5.1 K	71.0
Sep 2019	5.60	0.12	503	15.1 K	86.6 K	55.6 K	70.2 K	89	35	60 K	55.4 K	5.3 K	67.7
Oct 2019	4.51	0.01	399 K	9.6 K	82.3 K	43.7 K	61.2 K	84	27	51 K	42.2 K	4.7 K	57.1 K
Nov 2019	2.31 K	0.57	252	9.1 K	72.3 K	38.3	52.8	95	38	67 K	41.6 K	3.9 K	50.8 K
Dec 2019	1.06	2.74	153	11.0 K	58.9	42.1	49.7 K	99	70	89 K	46.6 K	5.0 K	51.2
Tots/Avgs	48.53	5.6	487	13.1	80.4	49.4	64.0	91	41	64	50.8	5.0	61.6

Holt - San Joaquin Valley - Station 248

Month Year	Total ETo (in)	Total Precip (in)	Avg Sol Rad (Ly/day)	Avg Vap Pres (mBars)	Avg Max Air Temp (°F)	Avg Min Air Temp (°F)	Avg Air Temp (°F)	Avg Max Rel Hum (%)	Avg Min Rel Hum (%)	Avg Rel Hum (%)	Avg Dew Point (°F)	Avg Wind Speed (mph)	Avg Soil Temp (°F)
Jan 2020	1.26	0.98	188	10.4	58.4	38.2	47.5	100	72	92	45.3	4.1	49.9
Feb 2020	3.13	0.01	366 K	8.5	69.0 K	36.7	51.1	94	38	66	39.8	5.1 K	51.0
Mar 2020	3.58	1.19 K	404 K	10.1	66.0 K	41.4	53.0 K	96	50	74 K	44.5 K	5.0 K	55.5
Tots/Avgs	7.97	2.2	319	9.7	64.5	38.8	50.5	97	53	77	43.2	4.7	52.1

Flag Legend	
M - All Daily Values Missing	K - One or More Daily Values Flagged
J - One or More Daily Values Missing	L - Missing and Flagged Daily Values

Conversion Factors		
W/sq.m = Ly/day/2.065	inches * 25.4 = mm	(F-32) * 5/9 = c
	mBars * 0.1 = kPa	--

	Monthly evaporation	Monthly precipitation	Evaporation - precipitation	Consecutive 6mth adjusted evaporation
Apr	5.09 in	0.31 in	4.78 in	38.32 in
May	5.86 in	1.88 in	3.98 in	38.04 in
Jun	8.29 in	0.01 in	8.28 in	35.80 in
Jul	8.35 in	0.00 in	8.35 in	27.52 in
Aug	7.46 in	0.01 in	7.45 in	19.45 in
Sep	5.60 in	0.12 in	5.48 in	15.12 in
Oct	4.51 in	0.01 in	4.50 in	12.03 in
Nov	2.31 in	0.57 in	1.74 in	12.31 in
Dec	1.06 in	2.74 in	0.00 in	14.55 in
Jan	1.26 in	0.98 in	0.28 in	22.83 in
Feb	3.13 in	0.01 in	3.12 in	30.90 in
Mar	3.58 in	1.19 in	2.39 in	35.23 in
Apr	5.09 in	0.31 in	4.78 in	
May	5.86 in	1.88 in	3.98 in	
Jun	8.29 in	0.01 in	8.28 in	
Jul	8.35 in	0.00 in	8.35 in	
Aug	7.46 in	0.01 in	7.45 in	

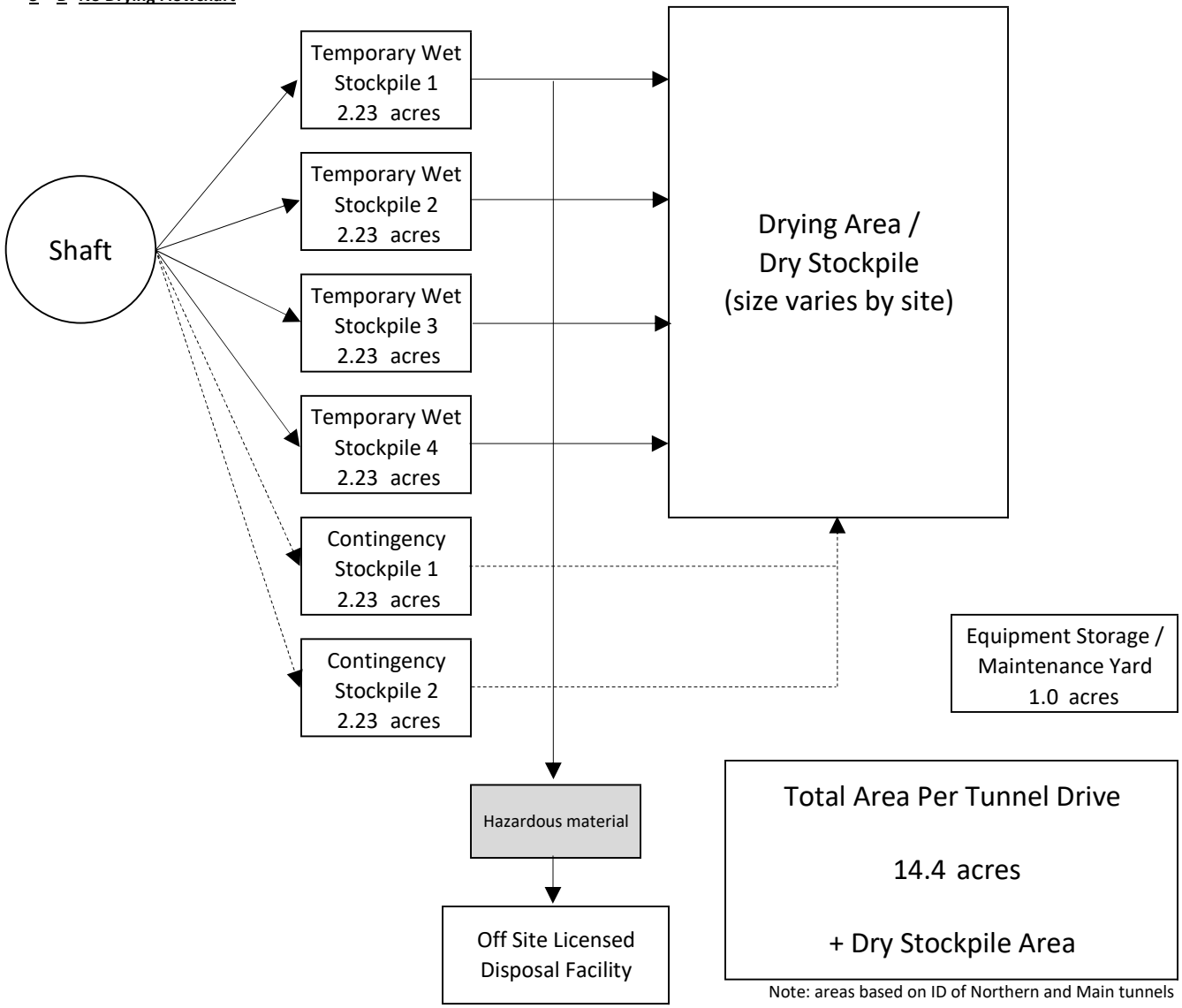
Max. continuous 6mth evaporation = 38.32 in
Average daily evaporation = 0.210 in
(Apr - Sept 2019)

Evaporation Rate

Vol. of water extracted during drying		1.65	gal/ft3	geotechnical calcs
Vol. of water extracted during drying	=	22.1%	of solids	conversion
Evaporation rate		0.210	in / day / area	from evaporation calc sheet
Evaporation rate	=	0.0175	ft / day / area	conversion
Evaporation rate	=	762.2	ft3 / day / acre	conversion
Height of drying stockpile		18.0	in	
Volume of 1 acre at 18 in high		65,340	ft3 / acre	
Volume of water to be removed from 1 acre		14,412	ft3 / acre	
Time required to dry 1 acre of RTM		18.91	days	regardless of area

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B No Drying Flowchart



Total Area Per Tunnel Drive

14.4 acres

+ Dry Stockpile Area

Note: areas based on ID of Northern and Main tunnels

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B No Drying Annual Process

Drying stockpile height per lift	18	in
Drying stockpile contingency	5	%
Tunnelling days / week	5	days / week
Tunnelling weeks / year	51	weeks / year
Wet season	7	months / year
Wet season	30	weeks / year

Season	Cell > / Area→ / Week↓	1 / 5.2	2 / 5.2	3 / 5.2	4 / 5.2	5 / 5.2	6 / 5.2	7 / 5.2	8 / 5.2	9 / 5.2	10 / 5.2	11 / 5.2	12 / 5.2	13 / 5.2	14 / 5.2	15 / 5.2	16 / 5.2	17 / 5.2	18 / 5.2	19 / 5.2	20 / 5.2	21 / 5.2	22 / 5.2	23 / 5.2	24 / 5.2	25 / 5.2	26 / 5.2	27 / 5.2	28 / 5.2	29 / 5.2	30 / 5.2	31 / 5.2	32 / 5.2	33 / 5.2	34 / 5.2	35 / 5.2	36 / 5.2	37 / 5.2	Spreading	Compacting
Wet	1	Hold	Hold	Hold	Fill	< wet season begins with 3 full cells from previous drying season																																	0	0
Wet	2	Hold	Hold	Hold	Hold	Fill																																	0	0
Wet	3	Hold	Hold	Hold	Hold	Hold	Fill																																0	0
Wet	4	Hold	Hold	Hold	Hold	Hold	Hold	Fill																															0	0
Wet	5	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																														0	0
Wet	6	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																													0	0
Wet	7	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																												0	0
Wet	8	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																											0	0
Wet	9	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																										0	0
Wet	10	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																									0	0
Wet	11	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																								0	0
Wet	12	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																							0	0
Wet	13	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																						0	0
Wet	14	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																					0	0
Wet	15	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																				0	0
Wet	16	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																			0	0
Wet	17	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																		0	0
Wet	18	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																	0	0
Wet	19	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																0	0
Wet	20	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill															0	0
Wet	21	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill														0	0
Wet	22	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill													0	0
Wet	23	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill												0	0
Wet	24	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill											0	0
Wet	25	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill										0	0
Wet	26	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill									0	0
Wet	27	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill								0	0
Wet	28	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill							0	0
Wet	29	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill						0	0
Wet	30	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill					0	0
Dry	31	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill + Spread				3	0
Dry	32	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry	Fill + Spread			3	0
Dry	33	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry	Dry	Fill + Spread		3	0
Dry	34	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry + Compact	Dry	Dry	Fill + Spread	3	3
Dry	35	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold		Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry + Compact	Dry	Dry		3	3
Dry	36	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold			Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold		Dry + Compact	Dry		3	3
Dry	37	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold				Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold			Dry + Compact		3	3
Dry	38	Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold					Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold					3	3
Dry	39		Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold						Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold					3	3
Dry	40			Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold							Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold					3	3
Dry	41				Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold								Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold					3	3
Dry	42					Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold									Dry + Compact	Dry	Dry	Spread	Hold	Hold					3	3
Dry	43						Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold										Dry + Compact	Dry	Dry	Spread	Hold					3	3
Dry	44							Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold											Dry + Compact	Dry	Dry	Spread					3	3
Dry	45								Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold												Dry + Compact	Dry	Dry					2	3
Dry	46									Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold													Dry + Compact	Dry					2	3
Dry	47										Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold														Dry + Compact					2	3
Dry	48											Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold																				2	2
Dry	49												Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread																				2	2
Dry	50	Fill												Dry + Compact	Dry	Dry		Dry + Compact	Dry	Dry																				0	2
Dry	51	Hold	Fill												Dry + Compact	Dry			Dry + Compact	Dry																				0	2
Dry	52	Hold	Hold	Fill												Dry + Compact				Dry + Compact																				0	2

Permanent stockpile

Shaft site	Stockpile area (acres)	Total vol. of RTM (yd3)	Final height of stockpile (ft)	Equivalent annual lift (in)
Bouldin Island	193	1,935,826	6.2	24
Lower Roberts	193	1,602,043	5.2	24

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B No Drying Areas

Excavation Rates	Main Tunnels		Southern Tunnels	
Tunnel lining ID	36	ft	38	ft
TBM cutterhead area	1,246	ft2	1,396	ft2
TBM advance rate (ave.)	40	ft / day	38	ft / day
TBM advance rate (peak)	80	ft / day	76	ft / day
Daily in-situ rate of excavation per tunnel (ave.)	1,846	yd3 / day	1,965	yd3 / day
Daily in-situ rate of excavation per tunnel (peak)	3,692	yd3 / day	3,931	yd3 / day
Bulking factor	1.30		1.30	
Daily excavated volume per tunnel (ave.)	2,400	yd3 / day	2,555	yd3 / day
Daily excavated volume per tunnel (peak)	4,800	yd3 / day	5,110	yd3 / day
Estimated duration of peak excavation	21	days	21	days
Volume loss due to drying	5	%	5	%
Equivalent daily dry excavated volume per tunnel (ave.)	2,280	yd3 / day	2,427	yd3 / day
Equivalent daily dry excavated volume per tunnel (peak.)	4,560	yd3 / day	4,855	yd3 / day

Temporary Wet Stockpile Area	Main Tunnels		Southern Tunnels		
No. of days storage	5	days	5	days	one week of excavation
Volume of RTM to stockpile at peak excavation rate	24,001	yd3	25,550	yd3	per stockpile
Height of stockpile	10	ft	10	ft	short term
Contingency	50	%	50	%	inc. allowance for conveyor pits
Area required at peak excavation rate	2.23	acres	2.38	acres	per stockpile
No. of temporary stockpiles	6.0		6.0		
Total area of temporary stockpiles	13.4	acres	14.3	acres	

Equipment Storage / Maintenance Yard

Area required for equipment storage / maintenance yard 1.0 acres

Drying Area / Dry Stockpile

Varies by tunnel drive and option

No Drying Area Summary

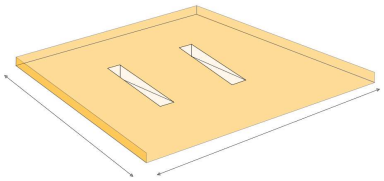
Alignment	Site	Tunnel Drive	Compacted RTM	Temporary Wet Stockpile 10 ft high	Equipment / Maintenance Yard	Total RTM Processing Area	Total RTM Processing Area
Central	Twin Cities	North	2.0 m yd3	13.4 acres	1 acres	14 acres	29 acres
		South	3.5 m yd3	13.4 acres	1 acres	14 acres	
	Bouldin Island	South	1.1 m yd3	13.4 acres	1 acres	14 acres	14 acres
	Southern Forebay	North	1.6 m yd3	13.4 acres	1 acres	14 acres	30 acres
		South	0.9 m yd3	14.3 acres	1 acres	15 acres	
Eastern	Twin Cities	North	2.0 m yd3	13.4 acres	1 acres	14 acres	29 acres
		South	3.1 m yd3	13.4 acres	1 acres	14 acres	
	Lower Roberts Island	North	2.3 m yd3	13.4 acres	1 acres	14 acres	14 acres
	Southern Forebay	North	2.8 m yd3	13.4 acres	1 acres	14 acres	30 acres
		South	0.9 m yd3	14.3 acres	1 acres	15 acres	

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B No Drying Equipment Main Tunnels

Temporary Wet Stockpile Filling

Volume of RTM to stockpile (peak)	24,001	yd3	per stockpile as for Natural Drying
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	34.5	hours / day	
Total hours at average excavation rate per day	17.2	hours / day	
Total hours for operation per year	4,397	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (peak)	24,001	yd3	per stockpile as for Natural Drying
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	10	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	34.5	hours / day	
Total hours at average excavation rate per day	17.2	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	4,397	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area / Dry Stockpile Moving

Daily excavated volume per tunnel (peak)	2,400	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	6.4	hours / day	
Total hours for operation per year	1,635	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Drying Area / Dry Stockpile Spreading

Volume of RTM to be spread per cell	12,000	yd3 / cell	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	day shift only
Average cycle time per shove	5	mins	assumed
Efficiency	80	%	assumed
Number of bulldozers per cell	2	bulldozers / cell	
Max. number of cells to spread in one week	3	cells	
Number of bulldozers required	6	bulldozers	
Number of cells to spread per year	52	cells / year	
Total hours for operation per year	4,397	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area per cell	5.2	acres	
Area per cell	25,201	yd2	
Speed	6.8	mph	
Speed	11,968	yd / hr	
Area/hr	27,925	yd2 / hr	
Working hours per day	10	hours	
Efficiency	50	%	assumed
Number of passes	2	passes	assumed
Time to compact one cell	3.6	hrs / cell	
Max. number of cells to compact in one week	3	cells / week	
Number of compactors required	1	compactors	
Number of cells to compact per year	52	cells / year	
Total hours for operation per year	188	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B No Drying Equipment Schedule Main Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average Excavation Rate: Total Hours / Year	Average Excavation Rate: Total Power / Year	Average Excavation Rate: Total Annual Operating Cost	Peak Excavation Rate: Quantity	Peak Excavation Rate: Total Capital Cost	Notes
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4397 hrs	$ 105	$ 196,000	4397 hrs	711 MWh	$ 461,650	2	$ 392,000	Day and night shift, 12mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0 hrs	- MWh	$ -	0	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4397 hrs	$ 105	$ 196,000	4397 hrs	711 MWh	$ 461,650	4	$ 784,000	Day shift only, 12mths
Wet Stockpile Moving	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	1635 hrs	$ 120	$ 180,000	1635 hrs	852 MWh	$ 196,159	2	$ 360,000	Day shift only, 12mths
Wet Stockpile Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4397 hrs	$ 105	$ 196,000	4397 hrs	711 MWh	$ 461,650	6	$ 1,176,000	Day shift only, 12mths
Wet Stockpile Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	188 hrs	$ 55	$ 73,100	188 hrs	18 MWh	$ 10,324	1	$ 73,100	One pass over full wet storage area
							Total Electrical		- hrs	- MWh	$ -	0	$ -	
							Total Gas/Diesel		15,012 hrs	3,005 MWh	$ 1,591,433	15	$ 2,785,100	
							Total		15,012 hrs	3,005 MWh	$ 1,591,433	15	$ 2,785,100	

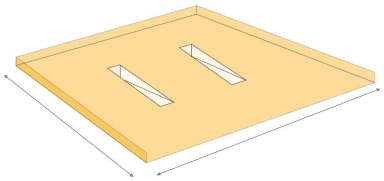
Equipment utilization 20%

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B No Drying Equipment Southern Tunnels

Temporary Wet Stockpile Filling

Volume of RTM to stockpile (peak)	25,550	yd3	per stockpile as for Natural Drying
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	36.7	hours / day	
Total hours at average excavation rate per day	18.4	hours / day	
Total hours for operation per year	4,681	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (peak)	25,550	yd3	per stockpile as for Natural Drying
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	10	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	36.7	hours / day	
Total hours at average excavation rate per day	18.4	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	4,681	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area / Dry Stockpile Moving

Daily excavated volume per tunnel (peak)	2,555	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	6.8	hours / day	
Total hours for operation per year	1,740	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Drying Area / Dry Stockpile Spreading

Volume of RTM to be spread per cell	12,000	yd3 / cell	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	day shift only
Average cycle time per shove	5	mins	assumed
Efficiency	80	%	assumed
Number of bulldozers per cell	2	bulldozers / cell	
Max. number of cells to spread in one week	3	cells	
Number of bulldozers required	6	bulldozers	
Number of cells to spread per year	52	cells / year	
Total hours for operation per year	4,397	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area per cell	5.2	acres	
Area per cell	25,201	yd2	
Speed	6.8	mph	
Speed	11,968	yd / hr	
Area/hr	27,925	yd2 / hr	
Working hours per day	10	hours	
Efficiency	50	%	assumed
Number of passes	2	passes	assumed
Time to compact one cell	3.6	hrs / cell	
Max. number of cells to compact in one week	3	cells / week	
Number of compactors required	1	compactors	
Number of cells to compact per year	52	cells / year	
Total hours for operation per year	188	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B No Drying Equipment Schedule Southern Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average Excavation Rate: Total Hours / Year	Average Excavation Rate: Total Power / Year	Average Excavation Rate: Total Annual Operating Cost	Peak Excavation Rate: Quantity	Peak Excavation Rate: Total Capital Cost	Notes
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4681 hrs	$ 105	$ 196,000	4681 hrs	757 MWh	$ 491,453	2	$ 392,000	Day and night shift, 12mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0 hrs	- MWh	$ -	0	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4681 hrs	$ 105	$ 196,000	4681 hrs	757 MWh	$ 491,453	4	$ 784,000	Day shift only, 12mths
Wet Stockpile Moving	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	1740 hrs	$ 120	$ 180,000	1740 hrs	907 MWh	$ 208,822	2	$ 360,000	Day shift only, 12mths
Wet Stockpile Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4397 hrs	$ 105	$ 196,000	4397 hrs	711 MWh	$ 461,650	6	$ 1,176,000	Day shift only, 12mths
Wet Stockpile Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	188 hrs	$ 55	$ 73,100	188 hrs	18 MWh	$ 10,324	1	$ 73,100	One pass over full wet storage area
								Total Electrical	- hrs	- MWh	$ -	0	$ -	
								Total Gas/Diesel	15,686 hrs	3,152 MWh	$ 1,663,702	15	$ 2,785,100	
								Total	15,686 hrs	3,152 MWh	$ 1,663,702	15	$ 2,785,100	

