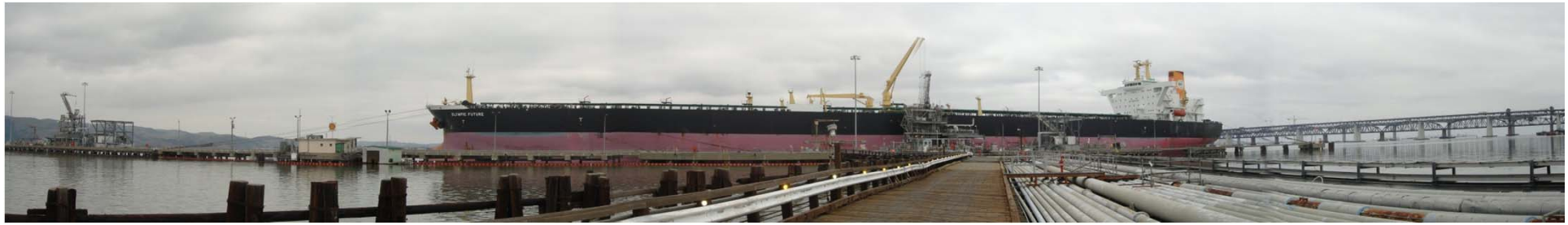
Prevention First 2016

Upgrades & MOTEMS Seismic Retrofit of the Shell Martinez Refinery Marine Terminal, Martinez, California

Craig Bambach, Production Supervisor
Capt. Roy Mathur, Wharfmaster
Shell Oil Products US

William Bruin, P.E., Senior Principal
Simpson Gumpertz & Heger Inc.



SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures

Presentation Outline

- Discuss MOTEMS & Project Upgrades
- Lessons Learned

Shell Martinez Refinery MOT

Shell Martinez Refinery MOT

MOTEMS & Project Upgrades

- Fender System Upgrade
- Mooring Hook Upgrade
- MOTEMS Seismic Retrofit
  - Approach Trestle
  - Loading Berths

New Fenders on Wharf

Lease Requirements on Shell Wharf

Lease Requirements for Shell Wharf

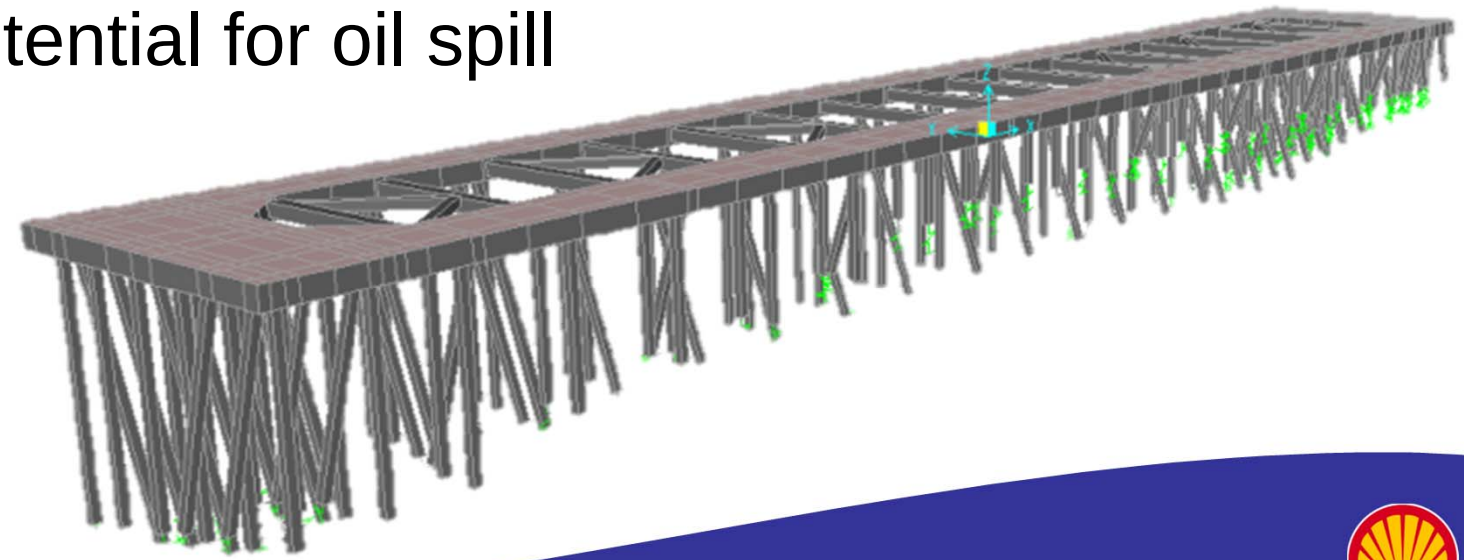
Mooring Hooks

Loading Berth Seismic Upgrade

- Existing Structure
  - 20” square, prestressed concrete piles
  - Precast/CIP deck perimeter
  - Prestressed deck ‘K’ struts

MOTEMS Seismic Deficiencies

- Risk of Progressive Collapse at L2 EQ
  - Batter piles fail in tension
  - Large lateral displacements
  - Failure of plumb piles
  - Potential for oil spill



Seismic Mitigation Goals

- Full MOTEMS L2 seismic compliance
- After earthquake …
  - No oil spill
  - Life-safety
- Maintain current operational function
- Minimal disruption of …
  - Environment
  - Operations

… during construction

Project Constraints

- Continued operations
- Remains of old wharf
- Environmental in-water work windows
  - Salmonoids
  - Clapper Rail

- Construction access
  - Approach trestle w/ 4-ton load limit
  - Shallow backside < 5’ draft (MLLW)

Concepts Considered

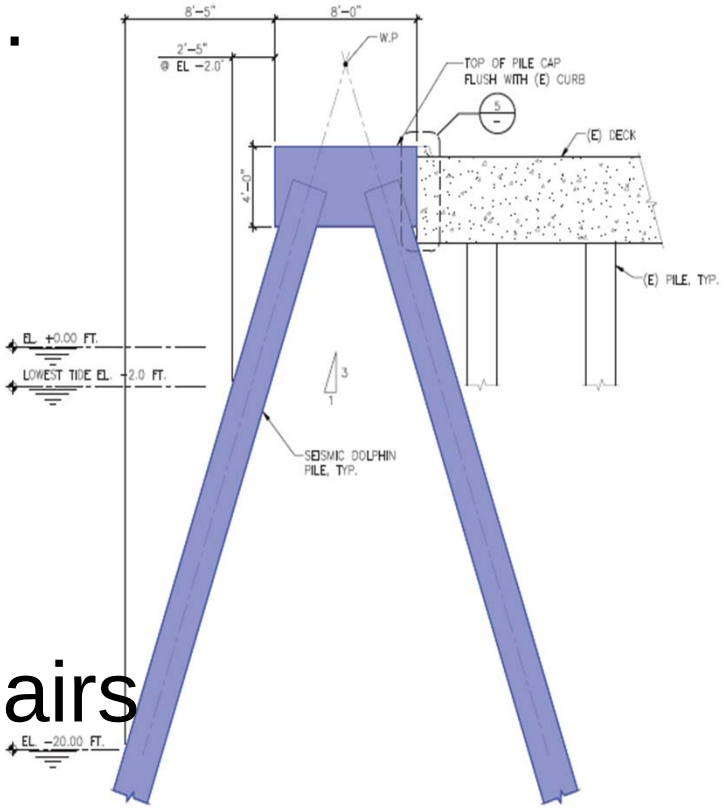
- ~~New Platform~~ $$$
- ~~Strengthen inside of wharf footprint~~

