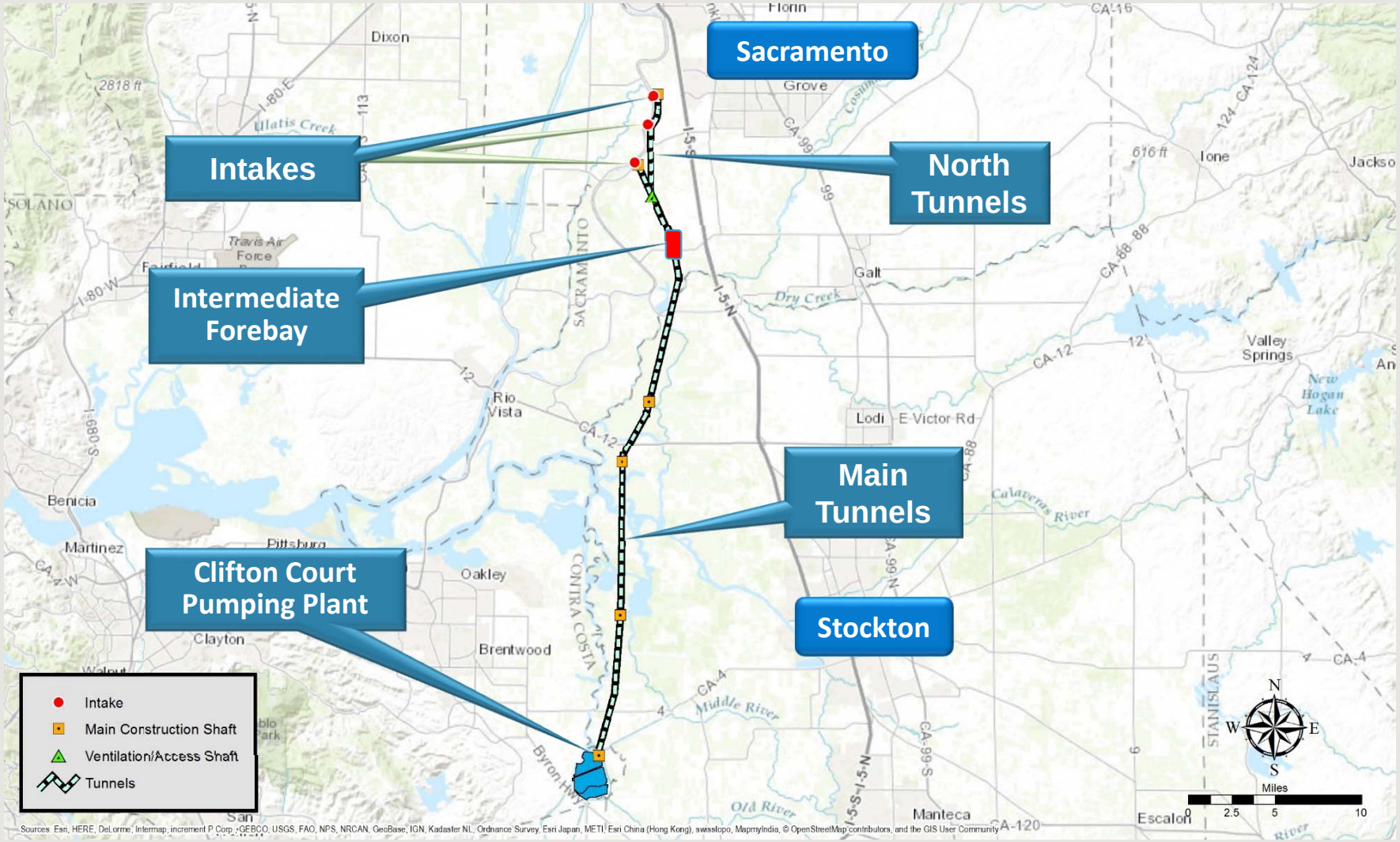
CALIFORNIA WATER FIX
RELIABLE. CLEAN. WATER.

