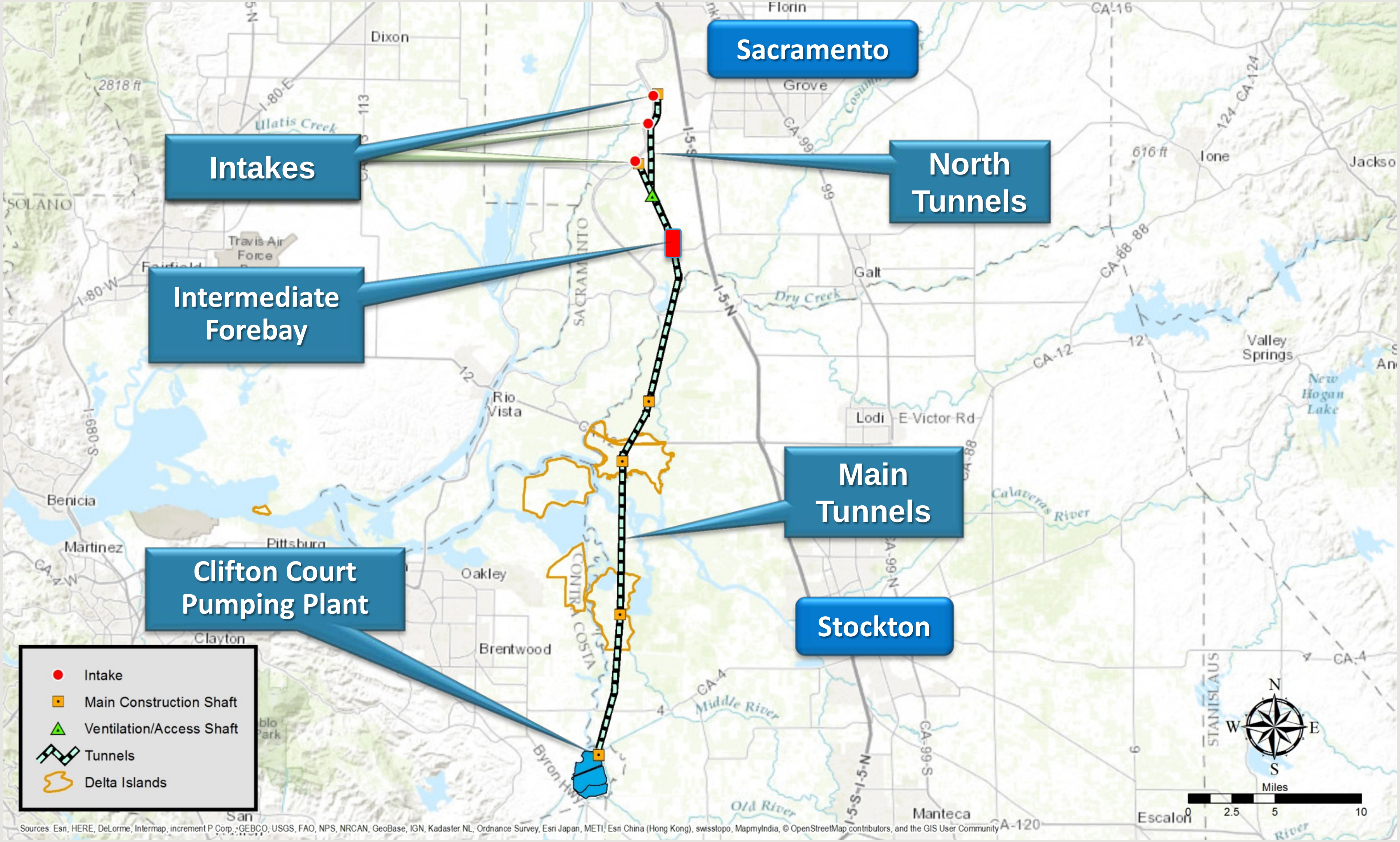
ENGINEERING REBUTTAL TESTIMONY

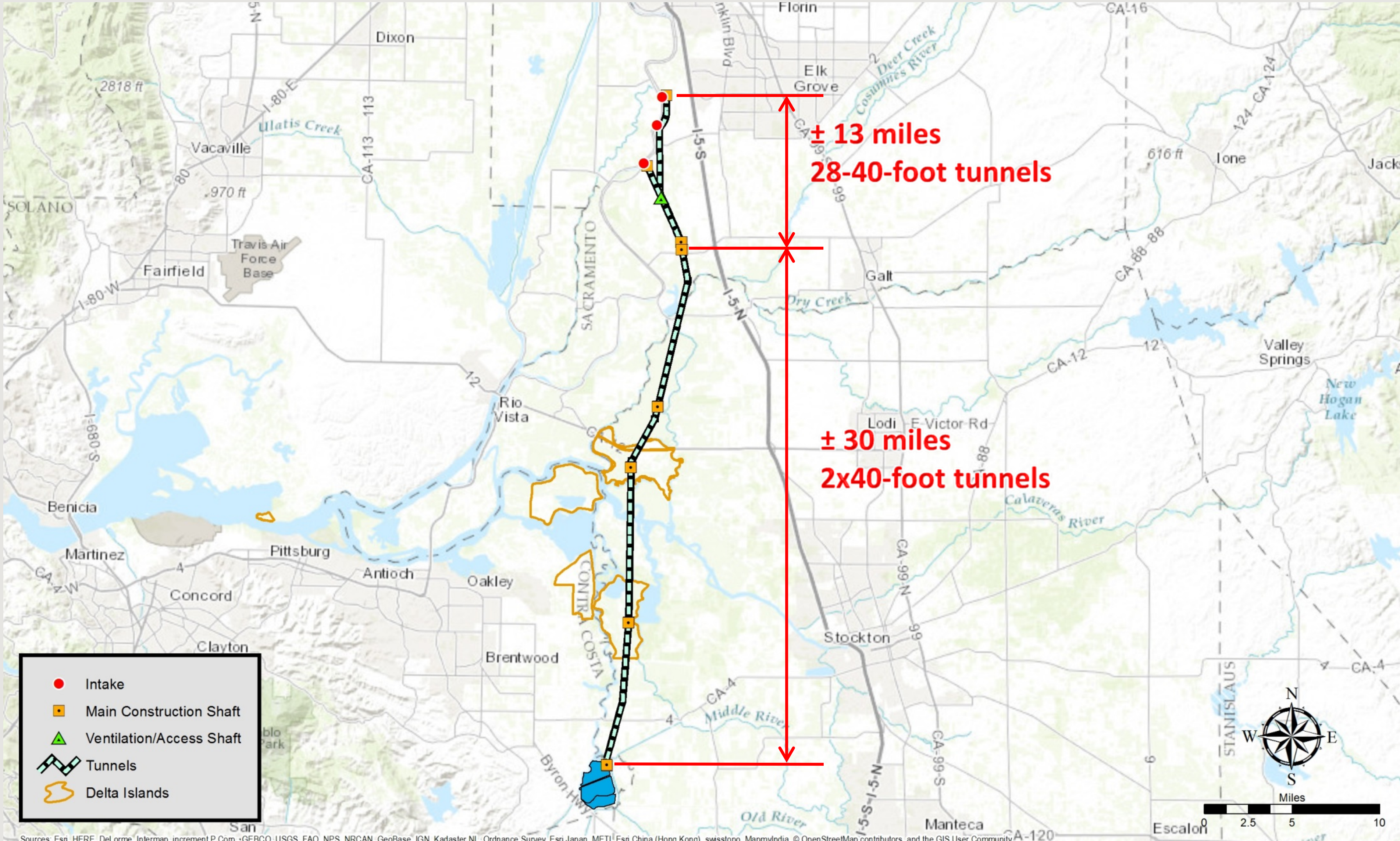
TOPICS OF DISCUSSION

- **Responses to previously identified concerns**
  - Large tunnel projects
  - Levees and proposed CWF construction
  - Existing/planned facilities and proposed CWF construction
  - Water supply from existing diversions and CWF facilities
  - Sea Level Rise

