I. **Survey Respondent:**

Name: David Tsztoo, Project Manager

II. **Presenter:**

Name: David Tsztoo, Project Manager, P.E.

Name: Dan McMaster, Construction Manager

III. **Project to be discussed at this site:**

We will be presenting an overview of how the New Irvington Tunnel (NIT) was constructed alongside the existing Irvington Tunnel. The 3.5 mile New Irvington Tunnel is located between Sunol Valley and the City of Fremont.

The project is part of the San Francisco Public Utilities Commission (SFPUC) $4.8B Water System Improvement Program (WSIP) to repair, replace, and seismically upgrade our facilities from the risk of earthquake damage. There are 83 projects including: pipelines, tunnels, dams, reservoirs, pump stations, storage tanks, and treatment facilities. Over 85 percent of the WSIP projects are completed.

IV. **Purpose of the project(s) in relation to system performance objectives:**

As part of the WSIP, three major water tunnels were built as seismically resistant water conveyance facilities near major earthquake faults: New Crystal Springs Tunnel near the San Andreas Fault on the San Francisco peninsula, Bay Tunnel—the first tunnel under San Francisco Bay, between the San Andreas Fault to the west and the Hayward Fault in the East Bay, and the New Irvington Tunnel between the Hayward Fault to the west and Calaveras Fault to the east in the Fremont area in the East Bay.
The NIT was constructed alongside the existing Irvington Tunnel. The old Irvington Tunnel was built between 1928 and 1932 and is an important component of the Hetch Hetchy Regional Water System. The SFPUC has not been able to take it out of service for inspection since 1966 due to customer water demands on the tunnel. Water demands ranges from about 200 million gallons per day in the winters and up to 300 million gallons per day in the hot summers. The tunnel transmits the majority of the drinking water the SFPUC provides its 2.6 million customers.

With the NIT in service, 2.6 million Bay Area customers benefit from a vastly improved water system that addresses level of service issues:

- Water Quality improved with a new tunnel constructed with a steel liner impervious to groundwater infiltration
- Seismic Reliability greatly improved with upgrades which allows for continuous water operations after major earthquakes
- Delivery Reliability improved, especially with the new and the old tunnels able to be operated in tandem or one at a time while the other tunnel can be shut down for maintenance or repairs

V. Description of what was built or is being built:

The NIT is a seismically designed tunnel that will withstand a maximum credible earthquake Magnitude 7.3 on the Hayward Fault or a Magnitude 7.1 on the Calaveras Fault. It provides the final piece of the seismic lifeline of the Hetch Hetchy Regional Water System. Now that the NIT is in service we can take the old tunnel out of service to inspect it and schedule future repairs. Both tunnels will remain in service during normal operations.

The NIT was excavated from four different headings, or directions - Two from the ends of the tunnel moving west and east, and both directions from a 115-foot shaft mid-way through the tunnel.

The NIT was constructed using conventional mining techniques using roadheaders and controlled detonation. (Roadheaders are heavy mining machines on tracks that have a rotating cutting head on the front of an articulated arm that grinds away at the rock in front of the machine.) When the rock became too hard for the roadheaders the crews used controlled detonations to break up the rock for removal by the roadheaders.

The excavated tunnel was lined with steel pipe in 50-foot long by 8.5-foot diameter sections. The space between the steel pipe and the excavated tunnel wall was filled with cement grout. During the final stages, the interior of the steel liner was lined with a cement mortar lining to protect the liner from corrosion.

Some key facts and figures about the NIT:
• Tunnel Length: 18,660 feet or 3.5 miles
• Location: Parallel to the existing tunnel between Sunol Valley and the City of Fremont in Alameda County.
• Depth: Between 30 feet to 700 feet underground
•Finished internal diameter: 8.5 feet
• Pounds of grout injected into the tunnel: More than 7.8 million pounds
• The New Irvington Tunnel will carry approximately 120 million gallons of water a day on average during normal operating conditions when both tunnels are in service. Therefore, both tunnels will carry a total of 240 million gallons a day on average.
• Approximately 300 million gallons of water per day is the maximum amount of water the tunnel can transport on its own—enough water to meet current customer water demands.
• The New Irvington Tunnel Project provided approximately 42% of its total construction labor hours to SFPUC service territory residents, and nearly half (48%) of its total apprentice hours to SFPUC service territory apprentices ensuring local workers and local residents were able to participate in this unique, once-in-a-lifetime construction opportunity.

