Internal Technical Review Panel Memorandum

To:	Kathryn Mallon, DCA Executive Director Tony Meyers, DCO Executive Director	Project:	Delta Conveyance
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Subject:	ITR December Workshop on Tunnel and Shafts - Report		

1.0 Introduction

The Delta Conveyance Project includes approximately 40 miles of 40-foot diameter tunnels, 8 deep shafts, and intake and outlet facilities required to convey water from south of Sacramento to near Discovery Bay, California. Various tunnel corridors and shaft locations have been under study by the DCA/DCO. The ground conditions can be characterized at the tunnel level by dense to very dense silty sand, poorly graded sand, and very stiff to hard silty clay and clayey silt.

On December 4th to 6th, 2019, an Independent Technical Review (ITR) Panel met in Sacramento, California to review and provide input on five major issues associated with the Delta Conveyance Project's Tunnels and Shafts:

- Achievable Tunnel Boring Machine (TBM) drive lengths;
- Tunnel alignment;
- Logistic & advanced procurement;
- Contract delivery and packaging; and,
- Stakeholder Concerns

Prior to the workshop, the ITR was provided with the following documents:

- Reconnaissance Alignment Assessment (Draft), October 30, 2019
- Viability of Long Tunnel Boring Machine Tunneling Drives (Draft), November 15, 2019
- Preliminary Draft Reusable Tunnel Material (RTM) Handling and Disposal, November 8, 2019
- Tunnel Corridors Map, Working Draft, November 5, 2019
- Draft Graphical Schedule for Central Corridor, no date
- California WaterFix Conceptual Engineering Report, Byron Tract Forebay Option, July 2018

- Compilation of Comments on Tunnel Construction and Reusable Tunnel Material from Previous Studies, Draft, November 11, 2019

On the morning of Day 1 (December 4), the DCA's Engineering Design Management team (EDM) presented Delta Conveyance background information including background geology, logistics information, project schedule and assumptions, and stakeholder concerns. The remainder of the day was spent driving along both the Central and Eastern corridors under study. The ITR visited each site except for the shared South Tunnel Outlet Structure site, as it was visible in the distance from Clifton Court Forebay site.

Day 2 was spent in a workshop with the ITR brainstorming and discussing the various topics of drive length, alignment, logistics, contract strategy and packaging, reusable tunnel material use and/or disposal, stakeholder considerations, and other various topics until consensus was obtained.

This consensus was shared with the DCA/DCO and EDM team late morning on Day 3. This memorandum summarizes the consensus and recommendation of the ITR for the tunnel and shaft related aspects of Delta Conveyance Project.

2.0 TBM Drive Lengths

The ITR's opinion is that TBM drive lengths up to 15 miles are achievable for this project. The key reasons being that 1) the alluvial deposits are relatively uniform and favorable to tunneling, 2) the inner diameter of the tunnel provides sufficient space to support of operations, and 3) issues that typically jeopardize TBM longevity, including high groundwater pressures, mixed ground conditions, and high boulder frequencies, are not present for this project.

The achievability of long tunnel drives is primarily driven by logistics. The size of the Delta Conveyance tunnel and favorable geology suit an extended drive without substantially raising the risk profile of the project. A summary of long tunnels is presented on Figure 1.