CALIFORNIA WATER FIX- OVERALL PROGRAM



TUNNEL PORTIONS OF PROGRAM

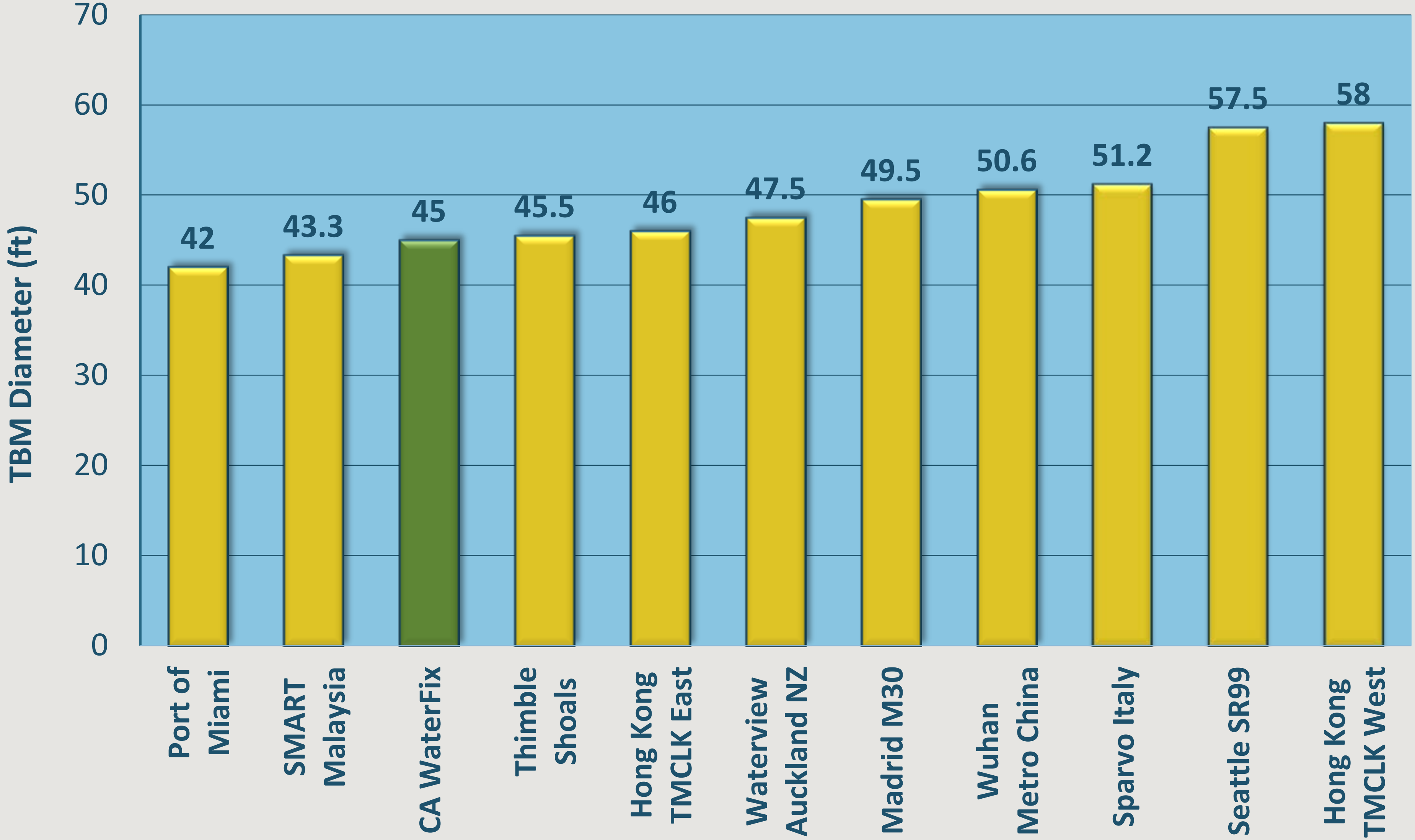


MAIN TUNNELS

- 100 year life
- Twin bore main tunnels
- 150 ft below grade
- Concrete segmental liner
- Pressurized face Tunnel Boring Machine construction
- 45 ft excavated diameter
- 40 ft finished internal diameter

Photo Courtesy: Port of Miami Tunnel

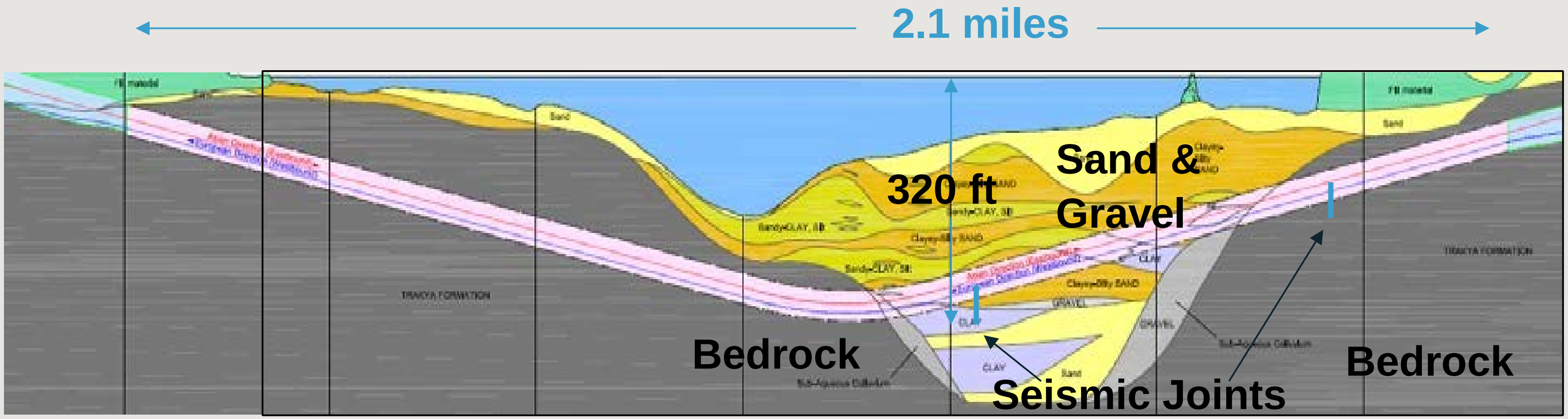
LARGE DIAMETER TUNNEL BORING MACHINE PROJECTS



REVIEW OF OTHER MEGA-TUNNEL PROJECTS

- **The Eurasia Tunnel - Turkey**
- **Lee Tunnel - London**
- **Port Of Miami Tunnel - Florida**
- **East Side Access - New York**
- **Blue Plains Tunnel Project - District of Columbia**
- **Bay Tunnel - San Francisco**
- **Willamette River Combined Sewer Outfall Program - Portland**
- **Gotthard Base Tunnel - Swiss Alps**
- **SR-99 Alaskan Way Replacement - Seattle**

THE EURASIA TUNNEL – TURKEY

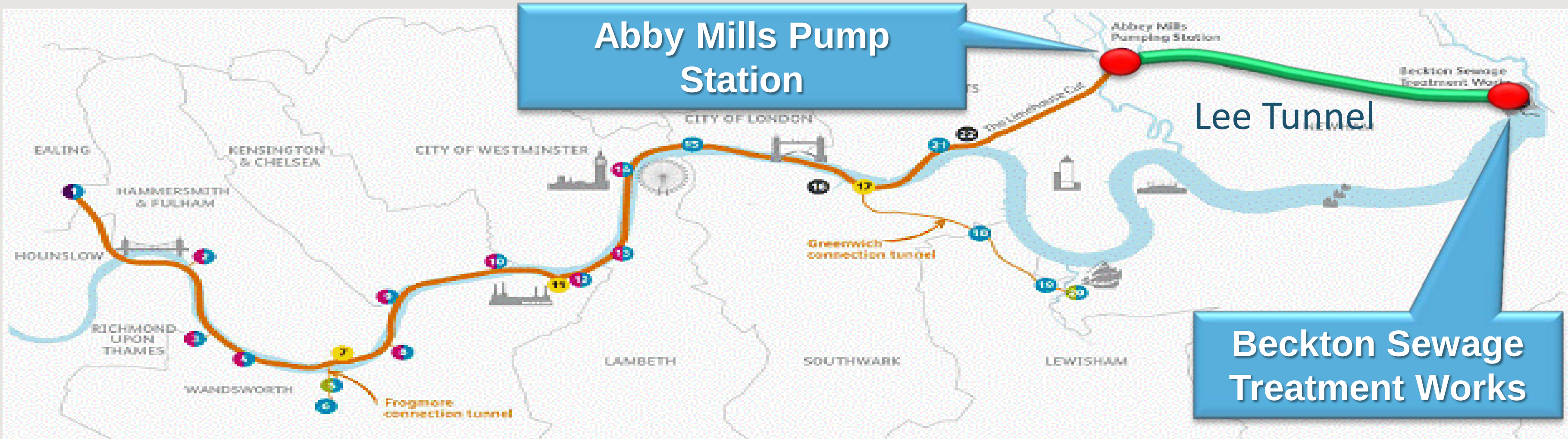


THE EURASIA TUNNEL – TURKEY

Project Information

- **Transportation Tunnel**
  45 ft Internal Diameter (ID) x 2.1 miles
- **320 ft deep**
- **Completed Dec 2016**
  – 3 months ahead of schedule
- **Challenges**
  - Complex geology, seismic deformations, and high groundwater pressure