Major Construction Milestones:
• Tunneling began in March 2011.
• Crews achieved their first ‘hole through’, where the two tunneling excavation teams met underground, on June 12, 2012 between Irvington Portal and Vargas Shaft.
• The second hole through, which completed tunnel excavation, was on October 8, 2013 between Vargas Shaft and Alameda West Portal.
• The tunnel and portal piping went into service on February 27, 2015.

Now that the tunnel is in service, the construction team will begin restoration of the above ground facilities. The SFPUC will take the existing tunnel out of service for inspection in early April 2015. The entire New Irvington Tunnel Project will be complete in Fall 2015.

VI. Engineering/Project Management/Environmental Challenges in Design, Construction, Testing, and Implementation:
• **Risk avoidance:** The NIT specified that the mining equipment had to be non-sparking gas permissible because of the potential for methane gas. This provision avoided months of delay and significant cost when CalOSHA reclassified the NIT from Potentially Gas to Full Gassy in June 2011.

• **Groundwater Management Plan (GMP):** Prior to construction, the design engineers created a computer model of the groundwater table and the new tunnel alignment. The model predicted the effect that the tunnel construction dewatering operations would have on the groundwater table. During tunneling, it is necessary to dewater the excavation to keep the tunnel safe and allow for productive mining. The model allowed the SFPUC to anticipate how much groundwater would flow into the tunnel during construction and map an area of affected groundwater levels and affected groundwater wells in the area. The model helped the SFPUC to plan for mitigation measures to address anticipated water losses by residential well users. More importantly, the GMP allowed the SFPUC to work with potentially affected property owners ahead of the construction and during the work to keep them informed and to mitigate the eventual groundwater loss due to tunnel construction during the duration of the project.

• An Environmental Allowance was set up in the construction contract to mitigate the groundwater well losses and allow for more immediate response to local residents who ran out of water.

Mitigation Measures included:

  a) Upgrades to existing well pump systems  
  b) Installations of new water tanks  
  c) Commercial water deliveries to periodically fill the tanks  
  d) Setting up 2.5 mile long irrigation supply system for the residents. whose usage is over 85% irrigation for livestock and landscaping  
  e) The irrigation system allowed the project to save up to $50K per month in commercial water truck deliveries

**Construction Challenges:** The specification of the Conventional Tunnel Mining Method and the construction of an intermediate shaft at Vargas Road/Highway 680 was fortuitous for NIT. The Contractor was able to excavate three different headings with three roadheader tunnel machines to expedite construction vs. a single heading tunnel.

The use of roadheaders also allowed mining operations to stay on schedule by squeezing ground that was confirmed for approximately 600 feet of the 18,660-foot alignment. Pre-extraction grouting to control the high influx of groundwater was facilitated by the open face accessibility of this excavation method vs. the relatively closed face method of a Tunnel Boring Machine.
VII. Lessons Learned from an Engineering/Project Management Perspective:

- **Constructability Review:** The value of constructability review cannot be underestimated for avoiding design revisions and change orders during construction. The NIT project found over 400 corrections to the bid documents prior to bidding.

- **Value Engineering:** Specification provisions allowed the contractor to propose a no-cost change order that replaced the contract specified tunnel liner with a full length steel pipe liner. The specified liner included sections of cast in place, concrete pipe, and steel pipe liner. The steel liner substitution provided the contractor a simplified and faster liner installation procedure, and provided the SFPUC a better product - impervious to groundwater seepage impacts on water quality.