Balancing Innovation, Constructability, and Maintenance to Cross the San Diego River

Nathan Johnson, PhD, PE, Project Manager

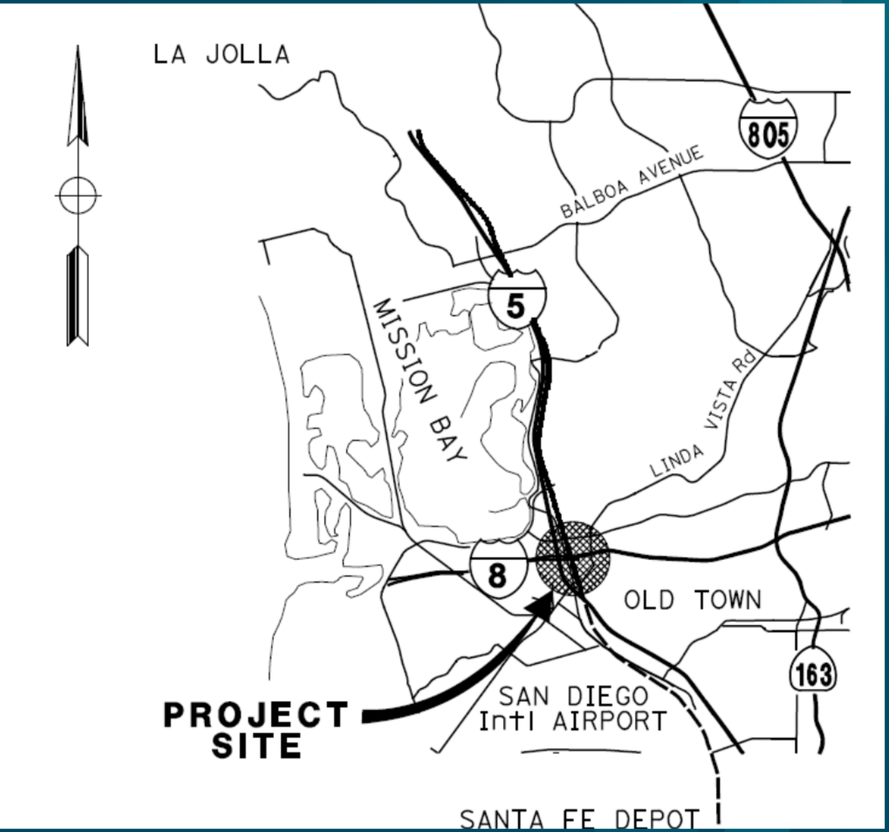
Kelly Burnell, PE, Structure Lead

KLEINFELDER
Bright People. Right Solutions.

Outline

- Project Background
- Constraints and Technical Challenges
- Stakeholders and Delivery Method
- Innovative Approach and Solutions
- Construction
- Lessons Learned

KLEINFELDER
Bright People. Right Solutions.

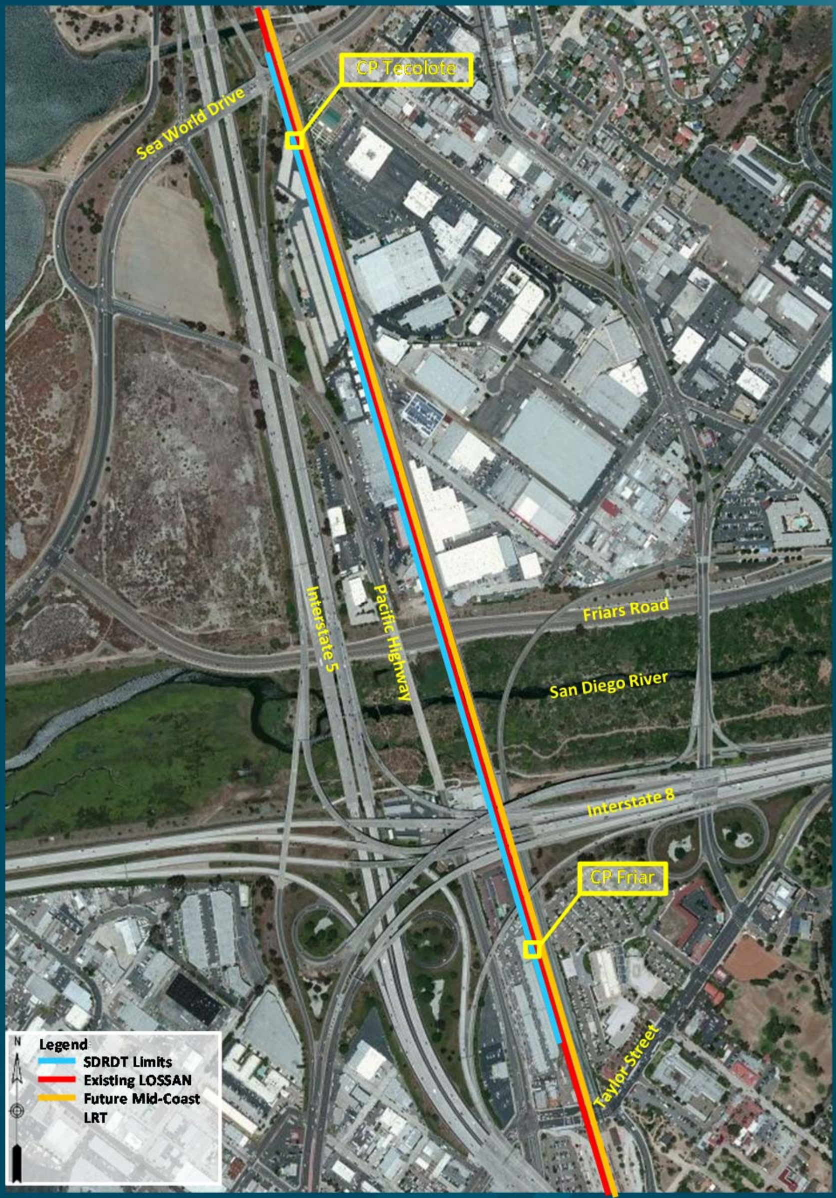


Location Map

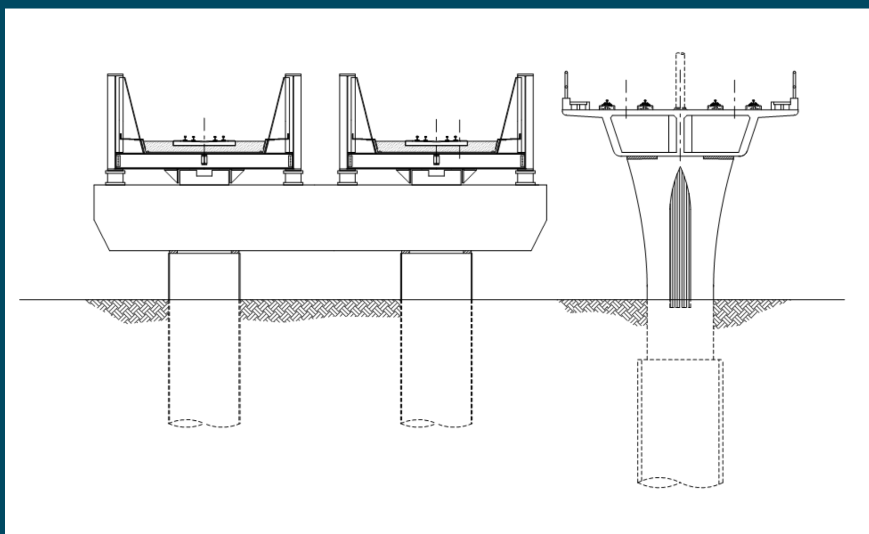
Vicinity Map

KLEINFELDER
Bright People. Right Solutions.