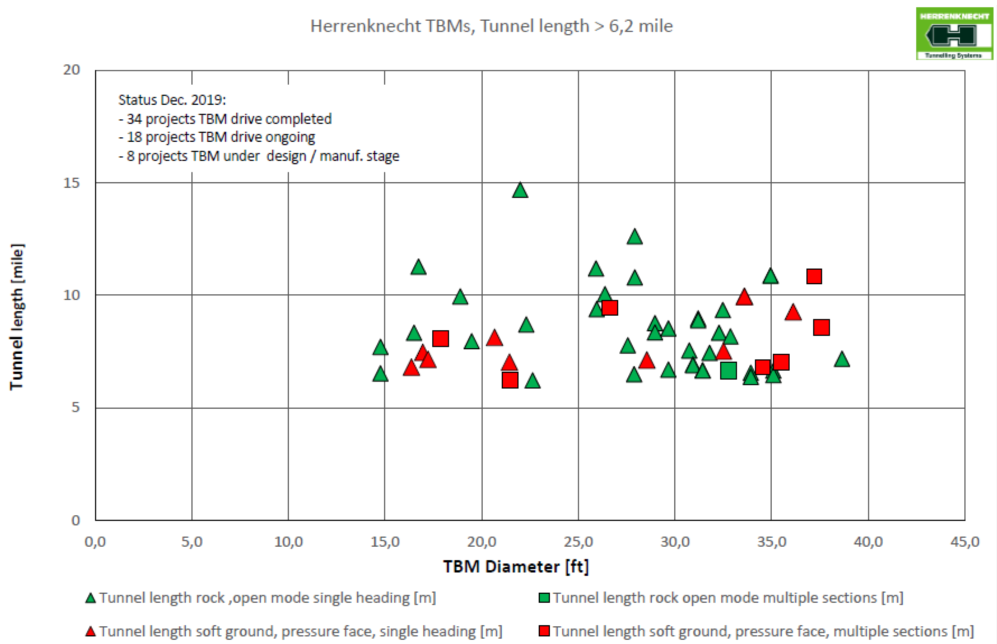

Figure 1. TBM Drive Lengths with Herrenknecht TBMs

For this project, where the ground conditions are favorable for tunneling and the TBM operating pressures are not excessively high, the drive length between shafts can be safely extended by implementing current technologies. Longevity of the TBM main bearing and ring/drive motors are the key as well as the ability to frequently exchange cutting tools along the drive. Cutting tool exchanges may be either through pressurized interventions or under atmospheric conditions if the TBM is equipped with accessible cutterhead technology. While there may not be a comparable soft ground TBM drive length example, the demands on a TBM in rock far exceed those for soft ground in terms of wear and tear on the machine. The durability of the mechanical elements for rock TBMs is typically far more difficult to overcome compared to soft ground TBMs in homogeneous ground conditions. Main bearing seal systems may see a higher load on pressurized TBMs in soft ground due to the face pressure, however, rock TBMs see higher cutterhead speeds. This means rock TBMs typically have main bearing seals that must withstand 2 – 6 times the propagation of soft ground TBMs for the same drive length.

But, more importantly, the critical elements for long tunnel drives are the logistics and safety elements. The drive lengths noted above have either been fully achieved or are currently underway. These projects demonstrated that the solutions currently exist to support extending TBM drive length and will only continue to improve by the time Delta Conveyance breaks ground.

The ITR recognized that longer drives carry additional risks. The mitigations to address the risks of longer drive lengths exist within current technology as described below.

2.1 Risk Mitigation Measures – TBM Drive Length

The following recommendations are made to manage the risk of a longer drive, all of which is current technology:

- Evaluating and/or including an accessible cutterhead option to reduce the need for pressurized interventions and simplify cutting tool maintenance
- Installing cutting tool and cutterhead structure condition monitoring systems
- Installing a camera system for remote chamber inspection
- Preparing the TBM for face and periphery drill pattern for ground consolidation from within the TBM
- Utilizing an engineering solution for tail shield brush replacement
- Requiring a strict maintenance and inspection program in place from the beginning ("industrialized tunneling" philosophy)

Further recommendations are detailed in the following subsections.

2.1.1 Main Bearing Replacement

TBMs have a main bearing that allows the cutterhead to rotate at the tunnel face. Historically, the main bearing has been a primary mechanical point of weakness on the TBM in that it sees significant stresses and, if it fails, it has required an emergency access shaft to replace it with a new one. While engineering solutions to replace a main bearing from within the tunnel exist, an access shaft is oftentimes selected as a simpler solution. Further, current bearing technology supports a main bearing life of 20,000 to 30,000 hours (time spent with the cutterhead rotating). Decisive factors for the main bearing life are the loads and the total number of revolutions. Both factors are significantly higher on rock TBMs compared to soft ground TBMs. Therefore, the experience gained from long distance rock tunnels can be applied to long soft ground tunnels. This would support the longest drive recommended without replacement unless an unanticipated failure occurred. It was noted by Mr. Burger of Herrenknecht that there are many examples of main bearings lasting longer under more strenuous circumstances than exist for this project. The ITR recommends that TBMs used for the longer drives through the Delta be designed to accommodate bearing replacement from within the tunnel as a risk mitigation measure.

2.1.2 Safe Havens

A safe haven is a location where unpressurized access to the TBM face can be achieved for inspection and maintenance purposes. The ITR recommend a minimum of one safe haven per tunnel drive, preferably fairly early in the drive to confirm assumptions and monitoring efforts on wear. The ITR debated the need for a second safe haven. It is prudent to have safe havens, but rarely is a safe haven in the location one needs it. If allowable within the constraints of the environmental documentation, it is recommended that an additional allowance for "unlocated" safe haven(s) (e.g., unplanned intervention) be included. This means, the contractor is allowed to develop a safe haven where necessary to support operations. It's important to point out that certain sites within reason can be excluded – such as in areas of biological resources.

The TBM safe haven can be a low-impact solution. As shown in Figure **2**, the ITR proposed a small 15-foot diameter shaft which could be a drilled shaft, sunken cast-in-place concrete or vertical shaft sinking (VSM) excavation with segmental lining. From within the shaft, ground treatment such as grouting or freezing can be performed in the horizontal direction providing coverage for the cutterhead. This process will minimize surface impacts as well reduce the surface impact schedule for the safe havens.

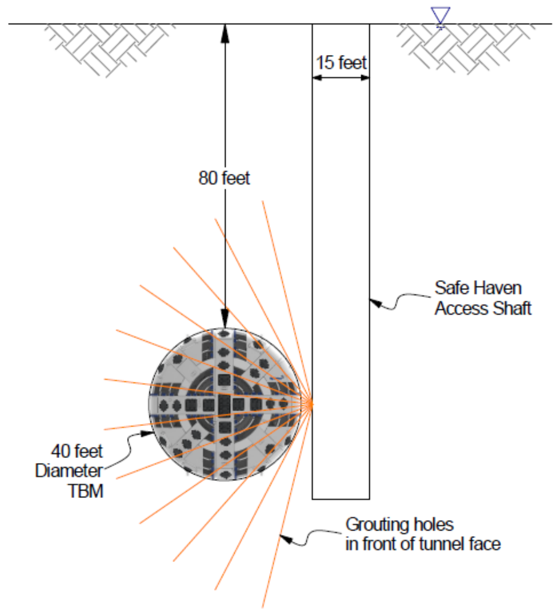

Figure 2. Safe Haven Concept

The ITR offered that knowledge gained from the first drive/contract (or portions thereof) would be quite valuable to have during planning for the next (e.g., 2nd) contract. With respect to the need for safe havens, knowledge gained from the first contract should be incorporated into subsequent ones.