Equipment utilization 21%

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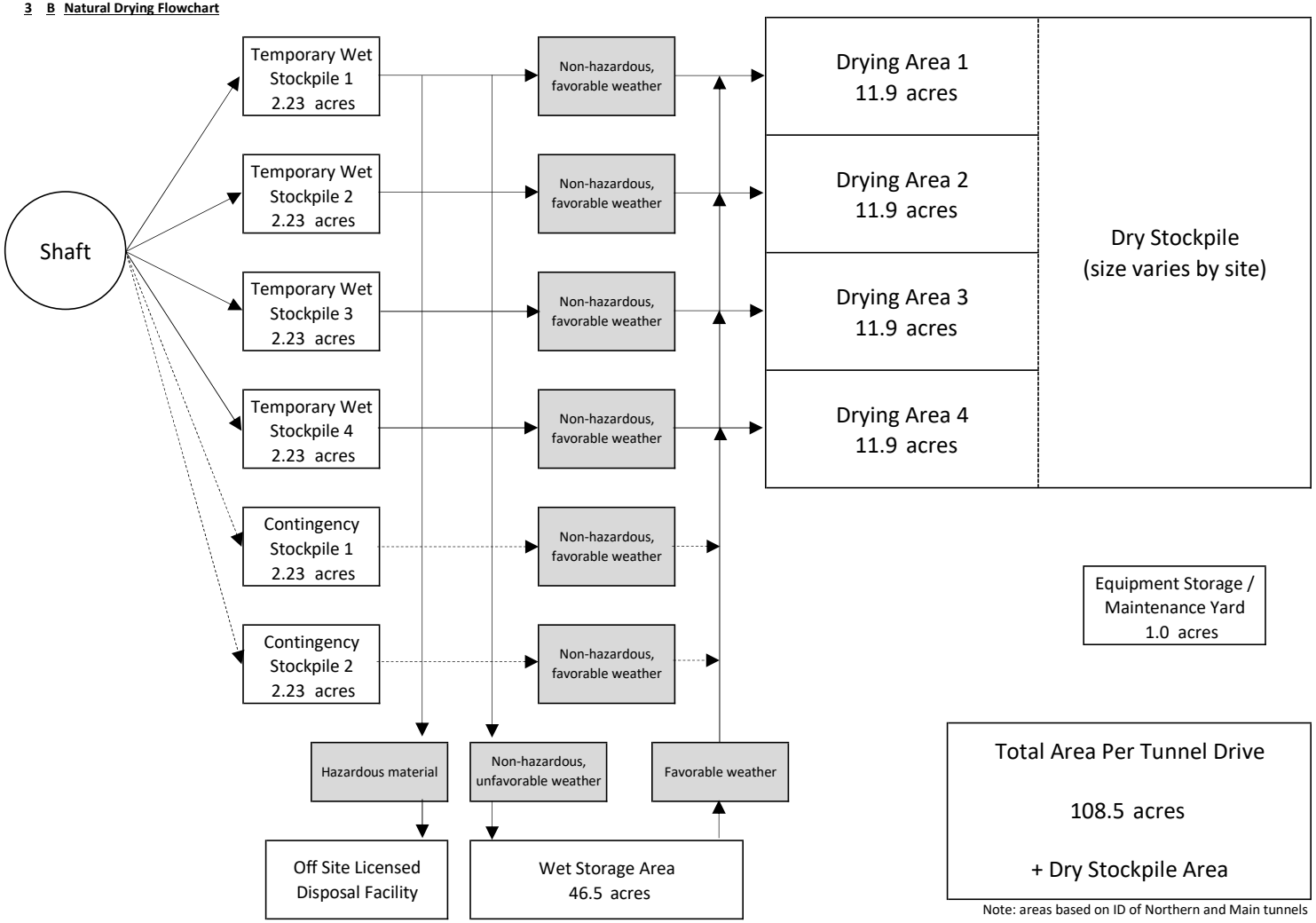
Option 3 B Natural Drying Flowchart



Equipment Storage / Maintenance Yard 1.0 acres

Total Area Per Tunnel Drive

108.5 acres

+ Dry Stockpile Area

Note: areas based on ID of Northern and Main tunnels

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B Natural Drying Areas

Excavation Rates	Main Tunnels		Southern Tunnels	
Tunnel lining ID	36	ft	38	ft
TBM cutterhead area	1,246	ft2	1,396	ft2
TBM advance rate (ave.)	40	ft / day	38	ft / day
TBM advance rate (peak)	80	ft / day	76	ft / day
Daily in-situ rate of excavation per tunnel (ave.)	1,846	yd3 / day	1,965	yd3 / day
Daily in-situ rate of excavation per tunnel (peak)	3,692	yd3 / day	3,931	yd3 / day
Bulking factor	1.30		1.30	
Daily excavated volume per tunnel (ave.)	2,400	yd3 / day	2,555	yd3 / day
Daily excavated volume per tunnel (peak)	4,800	yd3 / day	5,110	yd3 / day
Estimated duration of peak excavation	21	days	21	days
Volume loss due to drying	5	%	5	%
Equivalent daily dry excavated volume per tunnel (ave.)	2,280	yd3 / day	2,427	yd3 / day
Equivalent daily dry excavated volume per tunnel (peak.)	4,560	yd3 / day	4,855	yd3 / day

Temporary Wet Stockpile Area	Main Tunnels		Southern Tunnels		
No. of days storage	5	days	5	days	
Volume of RTM to stockpile at peak excavation rate	24,001	yd3	25,550	yd3	per stockpile
Height of stockpile	10	ft	10	ft	short term
Contingency	50	%	50	%	includes allowance for conveyor pits
Area required at peak excavation rate	2.23	acres	2.38	acres	per stockpile
No. of temporary stockpiles	6.0		6.0		
Total area of temporary stockpiles	13.4	acres	14.3	acres	

Drying Area	Main Tunnels		Southern Tunnels		
Volume of RTM to dry per stockpile	24,001	yd3	25,550	yd3	equivalent to 1 wk RTM at peak excavation
Contingency	20	%	20	%	
Height of stockpile	18.0	in	18.0	in	
Area required at peak excavation rate	11.9	acres	12.7	acres	per drying area
No. of drying areas	4.0		4.0		
Total area of drying areas	47.6	acres	50.7	acres	

Wet Storage Area	Main Tunnels		Southern Tunnels		
Period of wet weather	6	mths	6	mths	continuous storage
No. of days storage	130	days	130	days	based on working days
Volume of RTM to store at ave. excavation rate	312,865	yd3	333,063	yd3	
Height of stockpile	5.0	ft	5.0	ft	long term
Contingency	20	%	20	%	
Area required	46.5	acres	49.5	acres	

Equipment Storage / Maintenance Yard		
Area required for equipment storage / maintenance yard	1.0	acres

Permanent Stockpile		
Contingency	5	%

Natural Drying Area Summary

Alignment	Site	Tunnel Drive	Dry Partially Compacted RTM	Temporary Wet Stockpile 10 ft high	Drying Area 18 in high	Wet Storage 5 ft high	Equipment / Maintenance Yard	Total RTM Processing Area	Total RTM Processing Area	
Central	Twin Cities	North	2.0 m yd3	13.4 acres	48 acres	47 acres	1 acres	109 acres	217	acres
		South	3.5 m yd3	13.4 acres	48 acres	47 acres	1 acres	109 acres		
	Bouldin Island	South	2.4 m yd3	13.4 acres	48 acres	47 acres	1 acres	109 acres	109	acres
	Southern Forebay	North	1.6 m yd3	13.4 acres	48 acres	47 acres	1 acres	109 acres	224	acres
		South	0.9 m yd3	14.3 acres	51 acres	50 acres	1 acres	115 acres		
Eastern	Twin Cities	North	2.0 m yd3	13.4 acres	48 acres	47 acres	1 acres	109 acres	217	acres
		South	3.1 m yd3	13.4 acres	48 acres	47 acres	1 acres	109 acres		
	Lower Roberts Island	North	2.3 m yd3	13.4 acres	48 acres	47 acres	1 acres	109 acres	109	acres
	Southern Forebay	North	2.8 m yd3	13.4 acres	48 acres	47 acres	1 acres	109 acres	224	acres
		South	0.9 m yd3	14.3 acres	51 acres	50 acres	1 acres	115 acres		

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B Natural Drying Equipment Main Tunnels

Temporary Wet Stockpile Filling

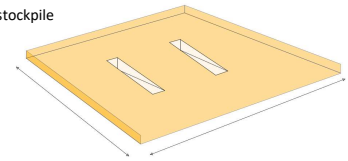
Volume of RTM to stockpile (peak)	24,001	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	34.5	hours / day	
Total hours at average excavation rate per day	17.2	hours / day	
Total hours for operation per year	4,397	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (peak)	24,001	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	10	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	34.5	hours / day	
Total hours at average excavation rate per day	17.2	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	4,397	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Spreading

Volume of RTM to be spread per day (peak)	2,400	yd3/day	per drying area
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	34.5	hours / day	
Total hours at average excavation rate per day	17.2	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	4,397	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Tilling

Drying Area	11.9	acres	per drying area
No. of drying areas	4.0		
Total drying area	47.6	acres	
Tilling rate per machine	14.50	acres/hr/tractor	includes 80% capacity
Passes per day	3	times	
Working hours per day	10	hours	
Min. number of tractors required	1	tractors	
Additional contingency	1	tractor	
No. of tractors required	2	tractors	
Total hours at average excavation rate per day	9.8	hours / day	
Total hours for operation per year	2,512	hours / year	

Example: John Deere 5090E (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area	47.6	acres	total drying area
Area	230,406	yd2	
Speed	6.8	mph	
Speed	11,968	yd/hr	
Area/hr	27,925	yd2/hr	
Efficiency	50	%	
Time to compact whole area	12	hrs	
Number of compactors required	2	compactors	to compact whole drying area in 1 day
Number of times to compact area per year	26	times/yr	assumed once a week for 6mths
Total hours for operation per year	322	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

Drying Area Piling

Volume of RTM to be piling per day (ave.)	2,280	yd3/day	dried volume, per drying area
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	32.8	hours / day	
Total hours for operation per year	8,354	hours / year	2 stockpiles emptied at any one time

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area to Dry Stockpile

Volume of RTM to be moved per day (ave.)	2,280	yd3/day	per drying area
Scraper capacity	24.00	yd3 / scraper	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of scrapers required	1	scrapers	
Total hours at average excavation rate per day	19.8	hours / day	
Total hours for operation per year	5,047	hours / year	2 stockpiles emptied at any one time

Example: Caterpillar 637K, Capacity = 24yd3 (see equipment schedule for details)

Wet Storage Stockpiling

Volume of RTM to be stockpiled per day	1,937	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	assuming bulldozers already on project site
Working hours per day	10	hours	
Average cycle time per shove	10	mins	
Efficiency	80	%	
Number of bulldozers required	3	bulldozers	
Total hours per day	27.8	hours / day	
Total hours for operation per year	3,549	hours / year	for 6mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

During peak excavation there will be 6 bulldozers operating in the various temporary stockpiles.
The wet stockpile will only be emptied when the excavation is below peak.
At average excavation there will be 3 bulldozers available for this operation.

Dry Stockpile Filling / Unloading

Bulldozers

Volume of RTM to be stockpiled per day per drying area (ave.)	2,280	yd3/day	per drying area
No. of drying areas to be emptied per day	2		
Volume of RTM to be stockpiled per day	4,560	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers	4	bulldozers	
Total hours at average excavation rate per day	32.8	hours / day	
Total hours for operation per year	8,354	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wheel Loaders

Daily excavated volume per tunnel (ave.)	2,280	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	12.2	hours / day	
Total hours for operation per year	3,106	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B Natural Drying Equipment Schedule Main Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average Excavation Rate: Total Hours / Year	Average Excavation Rate: Total Power / Year	Average Excavation Rate: Total Annual Operating Cost	Peak Excavation Rate: Quantity	Peak Excavation Rate: Total Capital Cost	Notes
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4397 hrs	$ 105	$ 196,000	4397 hrs	711 MWh	$ 461,650	2	$ 392,000	Day and night shift, 12mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0 hrs	- MWh	$ -	0	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4397 hrs	$ 105	$ 196,000	4397 hrs	711 MWh	$ 461,650	4	$ 784,000	Day shift only, 12mths
Drying Areas Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4397 hrs	$ 105	$ 196,000	4397 hrs	711 MWh	$ 461,650	4	$ 784,000	Day shift only, 12mths
Drying Areas Tilling	Tractors	John Deere	5090E	90 hp	67 kW	2512 hrs	$ 30	$ 58,750	2512 hrs	169 MWh	$ 75,346	2	$ 117,500	Day shift only, 12mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	322 hrs	$ 55	$ 73,100	322 hrs	31 MWh	$ 17,698	2	$ 146,200	Once a week during wet months
Drying Areas Piling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	8354 hrs	$ 105	$ 196,000	8354 hrs	1,352 MWh	$ 877,135	4	$ 784,000	Day shift only, 12mths
Drying Area to Dry Stockpile	Scrapers	Caterpiller	637K	570 hp	425 kW	5047 hrs	$ 150	$ 905,000	5047 hrs	2,145 MWh	$ 757,051	2	$ 1,810,000	Day shift only, 12mths
Wet Storage Stockpiling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	3549 hrs	$ 105	$ 196,000	3549 hrs	574 MWh	$ 372,628	0	$ -	Day shift only, 6mths
Dry Stockpile Filling/Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	8354 hrs	$ 105	$ 196,000	8354 hrs	1,352 MWh	$ 877,135	4	$ 784,000	Day shift only, 12mths
Dry Stockpile Filling/Unloading	Wheel Loaders	Caterpiller	990K	699 hp	521 kW	3106 hrs	$ 120	$ 180,000	3106 hrs	1,619 MWh	$ 372,702	2	$ 360,000	Day shift only, 12mths

Equipment utilization 34%

	Total Hours / Year	Total Power / Year	Total Annual Operating Cost	Total Capital Cost
Total Electrical	- hrs	- MWh	$ -	$ -
Total Gas/Diesel	44,432 hrs	9,376 MWh	$ 4,734,647	$ 5,961,700
Total	44,432 hrs	9,376 MWh	$ 4,734,647	$ 5,961,700

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B Natural Drying Equipment Southern Tunnels

Temporary Wet Stockpile Filling

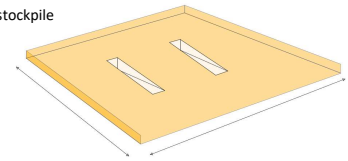
Volume of RTM to stockpile (peak)	25,550	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	36.7	hours / day	
Total hours at average excavation rate per day	18.4	hours / day	
Total hours for operation per year	4,681	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (peak)	25,550	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	10	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	36.7	hours / day	
Total hours at average excavation rate per day	18.4	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	4,681	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Spreading

Volume of RTM to be spread per day (peak)	2,555	yd3/day	per drying area
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	36.7	hours / day	
Total hours at average excavation rate per day	18.4	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	4,681	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Tilling

Drying Area	12.7	acres	per drying area
No. of drying areas	4.0		
Total drying area	50.7	acres	
Tilling rate per machine	14.50	acres/hr/tractor	includes 80% capacity
Passes per day	3	times	
Working hours per day	10	hours	
Min. number of tractors required	2	tractors	
Additional contingency	1	tractor	
No. of tractors required	3	tractors	
Total hours at average excavation rate per day	10.5	hours / day	
Total hours for operation per year	2,674	hours / year	

Example: John Deere 5090E (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area	50.7	acres	total drying area
Area	245,280	yd2	
Speed	6.8	mph	
Speed	11,968	yd/hr	
Area/hr	27,925	yd2/hr	
Efficiency	50	%	
Time to compact whole area	13	hrs	
Number of compactors required	2	compactors	to compact whole drying area in 1 day
Number of times to compact area per year	26	times/yr	assumed once a week for 6mths
Total hours for operation per year	343	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

Drying Area Piling

Volume of RTM to be piling per day (ave.)	2,427	yd3/day	dried volume, per drying area
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	34.9	hours / day	
Total hours for operation per year	8,893	hours / year	2 stockpiles emptied at any one time

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area to Dry Stockpile

Volume of RTM to be moved per day (ave.)	2,427	yd3/day	per drying area
Scraper capacity	24.00	yd3 / scraper	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of scrapers required	2	scrapers	
Total hours at average excavation rate per day	21.1	hours / day	
Total hours for operation per year	5,373	hours / year	2 stockpiles emptied at any one time

Example: Caterpillar 637K, Capacity = 24yd3 (see equipment schedule for details)

Wet Storage Stockpiling

Volume of RTM to be stockpiled per day	2,062	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	assuming bulldozers already on project site
Working hours per day	10	hours	
Average cycle time per shove	10	mins	
Efficiency	80	%	
Number of bulldozers required	3	bulldozers	
Total hours per day	29.6	hours / day	
Total hours for operation per year	3,778	hours / year	for 6mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

During peak excavation there will be 6 bulldozers operating in the various temporary stockpiles.
The wet stockpile will only be emptied when the excavation is below peak.
At average excavation there will be 3 bulldozers available for this operation.

Dry Stockpile Filling / Unloading

Bulldozers

Volume of RTM to be stockpiled per day per drying area (ave.)	2,427	yd3/day	per drying area
No. of drying areas to be emptied per day	2		
Volume of RTM to be stockpiled per day	4,855	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers	4	bulldozers	
Total hours at average excavation rate per day	34.9	hours / day	
Total hours for operation per year	8,893	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wheel Loaders

Daily excavated volume per tunnel (ave.)	2,427	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	13.0	hours / day	
Total hours for operation per year	3,306	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B Natural Drying Equipment Schedule Southern Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule (per tunnel drive)

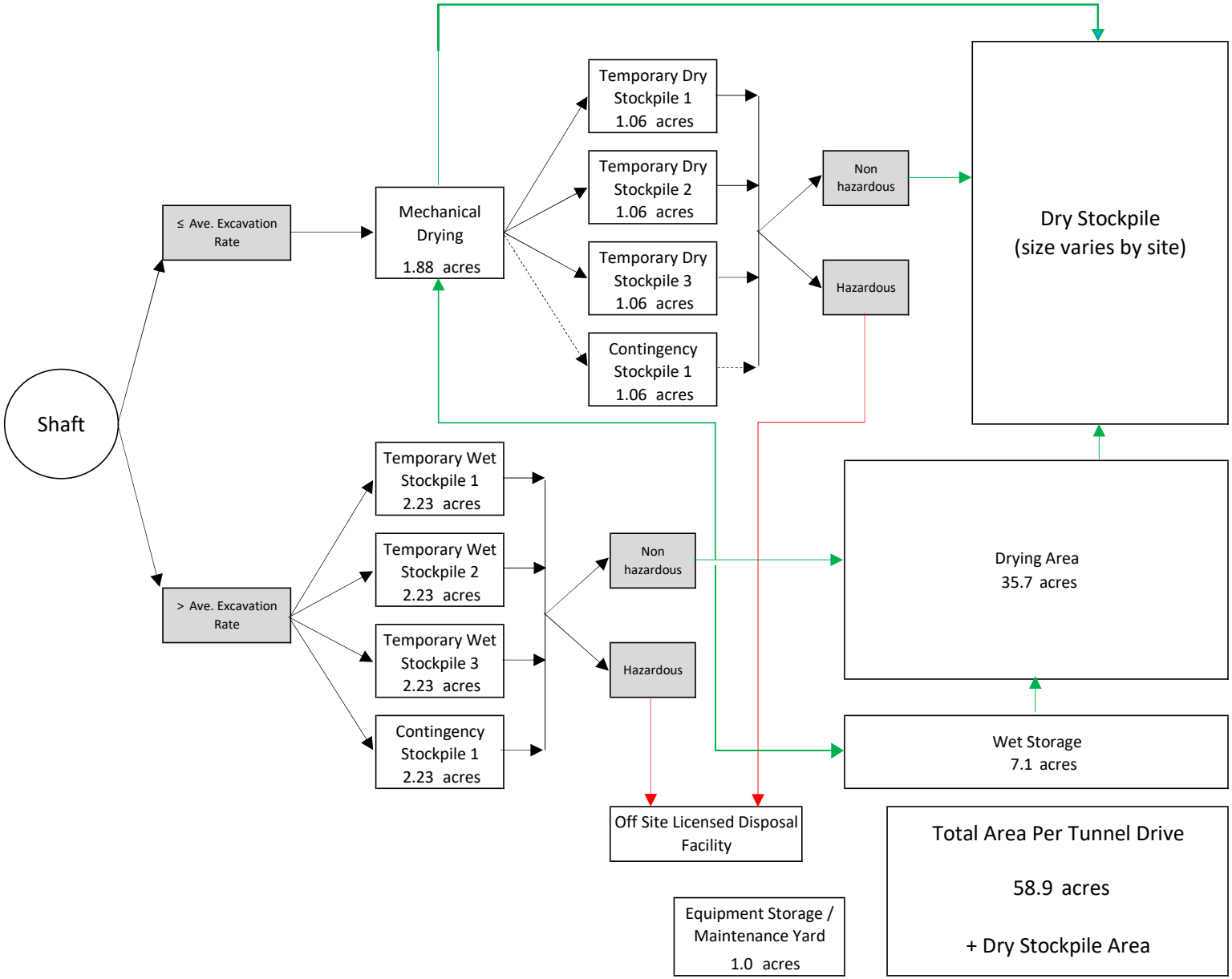
Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average Excavation Rate: Total Hours / Year	Average Excavation Rate: Total Power / Year	Average Excavation Rate: Total Annual Operating Cost	Peak Excavation Rate: Quantity	Peak Excavation Rate: Total Capital Cost	Notes
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4681 hrs	$ 105	$ 196,000	4681 hrs	757 MWh	$ 491,453	2	$ 392,000	Day and night shift, 12mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0 hrs	- MWh	$ -	0	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4681 hrs	$ 105	$ 196,000	4681 hrs	757 MWh	$ 491,453	4	$ 784,000	Day shift only, 12mths
Drying Areas Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4681 hrs	$ 105	$ 196,000	4681 hrs	757 MWh	$ 491,453	4	$ 784,000	Day shift only, 12mths
Drying Areas Tilling	Tractors	John Deere	5090E	90 hp	67 kW	2674 hrs	$ 30	$ 58,750	2674 hrs	179 MWh	$ 80,210	3	$ 176,250	Day shift only, 12mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	343 hrs	$ 55	$ 73,100	343 hrs	33 MWh	$ 18,840	2	$ 146,200	Once a week during wet months
Drying Areas Piling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	8893 hrs	$ 105	$ 196,000	8893 hrs	1,439 MWh	$ 933,760	4	$ 784,000	Day shift only, 12mths
Drying Area to Dry Stockpile	Scrapers	Caterpiller	637K	570 hp	425 kW	5373 hrs	$ 150	$ 905,000	5373 hrs	2,284 MWh	$ 805,924	4	$ 3,620,000	Day shift only, 12mths
Wet Storage Stockpiling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	3778 hrs	$ 105	$ 196,000	3778 hrs	611 MWh	$ 396,684	0	$ -	Day shift only, 6mths
Dry Stockpile Filling/Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	8893 hrs	$ 105	$ 196,000	8893 hrs	1,439 MWh	$ 933,760	4	$ 784,000	Day shift only, 12mths
Dry Stockpile Filling/Unloading	Wheel Loaders	Caterpiller	990K	699 hp	521 kW	3306 hrs	$ 120	$ 180,000	3306 hrs	1,723 MWh	$ 396,763	2	$ 360,000	Day shift only, 12mths