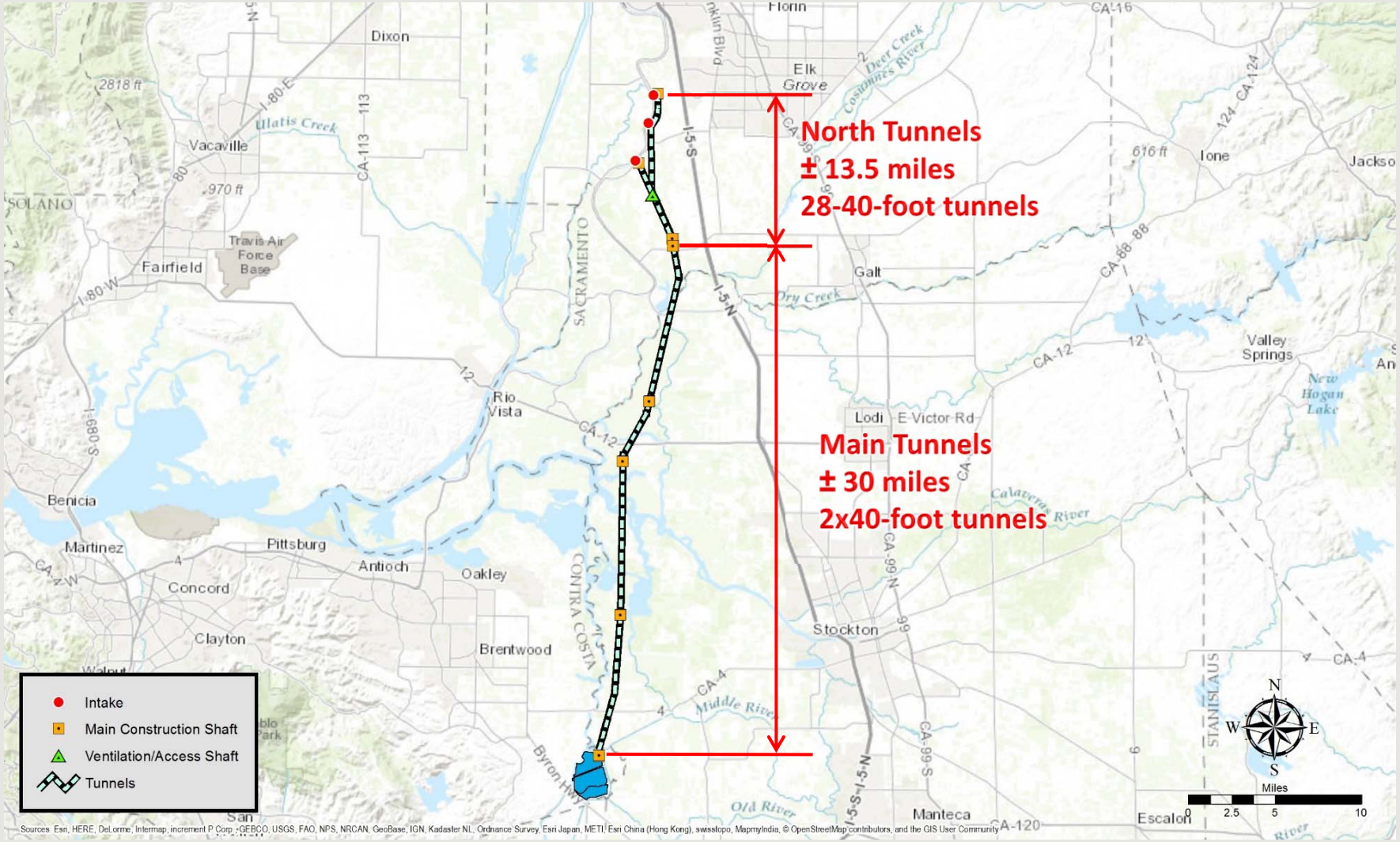
PROJECT IMPLEMENTATION CONSIDERATIONS FOR THE CALIFORNIA WATERFIX

San Luis Delta Mendota Water Authority
July 19, 2017

CALIFORNIA WATER FIX- OVERALL PROGRAM



TUNNEL PORTIONS OF PROGRAM

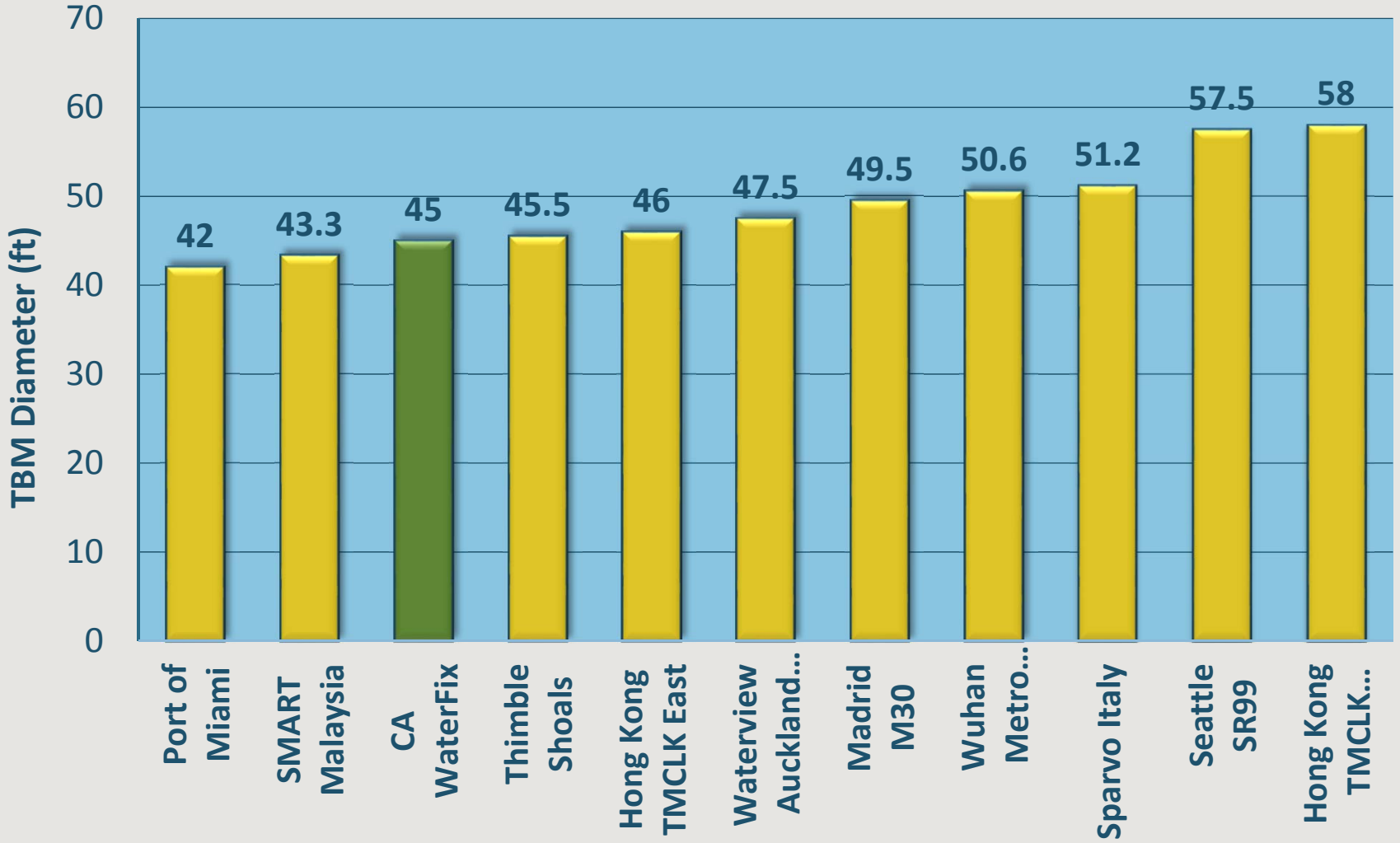


MAIN TUNNELS

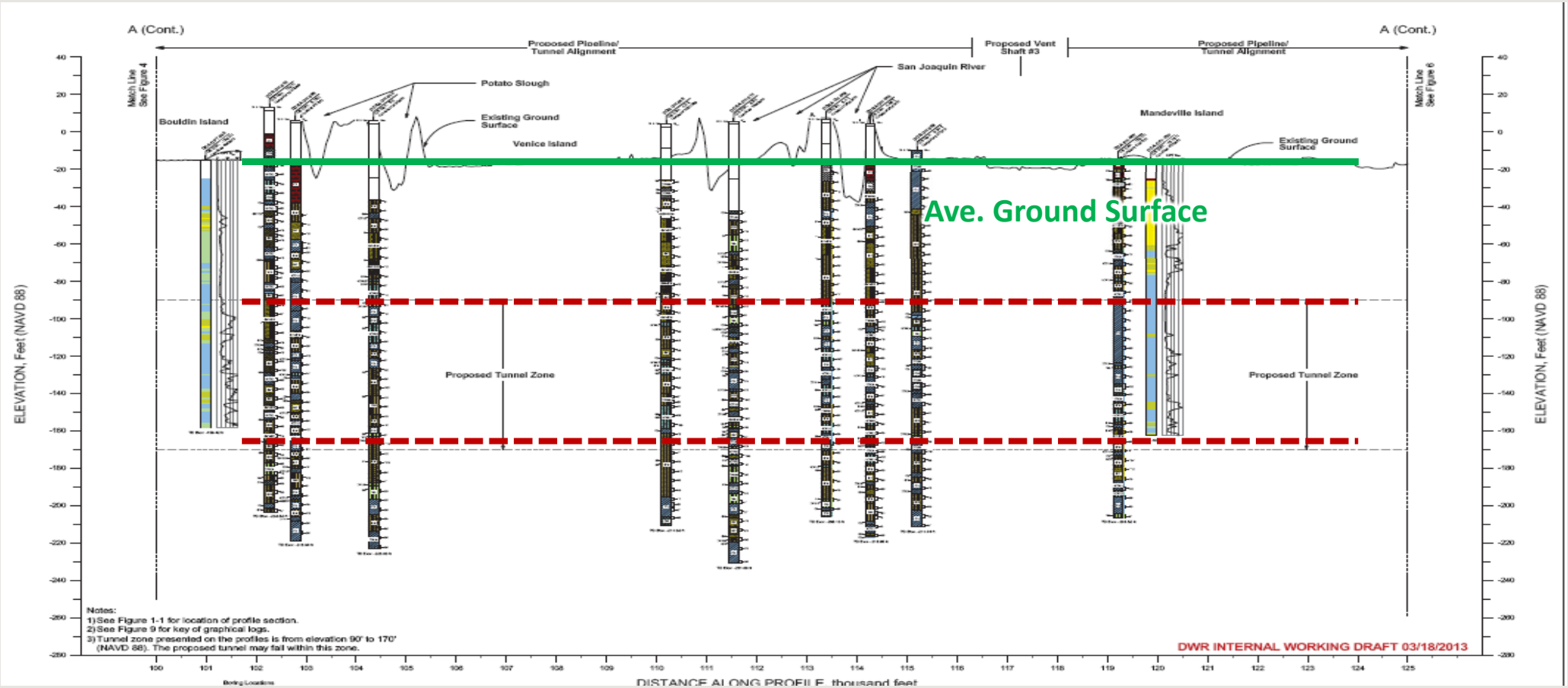
- 100 year life
- Twin bore main tunnels
- 150 ft below grade
- Concrete segmental liner
- Pressurized face Tunnel Boring Machine construction
- 45 ft excavated diameter
- 40 ft finished internal diameter

Photo Courtesy: Port of Miami Tunnel

LARGE DIAMETER TUNNEL BORING MACHINE PROJECTS



GEOTECHNICAL PROFILE AT TUNNEL DEPTH

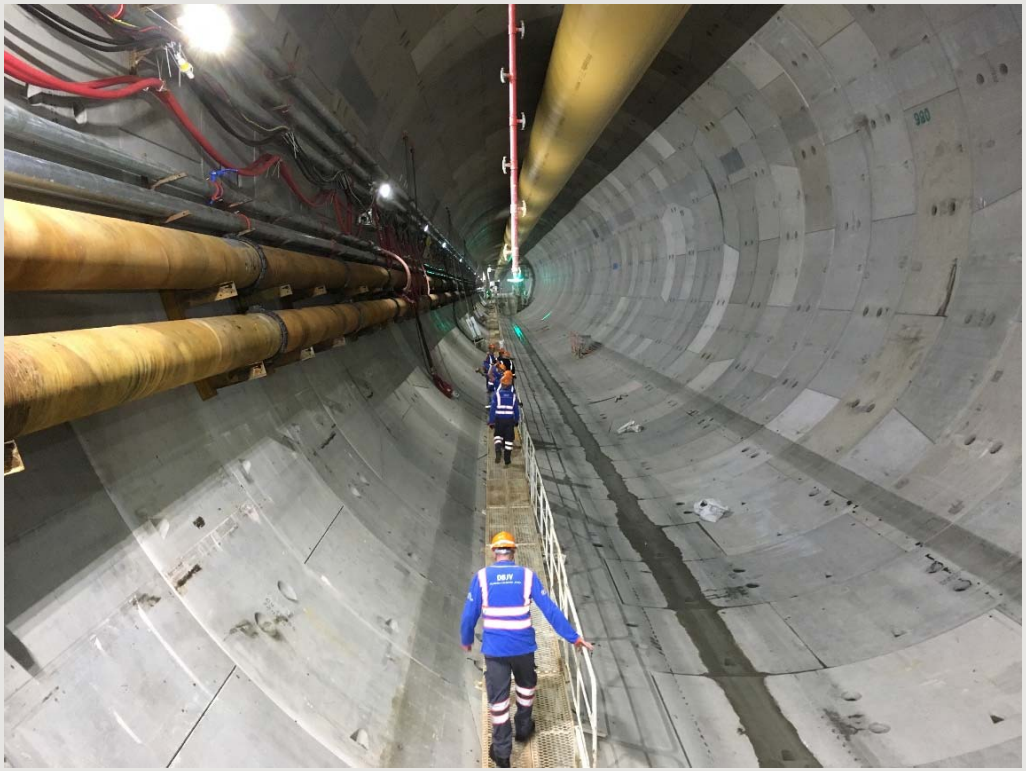


Note: Over 200 borings/CPTs completed

PROGRAM FACTS

- 700,000 tunnel segments
- 23 million cubic yards of excavated tunnel material
- 10-12 Tunnel Boring Machines operating simultaneously
- 195 Mega Watts of power required for Tunnel Boring Machines
- Existing levees protect project sites
- Limited highway access in Delta