LEE TUNNEL - LONDON



LEE TUNNEL – LONDON

Project Information

- **23.6 ft ID x 4.3 mile Combined Sewer Outfall (CSO) Tunnel**
- **160 ft deep**
- **Completed December 2015**
  - on schedule
  - Within budget
- **Challenges**
  - Groundwater contamination, complexity of Tunnel Boring Machine launch, and spoil removal

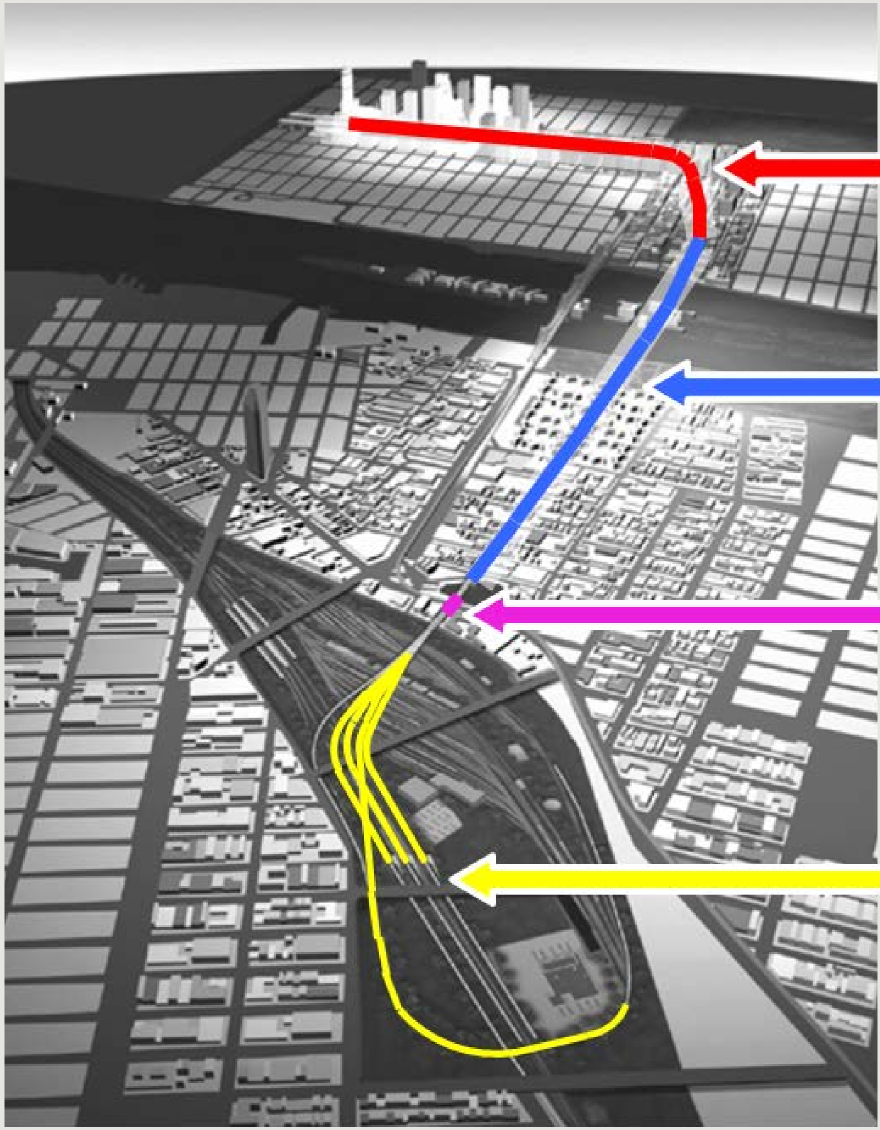
PORT OF MIAMI TUNNEL - FLORIDA

PORT OF MIAMI TUNNEL

Project Information

- (2) 39 ft ID x 4,200 ft Long Transportation Tunnels
- 120 ft deep
- Completion May 2014
  - On schedule
  - Within budget
- Challenges
  - Additional geotechnical investigations were critical to confirm the ground model

EAST SIDE ACCESS – NEW YORK



MANHATTAN TUNNELS & CAVERNS

63RD STREET TUNNELS

NORTHERN BOULEVARD CROSSING

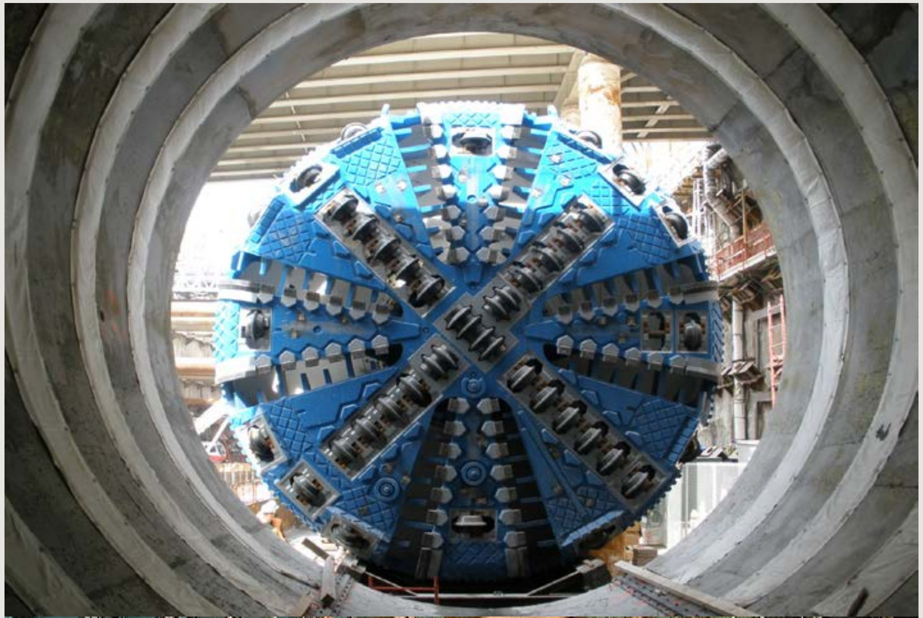
QUEENS BORED TUNNELS

Long Island Rail Road
East Side Access

EAST SIDE ACCESS – NEW YORK

Project Information

- **(4) 19 ft Railroad Tunnels**
- **60 ft deep**
- **Completion June 2013**
- **Challenges**
  - Small work areas, shallow ground cover, difficult ground conditions, active rail lines directly above tunnels