feasibility/disruption

- Strengthen outside of wharf footprint

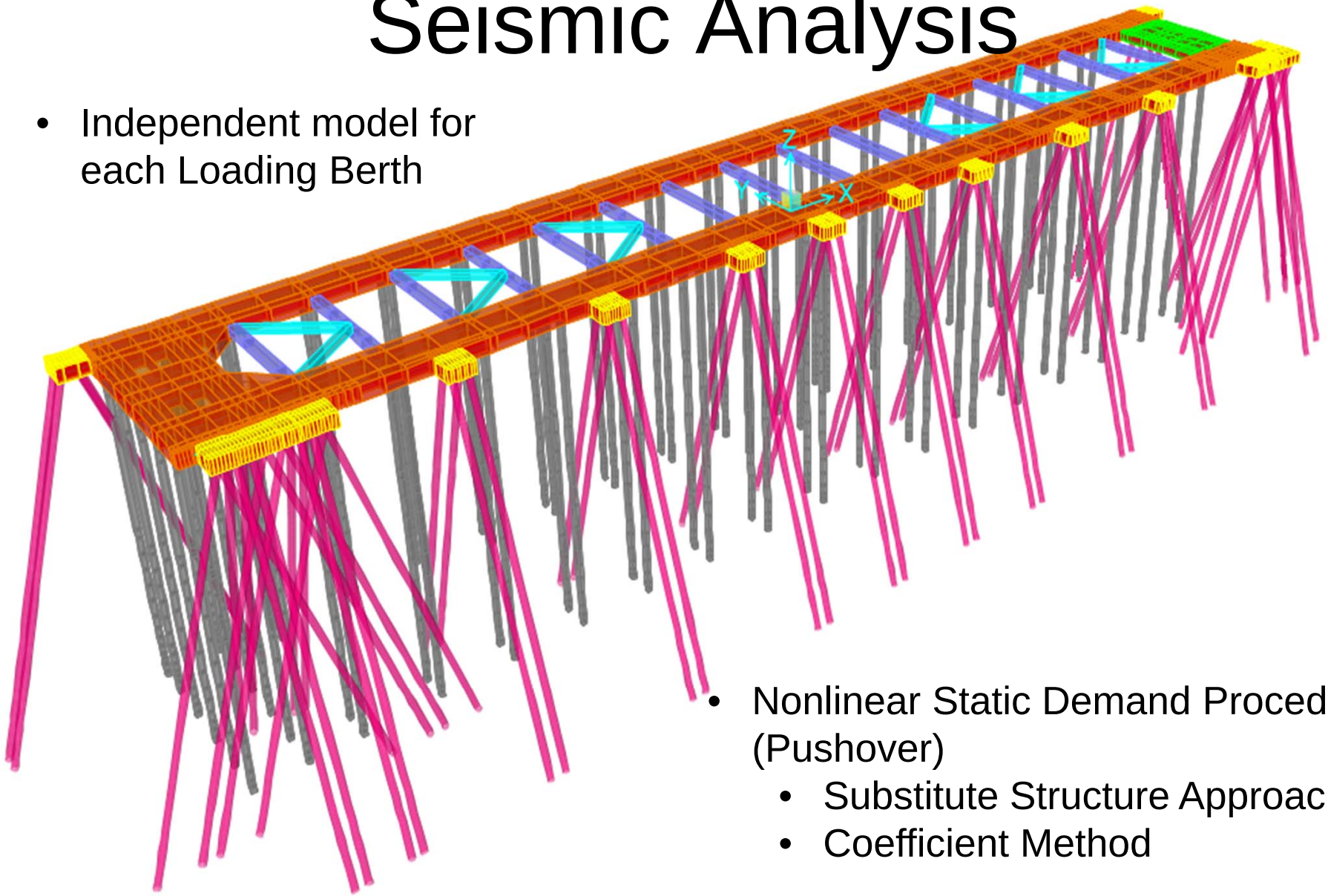
Seismic Dolphin Concept

- "Catch" Loading Berth to …
  - Limit lateral displacement
  - Allow (e)batter piles to fail
- Prevent …
  - Failure of plumb piles
  - Catastrophic collapse
- Utilizes typical batter pile pairs
  - Relatively stiff system
  - Axial capacity limited by soil