Equipment utilization 32%

	Total Hours / Year	Total Power / Year	Total Annual Operating Cost	Total Capital Cost
Total Electrical	- hrs	- MWh	$ -	$ -
Total Gas/Diesel	47,301 hrs	9,982 MWh	$ 5,040,300	$ 7,830,450
Total	47,301 hrs	9,982 MWh	$ 5,040,300	$ 7,830,450

CA Delta Conveyance Tunnel - RTM Calculations

Option 3 B Mechanical Drying Flowchart



Note: areas based on ID of Northern and Main tunnels

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B Mechanical Drying Areas

Excavation rates	Main Tunnels		Southern Tunnels	
Tunnel lining ID	36	ft	38	ft
TBM cutterhead area	1,246	ft2	1,396	ft2
TBM advance rate (ave.)	40	ft / day	38	ft / day
TBM advance rate (peak)	80	ft / day	76	ft / day
Rate of in-situ material excavation per tunnel (ave.)	1,846	yd3 / day	1,965	yd3 / day
Rate of in-situ material excavation per tunnel (peak)	3,692	yd3 / day	3,931	yd3 / day
Bulking factor	1.30		1.30	
Excavated rate of material per tunnel drive (ave.)	2,400	yd3 / day	2,555	yd3 / day
Excavated rate of material per tunnel drive (peak)	4,800	yd3 / day	5,110	yd3 / day
Estimated duration of peak excavation	21	days	21	days
Volume loss due to drying	5	%	5	%
Equivalent daily dry excavated volume per tunnel (ave.)	2,280	yd3 / day	2,427	yd3 / day
Equivalent daily dry excavated volume per tunnel (peak.)	4,560	yd3 / day	4,855	yd3 / day

Mechanical Drying Area

Inputs

Unit weight of soil entering dryer	100	lb/ft3
Unit weight of soil entering dryer	2,692	lb/yd3
Unit weight of soil produced per day (ave.)	162	tons/hr
Working hours per day	20	hours
Working hours per year	5,100	hours

Option 1 - Thermal Drying

Equipment details (Note this is one possible option presented as an example)

Manufacturer	Komline-Sanderson				
Machine	K-S Paddle Dryer				
Model	16W-3200				
Capacity	70,000	lb/hr	=	520	yd3 / day
Length	16,822	mm	=	55.2	ft
Width	3,835	mm	=	12.6	ft
Height	4,273	mm	=	14.0	ft
Weight	102,058	kg	=	112.5	tons
Power for heat source	32	MMBtu/hr		9,378	kWh
Power for motors	250	hp		186	kW
Estimated capital cost	$ 4,500,000				

Assumptions

Clear space required around each dryer	3	ft
Efficiency / redundancy	85	%

Option 2 - Rotary Drying

Equipment details (Note this is one possible option presented as an example)

Manufacturer	Vulcan Drying Systems					
Machine	Frac Sand Dryer					
Model	(Customized)					
Capacity	196,000	lb/hr	=	1,456	yd3 / day	
Length	22,860	mm	=	75.0	ft	assumed
Width	9,144	mm	=	30.0	ft	assumed
Height	6,096	mm	=	20.0	ft	assumed
Weight	90,718	kg	=	100.0	tons	assumed
Power for heat source	57	MMBtu/hr		16,705	kWh	
Power for motors	255	hp		190	kW	
Estimated capital cost	$ 400,000					

Assumptions

Clear space required around each dryer	3	ft
Efficiency / redundancy	85	%

Option 1 - Thermal Drying	Main Tunnels		Southern Tunnels		per tunnel drive, average excavation rates
Min. quantity required	6		6		
Additional contingency	2		2		
Quantity required	8		8		
Total weight of equipment	900	tons	900	tons	
Area required	9,096	yd2	9,096	yd2	
Area required	1.88	acres	1.88	acres	

Option 2 - Rotary Drying	Main Tunnels		Southern Tunnels		per tunnel drive, average excavation rates
Min. quantity required	2		3		assumes all drying systems of same size
Additional contingency	1		1		- dryers can be custom made for desired quantity
Quantity required	3		4		
Total weight of equipment	300	tons	400	tons	
Area required	8,748	yd2	11,664	yd2	
Area required	1.81	acres	2.41	acres	

Temporary Dry Stockpile Area	Main Tunnels		Southern Tunnels		
No. of days storage	5	days	5	days	assuming 5 days of excavation at ave. rate in a 7 day cycle
Volume of RTM to stockpile at average excavation rate	11,400	yd3	12,136	yd3	
Height of stockpile	10	ft	10	ft	short term
Contingency	50	%	50	%	includes allowance for conveyor pits
Area required	1.06	acres	1.13	acres	per stockpile
No. of temporary stockpiles	4.0		4.0		3 active + 1 contingency
Total area of temporary stockpiles	4.2	acres	4.5	acres	

Temporary Wet Stockpile Area	Main Tunnels		Southern Tunnels		
No. of days storage	5	days	5	days	assuming 5 days of excavation at ave. rate in a 7 day cycle
Volume of RTM to stockpile at peak excavation rate	12,000	yd3	12,775	yd3	per stockpile = 1wks worth at average excavation rate
Height of stockpile	5	ft	5	ft	long term
Contingency	50	%	50	%	includes allowance for conveyor pits
Area required	2.23	acres	2.38	acres	
No. of temporary stockpiles	4.0		4.0		3wks of average excavation + 1wks contingency
Total area of temporary stockpiles	8.9	acres	9.5	acres	

(Temporary Wet Stockpile + Wet Storage + Drying Area = 13wks = 3mths)

Wet Storage Area	Main Tunnels		Southern Tunnels		
Volume of RTM to store	48,001	yd3	51,100	yd3	4wks of average excavation
Height of stockpile	5	ft	5	ft	long term
Contingency	20	%	20	%	
Area required	7.1	acres	7.6	acres	

(Temporary Wet Stockpile + Wet Storage + Drying Area = 13wks = 3mths)

Drying Area	Main Tunnels		Southern Tunnels		
Volume of RTM to dry at any one time	72,002	yd3	76,650	yd3	6wks of average excavation
Height of stockpile	18.0	in	18.0	in	
Contingency	20	%	20	%	
Area required	35.7	acres	38.0	acres	

(Temporary Wet Stockpile + Wet Storage + Drying Area = 13wks = 3mths)

Equipment Storage / Maintenance Yard

Area required for equipment storage / maintenance yard 1.0 acres

Dry Stockpile

Note the dry stockpile area is based on the requirements for Option 3 as shown on the drawings, except for Option 4 which requires a larger area.
Contingency 5 %

Mechanical Drying Area Summary

Alignment	Site	Tunnel Drive	Dry Partially Compacted RTM	Mechanical Drying Area	Temporary Dry Stockpile 10 ft high	Temporary Wet Stockpile 5 ft high	Wet Storage 5 ft high	Drying Area 18 in high	Equipment / Maintenance Yard	Total RTM Processing Area	Total RTM Processing Area
Central	Twin Cities	North	2.0 m yd3	1.9 acres	4.2 acres	8.9 acres	7.1 acres	35.7 acres	1 acres	59 acres	118 acres
		South	3.5 m yd3	1.9 acres	4.2 acres	8.9 acres	7.1 acres	35.7 acres	1 acres	59 acres	
	Bouldin Island	South	2.4 m yd3	1.9 acres	4.2 acres	8.9 acres	7.1 acres	35.7 acres	1 acres	59 acres	59 acres
	Southern Forebay	North	1.6 m yd3	1.9 acres	4.2 acres	8.9 acres	7.1 acres	35.7 acres	1 acres	59 acres	122 acres
		South	0.9 m yd3	2.4 acres	4.5 acres	9.5 acres	7.6 acres	38.0 acres	1 acres	63 acres	
Eastern	Twin Cities	North	2.0 m yd3	1.9 acres	4.2 acres	8.9 acres	7.1 acres	35.7 acres	1 acres	59 acres	118 acres
		South	3.1 m yd3	1.9 acres	4.2 acres	8.9 acres	7.1 acres	35.7 acres	1 acres	59 acres	
	Lower Roberts Island	North	2.3 m yd3	1.9 acres	4.2 acres	8.9 acres	7.1 acres	35.7 acres	1 acres	59 acres	59 acres
	Southern Forebay	North	2.8 m yd3	1.9 acres	4.2 acres	8.9 acres	7.1 acres	35.7 acres	1 acres	59 acres	122 acres
		South	0.9 m yd3	2.4 acres	4.5 acres	9.5 acres	7.6 acres	38.0 acres	1 acres	63 acres	

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Option 3 B Mechanical Drying Equipment Main Tunnels

Temporary Dry Stockpile Filling

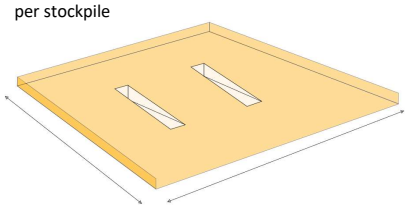
Volume of RTM to stockpile (ave.)	11,400	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	16.4	hours / day	
Total hours for operation per year	4,177	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Dry Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (ave.)	11,400	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	5	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	16.4	hours / day	
Total hours for operation per year	4,177	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Filling

Volume of RTM to be stockpiled per day (ave.)	2,400	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	17.2	hours / day	
Total hours for operation per year	1,099	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Volume of RTM to be stockpiled per day (ave.)	2,400	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	17.2	hours / day	
Total hours for operation per year	1,099	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wet Storage Filling/Emptying

Volume of RTM to be stockpiled per day (ave.)	2,400	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	17.2	hours / day	
Total hours for operation per year	338	hours / year	for 4wk operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Spreading

Volume of RTM to be spread per day (ave.)	2,400	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	17.2	hours / day	
Total hours for operation per year	1,099	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Tilling

Drying Area	35.7	acres	
No. of drying areas	1		
Total drying area	35.7	acres	
Tilling rate per machine	14.50	acres/hr/tractor	includes 80% capacity
Passes per day	3	times	
Working hours per day	10	hours	
Min. number of tractors required	1	tractors	
Additional contingency	1	tractor	
No. of tractors required	2	tractors	
Total hours at average excavation rate per day	7.4	hours / day	
Total hours for operation per year	471	hours / year	for 3mth operation

Example: John Deere 5090E (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area	35.7	acres	total drying area
Area	172,805	yd2	
Speed	6.8	mph	
Speed	11,968	yd/hr	
Area/hr	27,925	yd2/hr	
Efficiency	50	%	
Time to compact whole area	9	hrs	
Number of compactors required	1	compactors	to compact whole drying area in 1 day
Number of times to compact area per year	26	times/yr	assumed once a week for 6mths
Total hours for operation per year	241	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

Drying Area to Dry Stockpile

Volume of RTM to be moved per day (ave.)	2,280	yd3/day	dried volume
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	12.2	hours / day	
Total hours for operation per year	776	hours / year	for 3mth operation

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Dry Stockpile Filling / Unloading

Bulldozers

Volume of RTM to be stockpiled per day (ave.)	2,280	yd3/day	assume average excavation rate
No. of drying areas to be emptied per day	1		
Volume of RTM to be stockpiled per day	2,280	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers	2	bulldozers	
Total hours at average excavation rate per day	16.4	hours / day	
Total hours for operation per year	4,177	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wheel Loaders

Daily excavated volume per tunnel (ave.)	2,280	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	12.2	hours / day	
Total hours for operation per year	3,106	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Assume this will utilize the same equipment as for Drying Area to Dry Stockpile

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CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B Mechanical Drying Equipment Schedule Main Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule - Thermal Dryers (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average and Peak Excavation Rate: Quantity	Total Hours / Year	Total Power / Year	Total Annual Operating Cost	Total Capital Cost	Notes
Thermal Drying - heat source	Thermal Dryers	Komline-Sanderson	K-S Paddle Dryer	32 MMBtu	9378 kW	40800 hrs	$ 7.76	$ 4,500,000	8	40800 hrs	1,306 MMBtu	$ 10,131,456	$ 36,000,000	Day and night shift, 12mths
Thermal Drying - motors	Thermal Dryers	Komline-Sanderson	K-S Paddle Dryer	250 hp	186 kW	40800 hrs	$ 120.00		8	40800 hrs	7,606 MWh	$ 912,737		Day and night shift, 12mths
Temporary Dry Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4177 hrs	$ 105	$ 196,000	1	4177 hrs	676 MWh	$ 438,568	$ 196,000	Day and night shift, 12mths
Temporary Dry Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Dry Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4177 hrs	$ 105	$ 196,000	2	4177 hrs	676 MWh	$ 438,568	$ 392,000	Day shift only, 12mths
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1099 hrs	$ 105	$ 196,000	1	1099 hrs	178 MWh	$ 115,413	$ 196,000	Day and night shift, 3mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1099 hrs	$ 105	$ 196,000	1	1099 hrs	178 MWh	$ 115,413	$ 196,000	Day and night shift, 3mths
Wet Storage Filling/Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	338 hrs	$ 105	$ 196,000	1	338 hrs	55 MWh	$ 35,512	$ 196,000	Day and night shift, 4 wks
Drying Area Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1099 hrs	$ 105	$ 196,000	2	1099 hrs	178 MWh	$ 115,413	$ 392,000	Day shift only, 3mths
Drying Area Tilling	Tractors	John Deere	5090E	90 hp	67 kW	471 hrs	$ 30	$ 58,750	2	471 hrs	32 MWh	$ 14,127	$ 117,500	Day shift only, 3mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	241 hrs	$ 55	$ 73,100	1	241 hrs	24 MWh	$ 13,273	$ 73,100	Once a week during wet months
Drying Area to Dry Stockpile	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	776 hrs	$ 120	$ 180,000	2	776 hrs	405 MWh	$ 93,176	$ 360,000	Day shift only, 3mths
Dry Stockpile Filling / Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4177 hrs	$ 105	$ 196,000	2	4177 hrs	676 MWh	$ 438,568	$ 392,000	Day shift only, 12mths
Dry Stockpile Filling / Unloading	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	3106 hrs	$ 120	$ 180,000	2	3106 hrs	1,619 MWh	$ 372,702	$ 360,000	Day shift only, 12mths

Equipment utilization 61%

Total Natural Gas	8	40,800 hrs	1,306 MMBtu	$ 10,131,456		
Total Electrical	8	40,800 hrs	7,606 MWh	$ 912,737	$ 36,000,000	
Total Gas/Diesel	17	20,761 hrs	4,695 MWh	$ 2,190,731	$ 2,870,600	
Total	33	102,361 hrs	12,301 MWh	$ 13,234,923	$ 38,870,600	

Equipment Schedule - Rotary Dryers (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average and Peak Excavation Rate: Quantity	Total Hours / Year	Total Power / Year	Total Annual Operating Cost	Total Capital Cost	Notes
Rotary Drying - heat source	Rotary Dryers	Vulcan	Frac Sand Dryer	57 MMBtu	16705 kW	15300 hrs	$ 7.76	$ 400,000	3	15300 hrs	872 MMBtu	$ 6,767,496	$ 1,200,000	Day and night shift, 12mths
Rotary Drying - motors	Rotary Dryers	Vulcan	Frac Sand Dryer	255 hp	190 kW	15300 hrs	$ 120.00		3	15300 hrs	2,909 MWh	$ 349,122		Day and night shift, 12mths
Temporary Dry Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4177 hrs	$ 105	$ 196,000	1	4177 hrs	676 MWh	$ 438,568	$ 196,000	Day and night shift, 12mths
Temporary Dry Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Dry Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4177 hrs	$ 105	$ 196,000	2	4177 hrs	676 MWh	$ 438,568	$ 392,000	Day shift only, 12mths
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1099 hrs	$ 105	$ 196,000	1	1099 hrs	178 MWh	$ 115,413	$ 196,000	Day and night shift, 3mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1099 hrs	$ 105	$ 196,000	1	1099 hrs	178 MWh	$ 115,413	$ 196,000	Day and night shift, 3mths
Wet Storage Filling/Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	338 hrs	$ 105	$ 196,000	1	338 hrs	55 MWh	$ 35,512	$ 196,000	Day and night shift, 4 wks
Drying Area Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1099 hrs	$ 105	$ 196,000	2	1099 hrs	178 MWh	$ 115,413	$ 392,000	Day shift only, 3mths
Drying Area Tilling	Tractors	John Deere	5090E	90 hp	67 kW	471 hrs	$ 30	$ 58,750	2	471 hrs	32 MWh	$ 14,127	$ 117,500	Day shift only, 3mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	241 hrs	$ 55	$ 73,100	1	241 hrs	24 MWh	$ 13,273	$ 73,100	Once a week during wet months
Drying Area to Dry Stockpile	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	776 hrs	$ 120	$ 180,000	2	776 hrs	405 MWh	$ 93,176	$ 360,000	Day shift only, 3mths
Dry Stockpile Filling / Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4177 hrs	$ 105	$ 196,000	2	4177 hrs	676 MWh	$ 438,568	$ 392,000	Day shift only, 12mths
Dry Stockpile Filling / Unloading	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	3106 hrs	$ 120	$ 180,000	2	3106 hrs	1,619 MWh	$ 372,702	$ 360,000	Day shift only, 12mths

Equipment utilization 44%

Total Natural Gas	3	15,300 hrs	872 MMBtu	$ 6,767,496		
Total Electrical	3	15,300 hrs	2,909 MWh	$ 349,122	$ 1,200,000	
Total Gas/Diesel	17	20,761 hrs	4,695 MWh	$ 2,190,731	$ 2,870,600	
Total	23	51,361 hrs	7,604 MWh	$ 9,307,349	$ 4,070,600	

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B Mechanical Drying Equipment Southern Tunnels

Temporary Dry Stockpile Filling

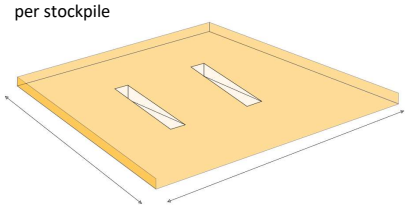
Volume of RTM to stockpile (ave.)	12,136	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	17.4	hours / day	
Total hours for operation per year	4,446	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Dry Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (ave.)	12,136	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	5	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	17.4	hours / day	
Total hours for operation per year	4,446	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Filling

Volume of RTM to be stockpiled per day (ave.)	2,555	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	18.4	hours / day	
Total hours for operation per year	1,170	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Volume of RTM to be stockpiled per day (ave.)	2,555	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	18.4	hours / day	
Total hours for operation per year	1,170	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wet Storage Filling/Emptying

Volume of RTM to be stockpiled per day (ave.)	2,555	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	18.4	hours / day	
Total hours for operation per year	360	hours / year	for 4wk operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Spreading

Volume of RTM to be spread per day (ave.)	2,555	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	18.4	hours / day	
Total hours for operation per year	1,170	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Tilling

Drying Area	38.0	acres	
No. of drying areas	1		
Total drying area	38.0	acres	
Tilling rate per machine	14.50	acres/hr/tractor	includes 80% capacity
Passes per day	3	times	
Working hours per day	10	hours	
Min. number of tractors required	1	tractors	
Additional contingency	1	tractor	
No. of tractors required	2	tractors	
Total hours at average excavation rate per day	7.9	hours / day	
Total hours for operation per year	501	hours / year	for 3mth operation

Example: John Deere 5090E (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area	38.0	acres	total drying area
Area	183,960	yd2	
Speed	6.8	mph	
Speed	11,968	yd/hr	
Area/hr	27,925	yd2/hr	
Efficiency	50	%	
Time to compact whole area	10	hrs	
Number of compactors required	1	compactors	to compact whole drying area in 1 day
Number of times to compact area per year	26	times/yr	assumed once a week for 6mths
Total hours for operation per year	257	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

Drying Area to Dry Stockpile

Volume of RTM to be moved per day (ave.)	2,427	yd3/day	dried volume
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	13.0	hours / day	
Total hours for operation per year	827	hours / year	for 3mth operation

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Dry Stockpile Filling / Unloading

Bulldozers

Volume of RTM to be stockpiled per day (ave.)	2,427	yd3/day	assume average excavation rate
No. of drying areas to be emptied per day	1		
Volume of RTM to be stockpiled per day	2,427	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers	2	bulldozers	
Total hours at average excavation rate per day	17.4	hours / day	
Total hours for operation per year	4,446	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wheel Loaders

Daily excavated volume per tunnel (ave.)	2,427	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	13.0	hours / day	
Total hours for operation per year	3,306	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Assume this will utilize the same equipment as for Drying Area to Dry Stockpile