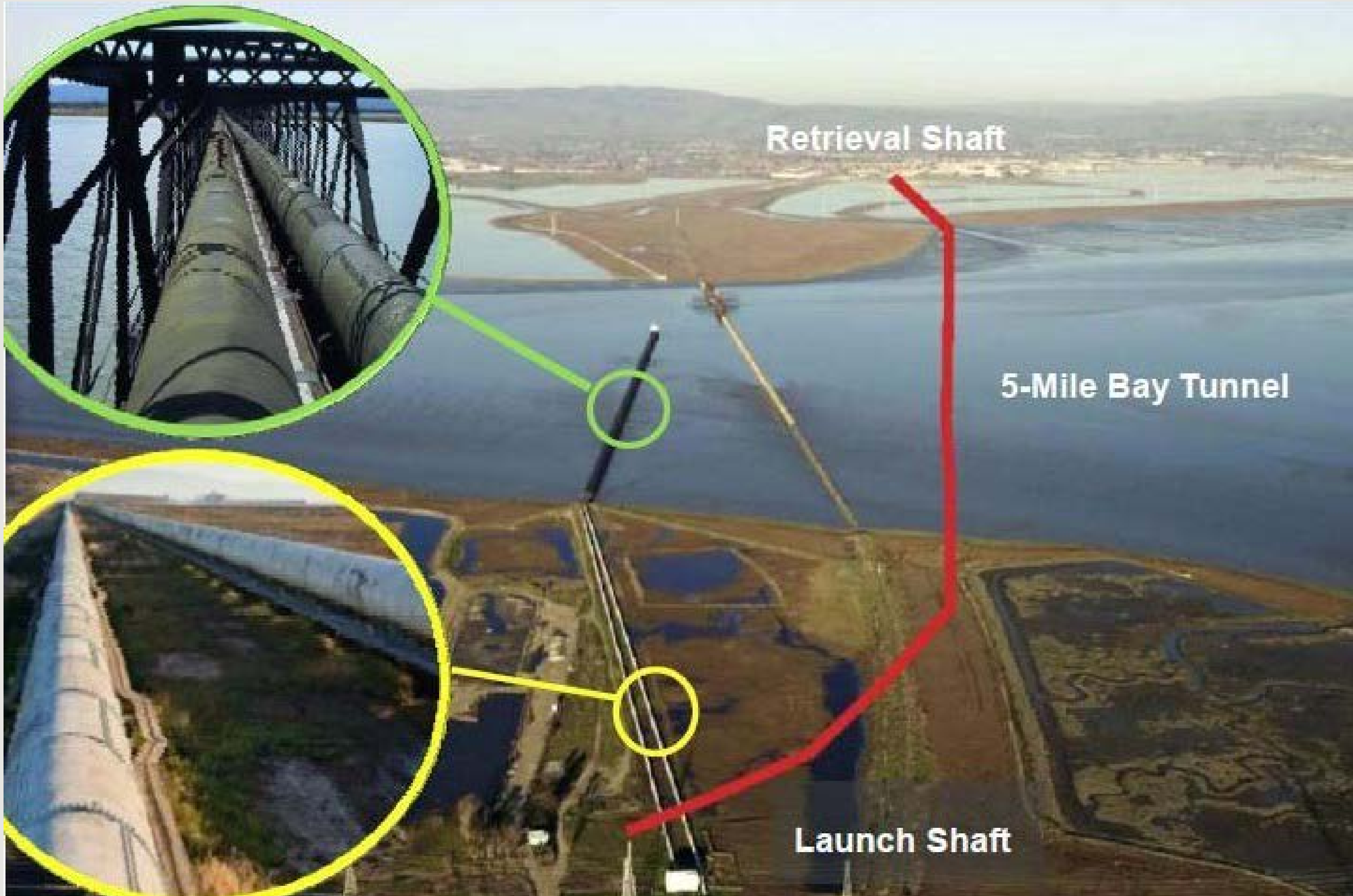
BLUE PLAINS TUNNEL PROJECT- DISTRICT OF COLUMBIA

BLUE PLAINS TUNNEL PROJECT

Project Information

- **23 ft ID x 24,200 ft CSO Tunnel**
- **160 ft deep**
- **Completed Dec 2015**
  - 3 months ahead of schedule
  - Under budget
- **Challenges**
  - Institutional resistance to change, existing infrastructure above tunne, and environmental permitting

BAY TUNNEL – SAN FRANCISCO



BAY TUNNEL – SAN FRANCISCO

Project Information

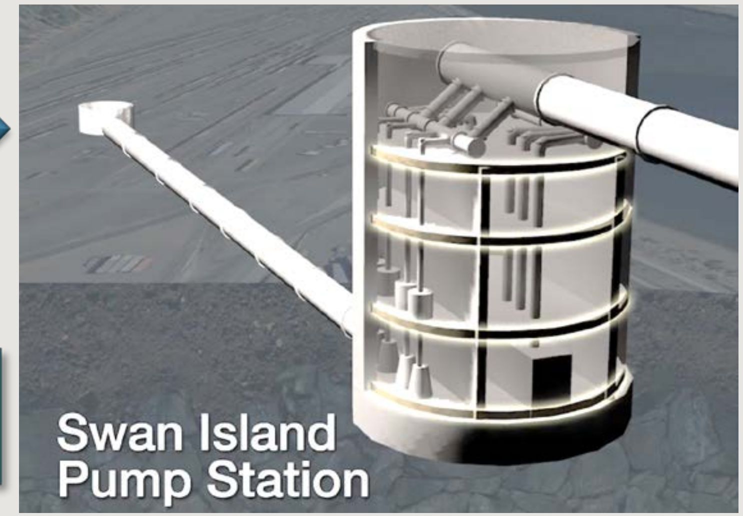
- **15 ft ID x 5 mile water tunnel**
- **110 ft deep**
- **Completed Oct, 2014**
  - on schedule
  - Within budget
- **Challenges**
  - Variable ground, contaminated soil, disposal of tunnel material, long tunnel drive, and high ground water pressure (3.5 bar)