Seismic Analysis

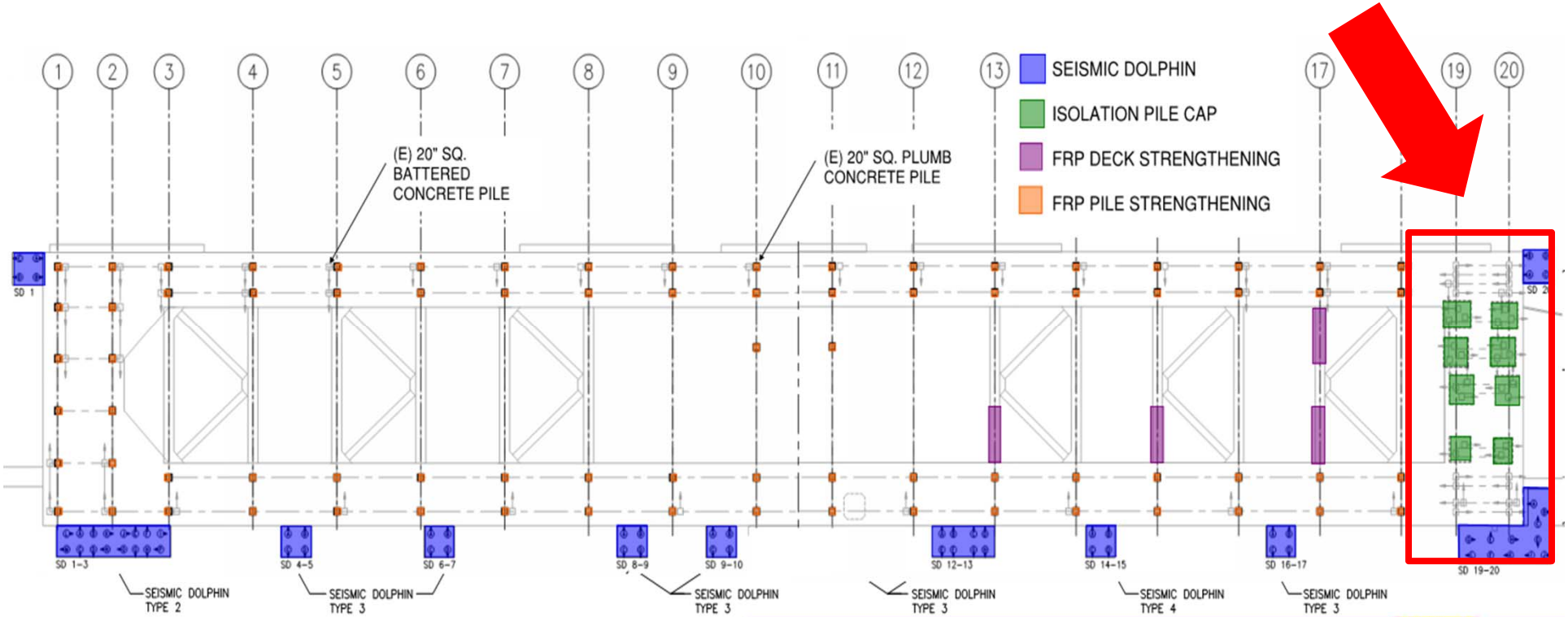
- Independent model for each Loading Berth



- Nonlinear Static Demand Procedure (Pushover)
  - Substitute Structure Approach
  - Coefficient Method

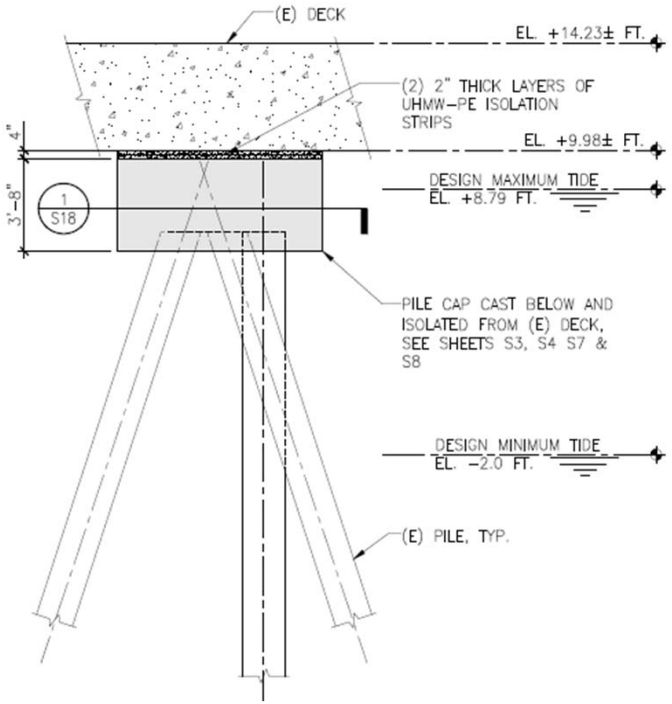
Final Strengthening Scheme

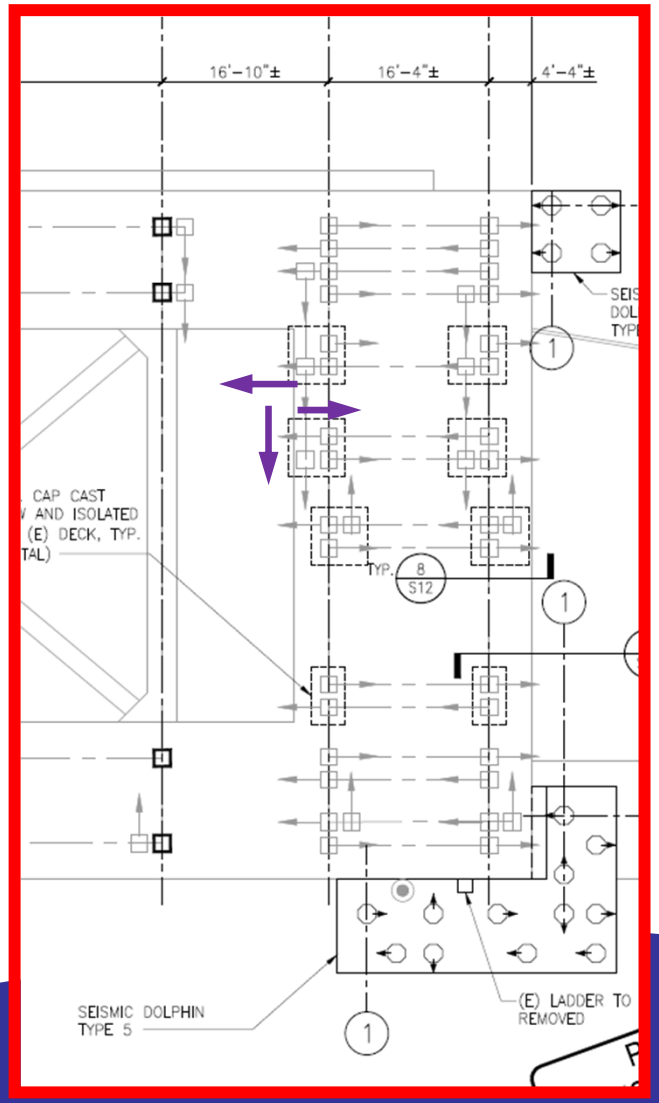
- 11 Seismic Dolphins
- Plumb Pile FRP
- Deck Beam FRP
- 8 Isolation Pile Caps