TYPICAL TUNNEL SEGMENTS AND LINED TUNNEL

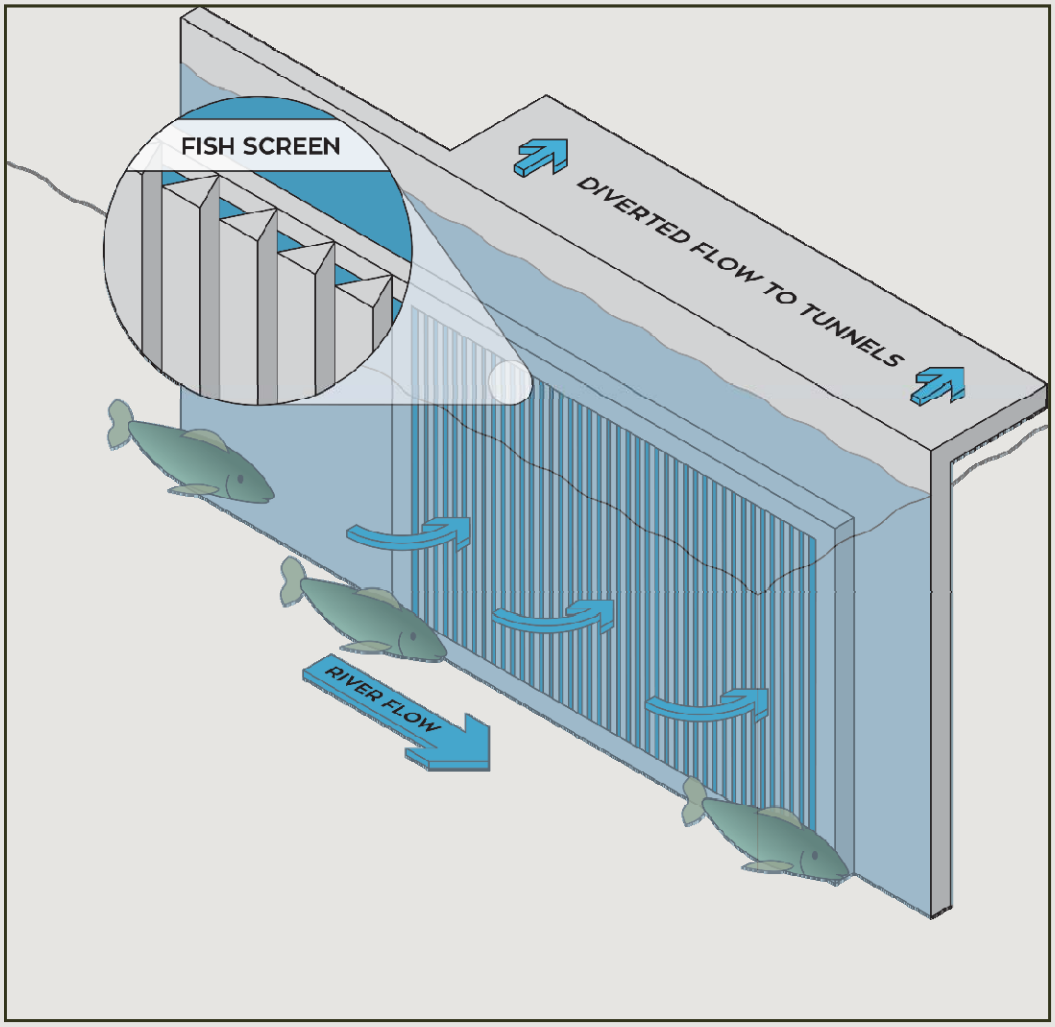


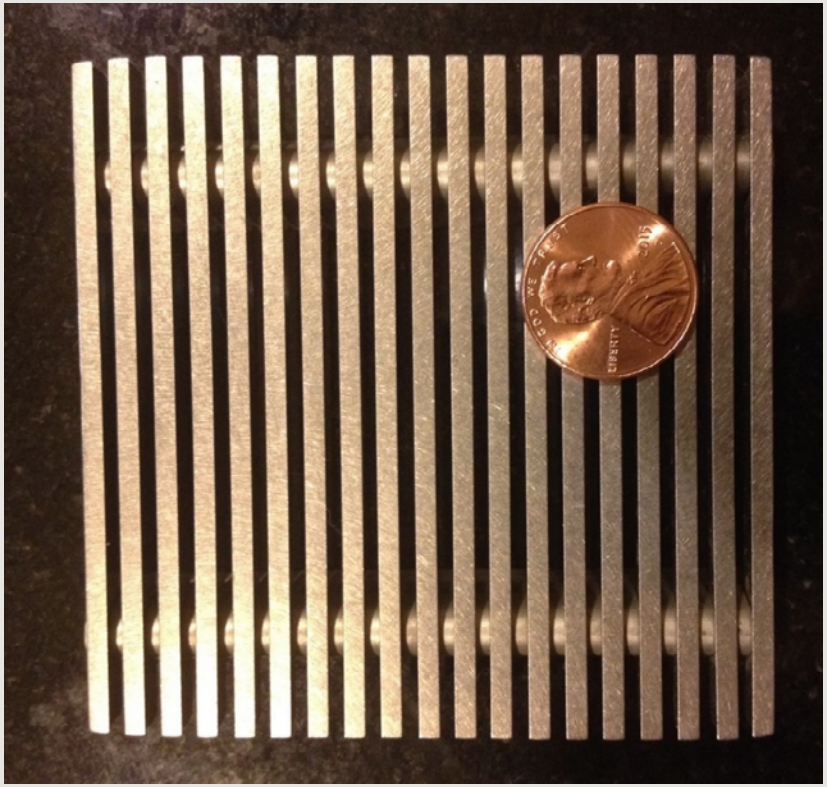
REUSABLE TUNNEL MATERIAL

- Preliminary level of testing (DWR Report)
  - Sterile material
  - Suitable for engineering fill
- Stockpiles at 6-14 ft
- Existing restoration uses
  - SFPUC Bay Tunnel Bair Island
  - London Crossrail Wallasea Island