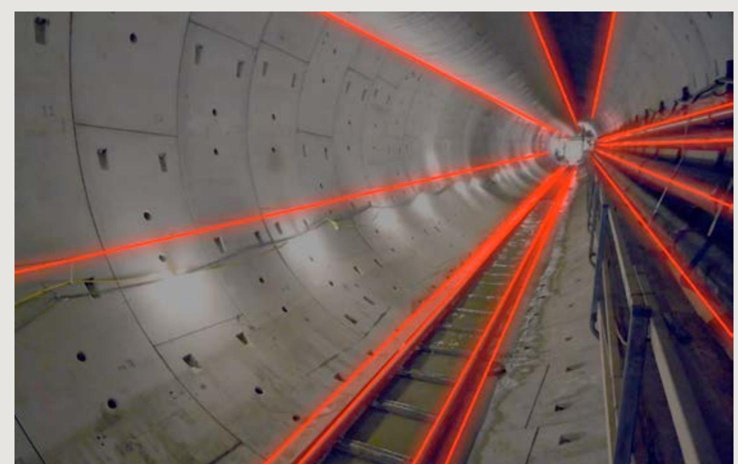
WILLAMETTE RIVER COMBINED SEWER OUTFALL PROGRAM – PORTLAND

Swan Island PS

Westside Tunnel

Eastside Tunnel



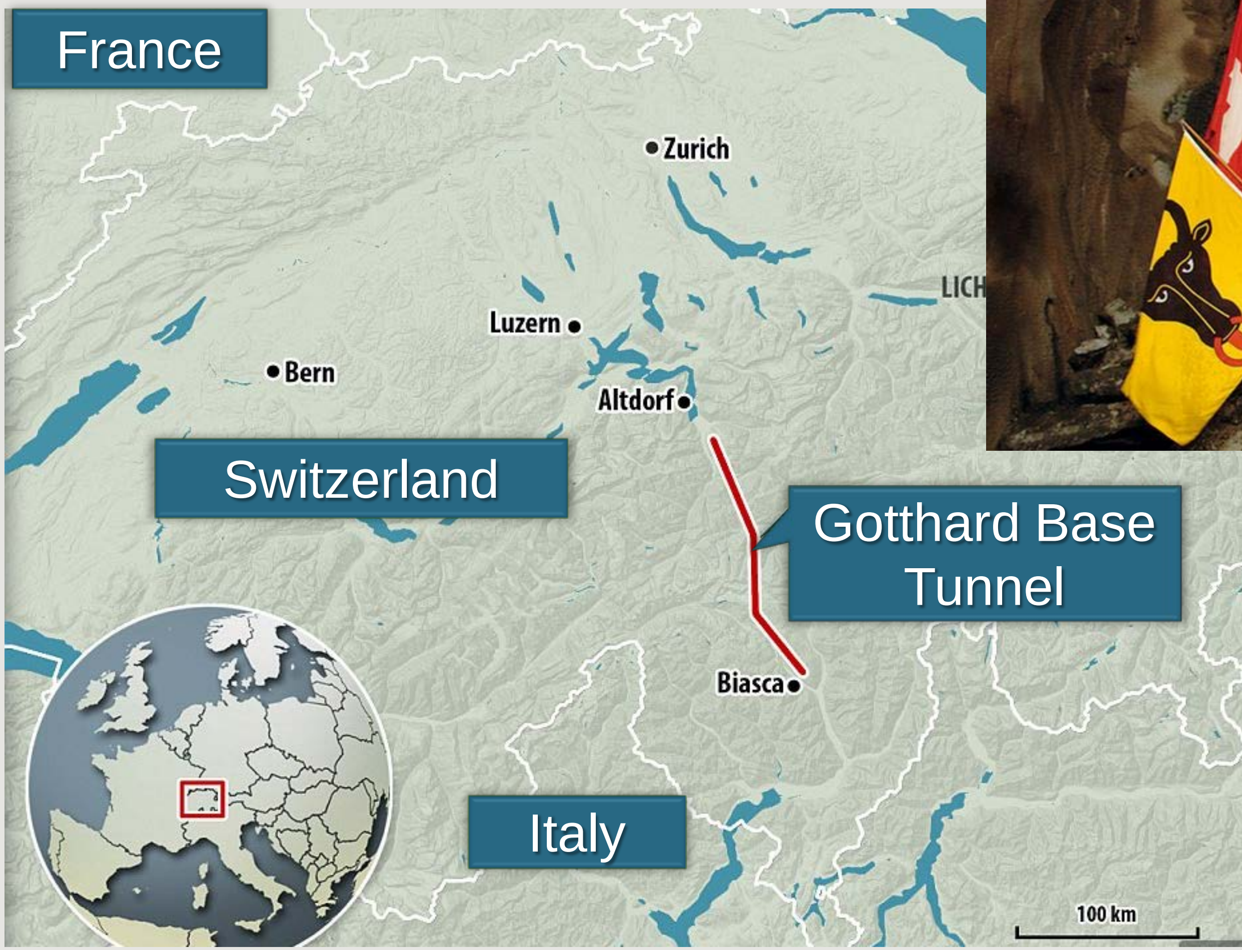


WILLAMETTE RIVER COMBINED SEWER OUTFALL PROGRAM – PORTLAND

Project Information

- **(1) 14 ft ID x 3.5 mile 120 ft deep and (1) 22 ft ID x 6 mile**
- **150 ft deep CSO tunnels**
- **Construction Complete Feb 2012**
  - 8 months ahead of schedule
  - Under budget
- **Challenges**
  - Schedule, existing infrastructure, groundwater, difficult ground conditions, soil modification, and subcontract changes

GOTTHARD BASE TUNNEL - SWISS ALPS

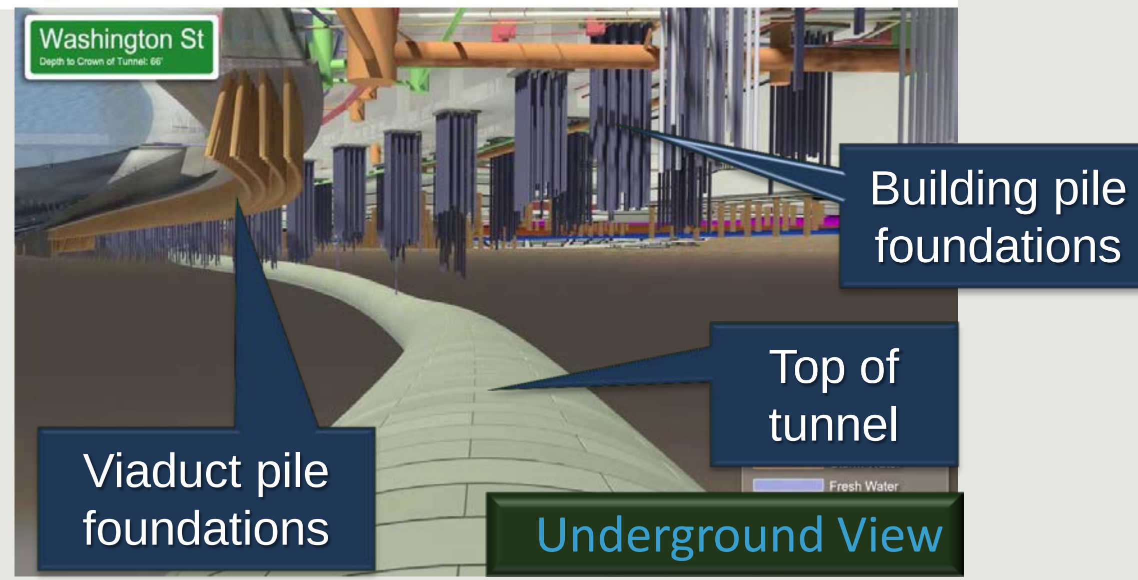


GOTTHARD BASE TUNNEL - SWISS ALPS

Project Information

- **(2) 30 ft ID x 35 mile rail tunnel**
- **Up to 6,560 ft deep**
- **For the 2 main tunnels and the safety, ventilation and cross cuts, a total of 95 miles tunnel was bored**
- **Completed June 2016**
  - within schedule (17 years)
- **Challenges: Safety, geology**