Isolation Pile Caps

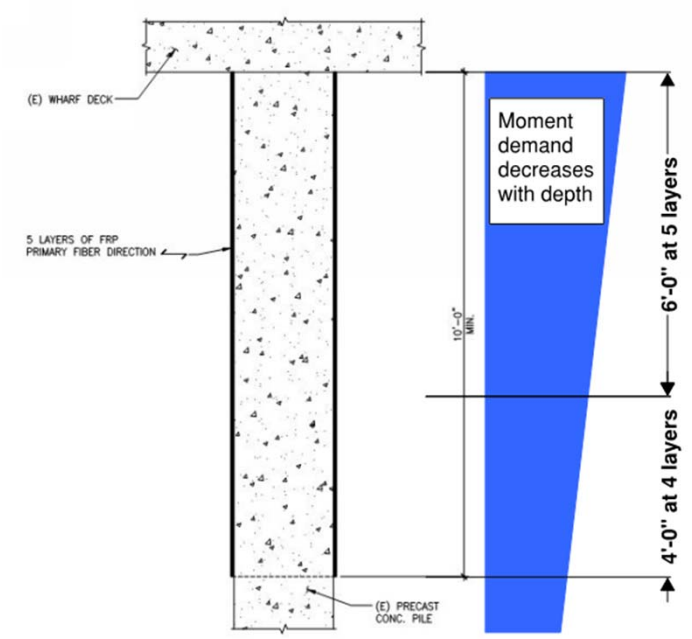
- 8 caps per Loading Berth
- Provide gravity support only
- UHMW to minimize lateral loads





Plumb Pile FRP

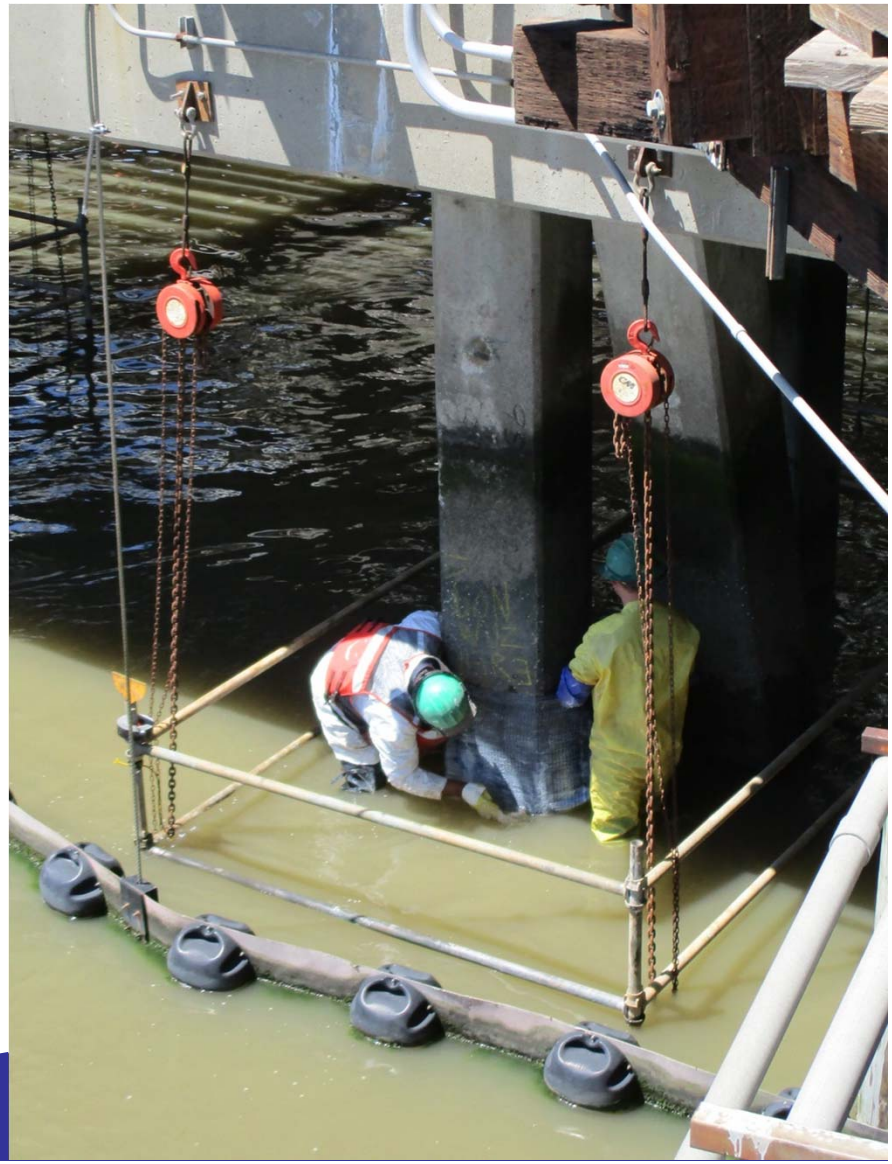
- Increase confinement
- Higher P-M capacity
- Horizontal fibers



- Address (e)Build-ups:
  - Strengthen splice
  - Longitudinal fibers

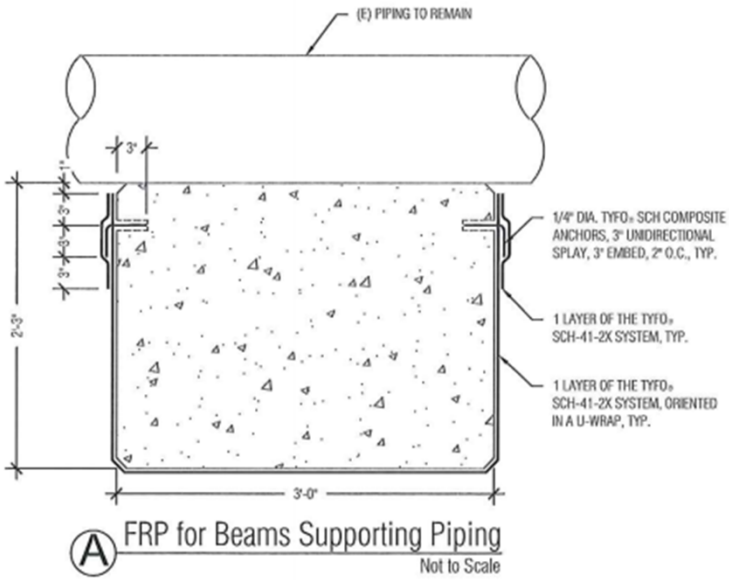
Plumb Pile FRP

- Movable work platform
  - Eliminated scaffolding
  - More access than scaffolding
  - Improved installer safety
  - Easy repositioning
  - Eliminated need for divers