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CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B Mechanical Drying Equipment Schedule Southern Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule - Thermal Dryers (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average and Peak Excavation Rate: Quantity	Total Hours / Year	Total Power / Year	Total Annual Operating Cost	Total Capital Cost	Notes
Thermal Drying - heat source	Thermal Dryers	Komline-Sanderson	K-S Paddle Dryer	32 MMBtu	9378 kW	40800 hrs	$ 7.76	$ 4,500,000	8	40800 hrs	1,306 MMBtu	$ 10,131,456	$ 36,000,000	Day and night shift, 12mths
Thermal Drying - motors	Thermal Dryers	Komline-Sanderson	K-S Paddle Dryer	250 hp	186 kW	40800 hrs	$ 120.00		8	40800 hrs	7,606 MWh	$ 912,737		Day and night shift, 12mths
Temporary Dry Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4446 hrs	$ 105	$ 196,000	1	4446 hrs	720 MWh	$ 466,880	$ 196,000	Day and night shift, 12mths
Temporary Dry Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Dry Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4446 hrs	$ 105	$ 196,000	2	4446 hrs	720 MWh	$ 466,880	$ 392,000	Day shift only, 12mths
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1170 hrs	$ 105	$ 196,000	1	1170 hrs	189 MWh	$ 122,863	$ 196,000	Day and night shift, 3mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1170 hrs	$ 105	$ 196,000	1	1170 hrs	189 MWh	$ 122,863	$ 196,000	Day and night shift, 3mths
Wet Storage Filling/Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	360 hrs	$ 105	$ 196,000	1	360 hrs	58 MWh	$ 37,804	$ 196,000	Day and night shift, 4 wks
Drying Area Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1170 hrs	$ 105	$ 196,000	2	1170 hrs	189 MWh	$ 122,863	$ 392,000	Day shift only, 3mths
Drying Area Tilling	Tractors	John Deere	5090E	90 hp	67 kW	501 hrs	$ 30	$ 58,750	2	501 hrs	34 MWh	$ 15,039	$ 117,500	Day shift only, 3mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	257 hrs	$ 55	$ 73,100	1	257 hrs	25 MWh	$ 14,130	$ 73,100	Once a week during wet months
Drying Area to Dry Stockpile	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	827 hrs	$ 120	$ 180,000	2	827 hrs	431 MWh	$ 99,191	$ 360,000	Day shift only, 3mths
Dry Stockpile Filling / Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4446 hrs	$ 105	$ 196,000	2	4446 hrs	720 MWh	$ 466,880	$ 392,000	Day shift only, 12mths
Dry Stockpile Filling / Unloading	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	3306 hrs	$ 120	$ 180,000	2	3306 hrs	1,723 MWh	$ 396,763	$ 360,000	Day shift only, 12mths

Equipment utilization 62%

Total Natural Gas	8	40,800 hrs	1,306 MMBtu	$ 10,131,456	
Total Electrical	8	40,800 hrs	7,606 MWh	$ 912,737	$ 36,000,000
Total Gas/Diesel	17	22,101 hrs	4,998 MWh	$ 2,332,157	$ 2,870,600
Total	33	103,701 hrs	12,604 MWh	$ 13,376,350	$ 38,870,600

Equipment Schedule - Rotary Dryers (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average and Peak Excavation Rate: Quantity	Total Hours / Year	Total Power / Year	Total Annual Operating Cost	Total Capital Cost	Notes
Rotary Drying - heat source	Rotary Dryers	Vulcan	Frac Sand Dryer	57 MMBtu	16705 kW	20400 hrs	$ 7.76	$ 400,000	3	20400 hrs	1,163 MMBtu	$ 9,023,328	$ 1,200,000	Day and night shift, 12mths
Rotary Drying - motors	Rotary Dryers	Vulcan	Frac Sand Dryer	255 hp	190 kW	20400 hrs	$ 120.00		3	20400 hrs	3,879 MWh	$ 465,496		Day and night shift, 12mths
Temporary Dry Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4446 hrs	$ 105	$ 196,000	1	4446 hrs	720 MWh	$ 466,880	$ 196,000	Day and night shift, 12mths
Temporary Dry Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Dry Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4446 hrs	$ 105	$ 196,000	2	4446 hrs	720 MWh	$ 466,880	$ 392,000	Day shift only, 12mths
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1170 hrs	$ 105	$ 196,000	1	1170 hrs	189 MWh	$ 122,863	$ 196,000	Day and night shift, 3mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1170 hrs	$ 105	$ 196,000	1	1170 hrs	189 MWh	$ 122,863	$ 196,000	Day and night shift, 3mths
Wet Storage Filling/Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	360 hrs	$ 105	$ 196,000	1	360 hrs	58 MWh	$ 37,804	$ 196,000	Day and night shift, 4 wks
Drying Area Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1170 hrs	$ 105	$ 196,000	2	1170 hrs	189 MWh	$ 122,863	$ 392,000	Day shift only, 3mths
Drying Area Tilling	Tractors	John Deere	5090E	90 hp	67 kW	501 hrs	$ 30	$ 58,750	2	501 hrs	34 MWh	$ 15,039	$ 117,500	Day shift only, 3mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	257 hrs	$ 55	$ 73,100	1	257 hrs	25 MWh	$ 14,130	$ 73,100	Once a week during wet months
Drying Area to Dry Stockpile	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	827 hrs	$ 120	$ 180,000	2	827 hrs	431 MWh	$ 99,191	$ 360,000	Day shift only, 3mths
Dry Stockpile Filling / Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4446 hrs	$ 105	$ 196,000	2	4446 hrs	720 MWh	$ 466,880	$ 392,000	Day shift only, 12mths
Dry Stockpile Filling / Unloading	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	3306 hrs	$ 120	$ 180,000	2	3306 hrs	1,723 MWh	$ 396,763	$ 360,000	Day shift only, 12mths

Equipment utilization 54%

Total Natural Gas	3	20,400 hrs	1,163 MMBtu	$ 9,023,328	
Total Electrical	3	20,400 hrs	3,879 MWh	$ 465,496	$ 1,200,000
Total Gas/Diesel	17	22,101 hrs	4,998 MWh	$ 2,332,157	$ 2,870,600
Total	23	62,901 hrs	8,877 MWh	$ 11,820,981	$ 4,070,600

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 3 B Transportation Calculations

Unit weight of RTM

Unit weight of in-situ RTM	120.00	lb/ft3	1.62	tons/yd3
Unit weight of wet excavated RTM	99.70	lb/ft3	1.35	tons/yd3
Unit weight of dry excavated RTM	95.00	lb/ft3	1.28	tons/yd3

Transportation Capacity

Road by weight (semi-end dump trucks)	18	tons / trip	semi end dump truck
Road by weight (bottom dump trucks)	20	tons / trip	bottom dump truck
Road by volume	18	yd3 / trip	based on one truck per trip
Rail by volume	1200	yd3 / trip	based on 60yd3 / car, 20 cars / train

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Trips required to move Wet Excavated RTM at average excavation rate - Main tunnels

Average excavation rate	2,400	yd3 / day	12,000	yd3 / week
Average excavation rate	3,230	tons / day	16,152	tons / week
Road (by weight)	180	trips / day	898	trips / week
Road (by volume)	134	trips / day	667	trips / week
Rail	3	trips / day	11	trips / week

Trips required to move Dry Excavated RTM at average excavation rate - Main tunnels

Average excavation rate	2,280	yd3 / day	11,400	yd3 / week
Average excavation rate	2,924	tons / day	14,621	tons / week
Road (by weight)	163	trips / day	813	trips / week
Road (by volume)	127	trips / day	634	trips / week
Rail	2	trips / day	10	trips / week

Trips required to move Dry Excavated RTM from Twin Cities to Southern Forebay

	Vol. to transport to SF	Weight to transport to SF	Road Trips	Rail Trips	Total Weeks
Central Alignment	2.3 m yd3	3.0 m tons	164,000	2,000	202
Eastern Alignment	1.7 m yd3	2.2 m tons	121,200	1,500	149

Attachment 4.4
RTM Calculations – 7,500cfs, 40ft ID Tunnel

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C RTM Volumes

Column Inputs	Internal Diameter	Tunnelling days / week	Tunnelling weeks / year	TBM Cutterhead Area	Bulking factor	Volume reduction due to drying	Full compaction factor	TBM Cutterhead Area	Bulking factor	Volume reduction due to drying	Full compaction factor
Northern tunnels ID	40.0 ft	5 days	51 wks	175 yd2	1.30	5.00 %	0.80	175 yd2	1.30	5.00 %	0.80
Main tunnels ID	40.0 ft	5 days	51 wks	175 yd2				175 yd2			
Southern tunnels ID	40.0 ft	5 days	51 wks	175 yd2				175 yd2			

Option	Element	Tunnel Length	Drive Options: Tunnel Drive	Drive Length	Drive Duration	TBM's	RTM Volume / Tunnel Length: In-Situ RTM Volume / Tunnel Length	Wet Excavated RTM Volume / Tunnel Length	Dry Excavated RTM Volume / Tunnel Length	Dry Compacted RTM Volume / Tunnel Length	RTM Volume / Shaft: Wet In-situ RTM Volume / Shaft	Wet Excavated RTM Volume / Shaft	Dry Excavated RTM Volume / Shaft	Dry Compacted RTM Volume / Shaft	RTM Volume / Tunnel Drive: Dry Compacted RTM Volume / Tunnel Drive	Ave. Quarterly Excavated Dry Compacted RTM Volume / Tunnel Drive
CENTRAL	Intake No. 2 Shaft		R													
	Northern Tunnel	2.110 mi	↑				651,395 yd3	846,814 yd3	804,473 yd3	643,578 yd3						
	Intake No. 3 Shaft		M													
	Northern Tunnel	2.550 mi	↑	10.300 mi	5.8 yrs		787,231 yd3	1,023,401 yd3	972,230 yd3	777,784 yd3					3,141,639 yd3	135,608 yd3
	Intake No. 5 Shaft		M													
	Northern Tunnel	5.640 mi	↑				1,741,170 yd3	2,263,521 yd3	2,150,345 yd3	1,720,276 yd3						
	Twin Cities Shaft (2)		L			2					7,659,296 yd3	9,957,085 yd3	9,459,231 yd3	7,567,385 yd3		
	Main Tunnel	4.250 mi	↓				1,312,052 yd3	1,705,668 yd3	1,620,384 yd3	1,296,307 yd3						
	New Hope Shaft		M													
	Main Tunnel	4.200 mi	↓	14.510 mi	7.8 yrs		1,296,616 yd3	1,685,601 yd3	1,601,321 yd3	1,281,057 yd3					4,425,746 yd3	141,702 yd3
	Staten Island Shaft		M													
	Main Tunnel	6.060 mi	↓				1,870,832 yd3	2,432,081 yd3	2,310,477 yd3	1,848,382 yd3						
	Bouldin Island Shaft		L/R			1					3,102,617 yd3	4,033,402 yd3	3,831,732 yd3	3,065,386 yd3		
	Main Tunnel	4.660 mi	↓				1,438,626 yd3	1,870,214 yd3	1,776,704 yd3	1,421,363 yd3						
	Mandeville Island Shaft		M	10.050 mi	5.1 yrs										3,065,386 yd3	151,035 yd3
	Main Tunnel	5.390 mi	↓				1,663,991 yd3	2,163,188 yd3	2,055,028 yd3	1,644,023 yd3						
	Bacon Island Shaft		R													
	Main Tunnel	5.760 mi	↑				1,778,216 yd3	2,311,681 yd3	2,196,097 yd3	1,756,878 yd3						
	Byron Tract Shaft		M	6.720 mi	4.6 yrs										2,049,691 yd3	112,265 yd3
	Main Tunnel	0.960 mi	↑				296,369 yd3	385,280 yd3	366,016 yd3	292,813 yd3						
	Southern Forebay (N+S) Shafts (4)		L			2					3,105,704 yd3	4,037,415 yd3	3,835,545 yd3	3,068,436 yd3		
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.6 yrs		1,031,118 yd3	1,340,454 yd3	1,273,431 yd3	1,018,745 yd3					1,018,745 yd3	96,232 yd3
	CA Aqueduct Shaft (2)		R													
	Total	44.92 mi	3	44.92 mi		5	13,867,617 yd3	18,027,902 yd3	17,126,507 yd3	13,701,206 yd3	13,867,617 yd3	18,027,902 yd3	17,126,507 yd3	13,701,206 yd3	13,701,206 yd3	636,842 yd3

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	In-Situ RTM Volume / Tunnel Length	Wet Excavated RTM Volume / Tunnel Length	Dry Excavated RTM Volume / Tunnel Length	Dry Compacted RTM Volume / Tunnel Length	Wet In-situ RTM Volume / Shaft	Wet Excavated RTM Volume / Shaft	Dry Excavated RTM Volume / Shaft	Dry Compacted RTM Volume / Shaft	Dry Compacted RTM Volume / Tunnel Drive	Ave. Quarterly Excavated Dry Compacted RTM Volume / Tunnel Drive
EASTERN	Intake No. 2 Shaft		R													
	Northern Tunnel	2.110 mi	↑				651,395 yd3	846,814 yd3	804,473 yd3	643,578 yd3						
	Intake No. 3 Shaft		M													
	Northern Tunnel	2.550 mi	↑	10.300 mi	5.8 yrs		787,231 yd3	1,023,401 yd3	972,230 yd3	777,784 yd3					3,141,639 yd3	135,608 yd3
	Intake No. 5 Shaft		M													
	Northern Tunnel	5.640 mi	↑				1,741,170 yd3	2,263,521 yd3	2,150,345 yd3	1,720,276 yd3						
	Twin Cities Shaft (2)		L			2					7,097,429 yd3	9,226,658 yd3	8,765,325 yd3	7,012,260 yd3		
	Main Tunnel	4.580 mi	↓				1,413,929 yd3	1,838,108 yd3	1,746,202 yd3	1,396,962 yd3						
	New Hope Shaft		M													
	Main Tunnel	3.000 mi	↓	12.690 mi	7.8 yrs		926,154 yd3	1,204,001 yd3	1,143,801 yd3	915,040 yd3					3,870,621 yd3	123,928 yd3
	Canal Ranch		M													
	Main Tunnel	5.110 mi	↓				1,577,550 yd3	2,050,814 yd3	1,948,274 yd3	1,558,619 yd3						
	Terminous Tract Shaft		R													
	Main Tunnel	3.940 mi	↑				1,216,349 yd3	1,581,254 yd3	1,502,191 yd3	1,201,753 yd3						
	King Island Shaft		M	9.500 mi	5.1 yrs										2,897,628 yd3	142,769 yd3
	Main Tunnel	5.560 mi	↑				1,716,473 yd3	2,231,414 yd3	2,119,844 yd3	1,695,875 yd3						
	Lower Roberts Island Shaft		L/R			1					2,932,822 yd3	3,812,669 yd3	3,622,035 yd3	2,897,628 yd3		
	Main Tunnel	5.180 mi	↑				1,599,160 yd3	2,078,908 yd3	1,974,962 yd3	1,579,970 yd3						
	Upper Jones Tract Shaft		M													
	Main Tunnel	5.650 mi	↑	11.790 mi	7.6 yrs		1,744,257 yd3	2,267,534 yd3	2,154,158 yd3	1,723,326 yd3					3,596,109 yd3	119,022 yd3
	Byron Tract		M													
	Main Tunnel	0.960 mi	↑				296,369 yd3	385,280 yd3	366,016 yd3	292,813 yd3						
	Southern Forebay (N+S) Shaft (4)		L			2					4,670,905 yd3	6,072,176 yd3	5,768,568 yd3	4,614,854 yd3		
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.1 yrs		1,031,118 yd3	1,340,454 yd3	1,273,431 yd3	1,018,745 yd3					1,018,745 yd3	123,947 yd3
	CA Aqueduct Shaft (2)		R													
	Total	47.62 mi	3	47.62 mi		5	14,701,156 yd3	19,111,503 yd3	18,155,928 yd3	14,524,742 yd3	14,701,156 yd3	19,111,503 yd3	18,155,928 yd3	14,524,742 yd3	14,524,742 yd3	645,274 yd3

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C RTM Volumes

Column Inputs	Internal Diameter	Tunnelling days / week	Tunnelling weeks / year
Northern tunnels ID	40.0 ft	5 days	51 wks
Main tunnels ID	40.0 ft	5 days	51 wks
Southern tunnels ID	40.0 ft	5 days	51 wks

Drive Options

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's
CENTRAL	Intake No. 2 Shaft		R			
	Northern Tunnel	2.110 mi	↑			
	Intake No. 3 Shaft		M			
	Northern Tunnel	2.550 mi	↑	10.300 mi	5.8 yrs	
	Intake No. 5 Shaft		M			
	Northern Tunnel	5.640 mi	↑			
	Twin Cities Shaft (2)		L			2
	Main Tunnel	4.250 mi	↓			
	New Hope Shaft		M			
	Main Tunnel	4.200 mi	↓	14.510 mi	7.8 yrs	
	Staten Island Shaft		M			
	Main Tunnel	6.060 mi	↓			
	Bouldin Island Shaft		L/R			1
	Main Tunnel	4.660 mi	↓			
	Mandeville Island Shaft		M	10.050 mi	5.1 yrs	
	Main Tunnel	5.390 mi	↓			
	Bacon Island Shaft		R			
	Main Tunnel	5.760 mi	↑			
	Byron Tract Shaft		M	6.720 mi	4.6 yrs	
	Main Tunnel	0.960 mi	↑			
	Southern Forebay (N+S) Shafts (4)		L			2
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.6 yrs	
	CA Aqueduct Shaft (2)		R			
	Total	44.92 mi	3	44.92 mi		5

Quarterly Dry Compacted RTM Volume Generated by Tunnel Drive (m yd3)

Start Quart.	HIDE	Y1				Y2				Y3				Y4				Y5				Y6				Y7				Y8				Y9				Y10				Y11				Y12				Y13				Y14			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
20	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.28	0.28	0.43	0.52	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.60	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.35	0.16	0.14	0.14	0.14	0.14	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's
EASTERN	Intake No. 2 Shaft		R			
	Northern Tunnel	2.110 mi	↑			
	Intake No. 3 Shaft		M			
	Northern Tunnel	2.550 mi	↑	10.300 mi	5.8 yrs	
	Intake No. 5 Shaft		M			
	Northern Tunnel	5.640 mi	↑			
	Twin Cities Shaft (2)		L			2
	Main Tunnel	4.580 mi	↓			
	New Hope Shaft		M			
	Main Tunnel	3.000 mi	↓	12.690 mi	7.8 yrs	
	Canal Ranch		M			
	Main Tunnel	5.110 mi	↓			
	Terminous Tract Shaft		R			
	Main Tunnel	3.940 mi	↑			
	King Island Shaft		M	9.500 mi	5.1 yrs	
	Main Tunnel	5.560 mi	↑			
	Lower Roberts Island Shaft		L/R			1
	Main Tunnel	5.180 mi	↑			
	Upper Jones Tract Shaft		M			
	Main Tunnel	5.650 mi	↑	11.790 mi	7.6 yrs	
	Byron Tract		M			
	Main Tunnel	0.960 mi	↑			
	Southern Forebay (N+S) Shaft (4)		L			2
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.1 yrs	
	CA Aqueduct Shaft (2)		R			
	Total	47.62 mi	3	47.62 mi		5

Start Quart.	HIDE	Y1				Y2				Y3				Y4				Y5				Y6				Y7				Y8				Y9				Y10				Y11				Y12				Y13				Y14			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
20	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.03	0.00	0.00
23	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.12	0.26	0.26	0.40	0.53	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.42	0.27	0.24	0.24	0.24	0.24	0.15	0.12	0.12	0.12	0.12	0.12	0.03	0.00	0.00

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C RTM Volumes

Column Inputs	Internal Diameter
Northern tunnels ID	40.0 ft
Main tunnels ID	40.0 ft
Southern tunnels ID	40.0 ft

Tunnelling days / week	Tunnelling weeks / year
5 days	51 wks
5 days	51 wks
5 days	51 wks

Drive Options

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's
CENTRAL	Intake No. 2 Shaft		R			
	Northern Tunnel	2.110 mi	↑			
	Intake No. 3 Shaft		M			
	Northern Tunnel	2.550 mi	↑	10.300 mi	5.8 yrs	
	Intake No. 5 Shaft		M			
	Northern Tunnel	5.640 mi	↑			
	Twin Cities Shaft (2)		L			2
	Main Tunnel	4.250 mi	↓			
	New Hope Shaft		M			
	Main Tunnel	4.200 mi	↓	14.510 mi	7.8 yrs	
	Staten Island Shaft		M			
	Main Tunnel	6.060 mi	↓			
	Bouldin Island Shaft		L/R			1
	Main Tunnel	4.660 mi	↓			
	Mandeville Island Shaft		M	10.050 mi	5.1 yrs	
	Main Tunnel	5.390 mi	↓			
	Bacon Island Shaft		R			
	Main Tunnel	5.760 mi	↑			
	Byron Tract Shaft		M	6.720 mi	4.6 yrs	
	Main Tunnel	0.960 mi	↑			
	Southern Forebay (N+S) Shafts (4)		L			2
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.6 yrs	
	CA Aqueduct Shaft (2)		R			
	Total	44.92 mi	3	44.92 mi		5

Quarterly Dry Compacted RTM Volume Generated at Each Shaft (m yd3)

Start	Y1				Y2				Y3				Y4				Y5				Y6				Y7				Y8				Y9				Y10				Y11				Y12				Y13				Y14			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
20																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.16	0.14	0.14	0.14	0.14	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.17	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.28	0.28	0.43	0.52	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.60	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.35	0.16	0.14	0.14	0.14	0.14	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF Only	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.5	0.7	0.9	1.1	1.3	1.6	1.8	2.0	2.1	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
TC + SF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.4	0.7	1.0	1.3	1.6	2.1	2.6	3.1	3.6	4.1	4.5	5.0	5.5	6.0	6.4	6.8	7.2	7.6	8.0	8.4	8.8	9.2	9.6	9.9	10.0	10.2	10.3	10.5	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6
All Shafts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.4	0.7	1.0	1.4	1.9	2.6	3.2	3.8	4.5	5.1	5.8	6.4	7.0	7.7	8.3	8.8	9.3	9.9	10.4	11.0	11.5	12.0	12.6	12.9	13.1	13.2	13.4	13.5	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's
EASTERN	Intake No. 2 Shaft		R			
	Northern Tunnel	2.110 mi	↑			
	Intake No. 3 Shaft		M			
	Northern Tunnel	2.550 mi	↑	10.300 mi	5.8 yrs	
	Intake No. 5 Shaft		M			
	Northern Tunnel	5.640 mi	↑			
	Twin Cities Shaft (2)		L			2
	Main Tunnel	4.580 mi	↓			
	New Hope Shaft		M			
	Main Tunnel	3.000 mi	↓	12.690 mi	7.8 yrs	
	Canal Ranch		M			
	Main Tunnel	5.110 mi	↓			
	Terminous Tract Shaft		R			
	Main Tunnel	3.940 mi	↑			
	King Island Shaft		M	9.500 mi	5.1 yrs	
	Main Tunnel	5.560 mi	↑			
	Lower Roberts Island Shaft		L/R			1
	Main Tunnel	5.180 mi	↑			
	Upper Jones Tract Shaft		M			
	Main Tunnel	5.650 mi	↑	11.790 mi	7.6 yrs	
	Byron Tract		M			
	Main Tunnel	0.960 mi	↑			
	Southern Forebay (N+S) Shaft (4)		L			2
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.1 yrs	
	CA Aqueduct Shaft (2)		R			
	Total	47.62 mi	3	47.62 mi		5