- Carries Commuter, Amtrak, and Freight
- Construct 1-mile of second main track
  - 1000-foot SD River crossing
  - Parallel to Mid-Coast LRT
  - Major design components



KLEINFELDER
Bright People. Right Solutions.



KLEINFELDER
Bright People. Right Solutions.

CMGC Delivery & Stakeholders

- CMGC Delivery
  - Optimize $2.0B Overlapping Projects
  - Cost/Constructability Input

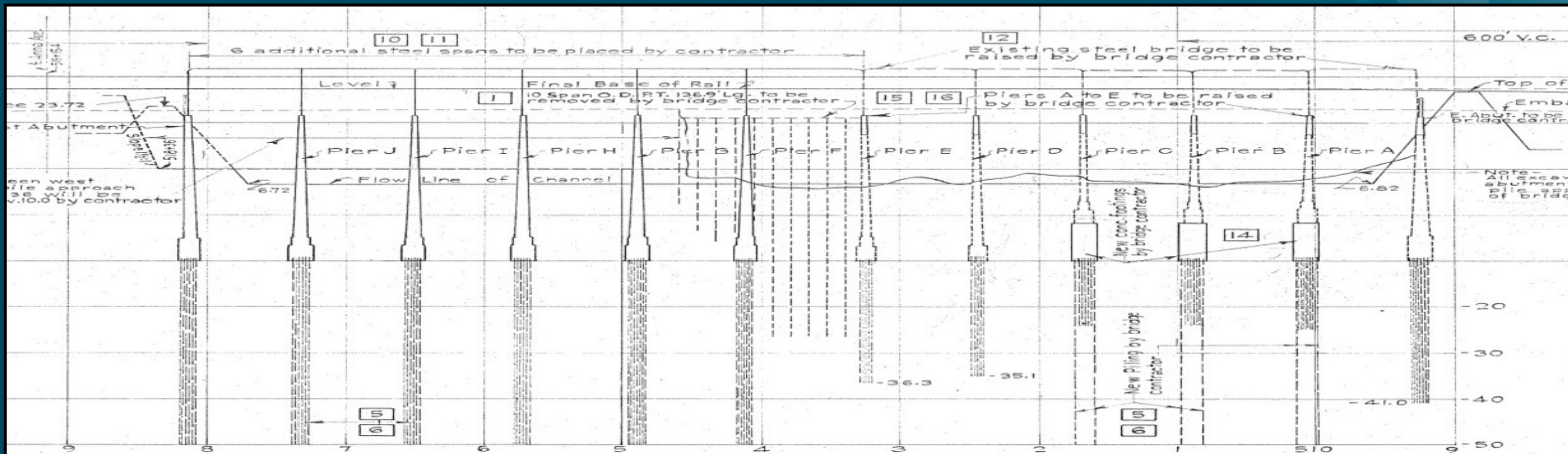
KLEINFELDER
Bright People. Right Solutions.

Schedule Challenges

- Utility Improvements and Relocations
- ROW Execution
- Design approvals
- Environmental Permit Conditions
- Timing of GMPs
- Seasonal Restrictions
  - Approved Work Windows to construct
  - Wet season in the San Diego River
  - Nesting birds

KLEINFELDER
Bright People. Right Solutions.

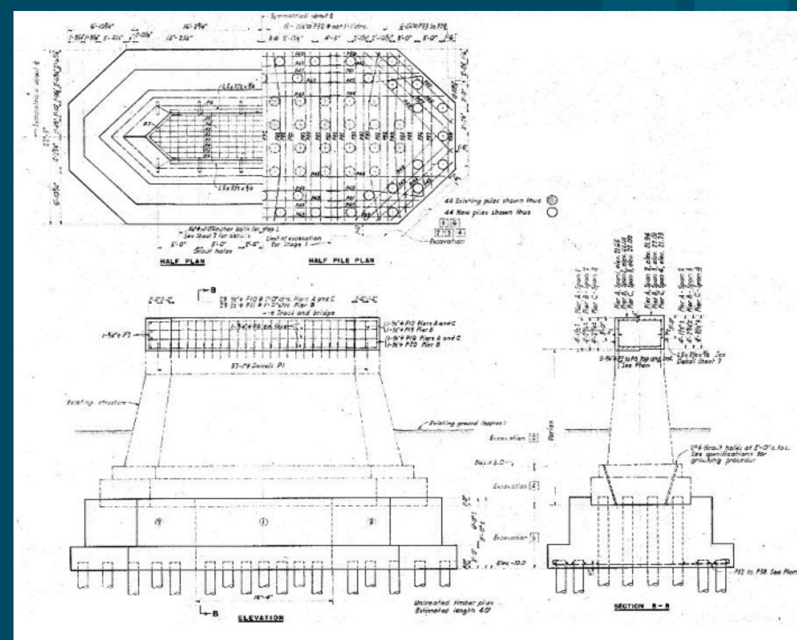
KLEINFELDER
Bright People. Right Solutions.