Deck Beam FRP

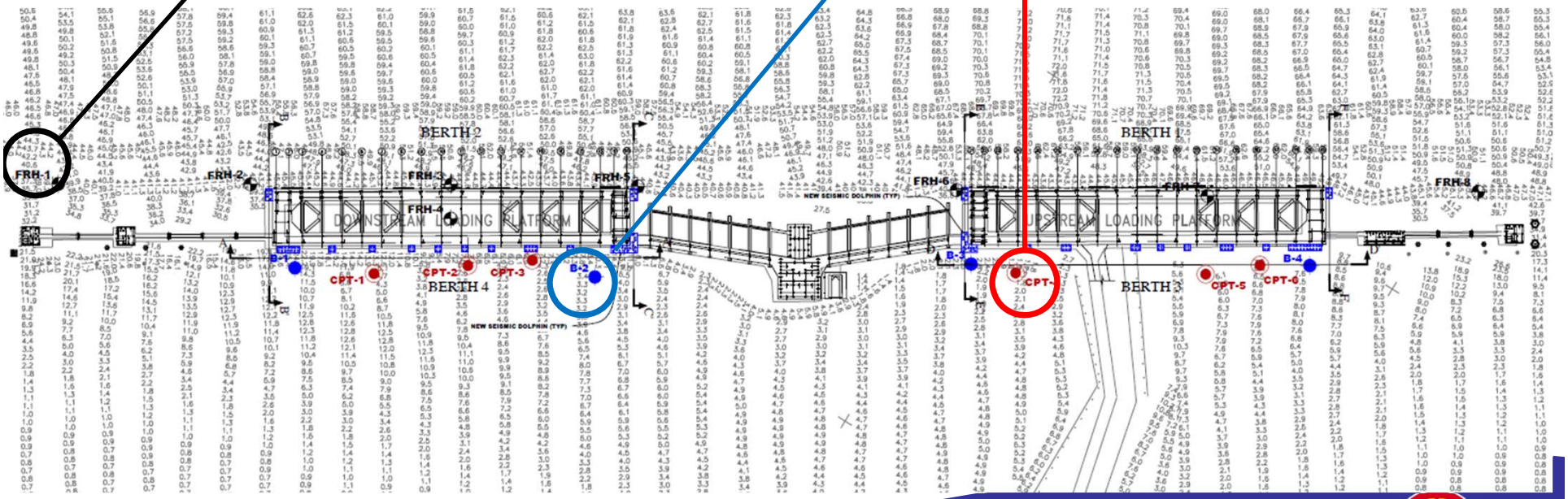
- Localized shear strengthening
- Minimize impact to pipelines and conduit
- U-shaped
- ACI 440.2R-08