2.1.3 Abrasivity

Soil abrasivity can lead to wear and tear on the TBM from the hardness of soil particles. Minimal soil abrasivity tests have been performed. The prior GDR reported AVS values between 7 and 59.5 with an average of 31 and median of 30. While further study and possible mitigation is recommended, tunneling in the alluvial soils is not going to be a similarly harsh environment when compared to long drives in quartz rock.

It is recommended that, no matter the case, state of the art heavy wear protection for the cutterhead structure should be required in combination with a structure monitoring system as mentioned above under Section 2.1. Heavy wear protection exists in today's technology. The benefits of tool wear sensors and potential use of accessible cutterhead technology enable data to be collected for proactive planning. The data of such wear monitoring systems will support the planning for any required additional safe haven ahead of time so that proper procedures and actions can be taken. The ITR further recommends a strict maintenance program that includes timely cutting tool maintenance and exchange to reduce the risk for structural wear.

All of the above mitigates against unplanned/long-term breakdowns.

3.0 Tunnel Alignment Corridors

The project team discussed and compared the current tunnel alignments under study in the Central (yellow) and Eastern (blue) corridors as shown in Figure 3.

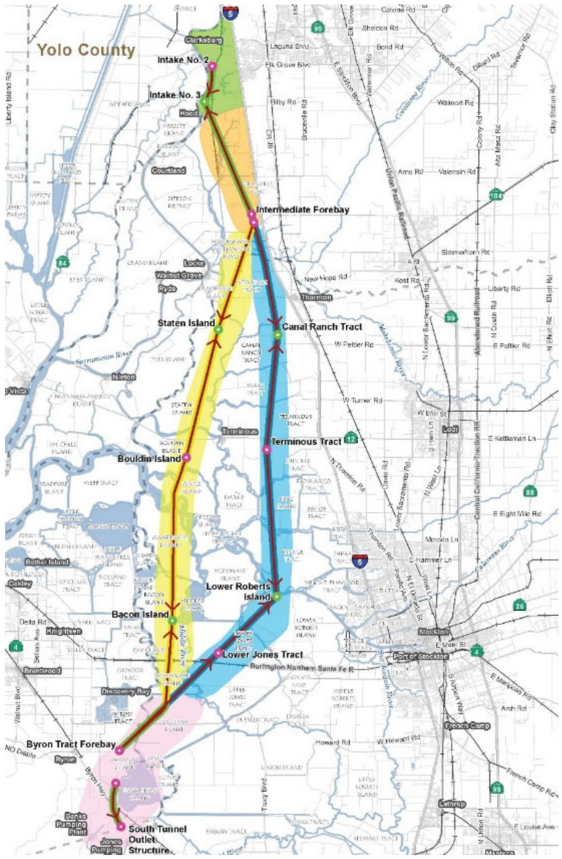

Figure 3. Studied Central (Yellow) and Eastern (Blue) Alignment Corridors

The consensus among the ITR was that the Central Corridor is logistically impractical and the ITR does not recommend this corridor be further studied. The shaft locations are located a significant distance from Interstate 5, accessible by only farm roads with hindrances such as narrow weight-restricted bridges and single lanes. This makes supporting large operations, which requires a constant transfer of materials and people in and out, impractical and expensive as well as difficult to price. In addition, addressing safety, including hospital access and tunnel safety duplication, creates a costly layer or redundancy without definitive costs. While it was recognized that extensive roadway, levee, and likely barge improvements could be constructed as part of the project for the Central Corridor, the ITR offered:

- The cost of improvements to provide reliable and safe access and egress at each site would exceed the cost of additional length of tunnel required for the East alignment.
- Levee re-build, barge, and site preparation & stabilization is temporary work, and much of it (e.g. barge facilities) will require removal;
- Site improvements and prep is driven by means and methods;

- Labor and construction safety costs, regardless of improvements, are too uncertain to price due to the location and distance from any shaft on the Central Alignment to developed land/communities.

For the reasons described above, the ITR recommended adjustments to the alignment as described in Section 3.1 which will facilitate large scale tunneling.

3.1 Recommended Alignment Adjustment

The ITR recommended that between the Terminous Shaft and the Lower Roberts Shaft, the alignment be shifted further to the east and closer to Interstate 5. Specifically, the following recommendations are made:

- Relocate Terminous shaft to the north and east
- Move shaft at Lower Roberts Island, south-east to industrial land in/closer to Stockton
- Eliminate Lower Jones Tract and Canal Ranch shafts

These proposed changes expand and/or shift the East (blue) corridor east as shown below on Figure 4. The longest tunnel drive length would become approximately 13.5 miles.