- Location
- Age
- Seismic Stability

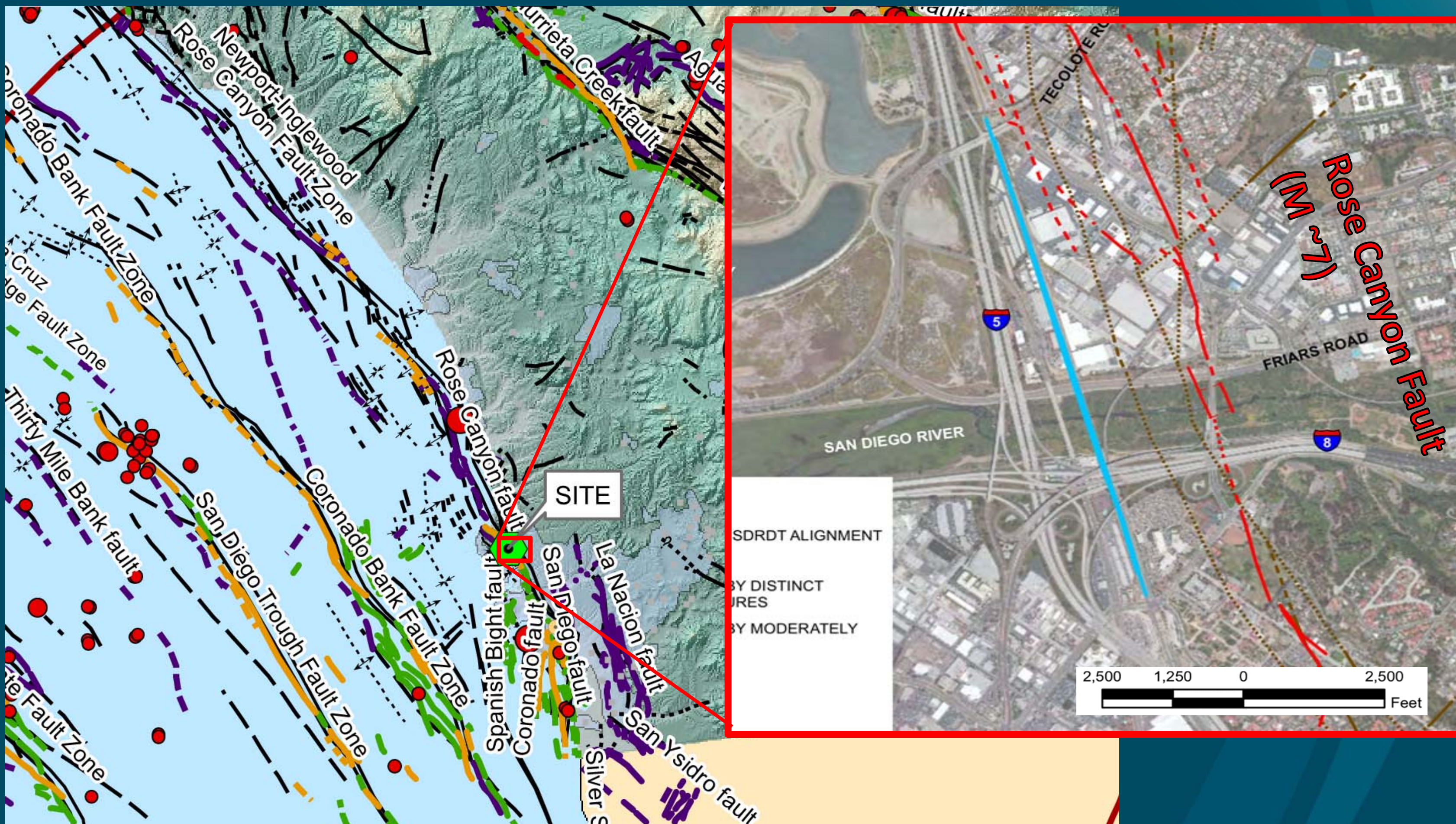
- Retrofit Life Cycle Cost

→ Replace the bridge



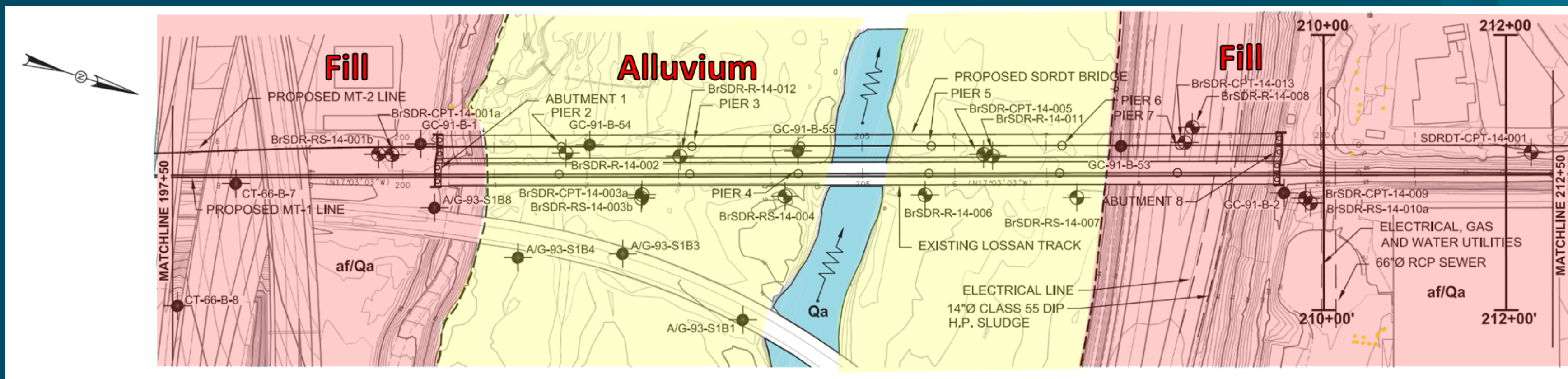
KLEINFELDER
Bright People. Right Solutions.

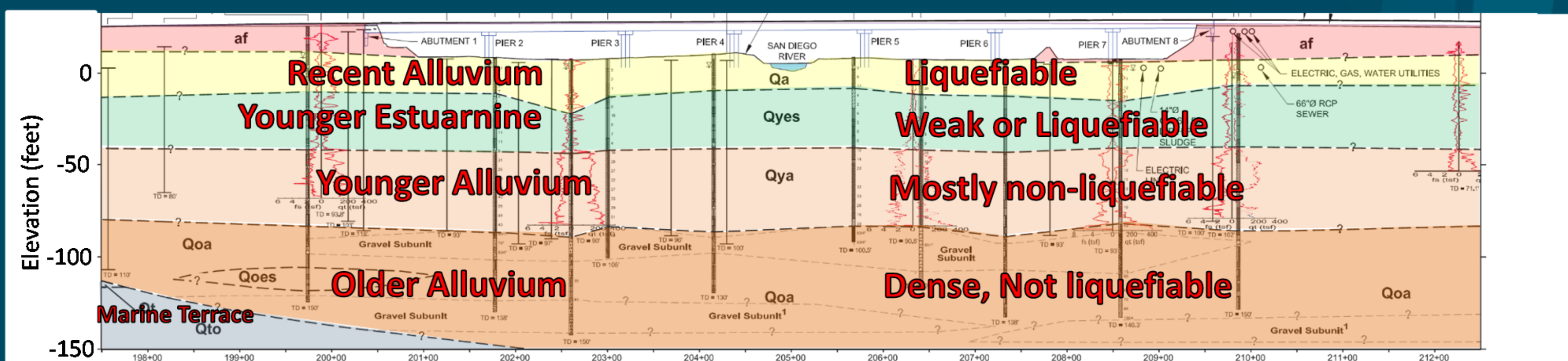
Regional Faulting and Seismicity



KLEINFELDER
Bright People. Right Solutions.

Geologic Plan & Profile





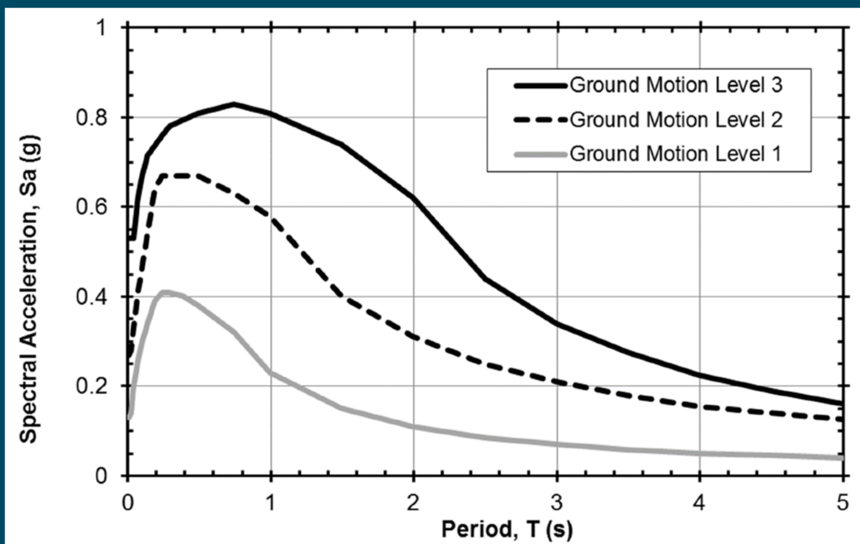
KLEINFELDER
Bright People. Right Solutions.