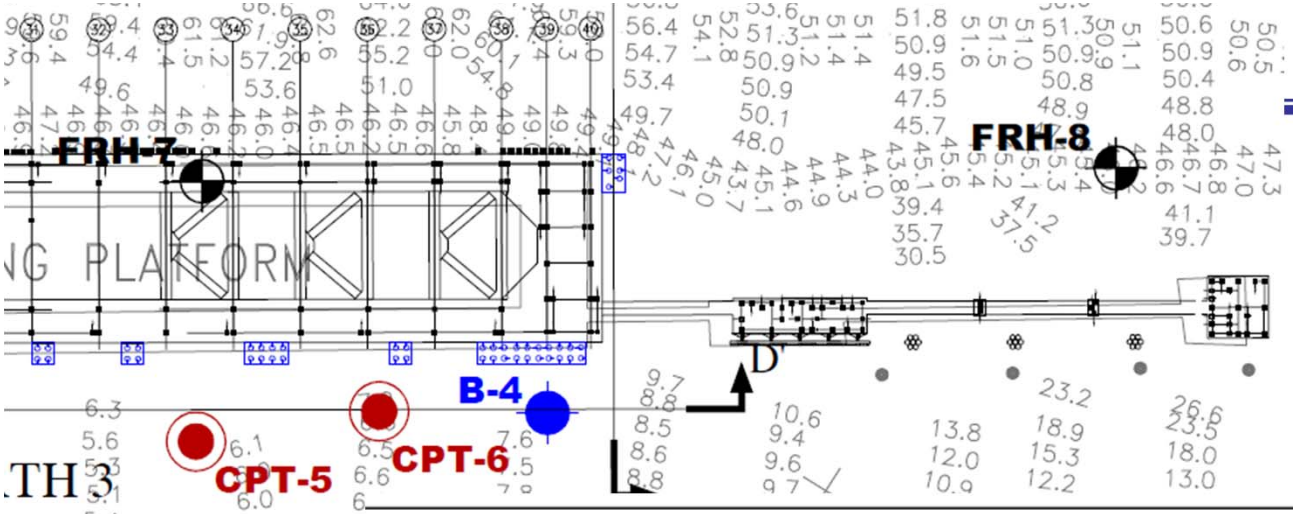


Finished Deck Beam FRP

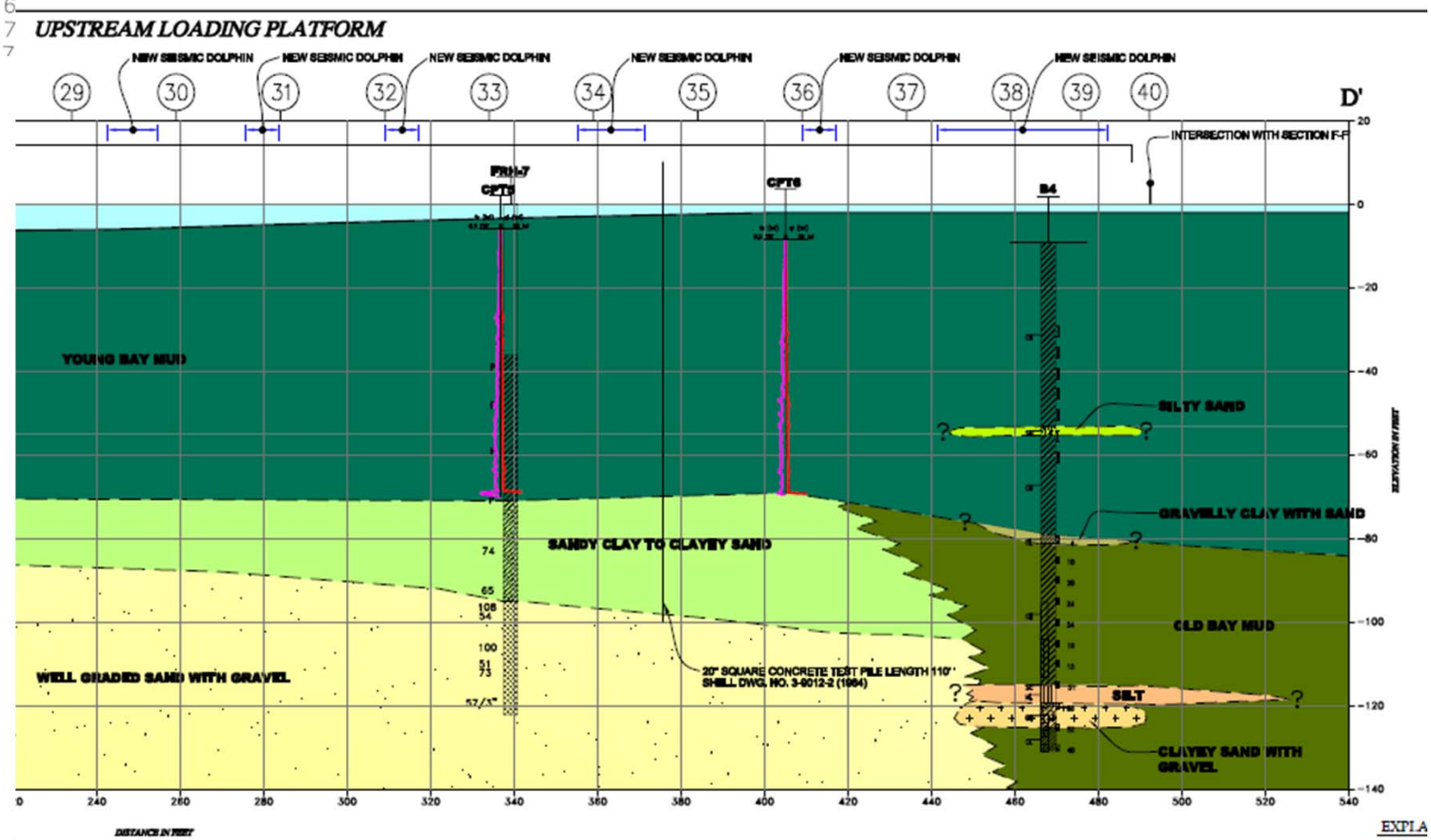
Soil Explorations

- 1963 Data
  - 8 borings; 60-90’ below ML
- 2013 Data
  - 4 borings; 108-121’ below ML
  - 6 CPTS



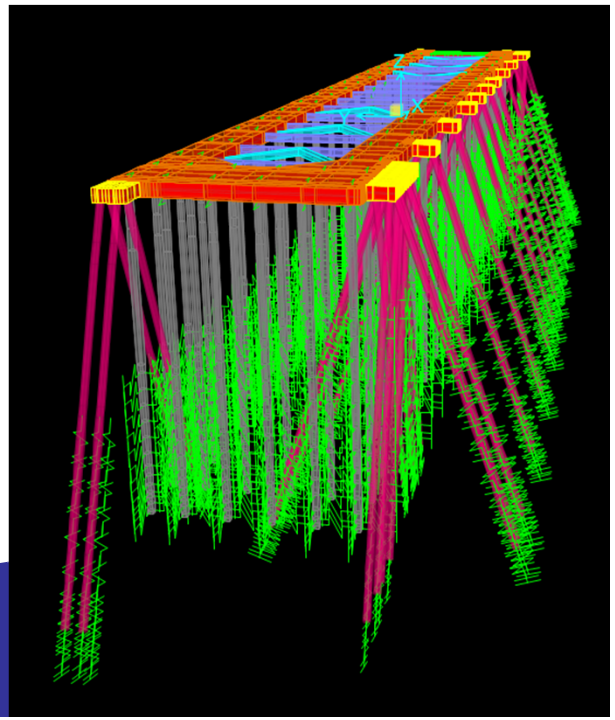


Alluvial Channel



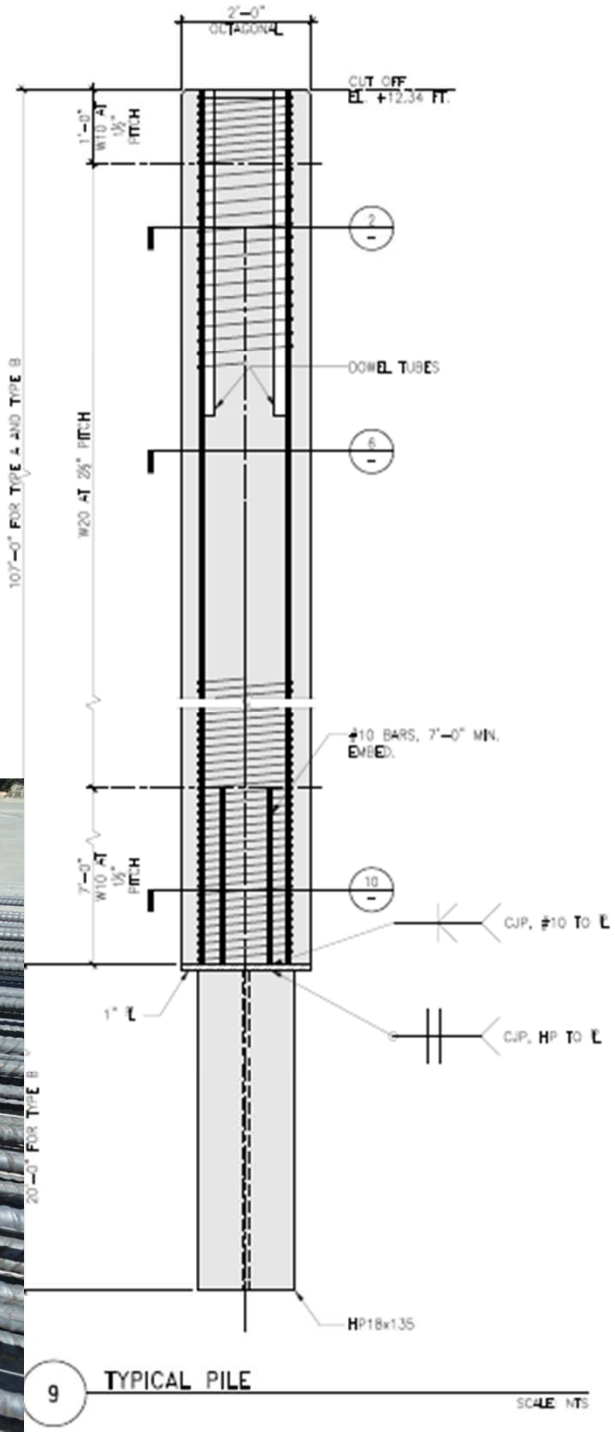
Results of Geotech Evaluation

- Lower response spectrum
- Refined soil springs, 7 discreet regions
- Discovered, prepared for, alluvial channel
- Fewer Piles
  - 12 less at Downstream
  - 14 less at Upstream
  - 26 less piles →17% reduction



Pile Stingers

- 5’ typical; 20’ in alluvial channel
- Improves driveability
- Penetration through debris
- Optimize skin friction, weight