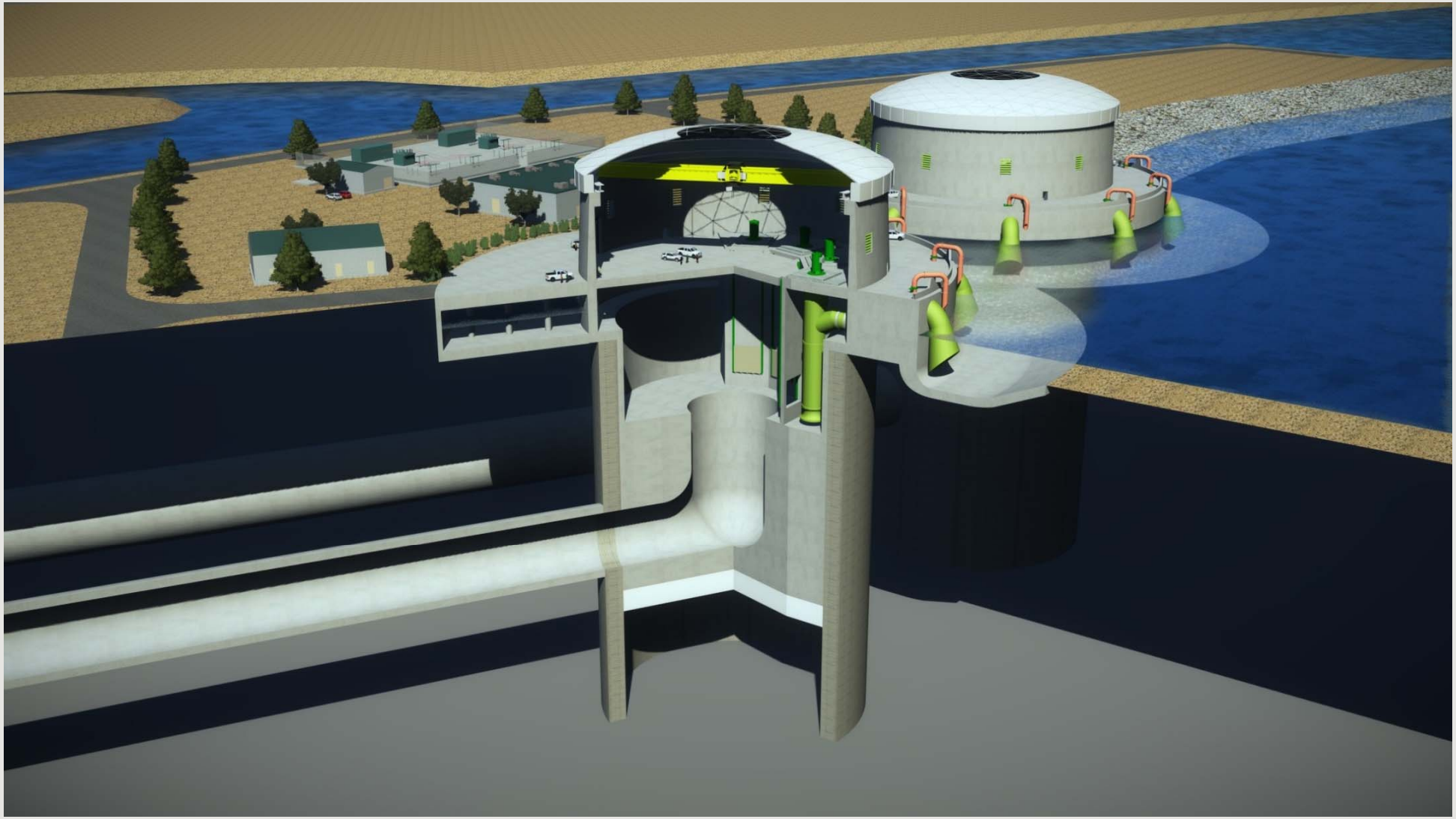
RIVER INTAKES

PROTECTING FISH





CLIFTON COURT PUMP PLANTS



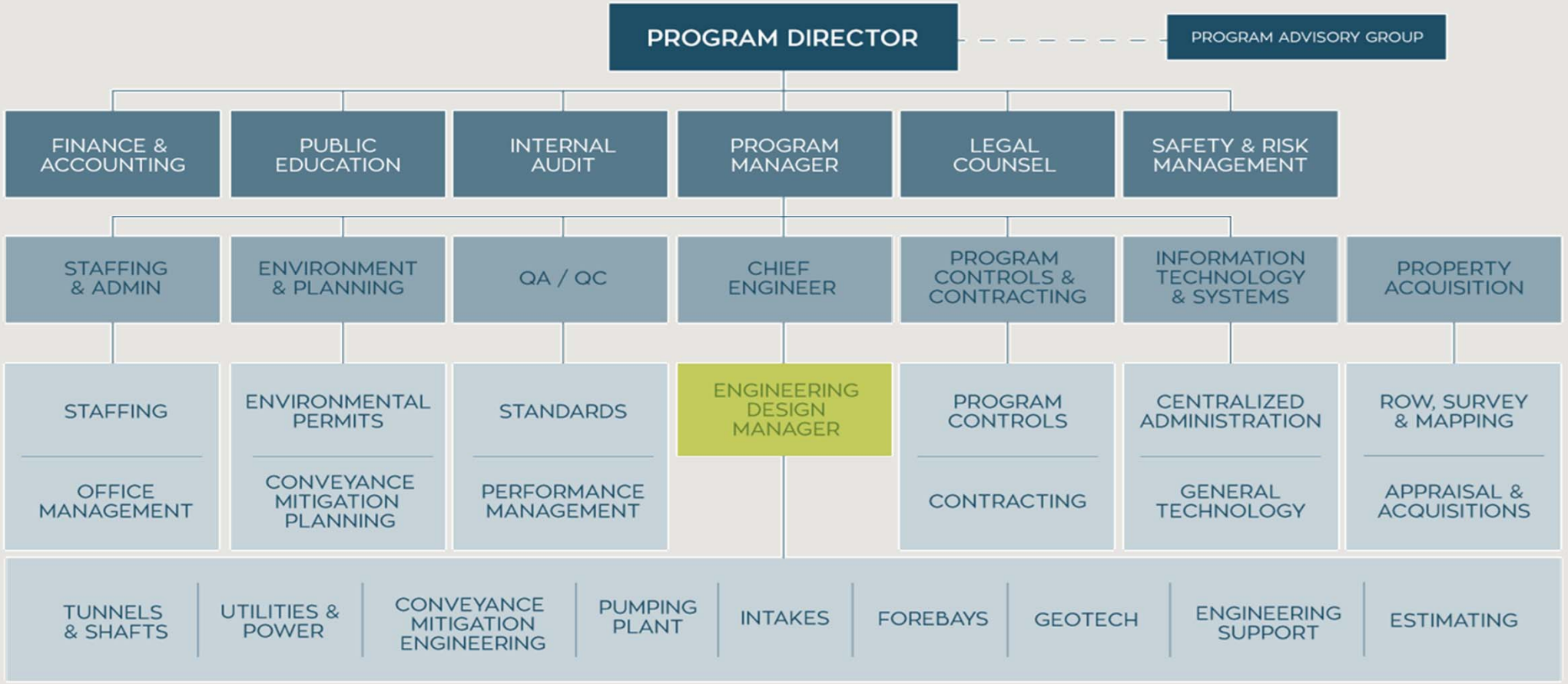
PROGRAM ESTIMATES

	Amount ($ billions)
Total	**$ 14.94**
PM/CM/Engineering	$ 1.91
Tunnels/Shafts Construction	$ 6.82
Remaining construction	$ 2.68
Land Acquisition	$ 0.15
Contingency *(approx. 36% for tunnels/shafts and remaining construction)*	$ 3.38