Ground Motion Development

- Rock response spectra developed using PSHA for 100, 500, 2400 year events
- Select recorded time histories & match rock
- Develop geodynamic models of site soils
- Propagate rock time histories through site soils
- Interpret design spectrum from results

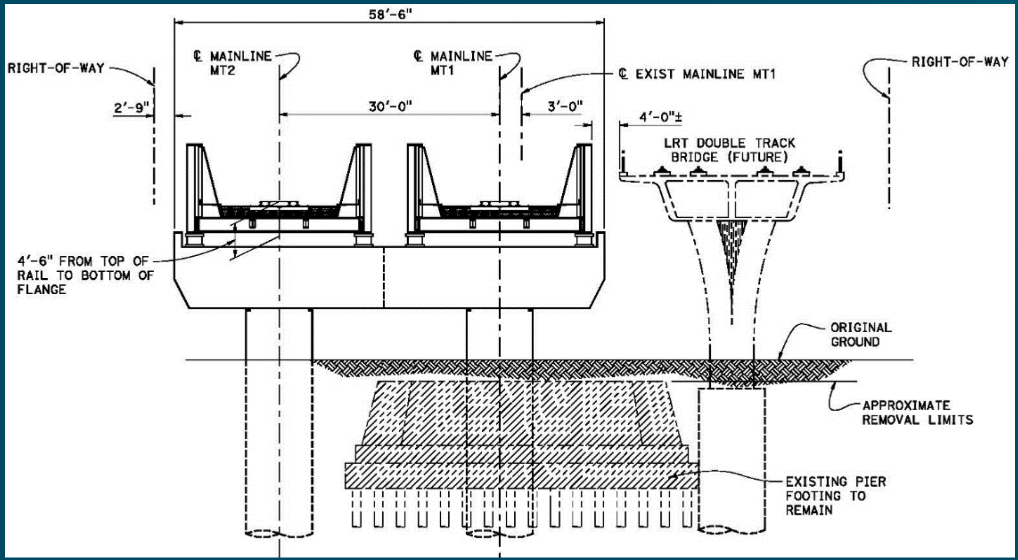
KLEINFELDER
Bright People. Right Solutions.

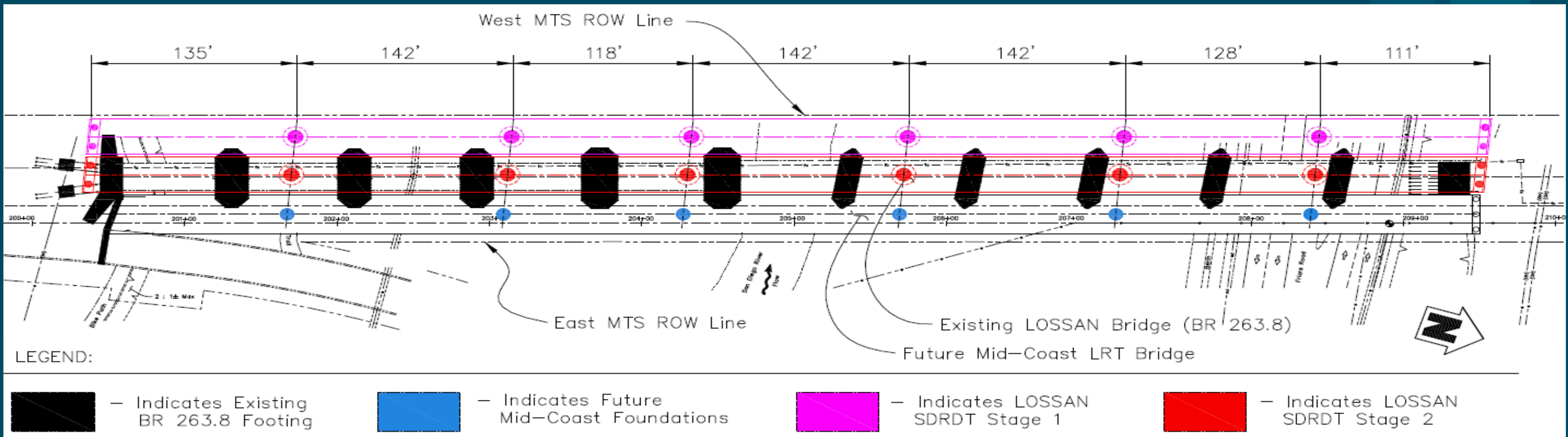
Design Motions & Liquefaction



Soil Properties	Layer Depth	Exist. Foundation	New Shaft Elevation
Sand	**5 ft**		9ft Diameter Cased Pile
Liquefiable Soft Clay	23 ft		
Stiff Clay	15 ft		
Liquefiable Soft Clay	28 ft		
Sand	69 ft		8ft Uncased

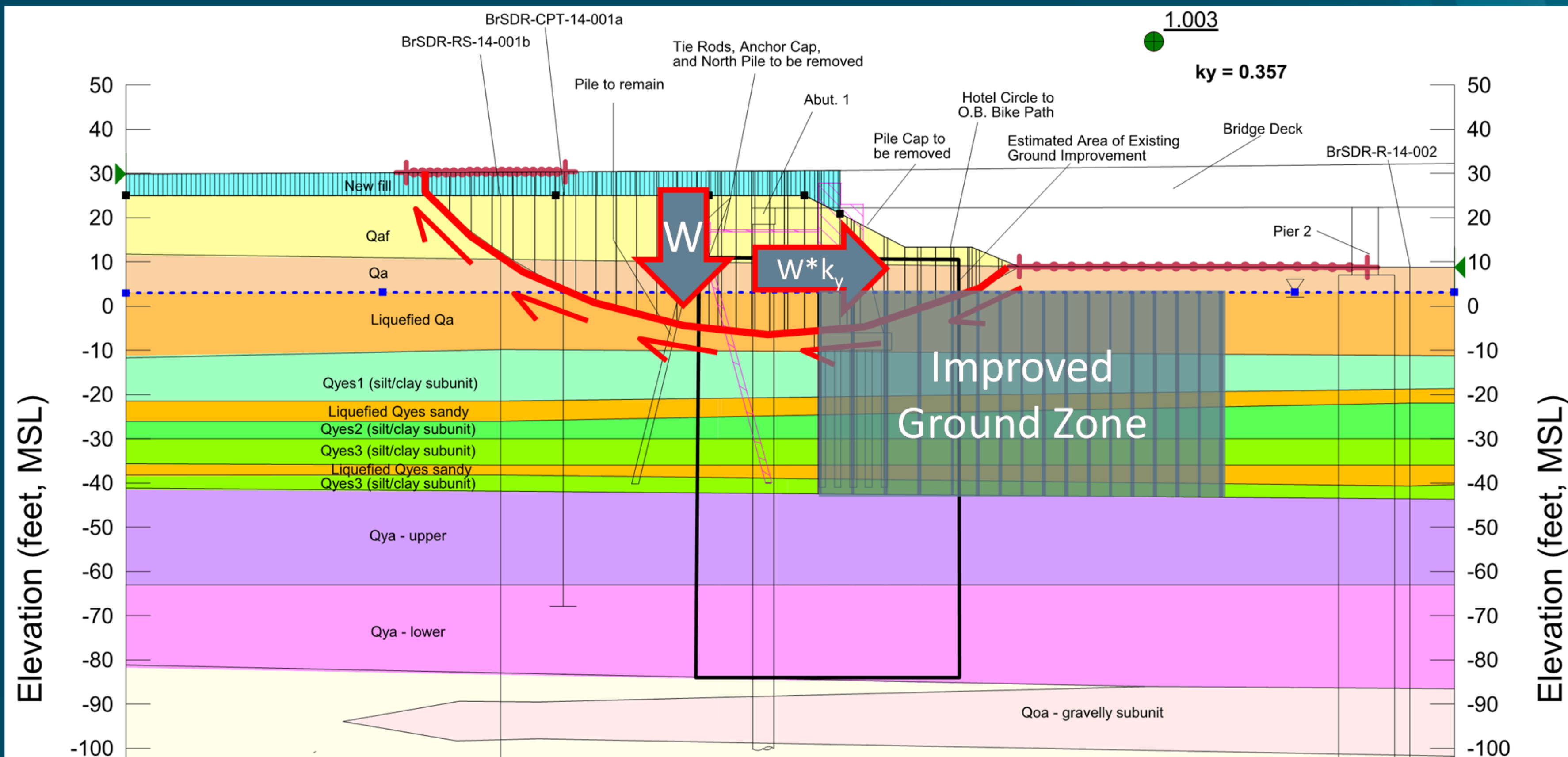
KLEINFELDER
Bright People. Right Solutions.