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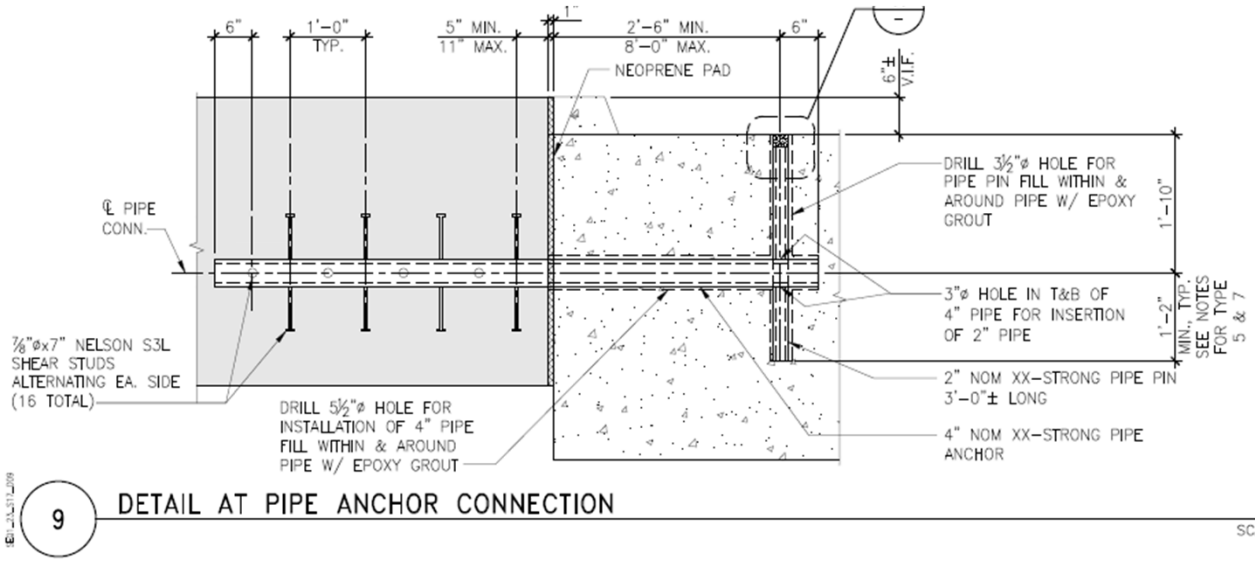
Dolphin-to-Deck Connection

- Custom designed pipe anchor connection
- Eliminated “Swiss Cheese” connection
- Easy installation, flexibility to avoid rebar



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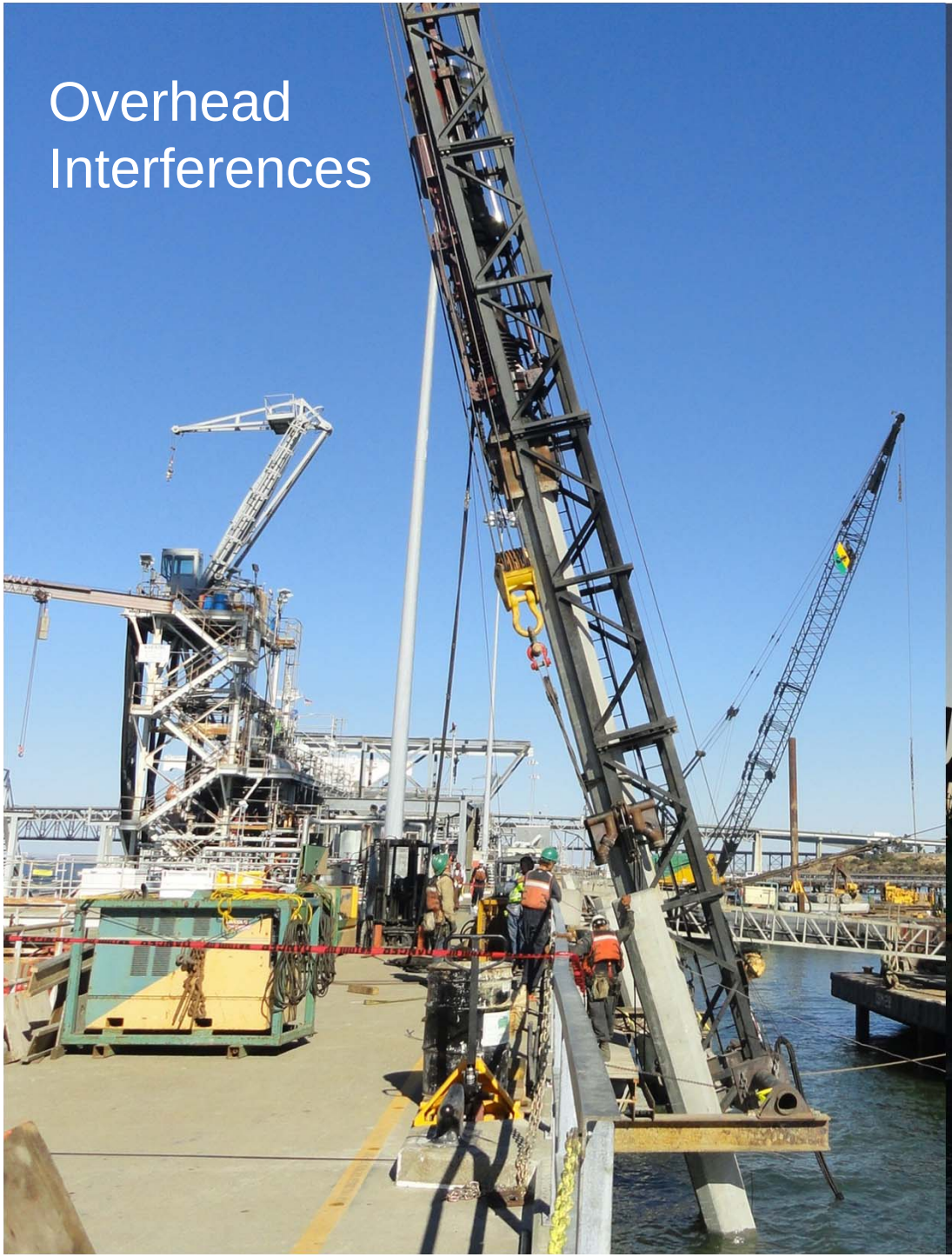
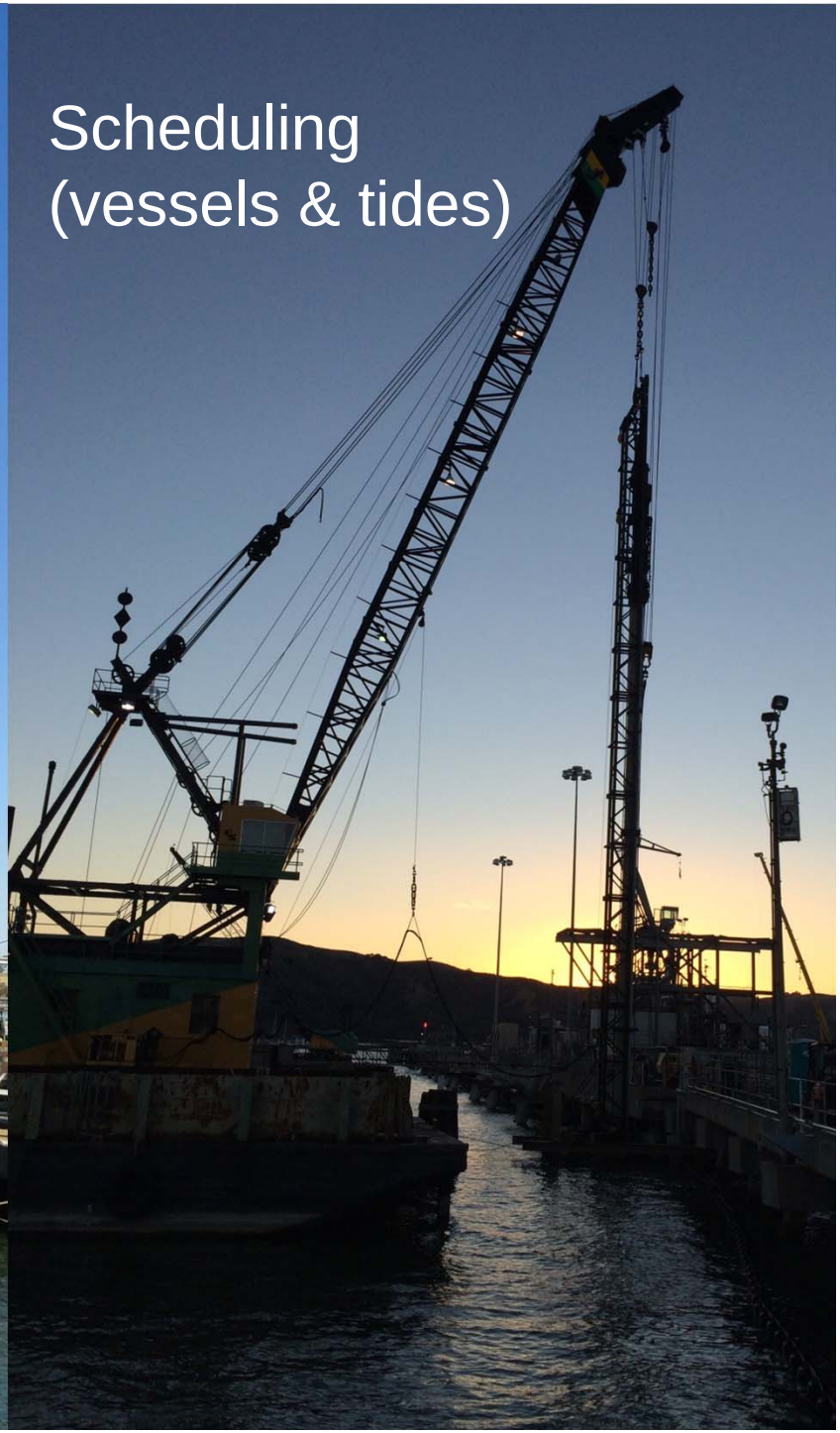
Pile Driving