For the vertical alignment, the ITR recommends raising the tunnel alignment by one tunnel diameter. This will reduce the operating pressures considerably which is beneficial to the overall operation of the machine and safety of the workers.

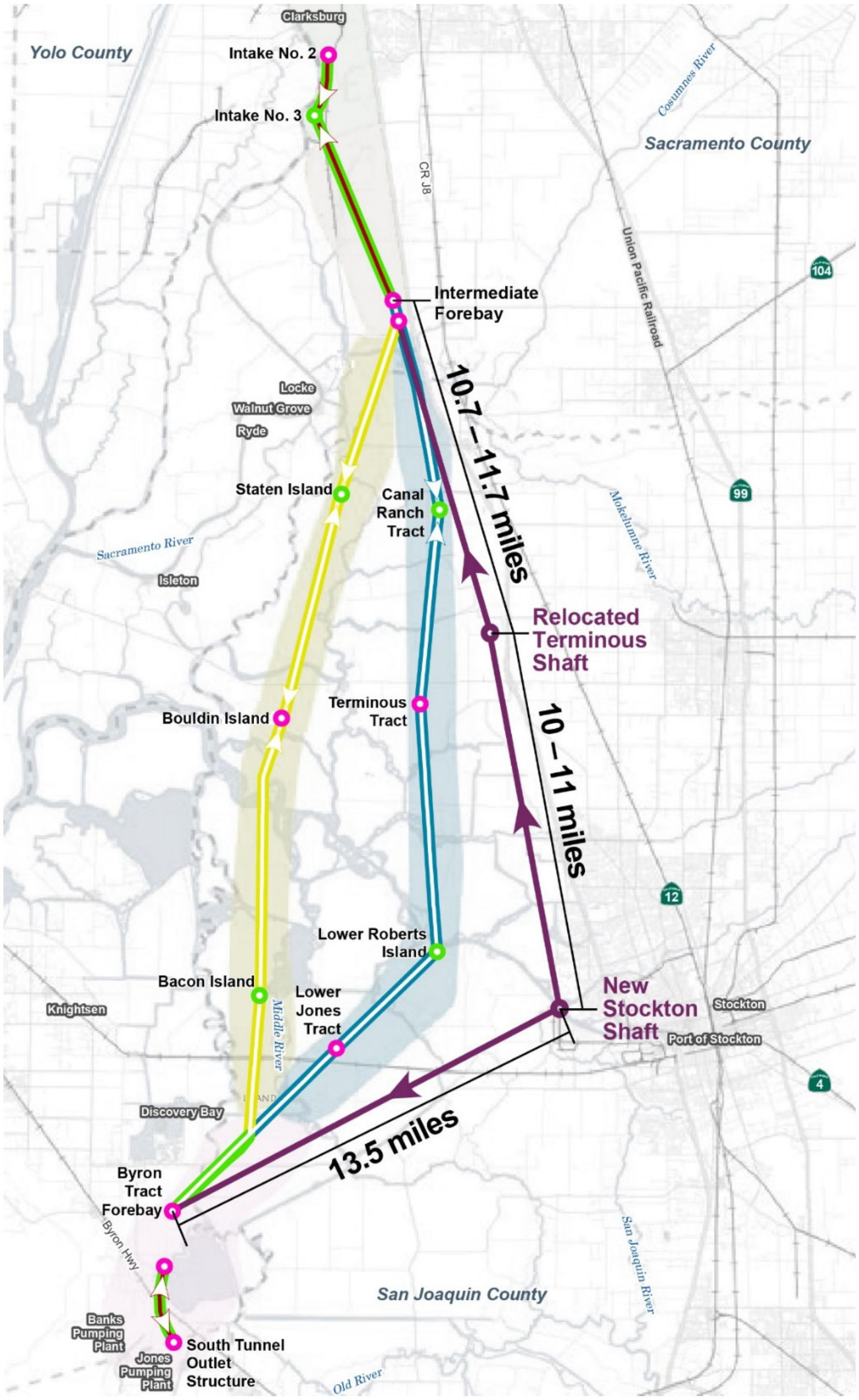

Figure 4. Recommended Far East Alignment Corridor

3.1.1 Terminous Shaft

Figure 5 shows a recommended placement for a relocated Terminous shaft. It is located approximately ½ mile west of the I-5 interchange and one mile north of Highway 12. Shifting the shaft north allows for trucks to enter the shaft site while minimizing impact to traffic on Highway 12. It is recommended that the ½ mile stretch of Highway 12 to the shaft access road be widened and a turn lane and signal be added at the shaft access road.

Figure 5. Relocated Terminous Shaft

3.1.2 New Stockton Shaft

Figure 6 shows the general placement of a New Stockton Shaft. In general, the recommendation is to shift east along the San Joaquin River closer to industrialized Stockton. The pin location shown in Figure 6 is just adjacent to the Port of Stockton and eliminate additional road widening and improvements to get to the Lower Roberts location as well as time. This site allows for segment production if desired and barge facilities to be developed. It is also adjacent to rail. This could be an important advantage, particularly when considering the contract packaging discussed below as a new Stockton Shaft as proposed would have 50% of the tunnel material (supply in, tunnel material out) flowing through that location.