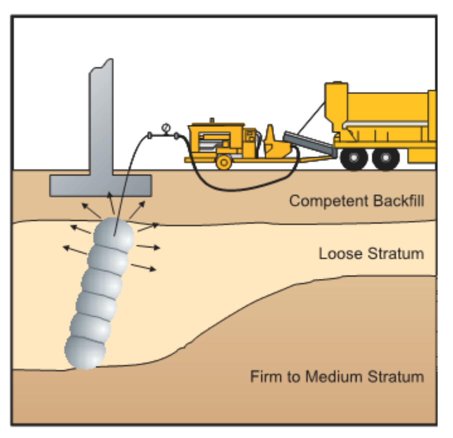
KLEINFELDER
Bright People. Right Solutions.

Slope Stability



KLEINFELDER
Bright People. Right Solutions.

Design Earthquake	Seismic Slope Displacement (feet)	
	No Ground Improvement	With Ground Improvement
Level 1 – 100 year RP	1	Negligible
Level 2 – 500 year RP	3	Negligible
Level 3 – 2400 year RP	3.7	0.1



KLEINFELDER
Bright People. Right Solutions.

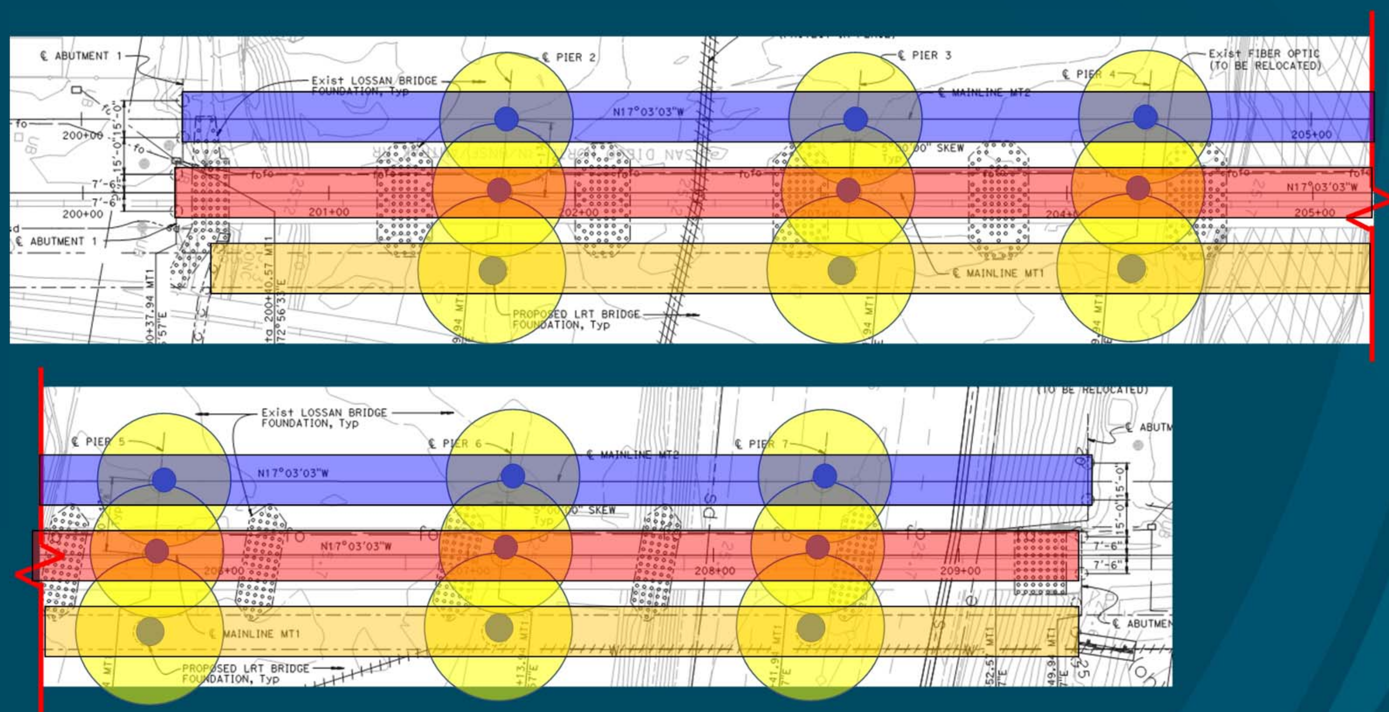
Foundation Construction

- Foundations often highest cost / risk
- How did the team mitigate this risk?

KLEINFELDER
Bright People. Right Solutions.

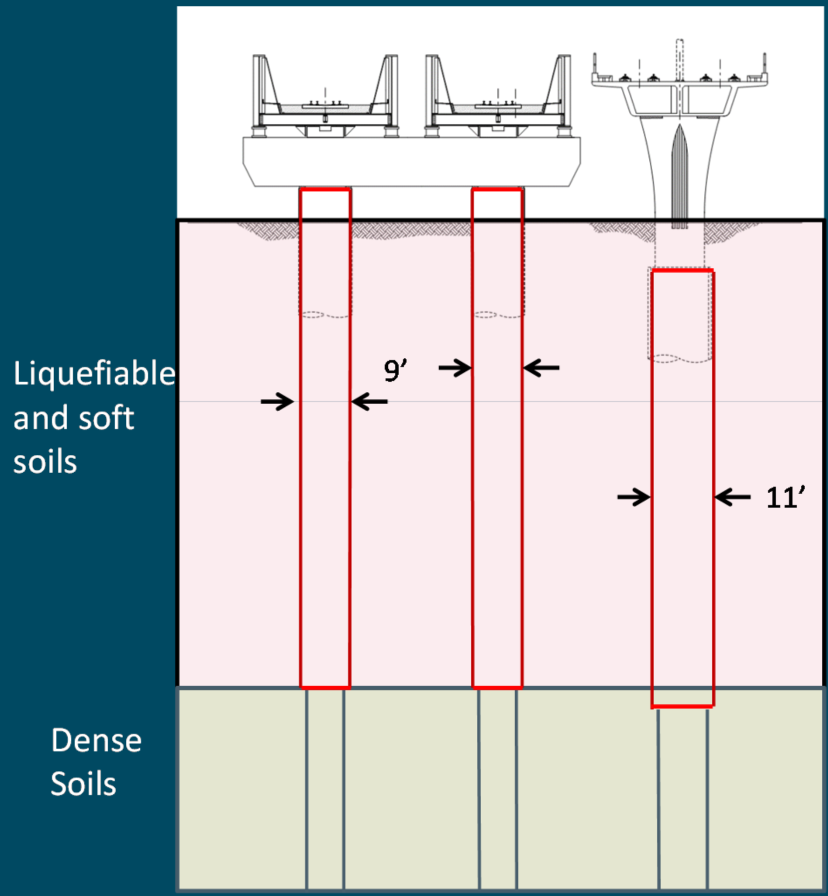
Pier Construction & Stability

- Original Approach – Ground Improvement
  - 90 feet deep with challenges



KLEINFELDER
Bright People. Right Solutions.