Start	Y1				Y2				Y3				Y4				Y5				Y6				Y7				Y8				Y9				Y10				Y11				Y12				Y13				Y14			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
20																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.12	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.15	0.12	0.12	0.12	0.12	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.15	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.03	0.00	0.00
23																																																									
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.12	0.26	0.26	0.40	0.53	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.42	0.27	0.24	0.24	0.24	0.24	0.15	0.12	0.12	0.12	0.12	0.12	0.03	0.00	0.00
SF Only	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.6	0.9	1.1	1.3	1.6	1.8	2.0	2.1	2.2	2.3	2.4	2.6	2.7	2.8	2.9	3.0	3.2	3.3	3.4	3.5	3.6	3.8	3.9	4.0	4.1	4.2	4.4	4.5	4.6	4.6	4.6	4.6
TC + SF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.1	5.5	5.8	6.2	6.6	7.0	7.3	7.7	8.1	8.5	8.9	9.2	9.6	9.9	10.1	10.4	10.6	10.9	11.0	11.1	11.2	11.4	11.5	11.6	11.6	11.6	11.6
All Shafts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.9	1.3	1.8	2.5	3.1	3.8	4.4	5.0	5.7	6.3	6.9	7.4	7.9	8.4	9.0	9.5	10.0	10.5	11.1	11.6	12.1	12.5	12.8	13.0	13.3	13.5	13.8	13.9	14.0	14.1	14.3	14.4	14.5	14.5	14.5	14.5

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C RTM Volumes

Column Inputs	Internal Diameter
Northern tunnels ID	40.0 ft
Main tunnels ID	40.0 ft
Southern tunnels ID	40.0 ft

Tunnelling days / week	Tunnelling weeks / year
5 days	51 wks
5 days	51 wks
5 days	51 wks

Working space / buffer
5 %

Working space / buffer
5 %

Full compaction factor	Working space / buffer
0.80	5 %

Drive Options

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	Area required to store all RTM at shafts Wet Excavated: Volume / Shaft	Storage Height	Area	Area required to store all RTM at shafts Dry Excavated: Volume / Shaft	Storage Height	Area	Area required to store all RTM at shafts Dry Fully Compacted: Volume / Shaft	Storage Height	Area
CENTRAL	Intake No. 2 Shaft		R												
	Northern Tunnel	2.110 mi	↑												
	Intake No. 3 Shaft		M												
	Northern Tunnel	2.550 mi	↑	10.300 mi	5.8 yrs										
	Intake No. 5 Shaft		M												
	Northern Tunnel	5.640 mi	↑												
	Twin Cities Shaft (2)		L			2	10.0 m yd3	8 ft	810 acres	9.5 m yd3	15 ft	410 acres	7.6 m yd3	15 ft	328 acres
	Main Tunnel	4.250 mi	↓												
	New Hope Shaft		M												
	Main Tunnel	4.200 mi	↓	14.510 mi	7.8 yrs										
	Staten Island Shaft		M												
	Main Tunnel	6.060 mi	↓												
	Bouldin Island Shaft		L/R			1	4.0 m yd3	8 ft	328 acres	3.8 m yd3	8 ft	312 acres	3.1 m yd3	8 ft	249 acres
	Main Tunnel	4.660 mi	↓												
	Mandeville Island Shaft		M	10.050 mi	5.1 yrs										
	Main Tunnel	5.390 mi	↓												
	Bacon Island Shaft		R												
	Main Tunnel	5.760 mi	↑												
	Byron Tract Shaft		M	6.720 mi	4.6 yrs										
	Main Tunnel	0.960 mi	↑												
	Southern Forebay (N+S) Shafts (4)		L			2	4.0 m yd3	8 ft	328 acres	3.8 m yd3	15 ft	166 acres	3.1 m yd3	15 ft	133 acres
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.6 yrs										
	CA Aqueduct Shaft (2)		R												
	Total	44.92 mi	3	44.92 mi		5	18.0 m yd3		1467 acres	17.1 m yd3		889 acres	13.7 m yd3		711 acres

Option	Element	Tunnel Length	Tunnel Drive	Drive Length	Drive Duration	TBM's	Volume / Shaft	Storage Height	Area	Volume / Shaft	Storage Height	Area	Volume / Shaft	Storage Height	Area
EASTERN	Intake No. 2 Shaft		R												
	Northern Tunnel	2.110 mi	↑												
	Intake No. 3 Shaft		M												
	Northern Tunnel	2.550 mi	↑	10.300 mi	5.8 yrs										
	Intake No. 5 Shaft		M												
	Northern Tunnel	5.640 mi	↑												
	Twin Cities Shaft (2)		L			2	9.2 m yd3	8 ft	751 acres	8.8 m yd3	15 ft	380 acres	7.0 m yd3	15 ft	304 acres
	Main Tunnel	4.580 mi	↓												
	New Hope Shaft		M												
	Main Tunnel	3.000 mi	↓	12.690 mi	7.8 yrs										
	Canal Ranch		M												
	Main Tunnel	5.110 mi	↓												
	Terminous Tract Shaft		R												
	Main Tunnel	3.940 mi	↑												
	King Island Shaft		M	9.500 mi	5.1 yrs										
	Main Tunnel	5.560 mi	↑												
	Lower Roberts Island Shaft		L/R			1	3.8 m yd3	8 ft	310 acres	3.6 m yd3	8 ft	295 acres	2.9 m yd3	8 ft	236 acres
	Main Tunnel	5.180 mi	↑												
	Upper Jones Tract Shaft		M												
	Main Tunnel	5.650 mi	↑	11.790 mi	7.6 yrs										
	Byron Tract		M												
	Main Tunnel	0.960 mi	↑												
	Southern Forebay (N+S) Shaft (4)		L			2	6.1 m yd3	8 ft	494 acres	5.8 m yd3	15 ft	250 acres	4.6 m yd3	15 ft	200 acres
	Southern Tunnels	3.340 mi	↓	3.340 mi	2.1 yrs										
	CA Aqueduct Shaft (2)		R												
	Total	47.62 mi	3	47.62 mi		5	19.1 m yd3		1555 acres	18.2 m yd3		925 acres	14.5 m yd3		740 acres

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C Stockpiles

Maximum allowable stockpile heights

Min. stockpile height at Twin Cities	10	ft	above grade
Max. stockpile height at Twin Cities	15	ft	above grade
Max. stockpile height at Bouldin Island	8	ft	above grade
Max. stockpile height at Lower Roberts	8	ft	above grade
Max. stockpile height at Southern Forebay	15	ft	above grade
Contingency	5	%	

Short term stockpiles (All RTM)

Central	Vol. of RTM to stockpile (yd3)	Area of temp. stockpile (acres)	Height of temp. stockpile (ft)
Twin Cities North	2,800,355	66	27.7
Twin Cities South	3,944,966	107	24.1
Bouldin Island	3,065,386	220	9.1
Southern Forebay North	2,049,691	156	8.6
Southern Forebay South	1,018,745	78	8.6

Eastern	Vol. of RTM to stockpile (yd3)	Area of temp. stockpile (acres)	Height of temp. stockpile (ft)
Twin Cities North	2,947,050	66	29.1
Twin Cities South	3,630,880	107	22.1
Lower Roberts	2,669,786	220	7.9
Southern Forebay North	3,596,109	182	12.9
Southern Forebay South	1,018,745	52	12.9

Notes

Twin Cities

Areas as shown on drawings

Bouldin Island and Lower Roberts

Same area used for short term and long term

see 'No Drying Annual Process' sheet.

Southern Forebay

Areas as shown on drawings

Long term stockpiles (Surplus RTM)

Central	Vol. of RTM to stockpile (yd3)	Area of perm. stockpile (acres)	Height of perm. stockpile (ft)
Twin Cities	6,073,783	264	15.0
Bouldin Island	2,452,308	220	6.9
Southern Forebay	-	234	0.0

Eastern	Vol. of RTM to stockpile (yd3)	Area of perm. stockpile (acres)	Height of perm. stockpile (ft)
Twin Cities	6,443,441	280	15.0
Lower Roberts	2,090,260	220	5.9
Southern Forebay	1,150,077	234	3.2

Notes

Twin Cities

Height limited to 15ft

Resulting area calculated

Bouldin Island and Lower Roberts

Same area used for short term and long term

see 'No Drying Annual Process' sheet.

Southern Forebay

Areas as shown on drawings

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Evaporation Calculation

California Irrigation Management Information System (CIMIS)

CIMIS Monthly Report

Rendered in ENGLISH Units.
April 2019 - March 2020
Printed on Wednesday, April 22, 2020

Holt - San Joaquin Valley - Station 248

Month Year	Total ETo (in)	Total Precip (in)	Avg Sol Rad (Ly/day)	Avg Vap Pres (mBars)	Avg Max Air Temp (°F)	Avg Min Air Temp (°F)	Avg Air Temp (°F)	Avg Max Rel Hum (%)	Avg Min Rel Hum (%)	Avg Rel Hum (%)	Avg Dew Point (°F)	Avg Wind Speed (mph)	Avg Soil Temp (°F)
Apr 2019	5.09	0.31	522 K	12.7 K	75.4 K	46.5	60.6 K	96	47	71 K	50.7 K	4.7 K	58.1
May 2019	5.86	1.88	570	12.9	76.3	47.6 K	61.6	95	46	69	51.0	4.9	60.5
Jun 2019	8.29 K	0.01	699	14.9 K	89.4 K	56.8 K	72.4 K	86	33	55 K	54.8 K	5.6 K	68.8
Jul 2019	8.35	0.00	680	15.5	90.4	57.2	73.3	85	34	56	56.3	5.5 K	69.2
Aug 2019	7.46	0.01	609	16.9 K	92.1 K	58.2 K	74.3 K	90	35	59 K	58.6 K	5.1 K	71.0
Sep 2019	5.60	0.12	503	15.1 K	86.6 K	55.6 K	70.2 K	89	35	60 K	55.4 K	5.3 K	67.7
Oct 2019	4.51	0.01	399 K	9.6 K	82.3 K	43.7 K	61.2 K	84	27	51 K	42.2 K	4.7 K	57.1 K
Nov 2019	2.31 K	0.57	252	9.1 K	72.3 K	38.3	52.8	95	38	67 K	41.6 K	3.9 K	50.8 K
Dec 2019	1.06	2.74	153	11.0 K	58.9	42.1	49.7 K	99	70	89 K	46.6 K	5.0 K	51.2
Tots/Avgs	48.53	5.6	487	13.1	80.4	49.4	64.0	91	41	64	50.8	5.0	61.6

Holt - San Joaquin Valley - Station 248

Month Year	Total ETo (in)	Total Precip (in)	Avg Sol Rad (Ly/day)	Avg Vap Pres (mBars)	Avg Max Air Temp (°F)	Avg Min Air Temp (°F)	Avg Air Temp (°F)	Avg Max Rel Hum (%)	Avg Min Rel Hum (%)	Avg Rel Hum (%)	Avg Dew Point (°F)	Avg Wind Speed (mph)	Avg Soil Temp (°F)
Jan 2020	1.26	0.98	188	10.4	58.4	38.2	47.5	100	72	92	45.3	4.1	49.9
Feb 2020	3.13	0.01	366 K	8.5	69.0 K	36.7	51.1	94	38	66	39.8	5.1 K	51.0
Mar 2020	3.58	1.19 K	404 K	10.1	66.0 K	41.4	53.0 K	96	50	74 K	44.5 K	5.0 K	55.5
Tots/Avgs	7.97	2.2	319	9.7	64.5	38.8	50.5	97	53	77	43.2	4.7	52.1

Flag Legend	
M - All Daily Values Missing	K - One or More Daily Values Flagged
J - One or More Daily Values Missing	L - Missing and Flagged Daily Values

Conversion Factors		
W/sq.m = Ly/day/2.065	inches * 25.4 = mm	(F-32) * 5/9 = c
	mBars * 0.1 = kPa	--

	Monthly evaporation	Monthly precipitation	Evaporation - precipitation	Consecutive 6mth adjusted evaporation
Apr	5.09 in	0.31 in	4.78 in	38.32 in
May	5.86 in	1.88 in	3.98 in	38.04 in
Jun	8.29 in	0.01 in	8.28 in	35.80 in
Jul	8.35 in	0.00 in	8.35 in	27.52 in
Aug	7.46 in	0.01 in	7.45 in	19.45 in
Sep	5.60 in	0.12 in	5.48 in	15.12 in
Oct	4.51 in	0.01 in	4.50 in	12.03 in
Nov	2.31 in	0.57 in	1.74 in	12.31 in
Dec	1.06 in	2.74 in	0.00 in	14.55 in
Jan	1.26 in	0.98 in	0.28 in	22.83 in
Feb	3.13 in	0.01 in	3.12 in	30.90 in
Mar	3.58 in	1.19 in	2.39 in	35.23 in
Apr	5.09 in	0.31 in	4.78 in	
May	5.86 in	1.88 in	3.98 in	
Jun	8.29 in	0.01 in	8.28 in	
Jul	8.35 in	0.00 in	8.35 in	
Aug	7.46 in	0.01 in	7.45 in	

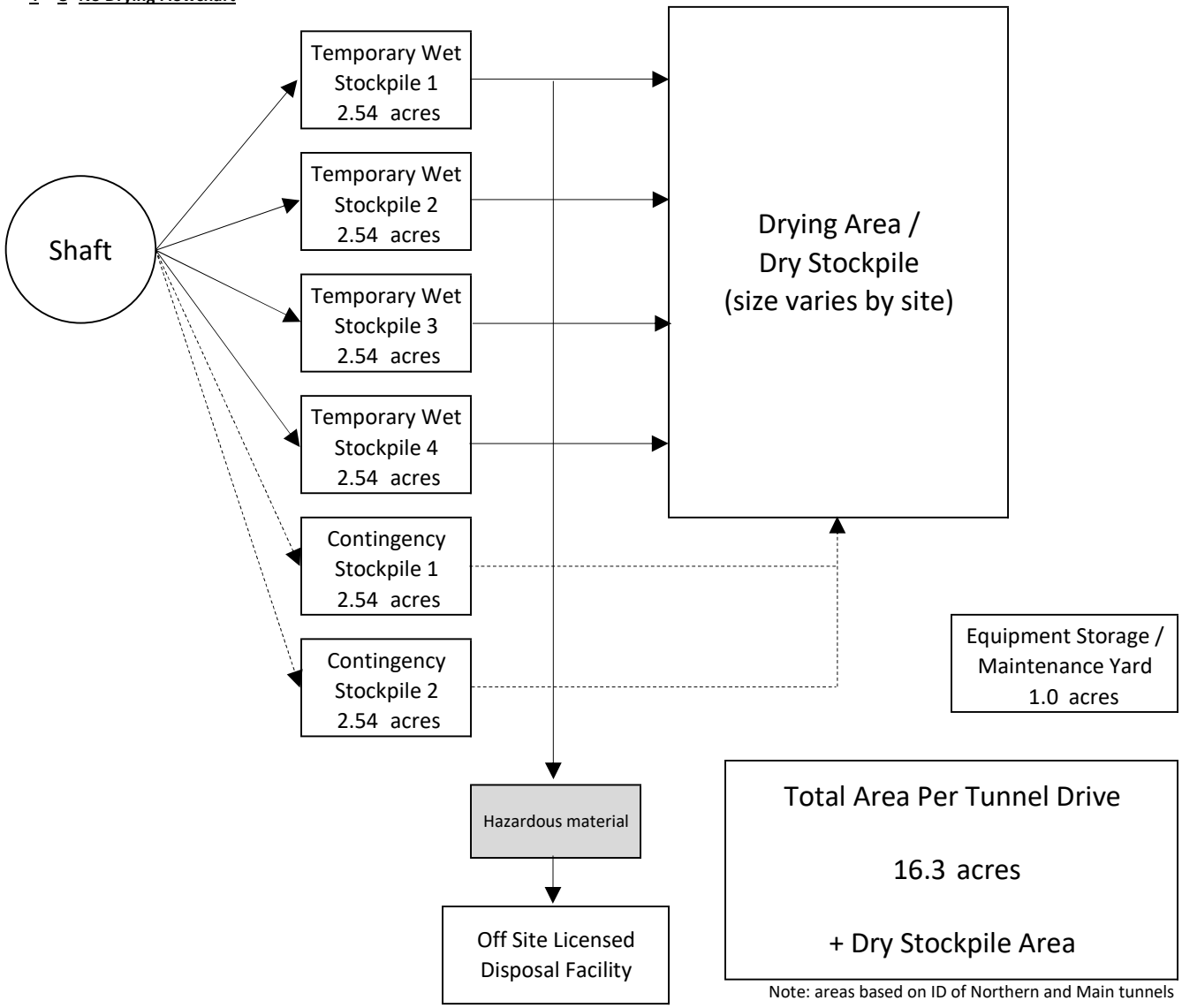
Max. continuous 6mth evaporation = 38.32 in
Average daily evaporation = 0.210 in
(Apr - Sept 2019)

Evaporation Rate

Vol. of water extracted during drying		1.65	gal/ft3	geotechnical calcs
Vol. of water extracted during drying	=	22.1%	of solids	conversion
Evaporation rate		0.210	in / day / area	from evaporation calc sheet
Evaporation rate	=	0.0175	ft / day / area	conversion
Evaporation rate	=	762.2	ft3 / day / acre	conversion
Height of drying stockpile		18.0	in	
Volume of 1 acre at 18 in high		65,340	ft3 / acre	
Volume of water to be removed from 1 acre		14,412	ft3 / acre	
Time required to dry 1 acre of RTM		18.91	days	regardless of area

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C No Drying Flowchart



Equipment Storage / Maintenance Yard 1.0 acres

Total Area Per Tunnel Drive

16.3 acres

+ Dry Stockpile Area

Note: areas based on ID of Northern and Main tunnels

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C No Drying Annual Process

Drying stockpile height per lift	18	in
Drying stockpile contingency	5	%
Tunnelling days / week	5	days / week
Tunnelling weeks / year	51	weeks / year
Wet season	7	months / year
Wet season	30	weeks / year

Season	Cell > / Area→ / Week↓	1 / 5.9	2 / 5.9	3 / 5.9	4 / 5.9	5 / 5.9	6 / 5.9	7 / 5.9	8 / 5.9	9 / 5.9	10 / 5.9	11 / 5.9	12 / 5.9	13 / 5.9	14 / 5.9	15 / 5.9	16 / 5.9	17 / 5.9	18 / 5.9	19 / 5.9	20 / 5.9	21 / 5.9	22 / 5.9	23 / 5.9	24 / 5.9	25 / 5.9	26 / 5.9	27 / 5.9	28 / 5.9	29 / 5.9	30 / 5.9	31 / 5.9	32 / 5.9	33 / 5.9	34 / 5.9	35 / 5.9	36 / 5.9	37 / 5.9	Spreading	Compacting
Wet	1	Hold	Hold	Hold	Fill	< wet season begins with 3 full cells from previous drying season																																	0	0
Wet	2	Hold	Hold	Hold	Hold	Fill																																	0	0
Wet	3	Hold	Hold	Hold	Hold	Hold	Fill																																0	0
Wet	4	Hold	Hold	Hold	Hold	Hold	Hold	Fill																															0	0
Wet	5	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																														0	0
Wet	6	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																													0	0
Wet	7	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																												0	0
Wet	8	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																											0	0
Wet	9	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																										0	0
Wet	10	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																									0	0
Wet	11	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																								0	0
Wet	12	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																							0	0
Wet	13	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																						0	0
Wet	14	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																					0	0
Wet	15	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																				0	0
Wet	16	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																			0	0
Wet	17	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																		0	0
Wet	18	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																	0	0
Wet	19	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill																0	0
Wet	20	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill															0	0
Wet	21	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill														0	0
Wet	22	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill													0	0
Wet	23	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill												0	0
Wet	24	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill											0	0
Wet	25	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill										0	0
Wet	26	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill									0	0
Wet	27	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill								0	0
Wet	28	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill							0	0
Wet	29	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill						0	0
Wet	30	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill					0	0
Dry	31	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Fill + Spread				3	0
Dry	32	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry	Fill + Spread			3	0
Dry	33	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry	Dry	Fill + Spread		3	0
Dry	34	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry + Compact	Dry	Dry	Fill + Spread	3	3
Dry	35	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold		Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Dry + Compact	Dry	Dry		3	3
Dry	36	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold			Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold		Dry + Compact	Dry		3	3
Dry	37	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold				Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold			Dry + Compact		3	3
Dry	38	Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold					Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold					3	3
Dry	39		Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold						Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold					3	3
Dry	40			Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold							Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold					3	3
Dry	41				Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold								Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold					3	3
Dry	42					Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold	Hold									Dry + Compact	Dry	Dry	Spread	Hold	Hold					3	3
Dry	43						Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold	Hold										Dry + Compact	Dry	Dry	Spread	Hold					3	3
Dry	44							Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold	Hold											Dry + Compact	Dry	Dry	Spread					3	3
Dry	45								Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold	Hold												Dry + Compact	Dry	Dry					2	3
Dry	46									Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold	Hold													Dry + Compact	Dry					2	3
Dry	47										Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold	Hold														Dry + Compact					2	3
Dry	48											Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread	Hold																				2	2
Dry	49												Dry + Compact	Dry	Dry	Fill + Spread	Dry + Compact	Dry	Dry	Spread																				2	2
Dry	50	Fill												Dry + Compact	Dry	Dry		Dry + Compact	Dry	Dry																				0	2
Dry	51	Hold	Fill												Dry + Compact	Dry			Dry + Compact	Dry																				0	2
Dry	52	Hold	Hold	Fill												Dry + Compact				Dry + Compact																				0	2