Figure 6. New Stockton Shaft

4.0 Logistics and Advanced Procurement

The recommendations on alignment (above) were almost entirely driven by project logistics. Quite simply, the tunneling through the Central Corridor was considered more of a logistics project than a tunnel project. Moving the alignment east, is thought to greatly simplify the logistics and as such, enhance competition for all materials that are needed to construct the tunnels due to increased modes of transport afforded by the industrialized eastern cities, barge and rail access.

4.1 Segment Manufacture

There was discussion as the most cost-effective way to provide the 40 miles of concrete segments for the project. The ITR considers the difference between on-site and off-site production, in terms of material transport, is insignificant, recommending that despite 80% of the tunnel segments being the same diameter:

- Plan for off-site production of segments, as it lowers cost and provides far more flexibility in the supply and delivery chain.
- Leave the design and construction of the segments to the contractor, as the configuration, length, and reinforcing details/requirements are all means and methods driven; and
- Progress with permitting as if on-site will be used, as a position point for the environmental documentation process (it's more environmentally challenging).

4.2 Tunnel Material

The handling and disposal of tunnel material is a major project driver that will influence the builder's approach to the project (TBM Selection, Site Configuration, sub-contracting, etc.). Based on ITR experience, soft ground tunnel material is not a commodity (has no residual value) and is difficult to dispose or find a use for. These two factors were part of the reasons the ITR recommends (above) moving the alignment closer to industrialized land, close to multiple modes of transport, to handle removal of it in the most economical manner.

As part of the advanced procurement work, the project would benefit from DCA working to find a location and negotiate terms for disposal and or reclamation using it in advance of advertising the tunnel contracts. This could include stockpiles and or temporary storage at the Southern Forebay site for re-use of the material on the site. However, the ITR cautions that the "reusability" of such material should not be over-sold within the project team, as no experience exists (within the ITR members) where material from a soft ground tunnel has been used as structural fill.

There are some projects that have used materials for quarry restoration (e.g., SR 99 in Seattle) or land reclamation (Bay Tunnel and numerous European projects), which were negotiated/established prior to the contract being let. In each case, advance analyses was performed to characterize the natural components and any potential for materials deemed as contaminants. There are several quarries within the project vicinity and early research and conversations with these quarry operators would benefit the project.

4.3 Tunnel Classification and Permissible Equipment

Based on what is known of the geology, it is anticipated that the tunnel will be classified as “gassy” or, at least, “potentially gassy”. For both potential and gassy classifications, Cal/OSHA will also implement a list of “special conditions” that add specific detail to existing regulations and add requirements. While it is difficult to predict what details or regulations Cal/OSHA will impose, quite often on large consequential projects, it is important that DCA meet with Cal/OSHA to start early discussion on what may need to be design “into the project” and set the basis for understanding of expectations.

It is likely that these discussions with Cal/OSHA will set forth that all equipment used in the tunnel including the TBM will have to have special gas detection systems and anti-explosion systems (e.g., permissible equipment). The TBM will be required to have a sophisticated gas detection system that will automatically shut down the systems and put it into emergency power mode in the event of detection. Safety trained and certified gas tester employees will have to be on site at the face full time.

4.4 Tunnel Rescue Plan and Communication

A detailed tunnel rescue plan is required by law before underground work can begin. The tunnel rescue plan will be developed by contractor(s) although the owner/engineer can have preliminary discussions on any specialized requirements. Because of the long tunnel drives, the rescue plan as well as the training requirements for workers will be more extensive. The length of tunnel means that it will take longer to get an injured person out of the tunnel. The plan will need to include requirements for practice and documentation.

A trained tunnel rescue team with a minimum of five people will need to be on-site within 30 minutes of the ingress/egress point at all times. This is another advantage of moving the alignment closer to I-5, particularly when you consider the duration (approximately 8 calendar years) of the project.

A refuge chamber (e.g., Figure 7) will be required on the TBM and at intervals along the tunnel. These chambers provide life support systems including primary and secondary oxygen supplies and CO/CO^2 scrubbing systems to regenerate the air. They also maintain positive internal pressure at all times.

Figure 7. Refuge Chamber Example

5.0 Contract Delivery and Packaging

5.1 Contract Delivery Methods

There are various methods by which the DCA/DCO can deliver the project. While explaining each in detail is beyond the scope of this memorandum, three popular contract delivery methods are mentioned herein. The most traditional is Design-Bid-Build (DBB) in which the owner's engineer prepares complete contract documents and the low bidder is awarded the job. There is also Construction Management/General Contractor (CMGC) which allows an owner to engage a construction manager to provide input during the design process. The owner and the construction manager agree on a price for construction of the project, and the construction manager becomes the general contractor. There is also Design-Build (DB) in which the owner released documents at an early design phase (often at 30%) and the contractor completes the design and builds the project. Selection methods for CM/GC and DB contractors vary and are not discussed herein. Each has merits for consideration.

5.2 Recommendation on Contract Delivery

The ITR members held a robust discussion on the merits of one delivery method over another.