Innovative Pier Approach



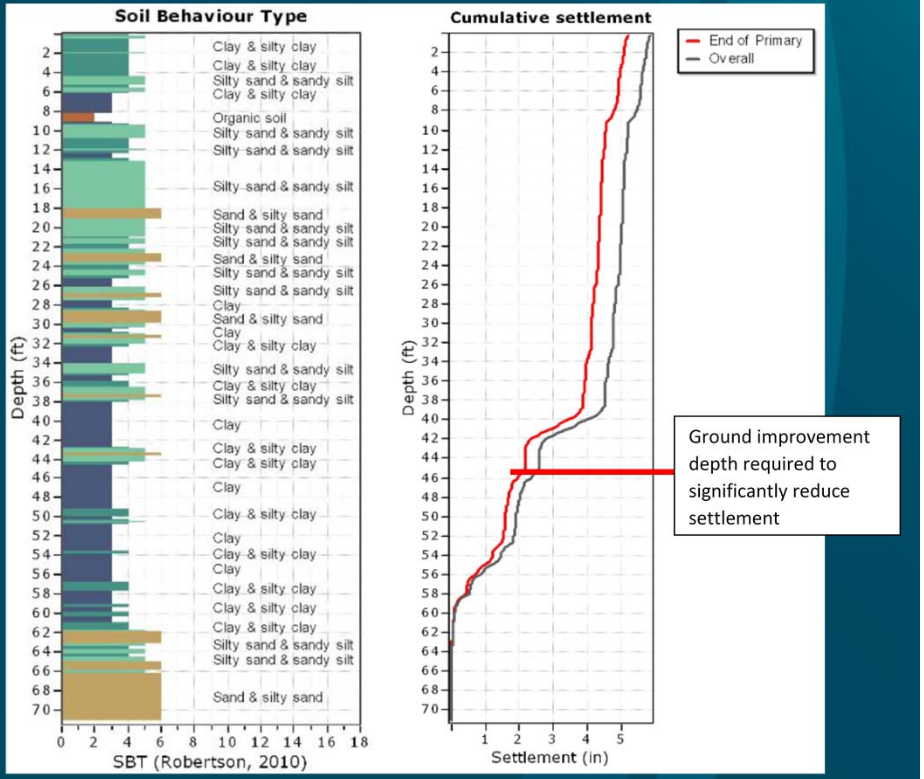
- Constructability
- Stiffness/Strength
- 5% Cost Savings

KLEINFELDER
Bright People. Right Solutions.

KLEINFELDER
Bright People. Right Solutions.

KLEINFELDER
Bright People. Right Solutions.

Approach Embankment Challenges



KLEINFELDER
Bright People. Right Solutions.

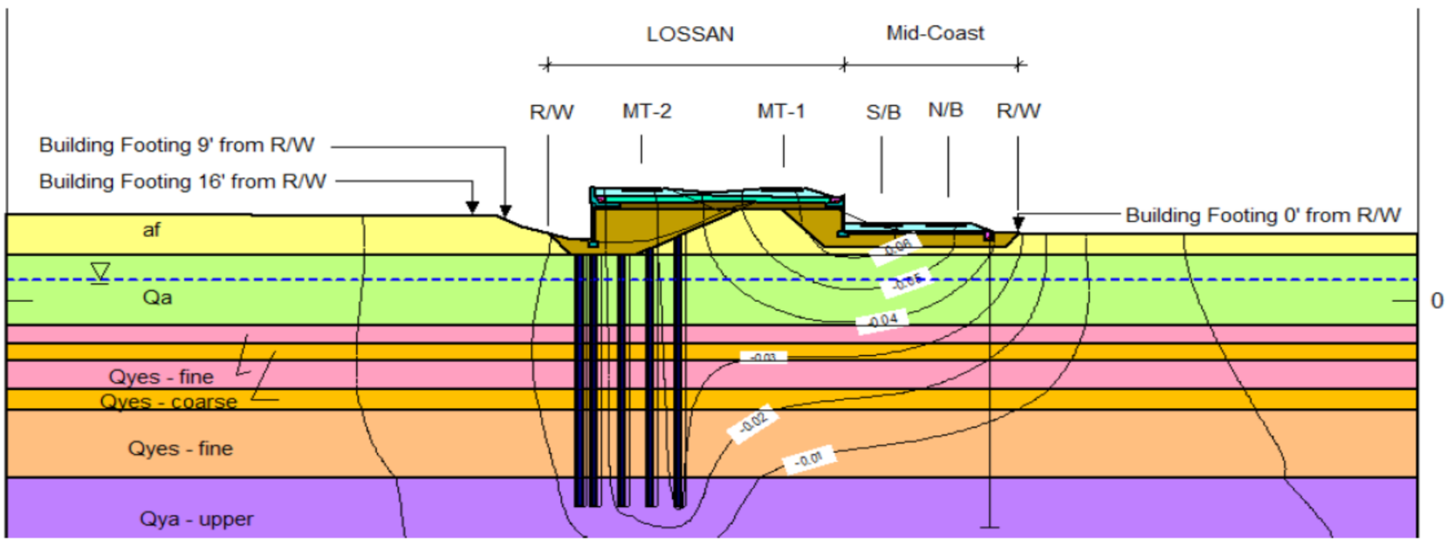
- Settlement of buildings, track, and utilities

KLEINFELDER
Bright People. Right Solutions.

Approach Embankment Solutions

- Bridge
- Cut-off wall
- Lightweight Fill
- Lower Profile
- Surcharge
- Ground Improvement

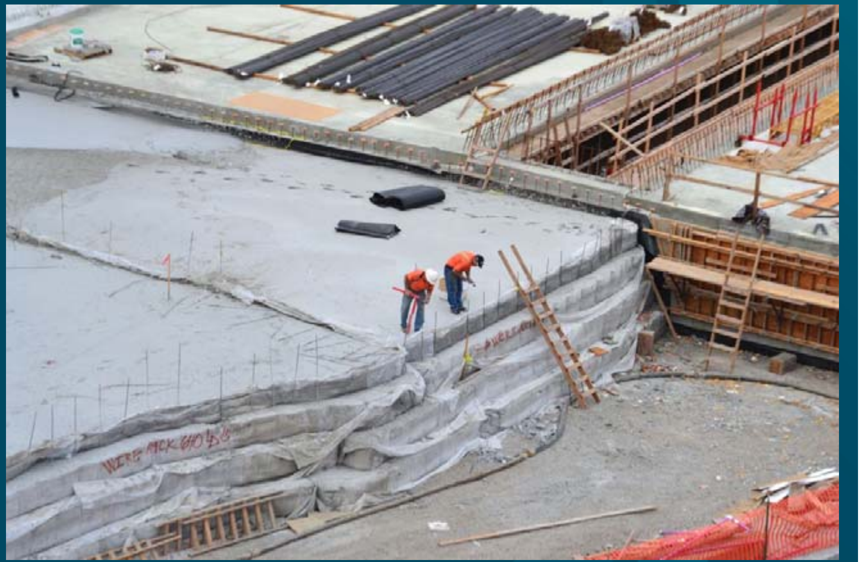
Cellular Concrete w/ Compaction Grouting (D = 2’, S = 6’, AR = 9%)
Soil Matrix not Improved
Maximum MT-2 track settlement = 0.04’ (0.5”)
Settlement along west Right-of-Way line = 0.01’ (0.12”)



KLEINFELDER
Bright People. Right Solutions.

Lightweight Concrete Fill

- Site mixed with foaming agent
- 2-3 foot lifts
- Approx. $40-50/cuyd (typical)
- Demonstrated for freeway, LRT, Heavy Rail



Cellular Concrete Class	Cast Density Pcf	Minimum Compressive Strength at 28 days* psi
I	24-29	10
II	30-35	40
III	36-41	80
IV	42-49	120
V	50-79	160
VI	80-90	300

KLEINFELDER
Bright People. Right Solutions.