SR-99 ALASKAN WAY REPLACEMENT-SEATTLE

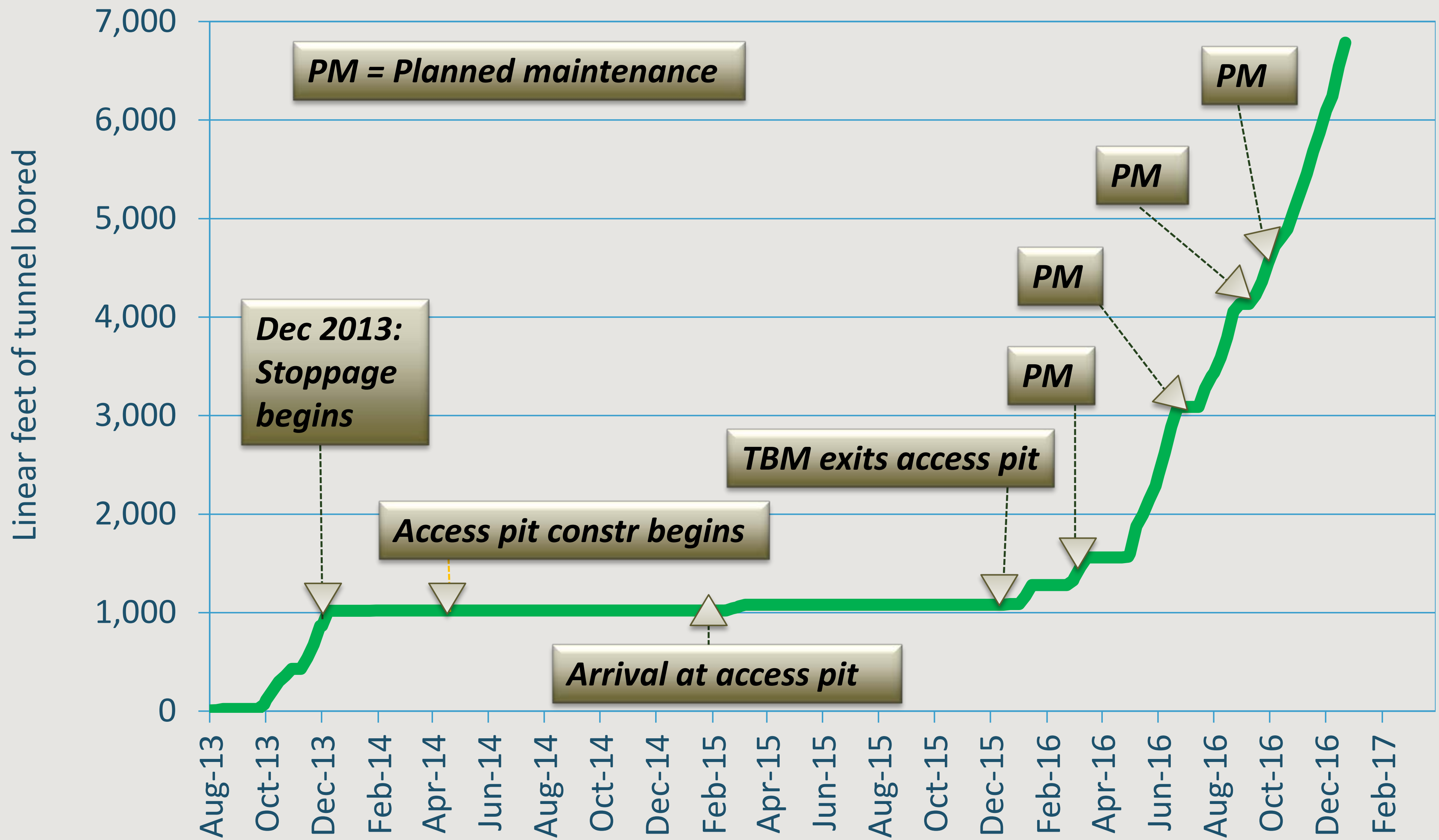


SR-99 ALASKAN WAY TUNNEL-SEATTLE

Project Information

- **53 ft ID x 2 mile transportation tunnel**
- **Construction schedule**
  - approximately 2 year delay
- **Challenges**
  - Equipment malfunction, existing pile foundations and other infrastructure, difficult ground

SR-99 ALASKAN WAY TUNNELING PROGRESS



LESSONS LEARNED

- **Conduct an extensive and thorough geotechnical program**
- **Utilize TBM technology that is well understood and project-proven**
- **Select only experienced tunneling contractors**
- **Implement a comprehensive monitoring and inspection program**
- **Implement proactive risk management strategy at all stages**

RELEVANT EXAMPLES OF PILE DRIVING AND LEVEE/STRUCTURE PERFORMANCE

- **Alternative Intake on Victoria Canal**
- **Freeport Intake**
- **Sankey Diversion Facility**
- **Cosumnus Power Plant**
- **Several DWR projects in the Delta- Extensive Experience**

ALTERNATIVE INTAKE ON VICTORIA ISLAND

- **2008-2009**
- **On the Victoria Canal North Bank**
- **Approx. 390 sheet and concrete piles driven**
- **Driven by impact hammer for foundation piles**
- **No observed damage**

FREEPORT INTAKE ON SACRAMENTO RIVER

- 2007-2008
- On the Sac River East Levee Bank
- ~ 800 ft. from the West Levee bank
- Approx. 520 sheet and H piles driven
- Driven by vibratory and impact hammers
- No observed damage

SANKEY DIVERSION FACILITY ON SACRAMENTO RIVER

- **2010-2011**
- **On the Sac River East Levee Bank**
- **~550 ft. from the West Levee Bank**
- **Approx. 270 piles driven**
- **Driven by impact and vibratory hammers**
- **No observed damage**

COSUMNUS POWER PLANT

- 2004
- 1,800 feet from Rancho Seco plant
- Approx. 2,000 piles
- driven by impact hammer
- No observed damages

SHEET AND PILE DRIVING TECHNOLOGIES

- **Sheet Piles**
  - Used for coffer dam (in-water) construction
  - Vibratory hammers (70%)
  - Impact hammers (30%)
- **Foundation Piles**
  - Either Driven piles or Cast-in-drilled hole piles
  - Type depends on final geotech studies

DWR SHEET AND PILE DRIVING COMMITMENTS (ENVIRONMENTAL COMMITMENTS 3B.2.1.1-2)

- **Perform pre-construction surveys to establish baseline conditions**
- **Collect subsurface data**
- **Perform geotechnical analyses**
- **Select appropriate pile types and installation methods**
- **Implement monitoring programs during construction**

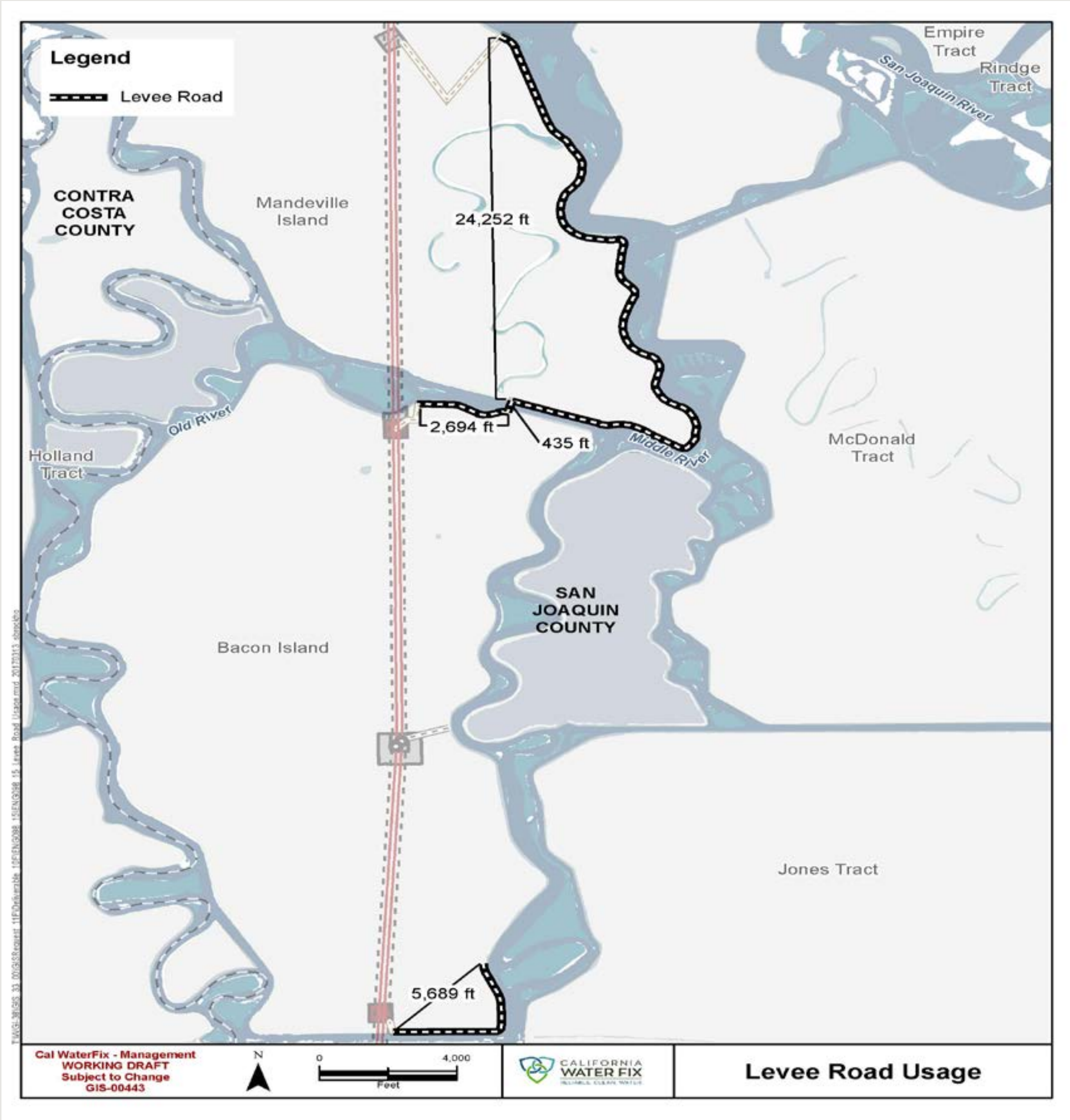
ENCROACHMENT INTO RIVER CHANNEL

- **Under jurisdiction of USACE and CVFPB**
- **Modifications must meet USACE's 408 requirements**
- **Safety assurance review by an independent panel of experts**
- **Must maintain "project'" conditions, purposes or outputs**

TRAFFIC ON LEVEES

- **Very little project traffic is planned to traverse on levees**
  - SR-160 is constructed on top of a levee
    - Suitable for H20 loading
    - Already experiences extensive traffic