Two companies from which the ITR has associated members had previously reviewed the project (when it was twin tunnels) and offered at that time that DBB and/or CMGC were preferred. DBB was previously recommended because it lowers the contractor's risk, and at the time was thought to provide a better opportunity to achieve a lower total project cost. CMGC was preferred because the "use and disposal" of tunnel material was such a large uncertainty; and, CMGC would allow the contractor to be engaged before resolution of material disposal was completed. However, after the site visit, and recognition that this project is "a logistics project with a tunnel in it", the ITR came to consensus recommending Design-Build delivery for the tunnel and shaft work. The key reasons that informed this recommendation for Design-Build include:

- Gives a much higher likelihood of completing the work by the estimated completion date of 2035 through concurrent work and ability to procure items such as the TBM and start-up of segment production;
- Enables the contractor to be engaged in the design, of all elements of the work, including logistics planning (site set-up, etc.); and,
- Nearly all the site work, material handling, and all the large shafts are temporary structures.

If the DCA/DCO establishes the internal diameter of the tunnel and permanent shafts, a horizontal alignment and rights of way/easements associated with it, negotiates power drops at each working shaft, and determines the extent of allowable use and/or locations to dispose of tunnel material, all other elements of the project would be means-and-methods driven, which aligns very well to Design-Build.

5.3 Recommendation on Contract Packaging

The ITR recommends five tunnel design build contracts in order of release as follows and shown in Figure 8:

- Contract 1: Stockton Shaft to Byron Forebay
- Contract 2: Terminous Shaft to Intermediate Forebay Shaft
- Contract 3: Stockton Shaft to Terminous Shaft
- Contract 4A: Intermediate Forebay to Intake 3
- Contract 4B: Intake 3 to Intake 2
- Contract 5: South Outlet Tunnels (twin tunnels)

If the release of contracts begins in Quarter 1 of 2023, completion of the project tunnels by 2035 is achievable. The ITR recommends that each contract be separated by approximately 9 months.

It is recommended that the logistics for each site including shaft height above ground surface, finalization of power drop, etc. be included in the DB contracts as it allows the contractor to set up the sites to suit their means and methods. Any early works contract can include items such as widening of the ½ mile of Highway 12, Twin Cities Road and improvements to the Clifton Court area.

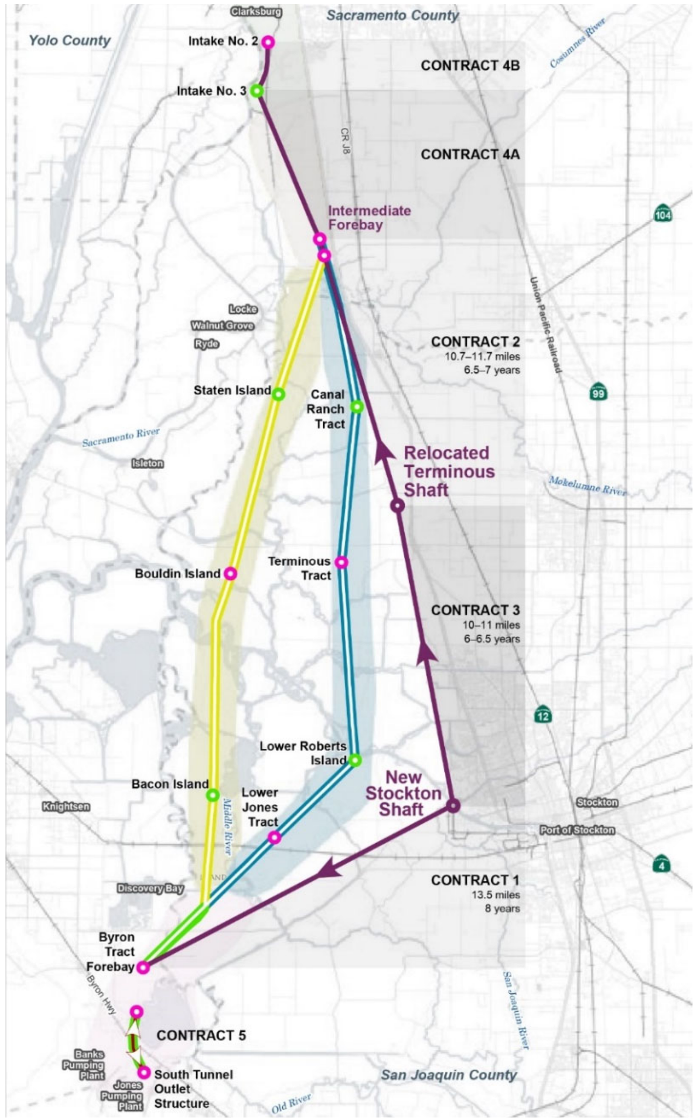

Figure 8. Recommended Tunnel DB Contract Packaging

5.4 Contract Value

The ITR recommends that the packaging of contracts be held at approximately $1.5 to $2 billion in order to ensure enough teams are available and to ensure bonding availability. All major tunnel contractors have capacity to team and to pursue the work. It is also recommended that the DCA/DCO also have initial discussions with bonding agencies.