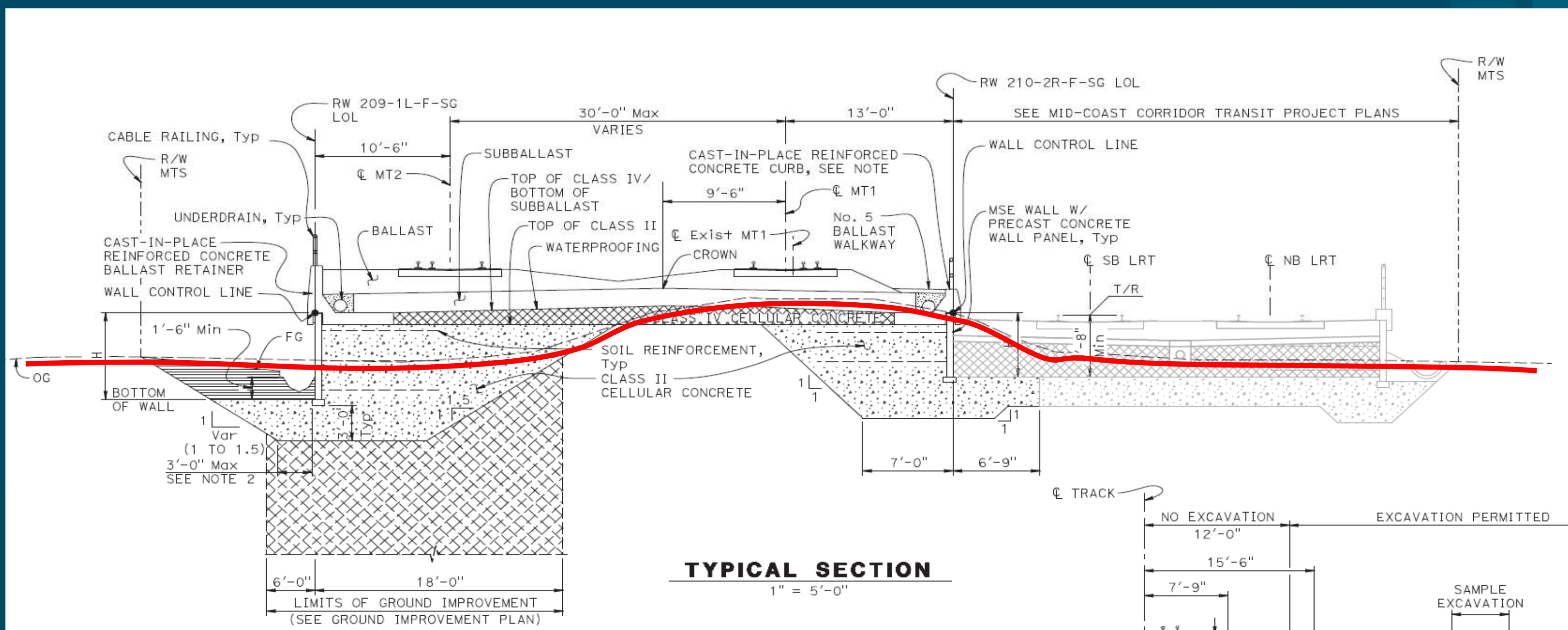
Approval Process

- Not a conventional solution
- What are the stakeholder concerns?
- How can we alleviate concerns?
- Is this really the right solution?

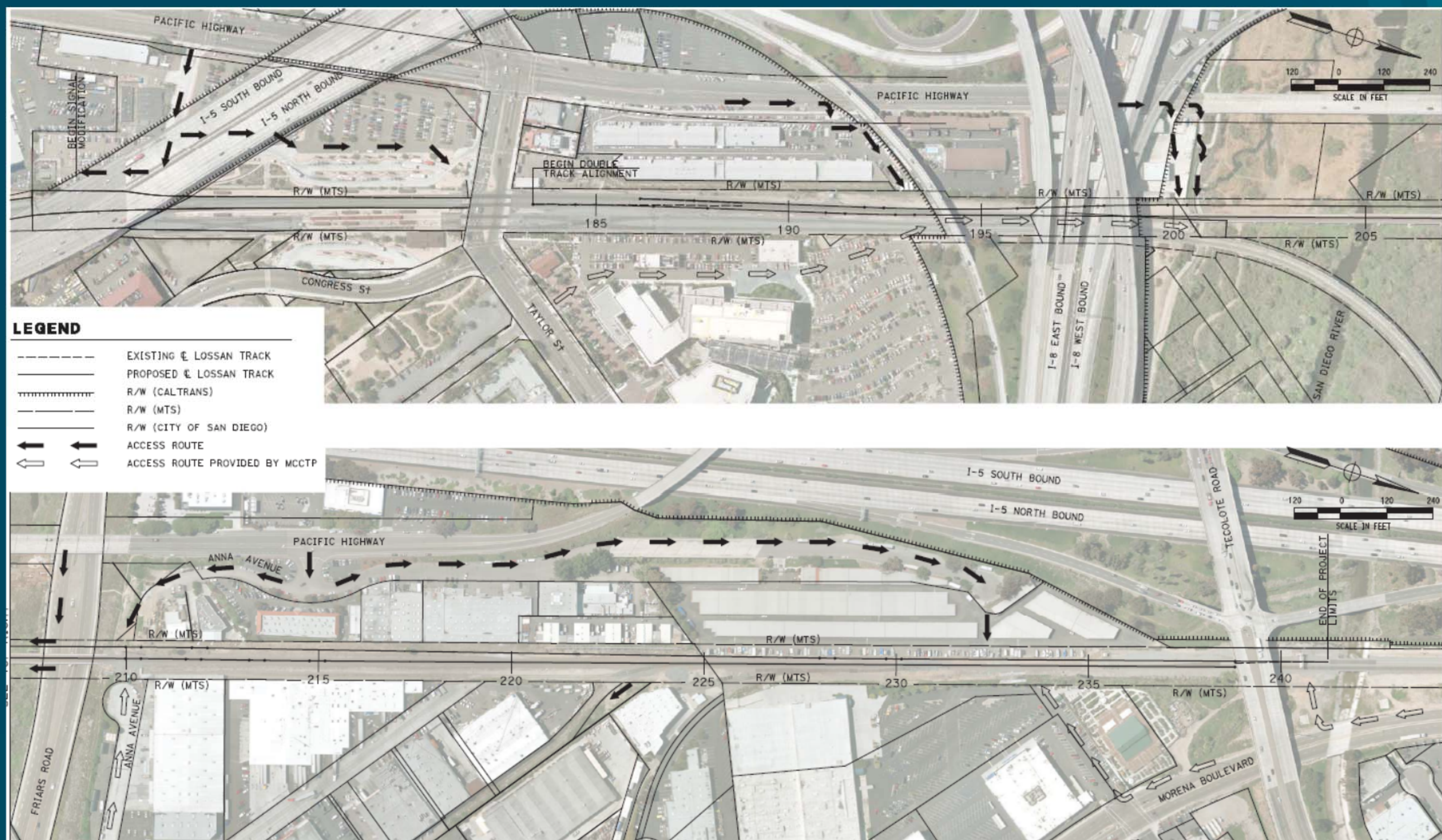
KLEINFELDER
Bright People. Right Solutions.