LEVEE ROAD USAGE FOR WATERFIX



BACON ISLAND: 1.6 MILES

MANDEVILLE ISLAND: 4.6 MILES

TRAFFIC ON LEVEES

- **DWR's commitments to levees and levee roads**
  – Preconstruction assessment
  – Ground stabilization, if needed
  – Monitoring during construction
  – Return roadways to preconstruction condition
- **Final EIR/EIS Commitments**
  – Mitigation Measures: TRANS-2a, 2b and 2c
  – Environmental Commitment 3B.2.1.2
    - Settlement Monitoring and Response Program

EXISTING WATER DIVERSIONS

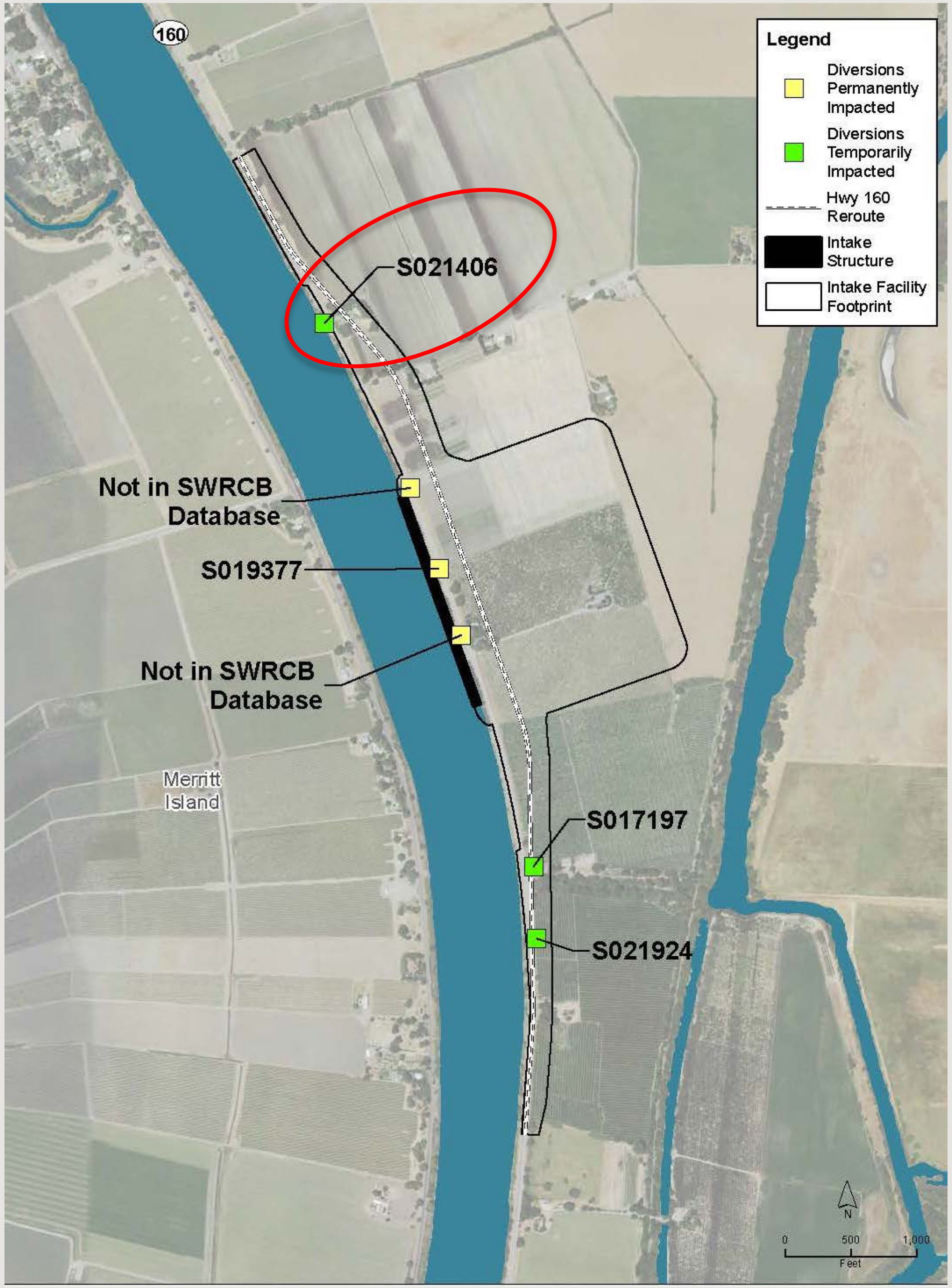
- **Total number of effected water rights**
  - Temporarily effected: 10
  - Permanently effected: 5
- **Mitigations for temporarily effected diversions**
  - Prior to construction, extend pipes and adjust pump locations on landside
  - Provide new groundwater wells
  - Provide alternate water supply from a permitted source

EXISTING WATER DIVERSIONS

- **Mitigations for permanently effected diversions**
  - Provide temporary mitigation measures until the mitigation measures below are completed:
    - Relocate existing diversions outside of the intake structure footprint
    - Provide a new turnout from the proposed CWF sedimentation basins

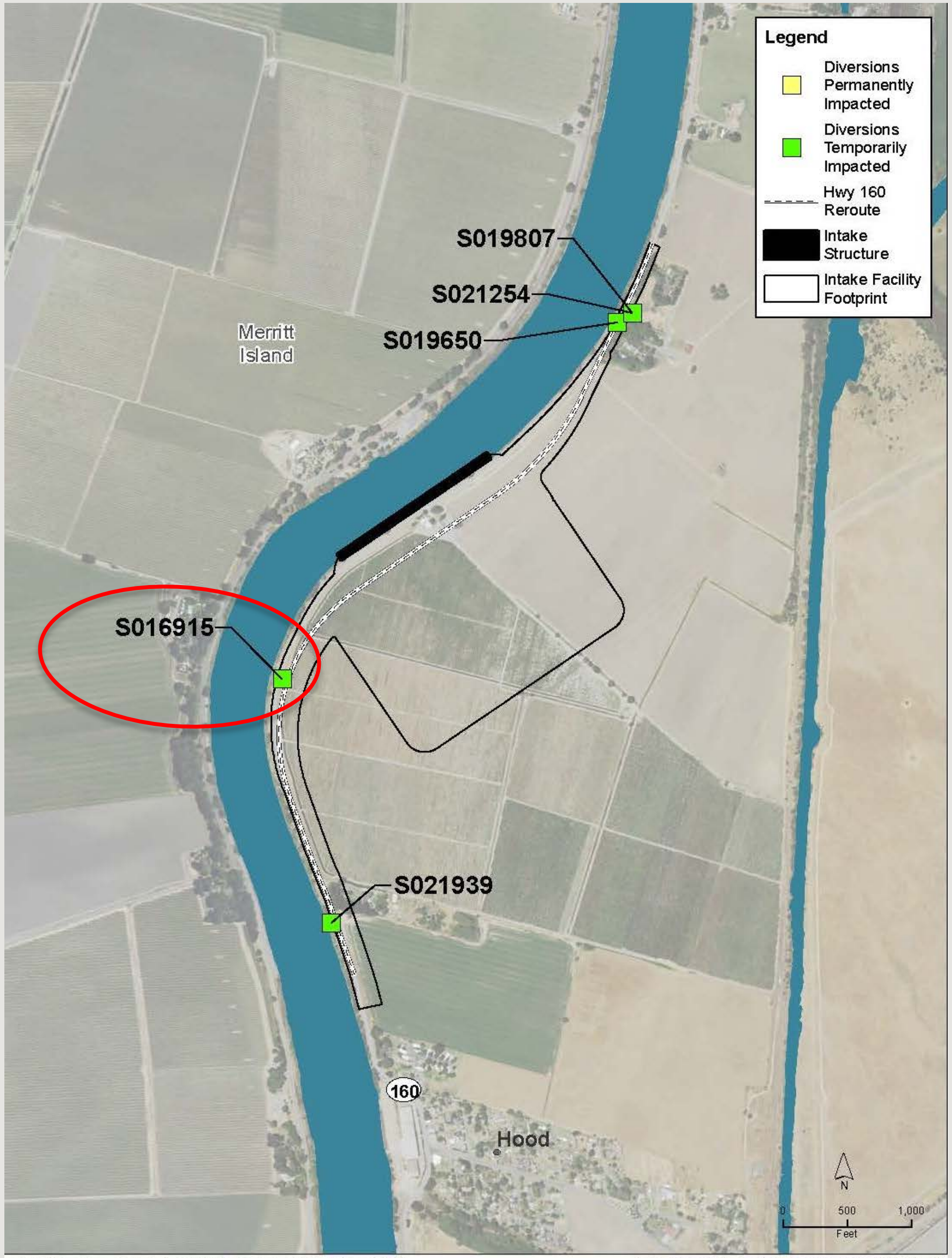
INTAKE 2 DIVERSIONS

- **Diversion S021406**
  - Falls outside of intake footprint
  - Within road relocation
  - Will not be permanently affected
  - Temporary impacts
  - Maintain quality and quantity of flow