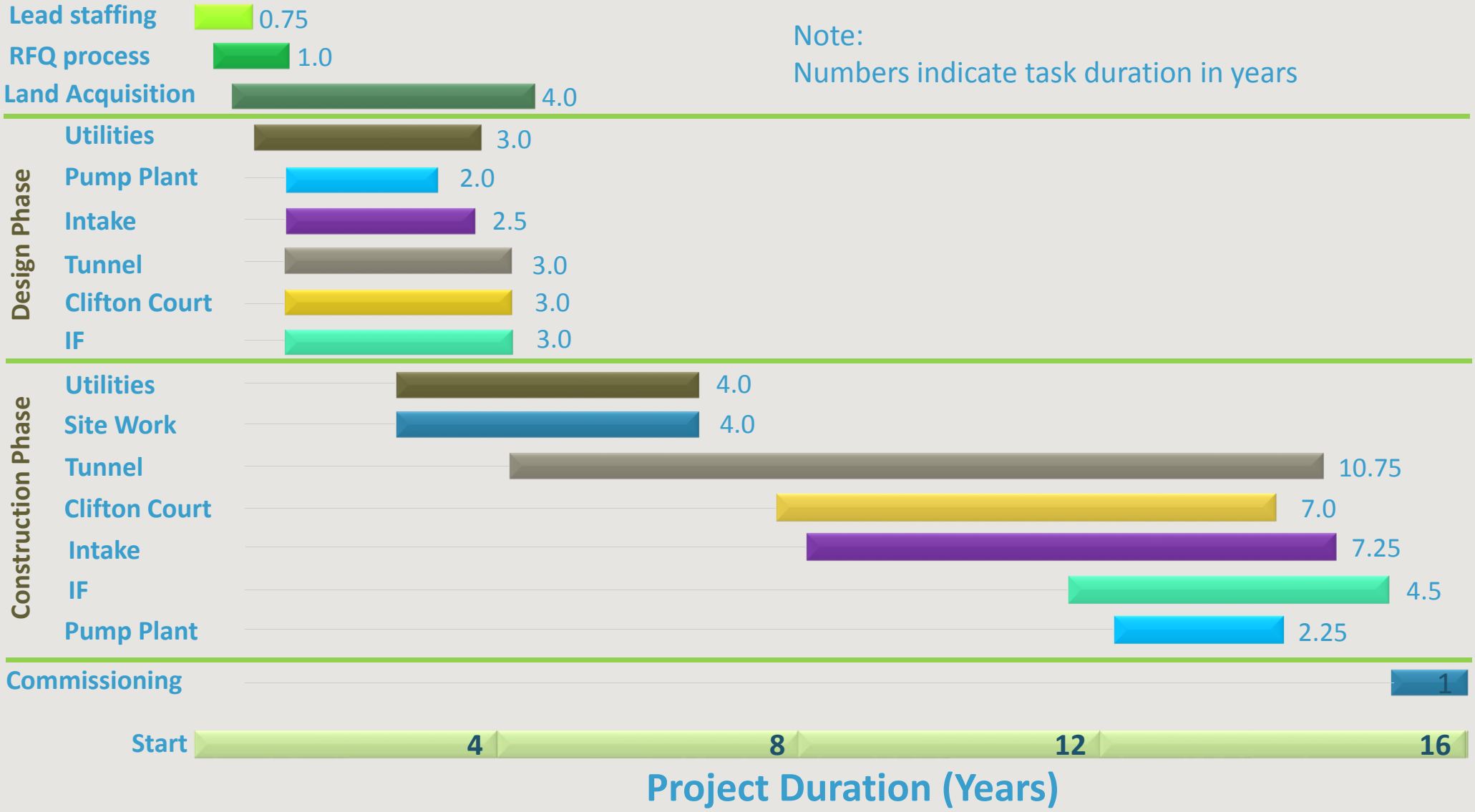
Program Estimate in 2014 Dollars

DESIGN AND CONSTRUCT ENTERPRISE

ORGANIZATIONAL STRUCTURE



DCE PROGRAM SCHEDULE



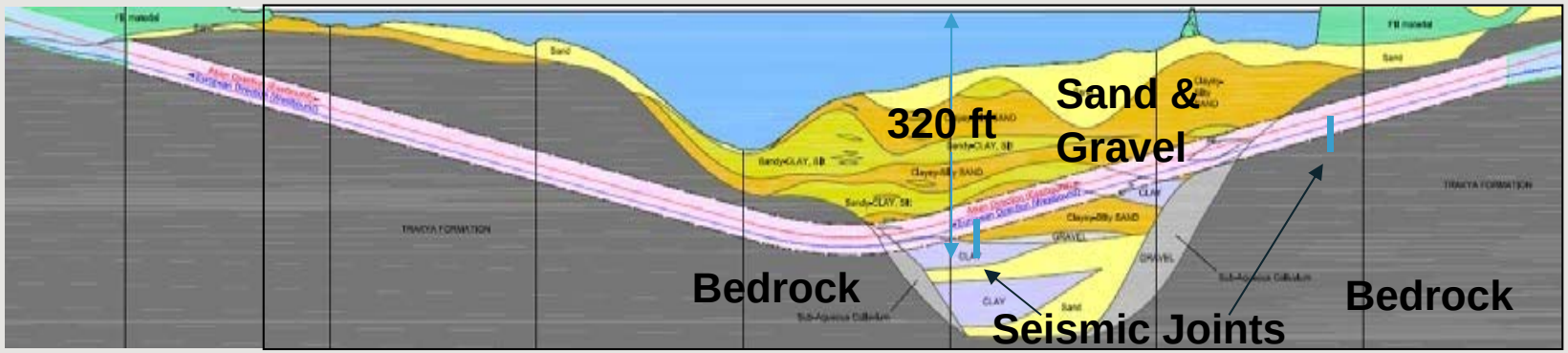
REVIEW OF OTHER MEGA-TUNNEL PROJECTS

- 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

✓ *= projects visited by program team*

THE EURASIA TUNNEL – TURKEY

2.1 miles

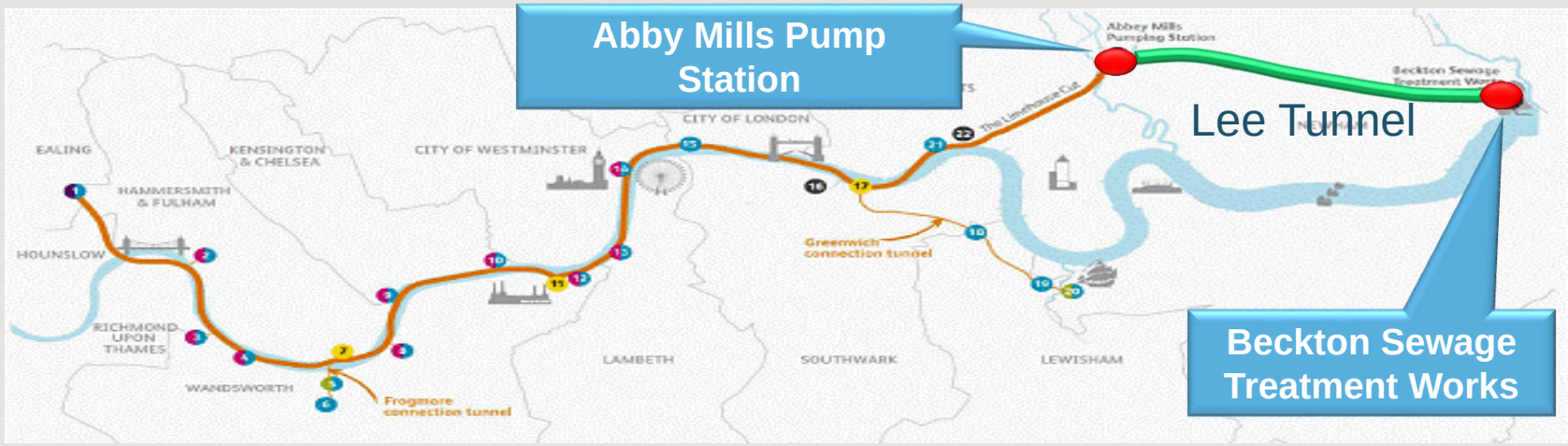


THE EURASIA TUNNEL – TURKEY

Project Information

- Transportation Tunnel
  40 ft Internal Diameter (ID) x 2.1 miles
- 320 ft deep
- Completed Dec 2016
  - 3 months ahead of schedule
- Challenges
  - Complex geology, seismically active zone, 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 - FLORIDA

Project Information

- (2) 39 ft ID x 4,200 ft Long Transportation Tunnels
- 120 ft deep
- Completion May 2014
  - On schedule
  - Within budget
- Challenges
  - Porous coral and limestone required grouting, restricted access above tunnel due to shipping channel

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
  - Large deep shafts, existing infrastructure above tunnel

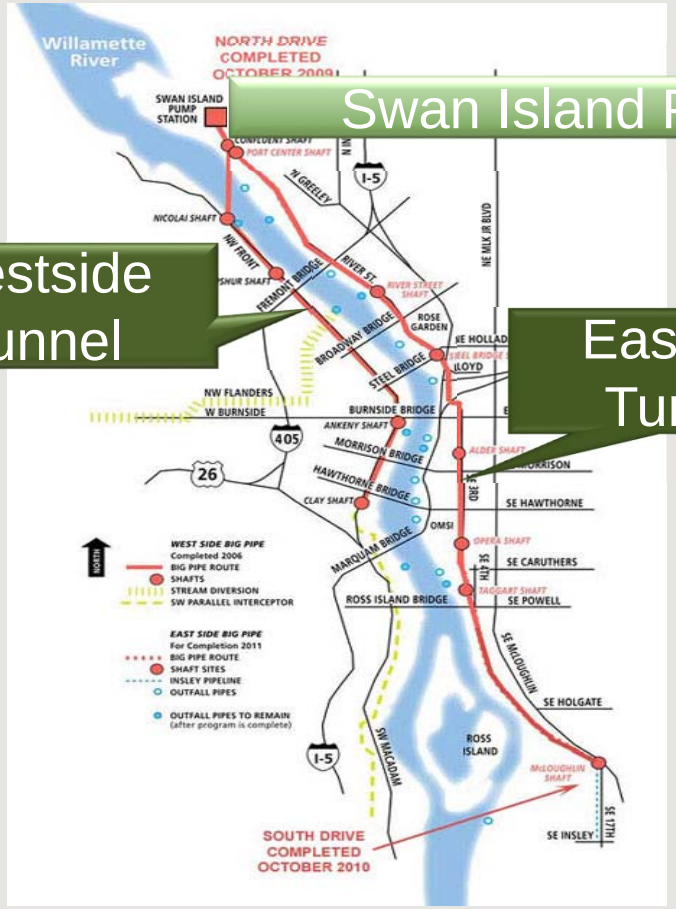
BAY TUNNEL – SAN FRANCISCO

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
  - Long tunnel drive, no intermediate shafts, limited surface access, and high ground water pressure

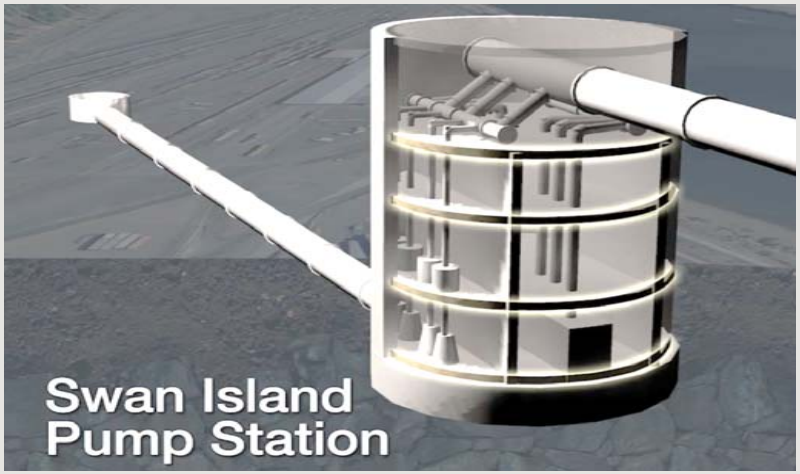
WILLAMETTE RIVER COMBINED SEWER OUTFALL PROGRAM – PORTLAND



Swan Island PS

Westside Tunnel

Eastside Tunnel



WILLAMETTE RIVER TUNNELS – 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
- Cost Reimbursable Fixed Fee
- Construction Complete Feb 2012
  8 months ahead of schedule
- Construction value US $719 M, 9% under budget
- Challenges
  - Schedule, existing infrastructure, groundwater, Tunnel Boring Machine breakout, soil modification, and subcontract changes

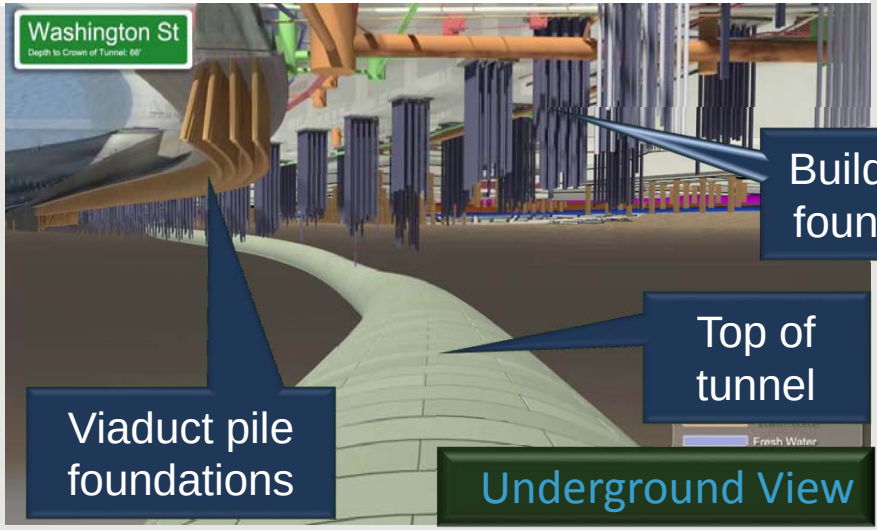
GOTTHARD BASE TUNNELS – SWISS ALPS

GOTTHARD BASE TUNNELS-SWISS ALPS

Project Information

- (2) 30 ft ID x 35 mile rail tunnel
- Up to 6,560 ft deep
- Completed June 2016 within schedule (17 years)
- Final construction cost $12.5B within budget
- Challenge: Safety, geology
- For the 2 main tunnels and the safety, ventilation and cross cuts, a total of 95 miles tunnel has been bored