Permanent stockpile

Shaft site	Stockpile area (acres)	Total vol. of RTM (yd3)	Final height of stockpile (ft)	Equivalent annual lift (in)
Bouldin Island	220	2,452,308	6.9	24
Lower Roberts	220	2,090,260	5.9	24

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C No Drying Areas

Excavation Rates	Main Tunnels		Southern Tunnels	
Tunnel lining ID	40	ft	40	ft
TBM cutterhead area	1,579	ft2	1,579	ft2
TBM advance rate (ave.)	36	ft / day	36	ft / day
TBM advance rate (peak)	72	ft / day	72	ft / day
Daily in-situ rate of excavation per tunnel (ave.)	2,105	yd3 / day	2,105	yd3 / day
Daily in-situ rate of excavation per tunnel (peak)	4,210	yd3 / day	4,210	yd3 / day
Bulking factor	1.30		1.30	
Daily excavated volume per tunnel (ave.)	2,736	yd3 / day	2,736	yd3 / day
Daily excavated volume per tunnel (peak)	5,473	yd3 / day	5,473	yd3 / day
Estimated duration of peak excavation	21	days	21	days
Volume loss due to drying	5	%	5	%
Equivalent daily dry excavated volume per tunnel (ave.)	2,600	yd3 / day	2,600	yd3 / day
Equivalent daily dry excavated volume per tunnel (peak.)	5,199	yd3 / day	5,199	yd3 / day

Temporary Wet Stockpile Area	Main Tunnels		Southern Tunnels		
No. of days storage	5	days	5	days	one week of excavation
Volume of RTM to stockpile at peak excavation rate	27,364	yd3	27,364	yd3	per stockpile
Height of stockpile	10	ft	10	ft	short term
Contingency	50	%	50	%	inc. allowance for conveyor pits
Area required at peak excavation rate	2.54	acres	2.54	acres	per stockpile
No. of temporary stockpiles	6.0		6.0		
Total area of temporary stockpiles	15.3	acres	15.3	acres	

Equipment Storage / Maintenance Yard

Area required for equipment storage / maintenance yard 1.0 acres

Drying Area / Dry Stockpile

Varies by tunnel drive and option

No Drying Area Summary

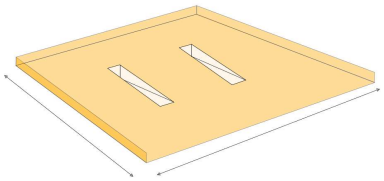
Alignment	Site	Tunnel Drive	Compacted RTM	Temporary Wet Stockpile 10 ft high	Equipment / Maintenance Yard	Total RTM Processing Area	Total RTM Processing Area	
Central	Twin Cities	North	3.1 m yd3	15.3 acres	1 acres	16 acres	33	acres
		South	4.4 m yd3	15.3 acres	1 acres	16 acres		
	Bouldin Island	South	1.4 m yd3	15.3 acres	1 acres	16 acres	16	acres
	Southern Forebay	North	2.0 m yd3	15.3 acres	1 acres	16 acres	33	acres
		South	1.0 m yd3	15.3 acres	1 acres	16 acres		
Eastern	Twin Cities	North	3.1 m yd3	15.3 acres	1 acres	16 acres	33	acres
		South	3.9 m yd3	15.3 acres	1 acres	16 acres		
	Lower Roberts Island	North	2.9 m yd3	15.3 acres	1 acres	16 acres	16	acres
	Southern Forebay	North	3.6 m yd3	15.3 acres	1 acres	16 acres	33	acres
		South	1.0 m yd3	15.3 acres	1 acres	16 acres		

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C No Drying Equipment Main Tunnels

Temporary Wet Stockpile Filling

Volume of RTM to stockpile (peak)	27,364	yd3	per stockpile as for Natural Drying
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	39.3	hours / day	
Total hours at average excavation rate per day	19.7	hours / day	
Total hours for operation per year	5,013	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (peak)	27,364	yd3	per stockpile as for Natural Drying
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	10	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	39.3	hours / day	
Total hours at average excavation rate per day	19.7	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	5,013	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area / Dry Stockpile Moving

Daily excavated volume per tunnel (peak)	2,736	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	7.3	hours / day	
Total hours for operation per year	1,864	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Drying Area / Dry Stockpile Spreading

Volume of RTM to be spread per cell	13,682	yd3 / cell	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	day shift only
Average cycle time per shove	5	mins	assumed
Efficiency	80	%	assumed
Number of bulldozers per cell	2	bulldozers / cell	
Max. number of cells to spread in one week	3	cells	
Number of bulldozers required	6	bulldozers	
Number of cells to spread per year	52	cells / year	
Total hours for operation per year	5,013	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area per cell	5.9	acres	
Area per cell	28,732	yd2	
Speed	6.8	mph	
Speed	11,968	yd / hr	
Area/hr	27,925	yd2 / hr	
Working hours per day	10	hours	
Efficiency	50	%	assumed
Number of passes	2	passes	assumed
Time to compact one cell	4.1	hrs / cell	
Max. number of cells to compact in one week	3	cells / week	
Number of compactors required	1	compactors	
Number of cells to compact per year	52	cells / year	
Total hours for operation per year	214	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C No Drying Equipment Schedule Main Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average Excavation Rate: Total Hours / Year	Average Excavation Rate: Total Power / Year	Average Excavation Rate: Total Annual Operating Cost	Peak Excavation Rate: Quantity	Peak Excavation Rate: Total Capital Cost	Notes
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	5013 hrs	$ 105	$ 196,000	5013 hrs	811 MWh	$ 526,337	2	$ 392,000	Day and night shift, 12mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0 hrs	- MWh	$ -	0	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	5013 hrs	$ 105	$ 196,000	5013 hrs	811 MWh	$ 526,337	4	$ 784,000	Day shift only, 12mths
Wet Stockpile Moving	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	1864 hrs	$ 120	$ 180,000	1864 hrs	971 MWh	$ 223,645	2	$ 360,000	Day shift only, 12mths
Wet Stockpile Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	5013 hrs	$ 105	$ 196,000	5013 hrs	811 MWh	$ 526,337	6	$ 1,176,000	Day shift only, 12mths
Wet Stockpile Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	214 hrs	$ 55	$ 73,100	214 hrs	21 MWh	$ 11,770	1	$ 73,100	One pass over full wet storage area
								Total Electrical	- hrs	- MWh	$ -	0	$ -	
								Total Gas/Diesel	17,116 hrs	3,426 MWh	$ 1,814,428	15	$ 2,785,100	
								Total	17,116 hrs	3,426 MWh	$ 1,814,428	15	$ 2,785,100	

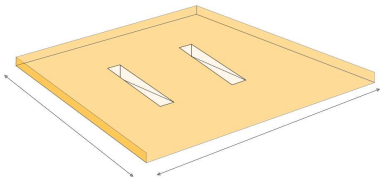
Equipment utilization 22%

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C No Drying Equipment Southern Tunnels

Temporary Wet Stockpile Filling

Volume of RTM to stockpile (peak)	27,364	yd3	per stockpile as for Natural Drying
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	39.3	hours / day	
Total hours at average excavation rate per day	19.7	hours / day	
Total hours for operation per year	5,013	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (peak)	27,364	yd3	per stockpile as for Natural Drying
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	10	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	39.3	hours / day	
Total hours at average excavation rate per day	19.7	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	5,013	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area / Dry Stockpile Moving

Daily excavated volume per tunnel (peak)	2,736	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	7.3	hours / day	
Total hours for operation per year	1,864	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Drying Area / Dry Stockpile Spreading

Volume of RTM to be spread per cell	13,682	yd3 / cell	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	day shift only
Average cycle time per shove	5	mins	assumed
Efficiency	80	%	assumed
Number of bulldozers per cell	2	bulldozers / cell	
Max. number of cells to spread in one week	3	cells	
Number of bulldozers required	6	bulldozers	
Number of cells to spread per year	52	cells / year	
Total hours for operation per year	5,013	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area per cell	5.9	acres	
Area per cell	28,732	yd2	
Speed	6.8	mph	
Speed	11,968	yd / hr	
Area/hr	27,925	yd2 / hr	
Working hours per day	10	hours	
Efficiency	50	%	assumed
Number of passes	2	passes	assumed
Time to compact one cell	4.1	hrs / cell	
Max. number of cells to compact in one week	3	cells / week	
Number of compactors required	1	compactors	
Number of cells to compact per year	52	cells / year	
Total hours for operation per year	214	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C No Drying Equipment Schedule Southern Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

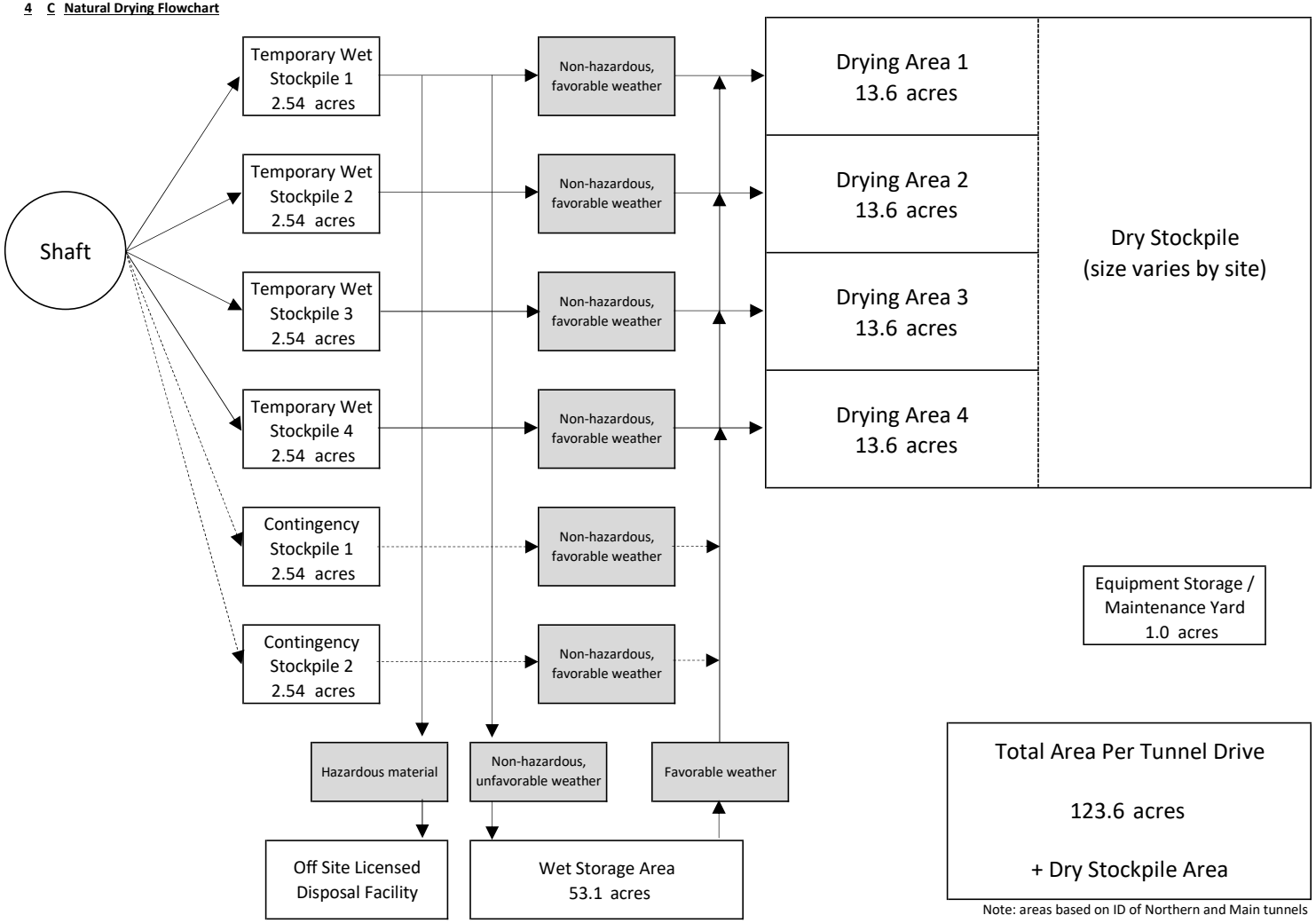
Equipment Schedule (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average Excavation Rate: Total Hours / Year	Average Excavation Rate: Total Power / Year	Average Excavation Rate: Total Annual Operating Cost	Peak Excavation Rate: Quantity	Peak Excavation Rate: Total Capital Cost	Notes
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	5013 hrs	$ 105	$ 196,000	5013 hrs	811 MWh	$ 526,337	2	$ 392,000	Day and night shift, 12mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0 hrs	- MWh	$ -	0	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	5013 hrs	$ 105	$ 196,000	5013 hrs	811 MWh	$ 526,337	4	$ 784,000	Day shift only, 12mths
Wet Stockpile Moving	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	1864 hrs	$ 120	$ 180,000	1864 hrs	971 MWh	$ 223,645	2	$ 360,000	Day shift only, 12mths
Wet Stockpile Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	5013 hrs	$ 105	$ 196,000	5013 hrs	811 MWh	$ 526,337	6	$ 1,176,000	Day shift only, 12mths
Wet Stockpile Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	214 hrs	$ 55	$ 73,100	214 hrs	21 MWh	$ 11,770	1	$ 73,100	One pass over full wet storage area
								Total Electrical	- hrs	- MWh	$ -	0	$ -	
								Total Gas/Diesel	17,116 hrs	3,426 MWh	$ 1,814,428	15	$ 2,785,100	
								Total	17,116 hrs	3,426 MWh	$ 1,814,428	15	$ 2,785,100	

Equipment utilization 22%

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C Natural Drying Flowchart



Equipment Storage / Maintenance Yard 1.0 acres

Total Area Per Tunnel Drive

123.6 acres

+ Dry Stockpile Area

Note: areas based on ID of Northern and Main tunnels

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C Natural Drying Areas

Excavation Rates	Main Tunnels		Southern Tunnels	
Tunnel lining ID	40	ft	40	ft
TBM cutterhead area	1,579	ft2	1,579	ft2
TBM advance rate (ave.)	36	ft / day	36	ft / day
TBM advance rate (peak)	72	ft / day	72	ft / day
Daily in-situ rate of excavation per tunnel (ave.)	2,105	yd3 / day	2,105	yd3 / day
Daily in-situ rate of excavation per tunnel (peak)	4,210	yd3 / day	4,210	yd3 / day
Bulking factor	1.30		1.30	
Daily excavated volume per tunnel (ave.)	2,736	yd3 / day	2,736	yd3 / day
Daily excavated volume per tunnel (peak)	5,473	yd3 / day	5,473	yd3 / day
Estimated duration of peak excavation	21	days	21	days
Volume loss due to drying	5	%	5	%
Equivalent daily dry excavated volume per tunnel (ave.)	2,600	yd3 / day	2,600	yd3 / day
Equivalent daily dry excavated volume per tunnel (peak.)	5,199	yd3 / day	5,199	yd3 / day

Temporary Wet Stockpile Area	Main Tunnels		Southern Tunnels		
No. of days storage	5	days	5	days	
Volume of RTM to stockpile at peak excavation rate	27,364	yd3	27,364	yd3	per stockpile
Height of stockpile	10	ft	10	ft	short term
Contingency	50	%	50	%	includes allowance for conveyor pits
Area required at peak excavation rate	2.54	acres	2.54	acres	per stockpile
No. of temporary stockpiles	6.0		6.0		
Total area of temporary stockpiles	15.3	acres	15.3	acres	

Drying Area	Main Tunnels		Southern Tunnels		
Volume of RTM to dry per stockpile	27,364	yd3	27,364	yd3	equivalent to 1 wk RTM at peak excavation
Contingency	20	%	20	%	
Height of stockpile	18.0	in	18.0	in	
Area required at peak excavation rate	13.6	acres	13.6	acres	per drying area
No. of drying areas	4.0		4.0		
Total area of drying areas	54.3	acres	54.3	acres	

Wet Storage Area	Main Tunnels		Southern Tunnels		
Period of wet weather	6	mths	6	mths	continuous storage
No. of days storage	130	days	130	days	based on working days
Volume of RTM to store at ave. excavation rate	356,705	yd3	356,705	yd3	
Height of stockpile	5.0	ft	5.0	ft	long term
Contingency	20	%	20	%	
Area required	53.1	acres	53.1	acres	

Equipment Storage / Maintenance Yard		
Area required for equipment storage / maintenance yard	1.0	acres

Permanent Stockpile		
Contingency	5	%

Natural Drying Area Summary

Alignment	Site	Tunnel Drive	Dry Partially Compacted RTM	Temporary Wet Stockpile 10 ft high	Drying Area 18 in high	Wet Storage 5 ft high	Equipment / Maintenance Yard	Total RTM Processing Area	Total RTM Processing Area	
Central	Twin Cities	North	3.1 m yd3	15.3 acres	54 acres	53 acres	1 acres	124 acres	247	acres
		South	4.4 m yd3	15.3 acres	54 acres	53 acres	1 acres	124 acres		
	Bouldin Island	South	3.1 m yd3	15.3 acres	54 acres	53 acres	1 acres	124 acres	124	acres
	Southern Forebay	North	2.0 m yd3	15.3 acres	54 acres	53 acres	1 acres	124 acres	247	acres
		South	1.0 m yd3	15.3 acres	54 acres	53 acres	1 acres	124 acres		
Eastern	Twin Cities	North	3.1 m yd3	15.3 acres	54 acres	53 acres	1 acres	124 acres	247	acres
		South	3.9 m yd3	15.3 acres	54 acres	53 acres	1 acres	124 acres		
	Lower Roberts Island	North	2.9 m yd3	15.3 acres	54 acres	53 acres	1 acres	124 acres	124	acres
	Southern Forebay	North	3.6 m yd3	15.3 acres	54 acres	53 acres	1 acres	124 acres	247	acres
		South	1.0 m yd3	15.3 acres	54 acres	53 acres	1 acres	124 acres		

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C Natural Drying Equipment Main Tunnels

Temporary Wet Stockpile Filling

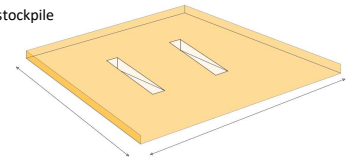
Volume of RTM to stockpile (peak)	27,364	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	39.3	hours / day	
Total hours at average excavation rate per day	19.7	hours / day	
Total hours for operation per year	5,013	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (peak)	27,364	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	10	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	39.3	hours / day	
Total hours at average excavation rate per day	19.7	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	5,013	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Spreading

Volume of RTM to be spread per day (peak)	2,736	yd3/day	per drying area
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	39.3	hours / day	
Total hours at average excavation rate per day	19.7	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	5,013	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Tilling

Drying Area	13.6	acres	per drying area
No. of drying areas	4.0		
Total drying area	54.3	acres	
Tilling rate per machine	14.50	acres/hr/tractor	includes 80% capacity
Passes per day	3	times	
Working hours per day	10	hours	
Min. number of tractors required	2	tractors	
Additional contingency	1	tractor	
No. of tractors required	3	tractors	
Total hours at average excavation rate per day	11.2	hours / day	
Total hours for operation per year	2,863	hours / year	

Example: John Deere 5090E (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area	54.3	acres	total drying area
Area	262,691	yd2	
Speed	6.8	mph	
Speed	11,968	yd/hr	
Area/hr	27,925	yd2/hr	
Efficiency	50	%	
Time to compact whole area	14	hrs	
Number of compactors required	2	compactors	to compact whole drying area in 1 day
Number of times to compact area per year	26	times/yr	assumed once a week for 6mths
Total hours for operation per year	367	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

Drying Area Piling

Volume of RTM to be piling per day (ave.)	2,600	yd3/day	dried volume, per drying area
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	37.3	hours / day	
Total hours for operation per year	9,524	hours / year	2 stockpiles emptied at any one time

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area to Dry Stockpile

Volume of RTM to be moved per day (ave.)	2,600	yd3/day	per drying area
Scraper capacity	24.00	yd3 / scraper	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of scrapers required	2	scrapers	
Total hours at average excavation rate per day	22.6	hours / day	
Total hours for operation per year	5,754	hours / year	2 stockpiles emptied at any one time

Example: Caterpillar 637K, Capacity = 24yd3 (see equipment schedule for details)

Wet Storage Stockpiling

Volume of RTM to be stockpiled per day	2,209	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	assuming bulldozers already on project site
Working hours per day	10	hours	
Average cycle time per shove	10	mins	
Efficiency	80	%	
Number of bulldozers required	4	bulldozers	
Total hours per day	31.7	hours / day	
Total hours for operation per year	4,046	hours / year	for 6mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

During peak excavation there will be 6 bulldozers operating in the various temporary stockpiles.
The wet stockpile will only be emptied when the excavation is below peak.
At average excavation there will be 3 bulldozers available for this operation.