INTAKE 3 DIVERSIONS

- **Diversion S016915**
  - Falls outside of intake footprint
  - Within road relocation
  - Will not be permanently affected
  - Temporary impacts
  - Maintain quality and quantity of flow



ISSUE: POTENTIAL IMPACT OF TUNNELING UNDER/NEAR EXISTING INFRASTRUCTURE

- **EBMUD's Concerns**
  - Tunnel construction will undermine, cause settlement and reduce ground support of aqueduct foundation piles
  - CWF tunnel profile will intersect with existing and planned infrastructure

DWR COMMITMENTS
TO AVOID IMPACTS TO INFRASTRUCTURE

- **Existing DWR Commitments, outlined in:**
  - Appendix 3B, Section 3B.2.1
  - Ground treatment plan, ground settlement monitoring, and response plan
- **Additionally, DWR Commits to:**
  - Work collaboratively with EBMUD and other agencies on these issues during preliminary and final design
  - Provide contract specs and maintenance requirements to ensure safe tunneling
  - Provide appropriate levels of on-site inspection to ensure successful results

ISSUE: POTENTIAL IMPACT OF TUNNEL SEEPAGE ON EXISTING INFRASTRUCTURE

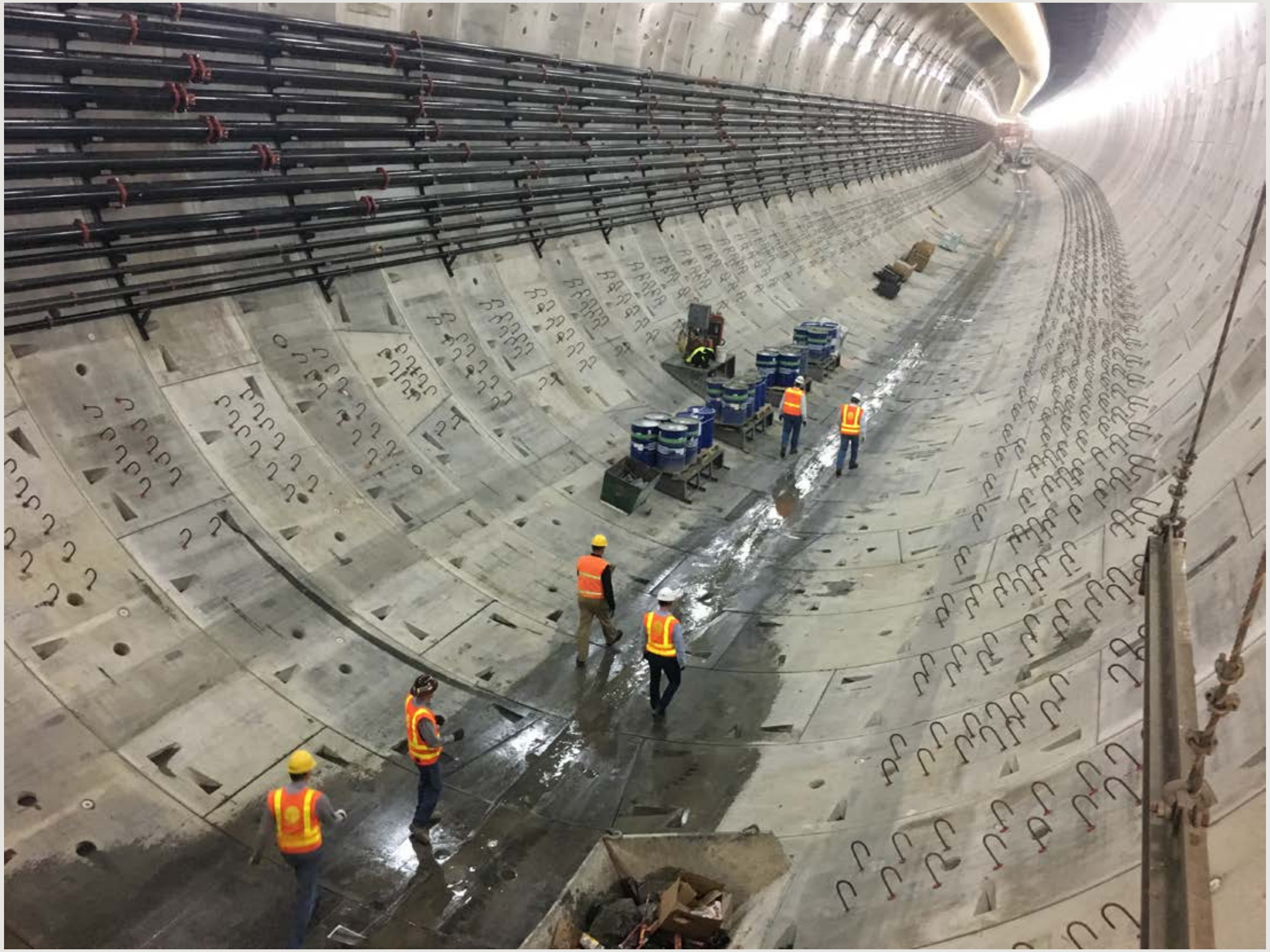
- **Concerns expressed by protestants over potential leakage from tunnels**
  - No estimates of potential leakage rates presented by protestants
  - No analysis of potential impacts presented by protestants

TUNNEL LEAKAGE STUDY – ARUP 2017

- **Findings**
  - Current CWF configuration minimizes potential for tunnel leakage
    - In most cases, tunnel internal pressure is less than external water pressures
  - For 73.5 miles of tunnel:
    - leakage rate estimated at 0.7 cfs
    - Inflow rate estimated at 3.7 cfs
    - Overall inflow rate: 3.0 cfs

SEATTLE TUNNEL INFLOWS

57-FOOT OUTSIDE DIAMETER TUNNEL



HONG KONG TUNNELS INFLOWS

46-FOOT OUTSIDE DIAMETER TUNNELS

Liantang Boundary Control Point Tunnel

Tuen Mun-Chek Lap Kok Tunnel

DWR COMMITMENTS
TO REDUCE TUNNEL LEAKAGE/INFLOW

- **Specify high-quality concrete in segments, and ensure results with proper QA/QC**
- **Provide careful details for inserts and grout holes**
- **Provide high quality segment connections and gasket details**
- **Specify “tight” build tolerances**
- **Provide good field inspection to enforce superior construction builds**

ISSUE: CONCERN OVER POWER LINES CROSSING AQUEDUCT

- **Potential for induced current to lead to corrosion**
- **Potential for induced current to lead to shock hazard**
- **Potential for power line to fall and strike aqueduct**

DWR COMMITMENTS TO REDUCE POWER LINE RISK POTENTIAL

- **Existing DWR Commitments, outlined in:**
  - Appendix 3B, Section 3B.2.3, and Section 3b.4.30 (AMM 30)
  - Design and construction transmission lines in accordance with Electrical Power and Transmission Line Design Guidelines
- **Additionally, DWR Commits to:**
  - Work collaboratively with EBMUD and other agencies on these issues during preliminary and final design
  - Provide contract specs and appropriate levels of on-site inspection and on-going observation to ensure successful results

SEA LEVEL RISE FOR FLOOD PROTECTION

- **Used 55 inches of SLR at Golden Gate Bridge**
- **SLR impact decreases farther inland**
- **18 inches of SLR added above 200-yr flood level for intakes**
- **To be reviewed and updated during next engineering phase**