SR-99 ALASKAN WAY REPLACEMENT-SEATTLE

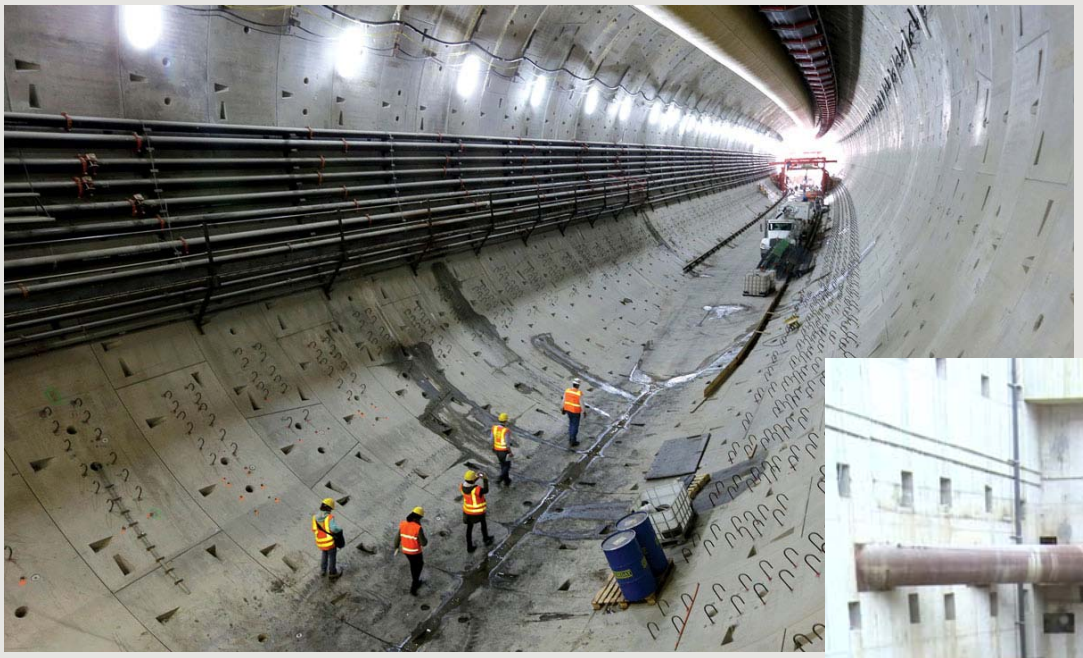


SR-99 ALASKAN WAY TUNNEL-SEATTLE

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

SEATTLE TUNNEL SUCCESS



Inside Tunnel, prior to roadway construction

Tunnel breakthrough April 4, 2017

LESSONS LEARNED

- Proactive risk management strategy at all stages
- Assign risk to appropriate party
- Select project delivery method to maximize project benefits
- Get construction input early
- Invest in good geotechnical program and GBR
- Must have strong owner involvement
- Co-locate project team
- Resolve Right-of-Way and property acquisition early
- Resolve utility issues early
- Identify long lead items early
- Proactively manage logistical issues
- Develop effective program communication strategy

QUESTIONS

The California WaterFix

April 2015 Construction Cost Estimate

Today's Presentation

1. 5RMK Qualifications/experience
2. Scope of program
3. Cost summary
4. Basis of estimate
5. Intakes
6. Clifton Court pump plants
7. Tunnel reaches

1. 5RMK Qualifications

5RMK Is a project management and planning organization providing the following services to the infrastructure and resource development industries:

- Estimating, scheduling, project planning
- Permitting, siting assessments, environmental compliance
- Program & construction management
- Claims support, defense & dispute resolution

1. 5RMK Qualifications

DRAFT

2. Scope of 2015 Estimate

- New class 3 estimate as defined by the Association for The Advancement of Cost Engineering International
- New scope definition based on new quantity take-offs, crew definitions, equipment selections and productivities
- Scope of the Project:
  - 3 - 3000 CFS Intakes
  - 2 - 4500 CFS Clifton Court Pump Plants
  - 1 - Intermediate Forebay
  - 1 - Clifton Court modifications, include embankments, siphons, canals and control structures
  - Tunnels with shafts and safe havens
    - 1- 28 ft inside diameter x 2 mile long (reach 1)
    - 1 - 28 ft inside diameter x 4.8 mile long (reach 3)
    - 1 - 40 ft inside diameter x 6.8 mile long (reach 2)
    - 2 - 40 ft inside diameter x 30.1 mile long (reaches 4-7)

2. Scope of 2015 Estimate

Total constructed value includes:

- All craft labor costs
- Construction equipment operating and ownership cost
- All permanent material and supply cost
- Field offices, laydown and staging area development
- Personnel, material, equipment and other transport cost
- Construction supervision, administration and management

Cost does not include:

- Land Acquisition, Program Management, Construction Management, Engineering, or Contingency

4. Basis of Estimate

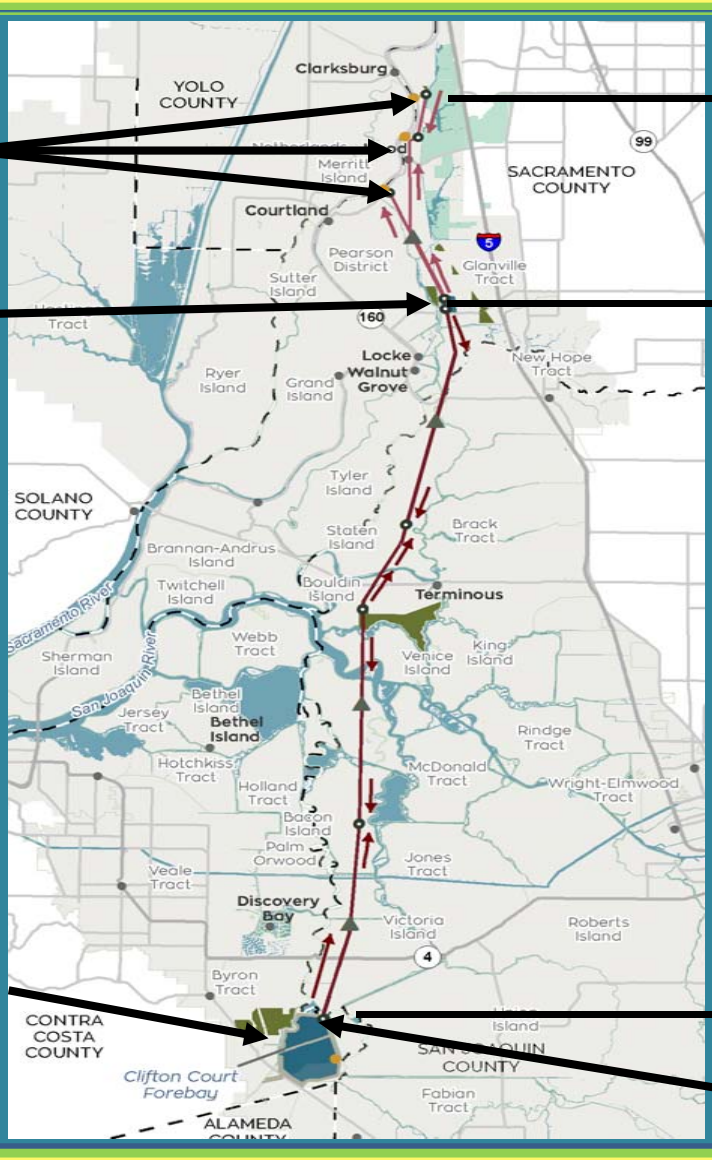
- Based on April 1, 2015 Conceptual Engineering Report (CER)
- Detailed quantity takeoffs prepared from CER
- Wage & workmen's comp rates based on "prevailing rates" listed by California Department of Industrial Relations
- Equipment ownership and operating costs based on US Army Corps Engineers
- Vendor and subcontract costs based on independent supplier solicitations
- All costs data is in 2014 dollars
- Work shifts – surface facilities: 4 days per week, 10 hours per day
- Work shifts – tunnels: 5 days per week, (2)10 hours shifts per day
- Geotechnical data is limited – further investigations are planned
- Advance rate for 40' diameter tunnels – 31.1 to 34.1 ft/day
- Advance rate for 28' diameter tunnels - 34.5 ft/day (reach 1); 40.4 ft/day (reach 2)

7. Tunnel Reaches

Intakes

Intermediate Forebay

Clifton Court



North Tunnel Reaches 1,2,3

Main Tunnel Reaches 4-7

Pump Plants

3. Construction Cost

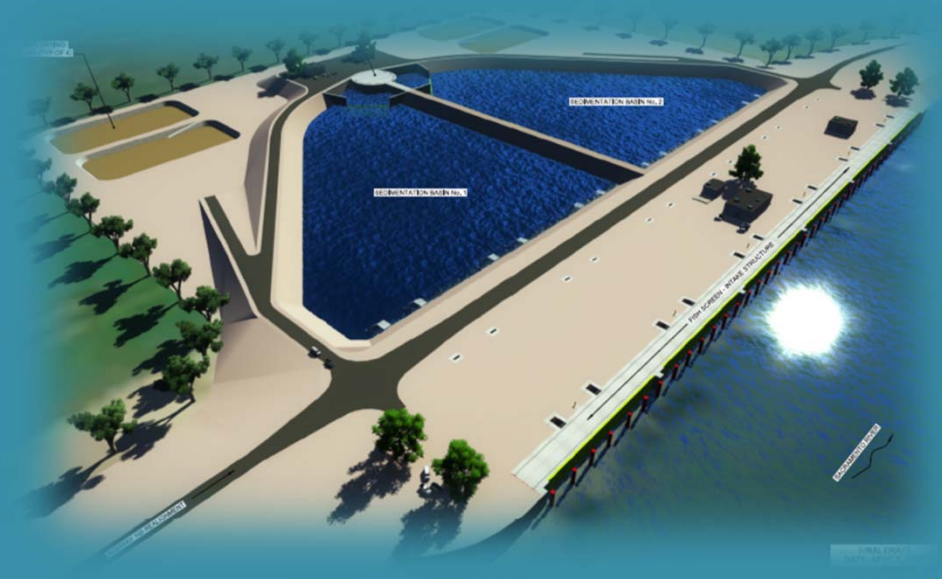
CWF April 2015 Estimate Summary		
Contract		**Estimate**
Intakes 2,3, 5	$	1,082,880,306
Intermediate Forebay	$	159,579,782
Clifton Court Forebay	$	593,720,041
Clifton Court Pump Plant	$	446,577,237
Reach 7 Tunnels	$	1,538,449,966
Reach 6 Tunnels	$	1,559,673,985
Reach 5 Tunnels	$	899,619,545
Reach 4 Tunnels	$	1,603,383,401
Reach 1, 2, & 3 Tunnels	$	1,218,681,541
Communication Network, Scada	$	25,065,734
Access, Power Delivery & Utility Relocations	$	371,300,000
Construction Total	**$**	**9,498,931,538**

Estimate Summary

Item	5RMK Estimate [(1),(2)] (Billions)
Construction	$9.50
Contingency	$3.38
Construction Subtotal	**$12.88**
PM/CM/Eng	$1.91
Land acquisition	$0.15
Grand Total	**$14.94**

(1) Program estimates in 2014 dollars
(2) ~36% Contingency on construction

California WaterFix



Questions?