Dry Stockpile Filling / Unloading

Bulldozers

Volume of RTM to be stockpiled per day per drying area (ave.)	2,600	yd3/day	per drying area
No. of drying areas to be emptied per day	2		
Volume of RTM to be stockpiled per day	5,199	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers	4	bulldozers	
Total hours at average excavation rate per day	37.3	hours / day	
Total hours for operation per year	9,524	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wheel Loaders

Daily excavated volume per tunnel (ave.)	2,600	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	13.9	hours / day	
Total hours for operation per year	3,541	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C Natural Drying Equipment Schedule Main Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average Excavation Rate: Total Hours / Year	Average Excavation Rate: Total Power / Year	Average Excavation Rate: Total Annual Operating Cost	Peak Excavation Rate: Quantity	Peak Excavation Rate: Total Capital Cost	Notes
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	5013 hrs	$ 105	$ 196,000	5013 hrs	811 MWh	$ 526,337	2	$ 392,000	Day and night shift, 12mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0 hrs	- MWh	$ -	0	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	5013 hrs	$ 105	$ 196,000	5013 hrs	811 MWh	$ 526,337	4	$ 784,000	Day shift only, 12mths
Drying Areas Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	5013 hrs	$ 105	$ 196,000	5013 hrs	811 MWh	$ 526,337	4	$ 784,000	Day shift only, 12mths
Drying Areas Tilling	Tractors	John Deere	5090E	90 hp	67 kW	2863 hrs	$ 30	$ 58,750	2863 hrs	192 MWh	$ 85,904	3	$ 176,250	Day shift only, 12mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	367 hrs	$ 55	$ 73,100	367 hrs	36 MWh	$ 20,178	2	$ 146,200	Once a week during wet months
Drying Areas Piling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	9524 hrs	$ 105	$ 196,000	9524 hrs	1,541 MWh	$ 1,000,041	4	$ 784,000	Day shift only, 12mths
Drying Area to Dry Stockpile	Scrapers	Caterpiller	637K	570 hp	425 kW	5754 hrs	$ 150	$ 905,000	5754 hrs	2,446 MWh	$ 863,131	4	$ 3,620,000	Day shift only, 12mths
Wet Storage Stockpiling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4046 hrs	$ 105	$ 196,000	4046 hrs	655 MWh	$ 424,841	0	$ -	Day shift only, 6mths
Dry Stockpile Filling/Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	9524 hrs	$ 105	$ 196,000	9524 hrs	1,541 MWh	$ 1,000,041	4	$ 784,000	Day shift only, 12mths
Dry Stockpile Filling/Unloading	Wheel Loaders	Caterpiller	990K	699 hp	521 kW	3541 hrs	$ 120	$ 180,000	3541 hrs	1,846 MWh	$ 424,926	2	$ 360,000	Day shift only, 12mths
								Total Electrical	- hrs	- MWh	$ -	0	$ -	
								Total Gas/Diesel	50,658 hrs	10,690 MWh	$ 5,398,074	29	$ 7,830,450	
								Total	50,658 hrs	10,690 MWh	$ 5,398,074	29	$ 7,830,450	

Equipment utilization 34%

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C Natural Drying Equipment Southern Tunnels

Temporary Wet Stockpile Filling

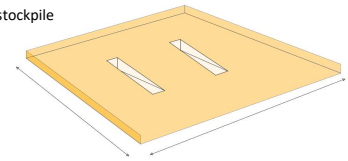
Volume of RTM to stockpile (peak)	27,364	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	39.3	hours / day	
Total hours at average excavation rate per day	19.7	hours / day	
Total hours for operation per year	5,013	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (peak)	27,364	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	10	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	39.3	hours / day	
Total hours at average excavation rate per day	19.7	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	5,013	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Spreading

Volume of RTM to be spread per day (peak)	2,736	yd3/day	per drying area
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
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Number of bulldozers required	2	bulldozers	
Total hours at peak excavation rate per day	39.3	hours / day	
Total hours at average excavation rate per day	19.7	hours / day	2 stockpiles emptied at any one time
Total hours for operation per year	5,013	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Tilling

Drying Area	13.6	acres	per drying area
No. of drying areas	4.0		
Total drying area	54.3	acres	
Tilling rate per machine	14.50	acres/hr/tractor	includes 80% capacity
Passes per day	3	times	
Working hours per day	10	hours	
Min. number of tractors required	2	tractors	
Additional contingency	1	tractor	
No. of tractors required	3	tractors	
Total hours at average excavation rate per day	11.2	hours / day	
Total hours for operation per year	2,863	hours / year	

Example: John Deere 5090E (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area	54.3	acres	total drying area
Area	262,691	yd2	
Speed	6.8	mph	
Speed	11,968	yd/hr	
Area/hr	27,925	yd2/hr	
Efficiency	50	%	
Time to compact whole area	14	hrs	
Number of compactors required	2	compactors	to compact whole drying area in 1 day
Number of times to compact area per year	26	times/yr	assumed once a week for 6mths
Total hours for operation per year	367	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

Drying Area Piling

Volume of RTM to be piling per day (ave.)	2,600	yd3/day	dried volume, per drying area
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	37.3	hours / day	
Total hours for operation per year	9,524	hours / year	2 stockpiles emptied at any one time

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area to Dry Stockpile

Volume of RTM to be moved per day (ave.)	2,600	yd3/day	per drying area
Scraper capacity	24.00	yd3 / scraper	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of scrapers required	2	scrapers	
Total hours at average excavation rate per day	22.6	hours / day	
Total hours for operation per year	5,754	hours / year	2 stockpiles emptied at any one time

Example: Caterpillar 637K, Capacity = 24yd3 (see equipment schedule for details)

Wet Storage Stockpiling

Volume of RTM to be stockpiled per day	2,209	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	assuming bulldozers already on project site
Working hours per day	10	hours	
Average cycle time per shove	10	mins	
Efficiency	80	%	
Number of bulldozers required	4	bulldozers	
Total hours per day	31.7	hours / day	
Total hours for operation per year	4,046	hours / year	for 6mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

During peak excavation there will be 6 bulldozers operating in the various temporary stockpiles.
The wet stockpile will only be emptied when the excavation is below peak.
At average excavation there will be 3 bulldozers available for this operation.

Dry Stockpile Filling / Unloading

Bulldozers

Volume of RTM to be stockpiled per day per drying area (ave.)	2,600	yd3/day	per drying area
No. of drying areas to be emptied per day	2		
Volume of RTM to be stockpiled per day	5,199	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers	4	bulldozers	
Total hours at average excavation rate per day	37.3	hours / day	
Total hours for operation per year	9,524	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wheel Loaders

Daily excavated volume per tunnel (ave.)	2,600	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	13.9	hours / day	
Total hours for operation per year	3,541	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C Natural Drying Equipment Schedule Southern Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average Excavation Rate: Total Hours / Year	Average Excavation Rate: Total Power / Year	Average Excavation Rate: Total Annual Operating Cost	Peak Excavation Rate: Quantity	Peak Excavation Rate: Total Capital Cost	Notes
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	5013 hrs	$ 105	$ 196,000	5013 hrs	811 MWh	$ 526,337	2	$ 392,000	Day and night shift, 12mths
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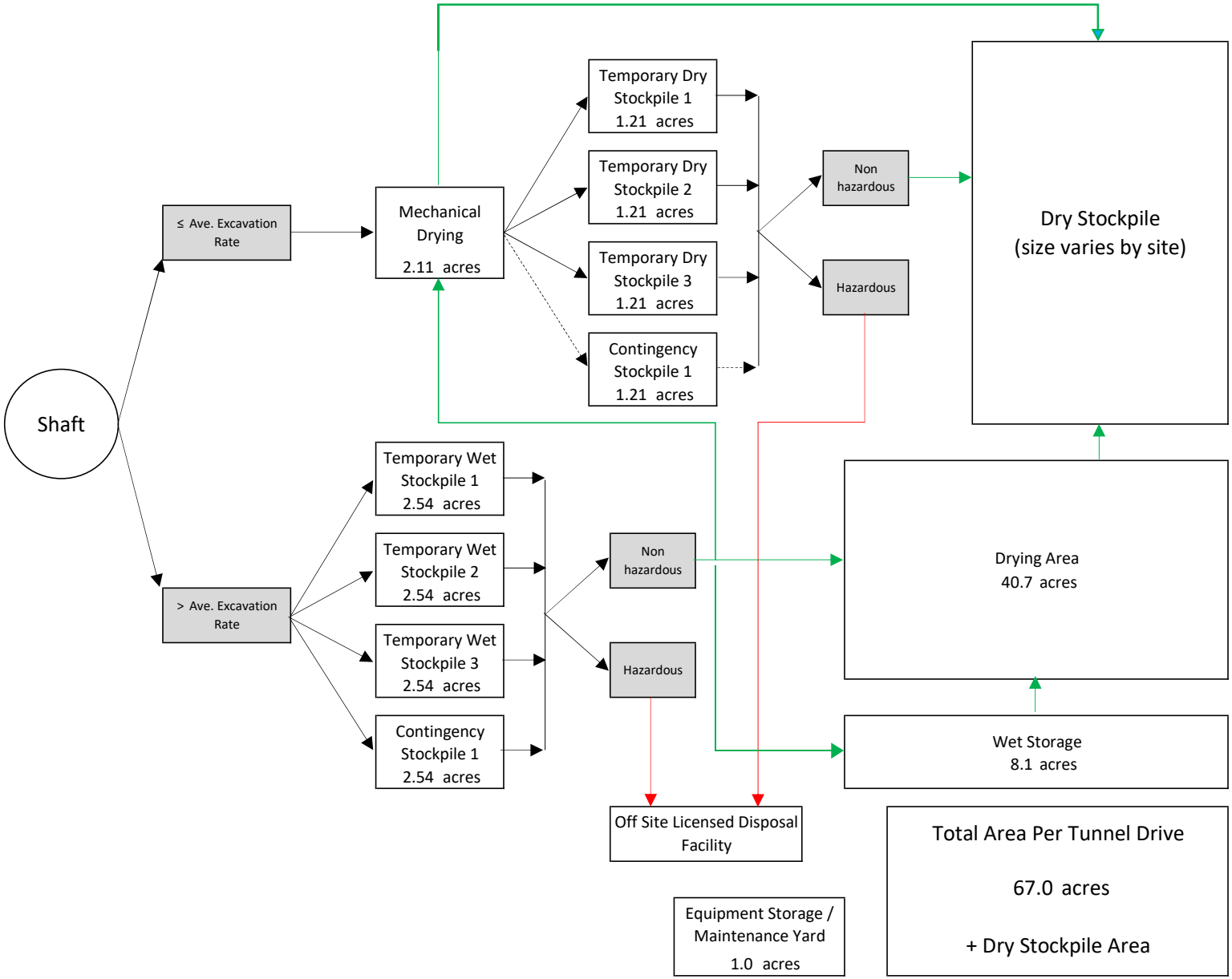
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	5013 hrs	$ 105	$ 196,000	5013 hrs	811 MWh	$ 526,337	4	$ 784,000	Day shift only, 12mths
Drying Areas Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	5013 hrs	$ 105	$ 196,000	5013 hrs	811 MWh	$ 526,337	4	$ 784,000	Day shift only, 12mths
Drying Areas Tilling	Tractors	John Deere	5090E	90 hp	67 kW	2863 hrs	$ 30	$ 58,750	2863 hrs	192 MWh	$ 85,904	3	$ 176,250	Day shift only, 12mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	367 hrs	$ 55	$ 73,100	367 hrs	36 MWh	$ 20,178	2	$ 146,200	Once a week during wet months
Drying Areas Piling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	9524 hrs	$ 105	$ 196,000	9524 hrs	1,541 MWh	$ 1,000,041	4	$ 784,000	Day shift only, 12mths
Drying Area to Dry Stockpile	Scrapers	Caterpiller	637K	570 hp	425 kW	5754 hrs	$ 150	$ 905,000	5754 hrs	2,446 MWh	$ 863,131	4	$ 3,620,000	Day shift only, 12mths
Wet Storage Stockpiling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4046 hrs	$ 105	$ 196,000	4046 hrs	655 MWh	$ 424,841	0	$ -	Day shift only, 6mths
Dry Stockpile Filling/Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	9524 hrs	$ 105	$ 196,000	9524 hrs	1,541 MWh	$ 1,000,041	4	$ 784,000	Day shift only, 12mths
Dry Stockpile Filling/Unloading	Wheel Loaders	Caterpiller	990K	699 hp	521 kW	3541 hrs	$ 120	$ 180,000	3541 hrs	1,846 MWh	$ 424,926	2	$ 360,000	Day shift only, 12mths
								Total Electrical	- hrs	- MWh	$ -	0	$ -	
								Total Gas/Diesel	50,658 hrs	10,690 MWh	$ 5,398,074	29	$ 7,830,450	
								Total	50,658 hrs	10,690 MWh	$ 5,398,074	29	$ 7,830,450	

Equipment utilization 34%

CA Delta Conveyance Tunnel - RTM Calculations

Option 4 C Mechanical Drying Flowchart



Note: areas based on ID of Northern and Main tunnels

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C Mechanical Drying Areas

Excavation rates	Main Tunnels		Southern Tunnels	
Tunnel lining ID	40	ft	40	ft
TBM cutterhead area	1,579	ft2	1,579	ft2
TBM advance rate (ave.)	36	ft / day	36	ft / day
TBM advance rate (peak)	72	ft / day	72	ft / day
Rate of in-situ material excavation per tunnel (ave.)	2,105	yd3 / day	2,105	yd3 / day
Rate of in-situ material excavation per tunnel (peak)	4,210	yd3 / day	4,210	yd3 / day
Bulking factor	1.30		1.30	
Excavated rate of material per tunnel drive (ave.)	2,736	yd3 / day	2,736	yd3 / day
Excavated rate of material per tunnel drive (peak)	5,473	yd3 / day	5,473	yd3 / day
Estimated duration of peak excavation	21	days	21	days
Volume loss due to drying	5	%	5	%
Equivalent daily dry excavated volume per tunnel (ave.)	2,600	yd3 / day	2,600	yd3 / day
Equivalent daily dry excavated volume per tunnel (peak.)	5,199	yd3 / day	5,199	yd3 / day

Mechanical Drying Area

Inputs

Unit weight of soil entering dryer	100	lb/ft3
Unit weight of soil entering dryer	2,692	lb/yd3
Unit weight of soil produced per day (ave.)	184	tons/hr
Working hours per day	20	hours
Working hours per year	5,100	hours

Option 1 - Thermal Drying

Equipment details (Note this is one possible option presented as an example)

Manufacturer	Komline-Sanderson				
Machine	K-S Paddle Dryer				
Model	16W-3200				
Capacity	70,000	lb/hr	=	520	yd3 / day
Length	16,822	mm	=	55.2	ft
Width	3,835	mm	=	12.6	ft
Height	4,273	mm	=	14.0	ft
Weight	102,058	kg	=	112.5	tons
Power for heat source	32	MMBtu/hr		9,378	kWh
Power for motors	250	hp		186	kW
Estimated capital cost	$ 4,500,000				

Option 2 - Rotary Drying

Equipment details (Note this is one possible option presented as an example)

Manufacturer	Vulcan Drying Systems					
Machine	Frac Sand Dryer					
Model	(Customized)					
Capacity	196,000	lb/hr	=	1,456	yd3 / day	
Length	22,860	mm	=	75.0	ft	assumed
Width	9,144	mm	=	30.0	ft	assumed
Height	6,096	mm	=	20.0	ft	assumed
Weight	90,718	kg	=	100.0	tons	assumed
Power for heat source	57	MMBtu/hr		16,705	kWh	
Power for motors	255	hp		190	kW	
Estimated capital cost	$ 400,000					

Assumptions

Clear space required around each dryer	3	ft
Efficiency / redundancy	85	%

Assumptions

Clear space required around each dryer	3	ft
Efficiency / redundancy	85	%

Option 1 - Thermal Drying	Main Tunnels		Southern Tunnels		per tunnel drive, average excavation rates
Min. quantity required	7		7		
Additional contingency	2		2		
Quantity required	9		9		
Total weight of equipment	1,013	tons	1,013	tons	
Area required	10,233	yd2	10,233	yd2	
Area required	2.11	acres	2.11	acres	

Option 2 - Rotary Drying	Main Tunnels		Southern Tunnels		per tunnel drive, average excavation rates
Min. quantity required	3		3		assumes all drying systems of same size
Additional contingency	1		1		- dryers can be custom made for desired quantity
Quantity required	4		4		
Total weight of equipment	400	tons	400	tons	
Area required	11,664	yd2	11,664	yd2	
Area required	2.41	acres	2.41	acres	

Temporary Dry Stockpile Area	Main Tunnels		Southern Tunnels		
No. of days storage	5	days	5	days	assuming 5 days of excavation at ave. rate in a 7 day cycle
Volume of RTM to stockpile at average excavation rate	12,998	yd3	12,998	yd3	
Height of stockpile	10	ft	10	ft	short term
Contingency	50	%	50	%	includes allowance for conveyor pits
Area required	1.21	acres	1.21	acres	per stockpile
No. of temporary stockpiles	4.0		4.0		3 active + 1 contingency
Total area of temporary stockpiles	4.8	acres	4.8	acres	

Temporary Wet Stockpile Area	Main Tunnels		Southern Tunnels		
No. of days storage	5	days	5	days	assuming 5 days of excavation at ave. rate in a 7 day cycle
Volume of RTM to stockpile at peak excavation rate	13,682	yd3	13,682	yd3	per stockpile = 1wks worth at average excavation rate
Height of stockpile	5	ft	5	ft	long term
Contingency	50	%	50	%	includes allowance for conveyor pits
Area required	2.54	acres	2.54	acres	
No. of temporary stockpiles	4.0		4.0		3wks of average excavation + 1wks contingency
Total area of temporary stockpiles	10.2	acres	10.2	acres	

(Temporary Wet Stockpile + Wet Storage + Drying Area = 13wks = 3mths)

Wet Storage Area	Main Tunnels		Southern Tunnels		
Volume of RTM to store	54,727	yd3	54,727	yd3	4wks of average excavation
Height of stockpile	5	ft	5	ft	long term
Contingency	20	%	20	%	
Area required	8.1	acres	8.1	acres	

(Temporary Wet Stockpile + Wet Storage + Drying Area = 13wks = 3mths)

Drying Area	Main Tunnels		Southern Tunnels		
Volume of RTM to dry at any one time	82,091	yd3	82,091	yd3	6wks of average excavation
Height of stockpile	18.0	in	18.0	in	
Contingency	20	%	20	%	
Area required	40.7	acres	40.7	acres	

(Temporary Wet Stockpile + Wet Storage + Drying Area = 13wks = 3mths)

Equipment Storage / Maintenance Yard

Area required for equipment storage / maintenance yard 1.0 acres

Dry Stockpile

Note the dry stockpile area is based on the requirements for Option 3 as shown on the drawings, except for Option 4 which requires a larger area.
Contingency 5 %

Mechanical Drying Area Summary

Alignment	Site	Tunnel Drive	Dry Partially Compacted RTM	Mechanical Drying Area	Temporary Dry Stockpile 10 ft high	Temporary Wet Stockpile 5 ft high	Wet Storage 5 ft high	Drying Area 18 in high	Equipment / Maintenance Yard	Total RTM Processing Area	Total RTM Processing Area
Central	Twin Cities	North	3.1 m yd3	2.4 acres	4.8 acres	10.2 acres	8.1 acres	40.7 acres	1 acres	67 acres	135 acres
		South	4.4 m yd3	2.4 acres	4.8 acres	10.2 acres	8.1 acres	40.7 acres	1 acres	67 acres	
	Bouldin Island	South	3.1 m yd3	2.4 acres	4.8 acres	10.2 acres	8.1 acres	40.7 acres	1 acres	67 acres	67 acres
	Southern Forebay	North	2.0 m yd3	2.4 acres	4.8 acres	10.2 acres	8.1 acres	40.7 acres	1 acres	67 acres	135 acres
		South	1.0 m yd3	2.4 acres	4.8 acres	10.2 acres	8.1 acres	40.7 acres	1 acres	67 acres	
Eastern	Twin Cities	North	3.1 m yd3	2.4 acres	4.8 acres	10.2 acres	8.1 acres	40.7 acres	1 acres	67 acres	135 acres
		South	3.9 m yd3	2.4 acres	4.8 acres	10.2 acres	8.1 acres	40.7 acres	1 acres	67 acres	
	Lower Roberts Island	North	2.9 m yd3	2.4 acres	4.8 acres	10.2 acres	8.1 acres	40.7 acres	1 acres	67 acres	67 acres
	Southern Forebay	North	3.6 m yd3	2.4 acres	4.8 acres	10.2 acres	8.1 acres	40.7 acres	1 acres	67 acres	135 acres
		South	1.0 m yd3	2.4 acres	4.8 acres	10.2 acres	8.1 acres	40.7 acres	1 acres	67 acres	

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Option 4 C Mechanical Drying Equipment Main Tunnels

Temporary Dry Stockpile Filling

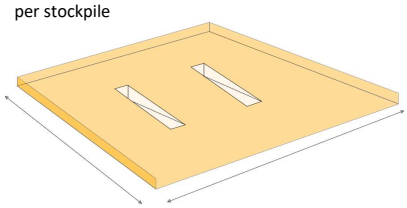
Volume of RTM to stockpile (ave.)	12,998	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	18.7	hours / day	
Total hours for operation per year	4,762	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Dry Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (ave.)	12,998	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	5	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	18.7	hours / day	
Total hours for operation per year	4,762	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Filling

Volume of RTM to be stockpiled per day (ave.)	2,736	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	19.7	hours / day	
Total hours for operation per year	1,253	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Volume of RTM to be stockpiled per day (ave.)	2,736	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	19.7	hours / day	
Total hours for operation per year	1,253	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wet Storage Filling/Emptying

Volume of RTM to be stockpiled per day (ave.)	2,736	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	19.7	hours / day	
Total hours for operation per year	386	hours / year	for 4wk operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Spreading

Volume of RTM to be spread per day (ave.)	2,736	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	19.7	hours / day	
Total hours for operation per year	1,253	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Tilling

Drying Area	40.7	acres	
No. of drying areas	1		
Total drying area	40.7	acres	
Tilling rate per machine	14.50	acres/hr/tractor	includes 80% capacity
Passes per day	3	times	
Working hours per day	10	hours	
Min. number of tractors required	1	tractors	
Additional contingency	1	tractor	
No. of tractors required	2	tractors	
Total hours at average excavation rate per day	8.4	hours / day	
Total hours for operation per year	537	hours / year	for 3mth operation

Example: John Deere 5090E (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area	40.7	acres	total drying area
Area	197,018	yd2	
Speed	6.8	mph	
Speed	11,968	yd/hr	
Area/hr	27,925	yd2/hr	
Efficiency	50	%	
Time to compact whole area	11	hrs	
Number of compactors required	2	compactors	to compact whole drying area in 1 day
Number of times to compact area per year	26	times/yr	assumed once a week for 6mths
Total hours for operation per year	275	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

Drying Area to Dry Stockpile

Volume of RTM to be moved per day (ave.)	2,600	yd3/day	dried volume
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	13.9	hours / day	
Total hours for operation per year	885	hours / year	for 3mth operation

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Dry Stockpile Filling / Unloading

Bulldozers

Volume of RTM to be stockpiled per day (ave.)	2,600	yd3/day	assume average excavation rate
No. of drying areas to be emptied per day	1		
Volume of RTM to be stockpiled per day	2,600	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers	2	bulldozers	
Total hours at average excavation rate per day	18.7	hours / day	
Total hours for operation per year	4,762	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wheel Loaders