6.0 Stakeholder and Community Concerns

The ITR was requested to review various stakeholder and community comments from prior phases of the project. All of the current comments were noted to be straightforward and could be answered by sharing engineering information. Each is addressed briefly in the following subsections.

In general, the ITR recommends that the DCA/DCO have a dedicated engineering liaison. They should be capable of translating tunnel engineering and construction to the public at large (e.g., breaking down complex topics into understandable terms with enough information). This person(s) should be supported by a team of people who can prepare graphic materials or other supporting information.

6.1 EBMUD – Mokelumne Aqueduct

East Bay Municipal Utilities District (EBMUD) expressed several concerns with the Delta Conveyance tunnel in terms of their future tunneling plans and potential conflicts. They also indicated the need for a secondary tunnel lining system. The ITR recommends that the DCA/DCO coordinate on some level with EBMUD to understand their tunnel alignment elevations and work jointly to determine an appropriate offset distance with the Delta Conveyance tunnel. The ITR does not concur with EBMUD's comment that the tunnel needs a secondary liner. There are many project examples that use a single pass segmental lining. The precast lining is sufficient to support the anticipated loads including seismic events.

6.2 Natural Gas Wells

There are several community comments with respect to unknown gas wells. The ITR noted that traditionally, the records of gas well installations are quite accurate. However, the team/contractor can perform a magnetometer survey when the final alignment is set (e.g, versus being a corridor), then the team can perform an alignment check/walk/survey to look for unknown wells.

6.3 Seismic Behavior of Tunnels

There are no active fault crossings along the Delta Conveyance alignment and the seismic demands are not extreme compared to other projects. A tunnel, in particular a segmentally lined tunnel, is capable of flexing and thus survival during an earthquake. The primary concern would be at the connection points such as the shaft/tunnel connection. These locations likely need specialized detailing to handle the localized increased stresses. This is not an unusual undertaking in areas of high seismicity.

6.4 Dewatering

There were several comments associated with dewatering caused by tunneling. The TBM will be a "pressurized face machine" meaning that it will balance both the groundwater loads and earth loads. With this type of tunneling, dewatering is not required for tunnel and lining operations. The segments are designed to be gasketed and sealed to handle water pressures and can be constructed to be watertight. The ITR does recommend that a bottom seal be required for shafts to avoid excessive pumping of groundwater out of the excavation. These comments can be answered by simply educating the stakeholders on the process of pressurized face tunneling.

6.5 Settlement

There were several comments associated with "subsidence." In reading these comments, it appeared that there was a general misuse of the word subsidence and that the concerns were related to settlement. The ITR recommends education to correct the terminology usage. Further, modern tunneling and proper face pressures mitigate against settlements.

6.6 Failure and Repair of the Lining

Failure of a segmental tunnel lining is highly unlikely and unprecedented. Segmental linings are fabricated with reinforced precast concrete in a highly controlled environment with strict quality control. A tunnel constructed with precast segments is generally considered by industry to be of higher quality than those lined by the cast-in-place concrete method. The design life is a minimum of 100 year and designed to appropriate standards and loads. We recommend sharing and explaining the calculations to the public.

Repair of the lining is highly unlikely to be necessary if designed for the service life. While transportation tunnels undergo regular maintenance due to their exposure to elements, water conveyance tunnels are not subject to the same stresses-meaning, there is not much that can damage the lining.

6.7 Emergency Response

Contractor’s are required by law to have a tunnel rescue plan approved by Cal/OSHA prior to beginning underground work. This job in particular will require a five person on-site dedicated rescue team at a minimum for each tunnel contract. Moving the alignment closer to I-5 significantly improves emergency response. The ITR recommend that the DCA/DCO develop a detailed emergency response plan as well as any specifics that can be passed into contractor protocols.

6.8 Flood Risk

Current plans assume significant overbuilding of the shaft pad areas. The ITR noted that only the shaft walls need to be overbuilt to a height addressing some level of flood risk. The surrounding pad doesn’t need to be as high as the shaft wall. Permanent works can be raised to the final elevation as necessary.

7.0 Conclusions

The ITR was asked to review and provide input on five major issues for the Delta Conveyance project with respect to achievable TBM drive lengths; tunnel alignment; logistics & advanced procurement for transport and storage; contract delivery and contract packaging, and stakeholder/community concerns.

The recommendations based on the December 2019 ITR workshop are as follows:

- 15-mile TBM drive lengths are achievable if appropriate mitigations are implemented;
- The tunnel alignment should move closer to Interstate 5 (further east) with shafts located adjacent to major roads and multiple methods of transport where feasible;
- Design-build delivery is preferred; and
- The existing stakeholder comments and community concerns are straightforward with simple answers.

These recommendations and conclusions are the opinion of the ITR members attending the December workshop and may not necessarily represent the unanimous opinion of the companies represented by the

ITR members. Further, the recommendations are based on the project information provided at the time, and knowledge obtained during the workshop.

The ITR thanks the DCA/DCO for their interest in engaging outside expertise and sharing the project information for brainstorming and new ideas.