ALDEA SERVICES

CALIFORNIA WATER FIX

RISK MANAGEMENT – DESIGN AND CONSTRUCTION

ALDEA SERVICES LLC
RELIABLE RESOURCES DELIVERED

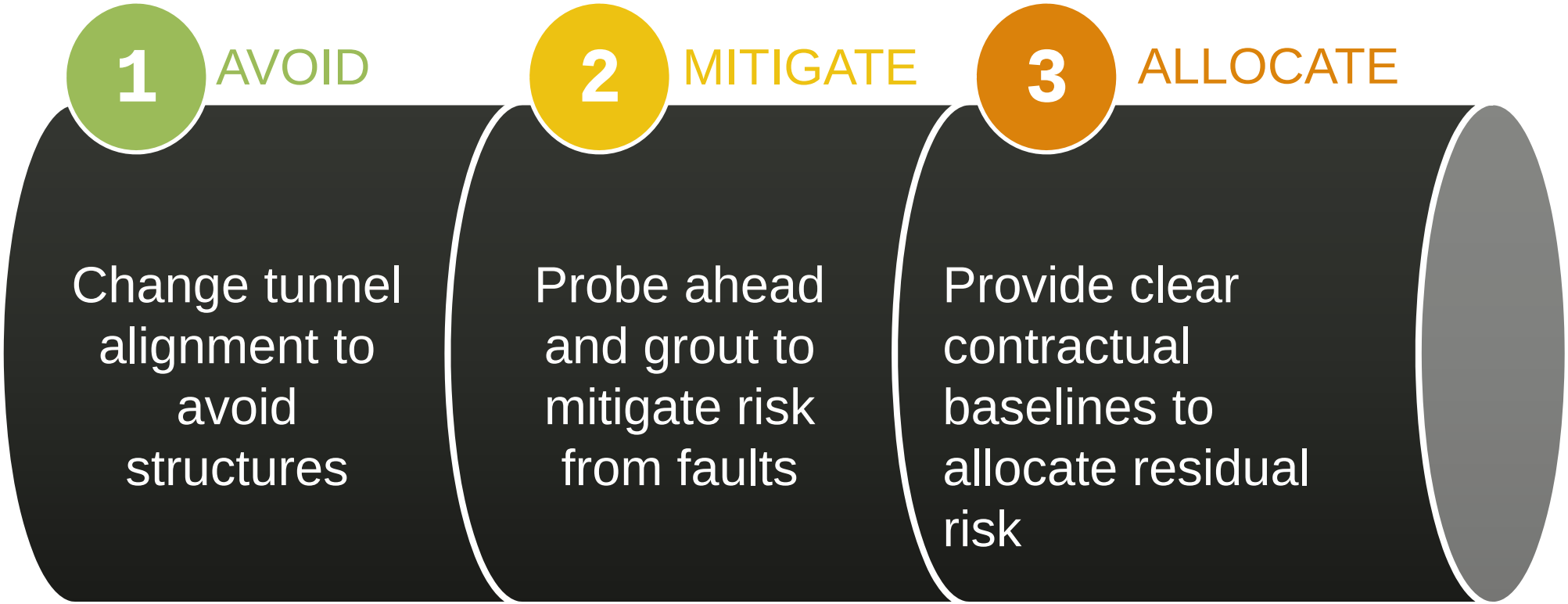
US Guidelines Exist for Risk Management on Tunnel Projects

- US Risk Management practice established by this document
- Published and available online by Underground Construction Association of Society for Mining, Metallurgy, and Exploration
- Emphasizes:
  - The importance of experience in project team
  - The use of Risk Registers as a risk management tool
  - Consistent risk management approach from early planning throughout life of project

http://www.smenet.org/SME/media/UCA/Resources/SME3409-GIRM-Report-Booklet-WEB.pdf

Process of Risk Management

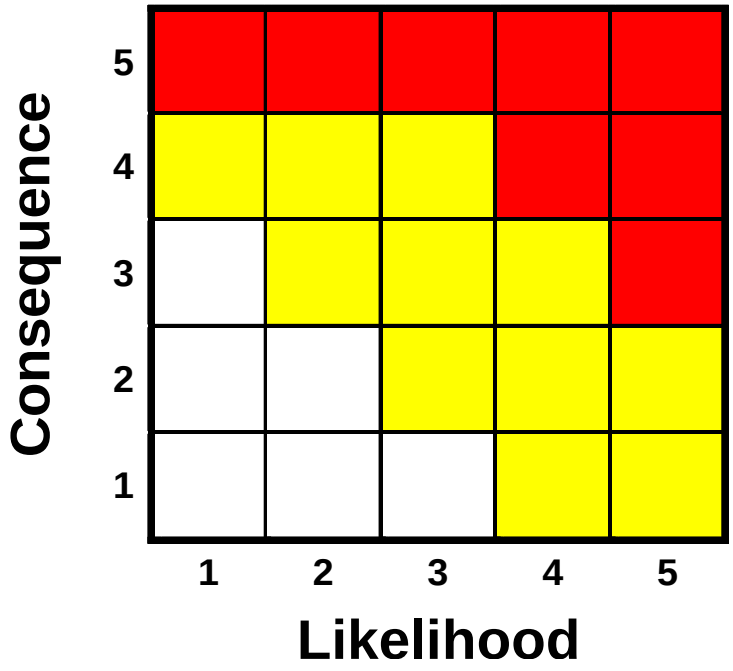
Three-Step Risk Management Process



Design and Construction Risks

Probability Rating	AKA
5	Probable
4	Likely
3	Possible
2	Unlikely
1	Improbable

Consequence



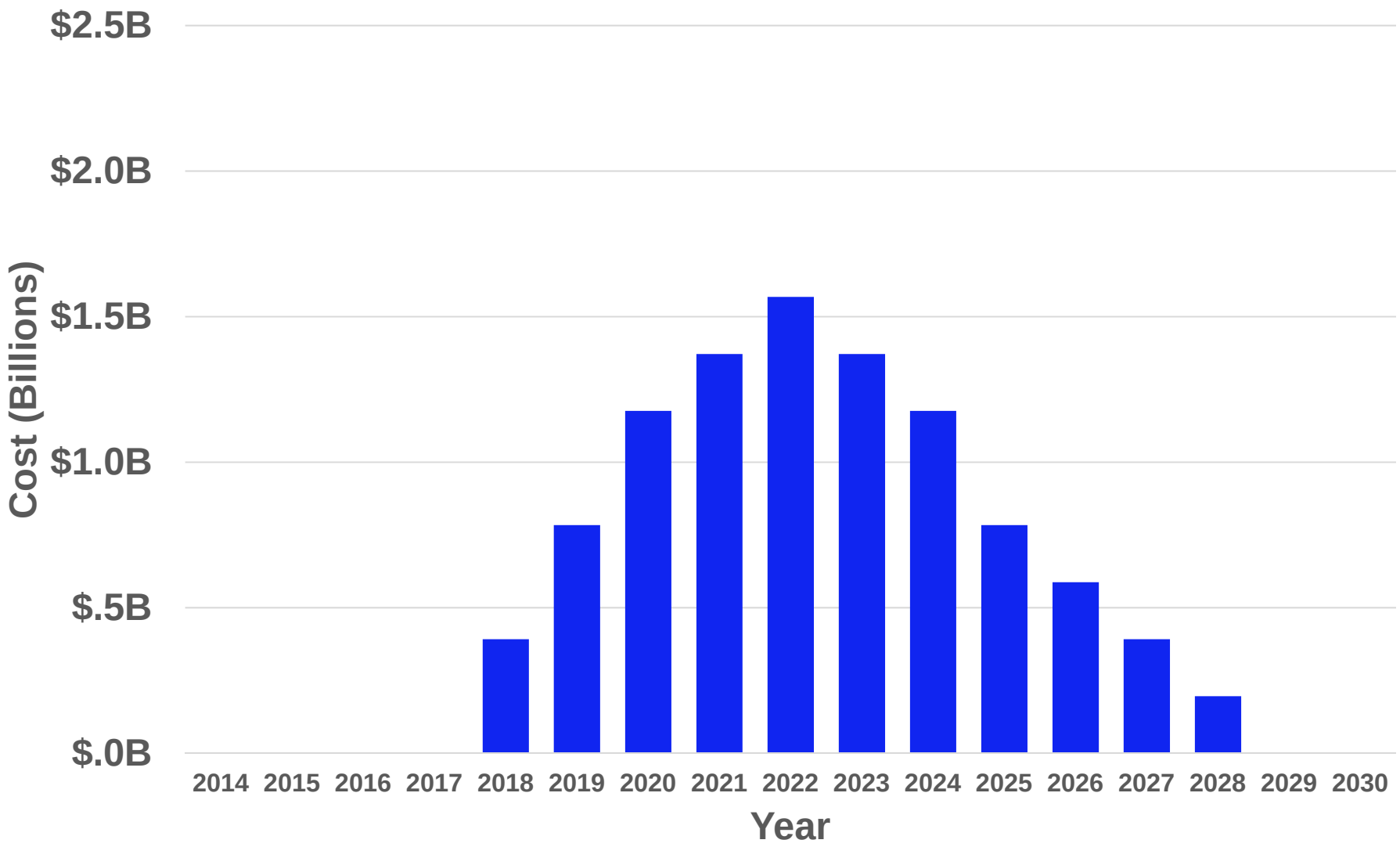
Risk Examples – Top Five

- Initial works delayed leading to consequent delays to main construction
- Geotechnical investigation delayed leading to delay in design completion and start of construction
- Transmission power delayed leading to delay to start of tunneling
- Differing geotechnical conditions leading to slower progress, increased cost and delay to completion of tunneling
- Substantial design change required during construction leading to delay in commissioning