Daily excavated volume per tunnel (ave.)	2,600	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	13.9	hours / day	
Total hours for operation per year	3,541	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Assume this will utilize the same equipment as for Drying Area to Dry Stockpile

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CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C Mechanical Drying Equipment Schedule Main Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule - Thermal Dryers (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average and Peak Excavation Rate: Quantity	Total Hours / Year	Total Power / Year	Total Annual Operating Cost	Total Capital Cost	Notes
Thermal Drying - heat source	Thermal Dryers	Komline-Sanderson	K-S Paddle Dryer	32 MMBtu	9378 kW	45900 hrs	$ 7.76	$ 4,500,000	9	45900 hrs	1,469 MMBtu	$ 11,397,888	$ 40,500,000	Day and night shift, 12mths
Thermal Drying - motors	Thermal Dryers	Komline-Sanderson	K-S Paddle Dryer	250 hp	186 kW	45900 hrs	$ 120.00		9	45900 hrs	8,557 MWh	$ 1,026,829		Day and night shift, 12mths
Temporary Dry Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4762 hrs	$ 105	$ 196,000	1	4762 hrs	771 MWh	$ 500,021	$ 196,000	Day and night shift, 12mths
Temporary Dry Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Dry Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4762 hrs	$ 105	$ 196,000	2	4762 hrs	771 MWh	$ 500,021	$ 392,000	Day shift only, 12mths
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1253 hrs	$ 105	$ 196,000	1	1253 hrs	203 MWh	$ 131,584	$ 196,000	Day and night shift, 3mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1253 hrs	$ 105	$ 196,000	1	1253 hrs	203 MWh	$ 131,584	$ 196,000	Day and night shift, 3mths
Wet Storage Filling/Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	386 hrs	$ 105	$ 196,000	1	386 hrs	62 MWh	$ 40,487	$ 196,000	Day and night shift, 4 wks
Drying Area Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1253 hrs	$ 105	$ 196,000	2	1253 hrs	203 MWh	$ 131,584	$ 392,000	Day shift only, 3mths
Drying Area Tilling	Tractors	John Deere	5090E	90 hp	67 kW	537 hrs	$ 30	$ 58,750	2	537 hrs	36 MWh	$ 16,107	$ 117,500	Day shift only, 3mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	275 hrs	$ 55	$ 73,100	2	275 hrs	27 MWh	$ 15,133	$ 146,200	Once a week during wet months
Drying Area to Dry Stockpile	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	885 hrs	$ 120	$ 180,000	2	885 hrs	461 MWh	$ 106,231	$ 360,000	Day shift only, 3mths
Dry Stockpile Filling / Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4762 hrs	$ 105	$ 196,000	2	4762 hrs	771 MWh	$ 500,021	$ 392,000	Day shift only, 12mths
Dry Stockpile Filling / Unloading	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	3541 hrs	$ 120	$ 180,000	2	3541 hrs	1,846 MWh	$ 424,926	$ 360,000	Day shift only, 12mths

Equipment utilization 63%

Total Natural Gas	9	45,900 hrs	1,469 MMBtu	$ 11,397,888	
Total Electrical	9	45,900 hrs	8,557 MWh	$ 1,026,829	$ 40,500,000
Total Gas/Diesel	18	23,670 hrs	5,353 MWh	$ 2,497,700	$ 2,943,700
Total	36	115,470 hrs	13,910 MWh	$ 14,922,417	$ 43,443,700

Equipment Schedule - Rotary Dryers (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average and Peak Excavation Rate: Quantity	Total Hours / Year	Total Power / Year	Total Annual Operating Cost	Total Capital Cost	Notes
Rotary Drying - heat source	Rotary Dryers	Vulcan	Frac Sand Dryer	57 MMBtu	16705 kW	20400 hrs	$ 7.76	$ 400,000	4	20400 hrs	1,163 MMBtu	$ 9,023,328	$ 1,600,000	Day and night shift, 12mths
Rotary Drying - motors	Rotary Dryers	Vulcan	Frac Sand Dryer	255 hp	190 kW	20400 hrs	$ 120.00		4	20400 hrs	3,879 MWh	$ 465,496		Day and night shift, 12mths
Temporary Dry Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4762 hrs	$ 105	$ 196,000	1	4762 hrs	771 MWh	$ 500,021	$ 196,000	Day and night shift, 12mths
Temporary Dry Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Dry Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4762 hrs	$ 105	$ 196,000	2	4762 hrs	771 MWh	$ 500,021	$ 392,000	Day shift only, 12mths
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1253 hrs	$ 105	$ 196,000	1	1253 hrs	203 MWh	$ 131,584	$ 196,000	Day and night shift, 3mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1253 hrs	$ 105	$ 196,000	1	1253 hrs	203 MWh	$ 131,584	$ 196,000	Day and night shift, 3mths
Wet Storage Filling/Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	386 hrs	$ 105	$ 196,000	1	386 hrs	62 MWh	$ 40,487	$ 196,000	Day and night shift, 4 wks
Drying Area Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1253 hrs	$ 105	$ 196,000	2	1253 hrs	203 MWh	$ 131,584	$ 392,000	Day shift only, 3mths
Drying Area Tilling	Tractors	John Deere	5090E	90 hp	67 kW	537 hrs	$ 30	$ 58,750	2	537 hrs	36 MWh	$ 16,107	$ 117,500	Day shift only, 3mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	275 hrs	$ 55	$ 73,100	2	275 hrs	27 MWh	$ 15,133	$ 146,200	Once a week during wet months
Drying Area to Dry Stockpile	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	885 hrs	$ 120	$ 180,000	2	885 hrs	461 MWh	$ 106,231	$ 360,000	Day shift only, 3mths
Dry Stockpile Filling / Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4762 hrs	$ 105	$ 196,000	2	4762 hrs	771 MWh	$ 500,021	$ 392,000	Day shift only, 12mths
Dry Stockpile Filling / Unloading	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	3541 hrs	$ 120	$ 180,000	2	3541 hrs	1,846 MWh	$ 424,926	$ 360,000	Day shift only, 12mths

Equipment utilization 49%

Total Natural Gas	4	20,400 hrs	1,163 MMBtu	$ 9,023,328	
Total Electrical	4	20,400 hrs	3,879 MWh	$ 465,496	$ 1,600,000
Total Gas/Diesel	18	23,670 hrs	5,353 MWh	$ 2,497,700	$ 2,943,700
Total	26	64,470 hrs	9,232 MWh	$ 11,986,524	$ 4,543,700

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C Mechanical Drying Equipment Southern Tunnels

Temporary Dry Stockpile Filling

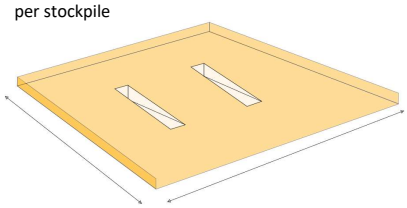
Volume of RTM to stockpile (ave.)	12,998	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for filling temporary stockpile	5	days	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	18.7	hours / day	
Total hours for operation per year	4,762	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Dry Stockpile Emptying

Assume two conveyor pits in the center of the temporary stockpile each to be loaded from both sides.

Volume of RTM to stockpile (ave.)	12,998	yd3	per stockpile
Bulldozer capacity	14.50	yd3 / bulldozer	
Target time for emptying temporary stockpile	5	days	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	18.7	hours / day	
Total hours for operation per year	4,762	hours / year	



Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Filling

Volume of RTM to be stockpiled per day (ave.)	2,736	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	19.7	hours / day	
Total hours for operation per year	1,253	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Temporary Wet Stockpile Emptying

Volume of RTM to be stockpiled per day (ave.)	2,736	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	19.7	hours / day	
Total hours for operation per year	1,253	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wet Storage Filling/Emptying

Volume of RTM to be stockpiled per day (ave.)	2,736	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	20	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	1	bulldozers	
Total hours at average excavation rate per day	19.7	hours / day	
Total hours for operation per year	386	hours / year	for 4wk operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Spreading

Volume of RTM to be spread per day (ave.)	2,736	yd3/day	half of peak excavation
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers required	2	bulldozers	
Total hours at average excavation rate per day	19.7	hours / day	
Total hours for operation per year	1,253	hours / year	for 3mth operation

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Drying Area Tilling

Drying Area	40.7	acres	
No. of drying areas	1		
Total drying area	40.7	acres	
Tilling rate per machine	14.50	acres/hr/tractor	includes 80% capacity
Passes per day	3	times	
Working hours per day	10	hours	
Min. number of tractors required	1	tractors	
Additional contingency	1	tractor	
No. of tractors required	2	tractors	
Total hours at average excavation rate per day	8.4	hours / day	
Total hours for operation per year	537	hours / year	for 3mth operation

Example: John Deere 5090E (see equipment schedule for details)

Drying Area Compacting

Roller width	84	in	
Roller width	2.33	yd	
Area	40.7	acres	total drying area
Area	197,018	yd2	
Speed	6.8	mph	
Speed	11,968	yd/hr	
Area/hr	27,925	yd2/hr	
Efficiency	50	%	
Time to compact whole area	11	hrs	
Number of compactors required	2	compactors	to compact whole drying area in 1 day
Number of times to compact area per year	26	times/yr	assumed once a week for 6mths
Total hours for operation per year	275	hours / year	

Example: Caterpillar, CS54B, Capacity = 84in roller at 6.8mph (see equipment schedule for details)

Drying Area to Dry Stockpile

Volume of RTM to be moved per day (ave.)	2,600	yd3/day	dried volume
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	13.9	hours / day	
Total hours for operation per year	885	hours / year	for 3mth operation

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Dry Stockpile Filling / Unloading

Bulldozers

Volume of RTM to be stockpiled per day (ave.)	2,600	yd3/day	assume average excavation rate
No. of drying areas to be emptied per day	1		
Volume of RTM to be stockpiled per day	2,600	yd3/day	
Bulldozer capacity	14.50	yd3 / bulldozer	
Working hours per day	10	hours	
Average cycle time per shove	5	mins	
Efficiency	80	%	
Number of bulldozers	2	bulldozers	
Total hours at average excavation rate per day	18.7	hours / day	
Total hours for operation per year	4,762	hours / year	

Example: Komatsu, D65EX-18 WH, Capacity = 14.5yd3 (see equipment schedule for details)

Wheel Loaders

Daily excavated volume per tunnel (ave.)	2,600	yd3 / day	to be moved per day
Wheel Loader capacity	19.50	yd3 / wheel loader	
Working hours per day	10	hours	
Average cycle time	5	mins	
Efficiency	80	%	
Number of wheel loaders	2	wheel loaders	
Total hours at average excavation rate per day	13.9	hours / day	
Total hours for operation per year	3,541	hours / year	

Example: Caterpillar, 990K, Capacity = 19.5yd3 (see equipment schedule for details)

Assume this will utilize the same equipment as for Drying Area to Dry Stockpile

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CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C Mechanical Drying Equipment Schedule Southern Tunnels

Working Hours / Year

Day shift only

Hours / day	10	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	2550	hours

Day and night shift

Hours / day	20	hours
Days / week	5	days
Weeks / year	51	weeks
Total hours / year	5100	hours

Equipment Schedule - Thermal Dryers (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average and Peak Excavation Rate: Quantity	Total Hours / Year	Total Power / Year	Total Annual Operating Cost	Total Capital Cost	Notes
Thermal Drying - heat source	Thermal Dryers	Komline-Sanderson	K-S Paddle Dryer	32 MMBtu	9378 kW	45900 hrs	$ 7.76	$ 4,500,000	9	45900 hrs	1,469 MMBtu	$ 11,397,888	$ 40,500,000	Day and night shift, 12mths
Thermal Drying - motors	Thermal Dryers	Komline-Sanderson	K-S Paddle Dryer	250 hp	186 kW	45900 hrs	$ 120.00		9	45900 hrs	8,557 MWh	$ 1,026,829		Day and night shift, 12mths
Temporary Dry Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4762 hrs	$ 105	$ 196,000	1	4762 hrs	771 MWh	$ 500,021	$ 196,000	Day and night shift, 12mths
Temporary Dry Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Dry Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4762 hrs	$ 105	$ 196,000	2	4762 hrs	771 MWh	$ 500,021	$ 392,000	Day shift only, 12mths
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1253 hrs	$ 105	$ 196,000	1	1253 hrs	203 MWh	$ 131,584	$ 196,000	Day and night shift, 3mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1253 hrs	$ 105	$ 196,000	1	1253 hrs	203 MWh	$ 131,584	$ 196,000	Day and night shift, 3mths
Wet Storage Filling/Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	386 hrs	$ 105	$ 196,000	1	386 hrs	62 MWh	$ 40,487	$ 196,000	Day and night shift, 4 wks
Drying Area Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1253 hrs	$ 105	$ 196,000	2	1253 hrs	203 MWh	$ 131,584	$ 392,000	Day shift only, 3mths
Drying Area Tilling	Tractors	John Deere	5090E	90 hp	67 kW	537 hrs	$ 30	$ 58,750	2	537 hrs	36 MWh	$ 16,107	$ 117,500	Day shift only, 3mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	275 hrs	$ 55	$ 73,100	2	275 hrs	27 MWh	$ 15,133	$ 146,200	Once a week during wet months
Drying Area to Dry Stockpile	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	885 hrs	$ 120	$ 180,000	2	885 hrs	461 MWh	$ 106,231	$ 360,000	Day shift only, 3mths
Dry Stockpile Filling / Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4762 hrs	$ 105	$ 196,000	2	4762 hrs	771 MWh	$ 500,021	$ 392,000	Day shift only, 12mths
Dry Stockpile Filling / Unloading	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	3541 hrs	$ 120	$ 180,000	2	3541 hrs	1,846 MWh	$ 424,926	$ 360,000	Day shift only, 12mths

Equipment utilization 63%

Total Natural Gas	9	45,900 hrs	1,469 MMBtu	$ 11,397,888		
Total Electrical	9	45,900 hrs	8,557 MWh	$ 1,026,829	$ 40,500,000	
Total Gas/Diesel	18	23,670 hrs	5,353 MWh	$ 2,497,700	$ 2,943,700	
Total	36	115,470 hrs	13,910 MWh	$ 14,922,417	$ 43,443,700	

Equipment Schedule - Rotary Dryers (per tunnel drive)

Operation	Equipment	Manufacturer	Model	Power	Power	Hours / Year / Operation	Hourly Operating Cost	Capital Cost	Average and Peak Excavation Rate: Quantity	Total Hours / Year	Total Power / Year	Total Annual Operating Cost	Total Capital Cost	Notes
Rotary Drying - heat source	Rotary Dryers	Vulcan	Frac Sand Dryer	57 MMBtu	16705 kW	20400 hrs	$ 7.76	$ 400,000	4	20400 hrs	1,163 MMBtu	$ 9,023,328	$ 1,600,000	Day and night shift, 12mths
Rotary Drying - motors	Rotary Dryers	Vulcan	Frac Sand Dryer	255 hp	190 kW	20400 hrs	$ 120.00		4	20400 hrs	3,879 MWh	$ 465,496		Day and night shift, 12mths
Temporary Dry Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4762 hrs	$ 105	$ 196,000	1	4762 hrs	771 MWh	$ 500,021	$ 196,000	Day and night shift, 12mths
Temporary Dry Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Dry Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4762 hrs	$ 105	$ 196,000	2	4762 hrs	771 MWh	$ 500,021	$ 392,000	Day shift only, 12mths
Temporary Wet Stockpiles Filling	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1253 hrs	$ 105	$ 196,000	1	1253 hrs	203 MWh	$ 131,584	$ 196,000	Day and night shift, 3mths
Temporary Wet Stockpiles Testing	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	0 hrs	$ 105	$ 196,000	0	0 hrs	- MWh	$ -	$ -	No activity
Temporary Wet Stockpiles Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1253 hrs	$ 105	$ 196,000	1	1253 hrs	203 MWh	$ 131,584	$ 196,000	Day and night shift, 3mths
Wet Storage Filling/Emptying	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	386 hrs	$ 105	$ 196,000	1	386 hrs	62 MWh	$ 40,487	$ 196,000	Day and night shift, 4 wks
Drying Area Spreading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	1253 hrs	$ 105	$ 196,000	2	1253 hrs	203 MWh	$ 131,584	$ 392,000	Day shift only, 3mths
Drying Area Tilling	Tractors	John Deere	5090E	90 hp	67 kW	537 hrs	$ 30	$ 58,750	2	537 hrs	36 MWh	$ 16,107	$ 117,500	Day shift only, 3mths
Drying Areas Compacting	Compactor	Caterpillar	CS54B	131 hp	98 kW	275 hrs	$ 55	$ 73,100	2	275 hrs	27 MWh	$ 15,133	$ 146,200	Once a week during wet months
Drying Area to Dry Stockpile	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	885 hrs	$ 120	$ 180,000	2	885 hrs	461 MWh	$ 106,231	$ 360,000	Day shift only, 3mths
Dry Stockpile Filling / Unloading	Bulldozers	Komatsu	D65EX-18 WH	217 hp	162 kW	4762 hrs	$ 105	$ 196,000	2	4762 hrs	771 MWh	$ 500,021	$ 392,000	Day shift only, 12mths
Dry Stockpile Filling / Unloading	Wheel Loaders	Caterpillar	990K	699 hp	521 kW	3541 hrs	$ 120	$ 180,000	2	3541 hrs	1,846 MWh	$ 424,926	$ 360,000	Day shift only, 12mths

Equipment utilization 49%

Total Natural Gas	4	20,400 hrs	1,163 MMBtu	$ 9,023,328		
Total Electrical	4	20,400 hrs	3,879 MWh	$ 465,496	$ 1,600,000	
Total Gas/Diesel	18	23,670 hrs	5,353 MWh	$ 2,497,700	$ 2,943,700	
Total	26	64,470 hrs	9,232 MWh	$ 11,986,524	$ 4,543,700	

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Option 4 C Transportation Calculations

Unit weight of RTM

Unit weight of in-situ RTM	120.00	lb/ft3	1.62	tons/yd3
Unit weight of wet excavated RTM	99.70	lb/ft3	1.35	tons/yd3
Unit weight of dry excavated RTM	95.00	lb/ft3	1.28	tons/yd3

Transportation Capacity

Road by weight (semi-end dump trucks)	18	tons / trip	semi end dump truck
Road by weight (bottom dump trucks)	20	tons / trip	bottom dump truck
Road by volume	18	yd3 / trip	based on one truck per trip
Rail by volume	1200	yd3 / trip	based on 60yd3 / car, 20 cars / train

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Trips required to move Wet Excavated RTM at average excavation rate - Main tunnels

Average excavation rate	2,736	yd3 / day	13,682	yd3 / week
Average excavation rate	3,683	tons / day	18,415	tons / week
Road (by weight)	205	trips / day	1,024	trips / week
Road (by volume)	153	trips / day	761	trips / week
Rail	3	trips / day	12	trips / week

Trips required to move Dry Excavated RTM at average excavation rate - Main tunnels

Average excavation rate	2,600	yd3 / day	12,998	yd3 / week
Average excavation rate	3,334	tons / day	16,670	tons / week
Road (by weight)	186	trips / day	927	trips / week
Road (by volume)	145	trips / day	723	trips / week
Rail	3	trips / day	11	trips / week

Trips required to move Dry Excavated RTM from Twin Cities to Southern Forebay

	Vol. to transport to SF	Weight to transport to SF	Road Trips	Rail Trips	Total Weeks
Central Alignment	0.9 m yd3	1.1 m tons	62,600	800	68
Eastern Alignment	0.3 m yd3	0.4 m tons	22,900	300	25

CA Delta Conveyance Tunnel - RTM Calculations 15 Jan 2021

Southern Forebay Complex to the Jones Pumping Plant Tunnel

This tunnel is only applicable to the 7,500cfs, 40ft ID tunnel options.
The tunnel would be the same for both the Central and Eastern alignment.

Excavation Volume

Tunnel lining ID	20	ft	
Lining thickness	12	in	assumed
Tailcan and overcut	5	in	assumed
TBM cutterhead area	409	ft2	
Length	7,400	ft	
Bulking factor	1.3		
Volume loss due to drying	5.0	%	
Compaction factor	0.8		
In-situ volume	3,030,123	ft3	
In-situ volume	112,227	yd3	
Wet excavated volume	145,895	yd3	
Dry excavated volume	138,600	yd3	
Dry compacted volume	110,880	yd3	
Excavation rate (ave.)	55	ft/day	assumed
Daily wet excavated volume (ave.)	29,278	ft3/day	
Daily wet excavated volume (ave.)	1,084	yd3/day	
Daily wet excavated volume (peak)	2,169	yd3/day	

Temporary Wet Stockpile Area

No. of days storage	5	days	one week of excavation
Volume of RTM to stockpile at peak excavation rate	10,844	yd3	per stockpile
Height of stockpile	10	ft	short term
Contingency	50	%	inc. allowance for conveyor pits
Area required at peak excavation rate	1.01	acres	per stockpile
No. of temporary stockpiles	6.0		
Total area of temporary stockpiles	6.0	acres	

Temporary Wet Storage Area

Volume of RTM to store	69,191	yd3	total wet volume
Height of stockpile	8	ft	less temporary storage
Contingency	20	%	less dry storage area
Area required	6.4	acres	

Dry Stockpile Area

Volume of RTM to store	110,880	yd3	
Height of stockpile	15	ft	assumed as for Southern Forebay
Contingency	5	%	assumed as for other stockpiles
Area required	4.8	acres	

Drying Process

Height during drying	18	in	assumed
Volume to dry at any one time	11,642	yd3	
Average drying time	19	days	
Drying period (including spreading and compacting)	21	days	drying time + 2 days
Drying period per year	6.0	mths	assumed
Total drying time for all RTM	1.44	years	

Transportation

Truck capacity (semi-end dump truck)	13.4	yd3/truck	= 18 tons/truck wet
Average daily volume to transport	1,084	yd3/day	
Average daily truck trips	81	trucks/day	= 405 trucks/week
Total volume to transport	145,895	yd3	
Total truck trips	10,909	trucks	