Solution

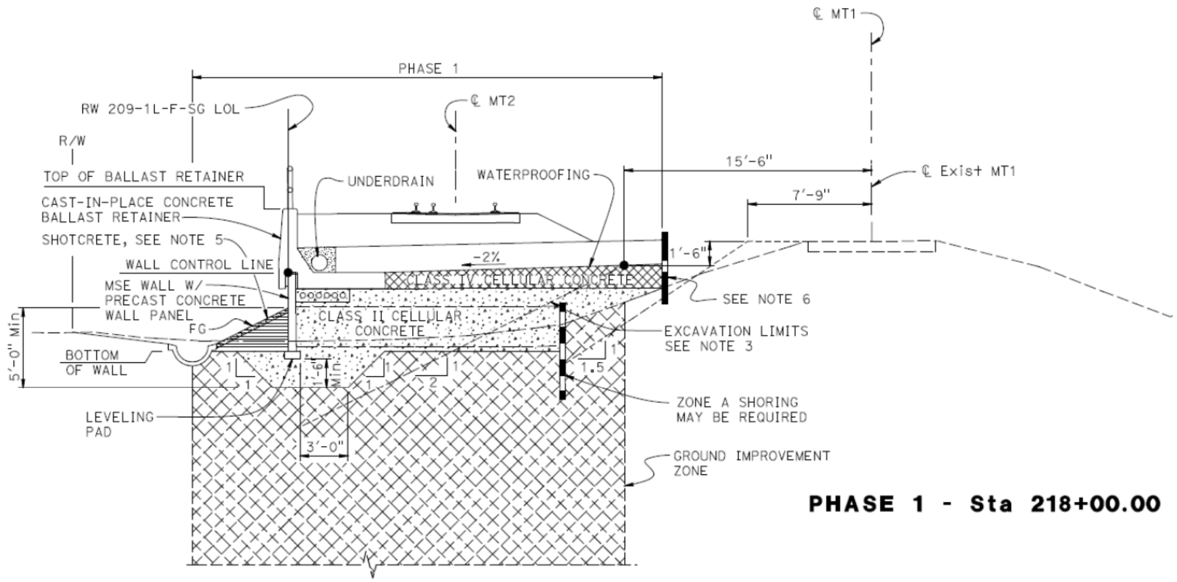
- Targeted Ground Improvement
- Less Surcharge + More Resistance
- Approx. 10% Project Cost Savings



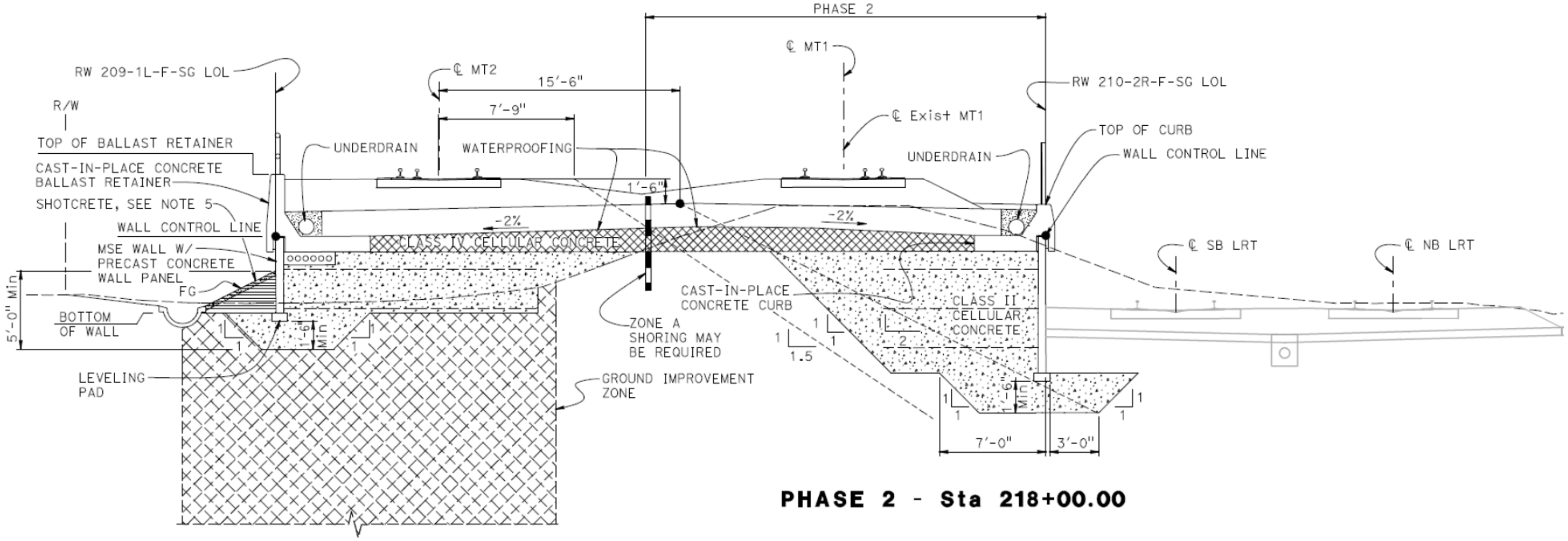
CMGC Design Input / Optimization



KLEINFELDER
Bright People. Right Solutions.

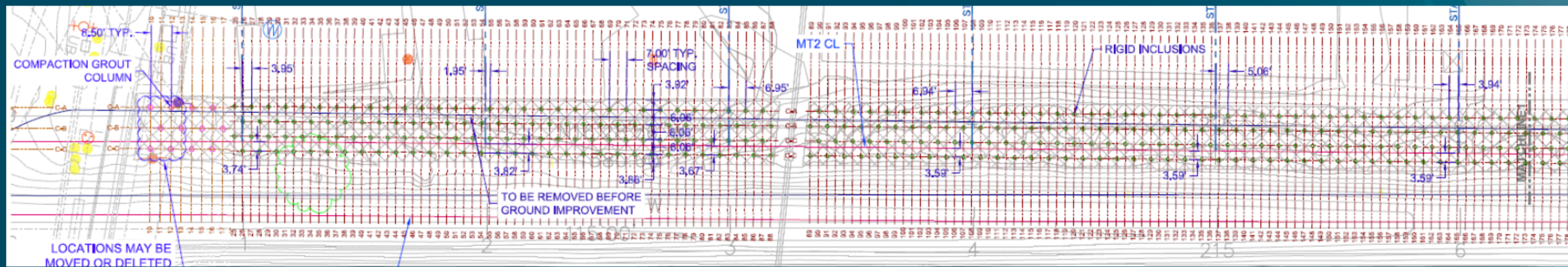


PHASE 1 - Sta 218+00.00



PHASE 2 - Sta 218+00.00

KLEINFELDER
Bright People. Right Solutions.



KLEINFELDER
Bright People. Right Solutions.

Construction

KLEINFELDER
Bright People. Right Solutions.

KLEINFELDER
Bright People. Right Solutions.

KLEINFELDER
Bright People. Right Solutions.

KLEINFELDER
Bright People. Right Solutions.

KLEINFELDER
Bright People. Right Solutions.

KLEINFELDER
Bright People. Right Solutions.


JACOBS

KLEINFELDER
Bright People. Right Solutions.

KLEINFELDER
Bright People. Right Solutions.

KLEINFELDER
Bright People. Right Solutions.

KLEINFELDER
Bright People. Right Solutions.

KLEINFELDER
Bright People. Right Solutions.

Summary

- CMGC River Crossing Case Study
- Costs and Risks Biased toward Structures
- Design and CMGC Team Interaction
- Use of Innovative Design Methods
- Team Engagement in a CMGC Project

KLEINFELDER
Bright People. Right Solutions.