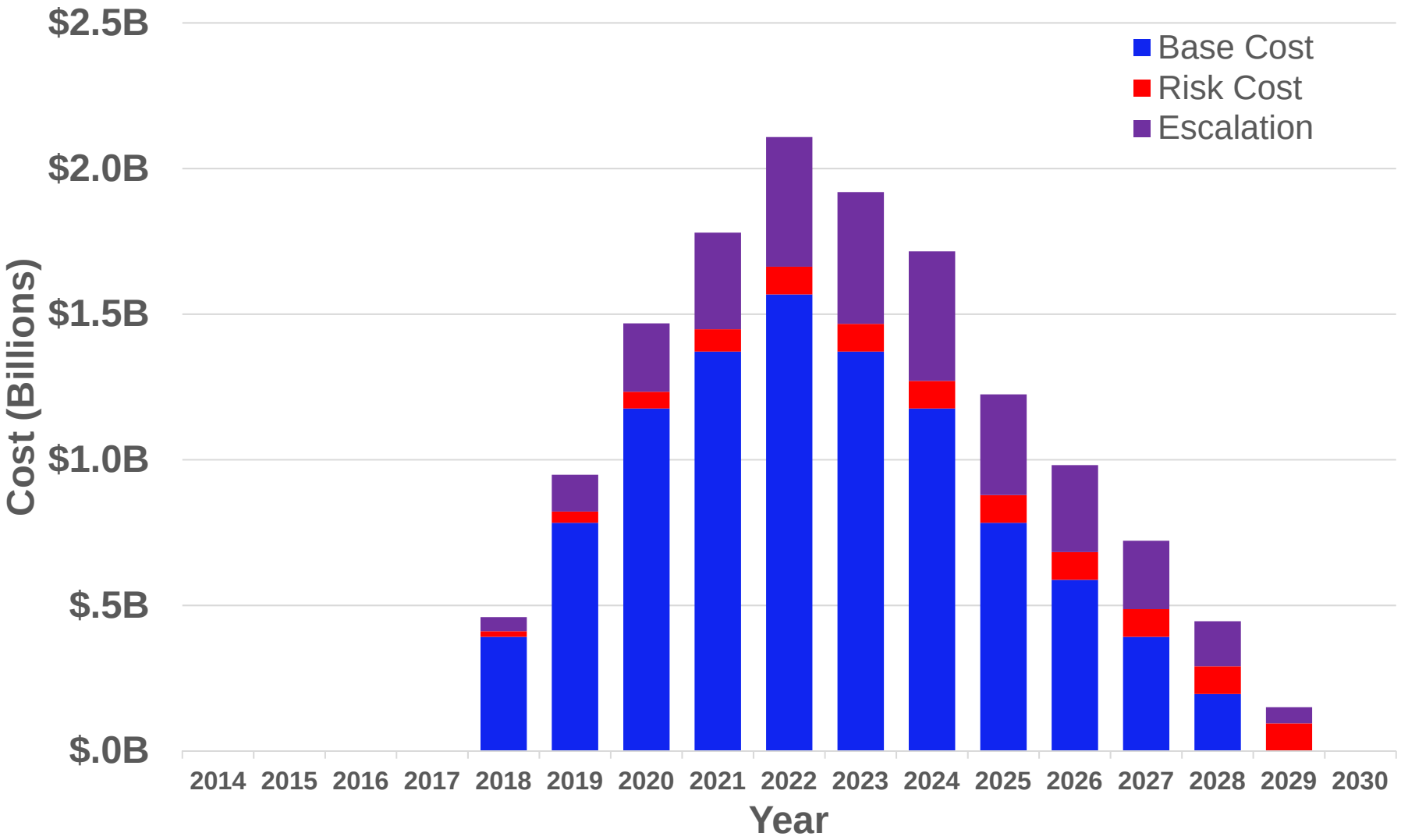
Program Estimate

Item	5RMK Estimate (Billions)
Estimated Base Construction Cost	$9.50
Contingency	$3.38
Program Management/Construction Management/Engineering	$1.91
Land Acquisition	$0.15
Grand Total	**$14.94**

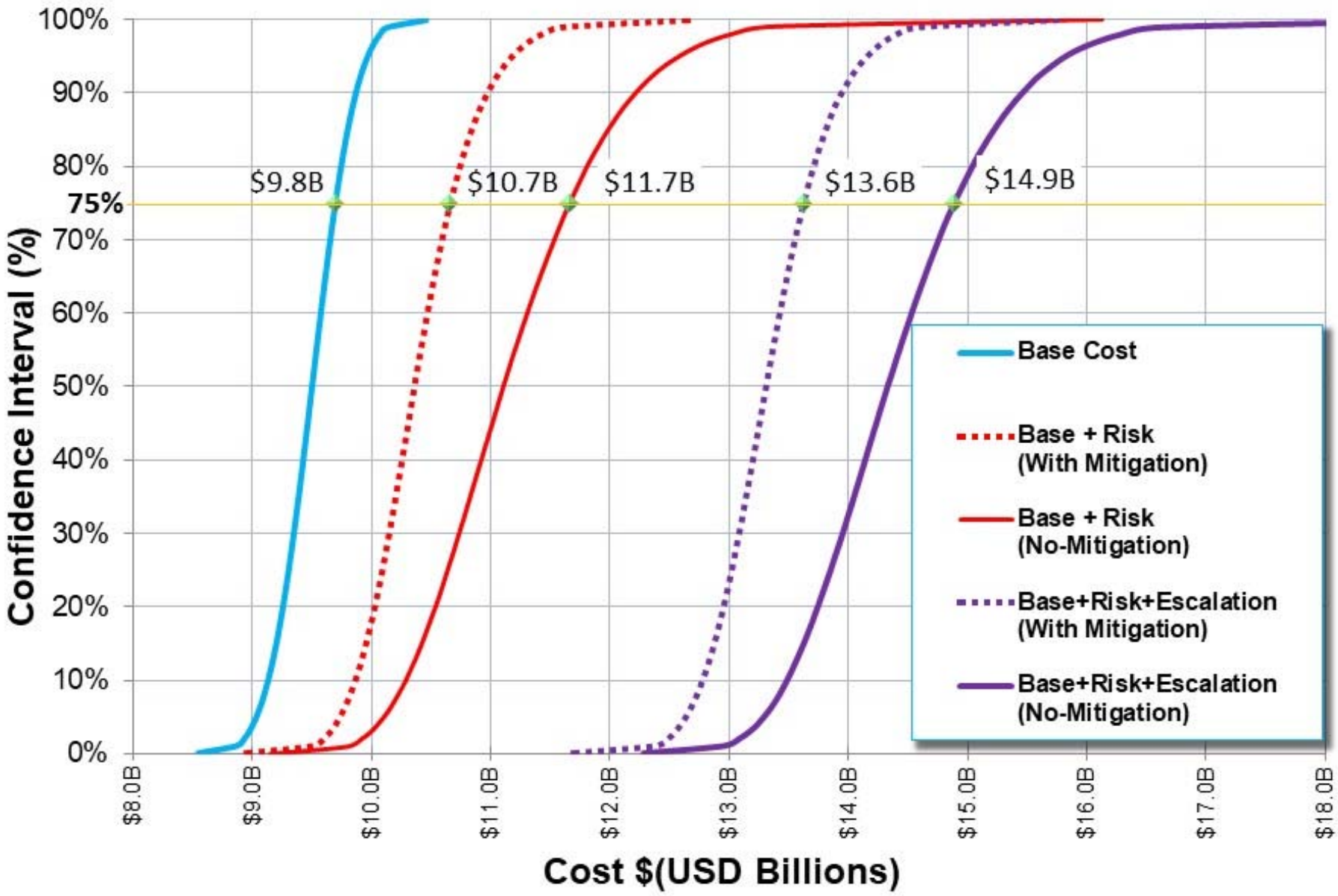
Annual Expenditures – 2014 Dollars



Annual Expenditures – with Risk and Inflation Cost



California WaterFix Construction Cost Distribution Profile



Estimate Summary

Item	Risk with Mitigation at 75% Confidence Interval [1][3] (Billions)	5RMK Estimate [1],[2] (Billions)	Jacobs Eng Estimate [1],[2] (Billions)
Construction	$10.66	$9.50	$8.86
Contingency	–	$3.38	$3.15
Construction Subtotal	**$10.66**	**$12.88**	**$12.01**
PM/CM/Eng	$1.91	$1.91	$1.91
Land acquisition	$0.15	$0.15	$0.15
Grand Total	**$12.72**	**$14.94**	**$14.07**

(1) Program estimates in 2014 dollars
(2) ~36% Contingency on construction for 5RMK and Jacob Engineering estimates
(3) Based on risks known at time of assessment

Questions ?