Respectfully,

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DCA Response to December 2019 Tunnel Independent Technical Review Panel Recommendations

Item No.	ITR Recommendation	DCA Response
1. TBM Drive Lengths		
	a. TBM drive lengths up to 15 miles achievable	a. Agree.
	b. TBMs used for the longer drive be designed to accommodate main bearing replacement from within the tunnel.	b. Agree.
	c. A minimum of one maintenance be provided per tunnel drive and that consideration be given to a smaller offset maintenance shaft if more needed.	c. Noted. DCA recommends two inline maintenance shafts spaced 4 to 5 miles apart with the last maintenance shaft used for a major TBM "tune up" (main bearing replacement, cutterhead face replacement, etc.) to reduce risk of TBM breakdown in the final section of long drives. Smaller off-set shafts may reduce flexibility for maintenance.
	d. Further study soil abrasivity and require state of the art heavy wear protection for the cutterhead structure in combination with a cutterhead structure monitoring system.	d. Agree. Studies on going with existing stored samples.
2. Tunnel Alignment Corridors		
	a. Central Corridor is logistically impractical and therefore should not be further studied.	a. Agree that Central corridor poses greater challenges for construction logistics than corridors closer to I-5. However, there are other considerations for siting the tunnel alignment that must be considered.
	b. Between Terminous and Lower Roberts, shift alignment further east and closer to Interstate 5.	b. Agree that proximity to I-5 facilitates construction logistics.
	c. Add new shaft along the San Joaquin River and closer to the industrialized area of Stockton.	c. DCA understands the proximity of port, rail and roadway access in this location but does not believe the alignment would benefit from shifting further east toward Stockton considering a wider range of issues.
	d. Raise vertical alignment by one-tunnel diameter to reduce operating pressures.	d. Noted but requires further study of US Army Corp of Engineers requirements and potential conflicts with the planned new East Bay Municipal Utilities District (EBMUD) Mokelumne Aqueduct tunnel.

3. Logistics and Advanced Procurement		
	a. An option for on-site production of tunnel liner segments may be feasible but the DCA should also plan for off-site production and leave the design and manufacture of the segments to the tunneling contractors.	a. Agree in principle but other factors may drive the decision on liner fabrication strategy.
	b. Based on past experience, soft ground tunnel material is difficult to dispose or find a use for. The Project would benefit from finding a location for disposal and/or reuse of the RTM in advance of advertising the tunnel contracts.	b. Noted. Significant testing will be done as part of the future field work activities to validate the composition and reuse of the tunnel spoils. Previous testing results indicate that the material is suitable for forebay embankment construction and other structural uses.
	c. Based on the known geology, it is anticipated that the tunnel will be classified as "gassy" or "potentially gassy". It is important that DCA meet with Cal/OSHA early to start discussions on what requirements may need to be designed into the project to address this issue.	c. Agree.
	d. A detailed tunnel rescue plan is required by law and because of the long tunnel drives, the rescue plan requirements will be more extensive.	d. Agree.
4. Contract Delivery and Packaging		
	a. Recommend Design-Build (DB) be used as the contract delivery method for the tunnel and shaft work.	a. Agree that D-B offers key benefits to the design and construction of the tunnel and should be explored. Legal hurdles may hinder its use for Delta Conveyance.
	b. Break the tunnel work into five DB contracts separated by 9 months and include work site early works in the DB contract.	b. Noted but subject to further DCA study.
	c. Hold contracts to less than \$1.5-\$2.0 billion in order to ensure enough teams are available and to ensure bonding availability.	c. Noted but subject to further DCA study.
5. Stakeholder and Community Concerns		
	a. Mokelumne Aqueduct – EBMUD expressed concerns that the Delta Conveyance tunnel conflicts with their future tunneling plans and that a secondary tunnel lining system is needed for the Delta Conveyance tunnel. Coordination with EBMUD needs to occur, however, the ITR does not concur with the need for a secondary liner.	a. Agree.

	b. Natural Gas Wells – perform magnetometer survey when the final alignment is set to locate unknown wells. c. Seismic Behavior of Tunnels – as there are no active fault crossings along the Delta Conveyance alignment, a segmentally lined tunnel is capable of flexing and thus surviving during an earthquake. The primary concern would be at the connection points, such as the shaft/tunnel connections, which require specialized detailing to handle the localized increased stresses. d. Dewatering – the TBM will be a pressurized face machine and therefore dewatering is not required for tunnel and lining operations since the segments are designed to be gasketed and sealed to handle the water pressure. A bottom seal should be required for shafts to avoid excessive pumping of groundwater out of the excavation. e. Settlement – modern tunneling techniques and maintaining a proper face pressure will mitigate against settlement. f. Failure and Repair of the Lining – failure and/or repair of a segmental tunnel lining is highly unlikely and unprecedented. g. Emergency Response – Contractors are required to have a tunnel rescue plan. Moving the alignment closer to I-5 significantly improves emergency response. The ITR recommends that the DCA develop a detailed emergency response plan. h. Flood Risk – permanent works need to be raised to protect against predicted flood levels, however only the shaft walls need to be overbuilt to a height addressing some level of flood risk. The surrounding pad doesn't need to be as high as the shaft wall.	b. Agree. c. Agree. d. Agree. e. Agree. f. Agree. g. Agree. h. Agree.