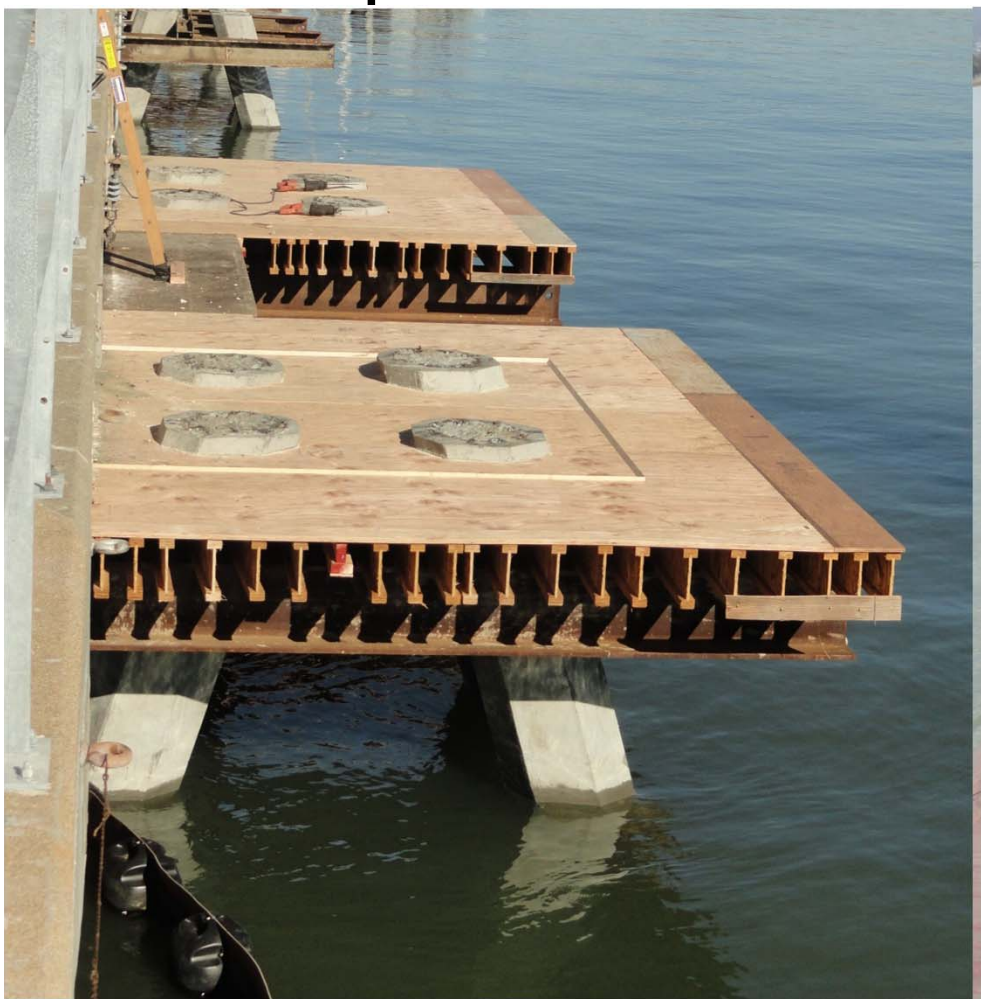
(Batter) Pile
Handling/Alignment


Overhead
Interferences


Scheduling
(vessels & tides)

Dolphin Installation

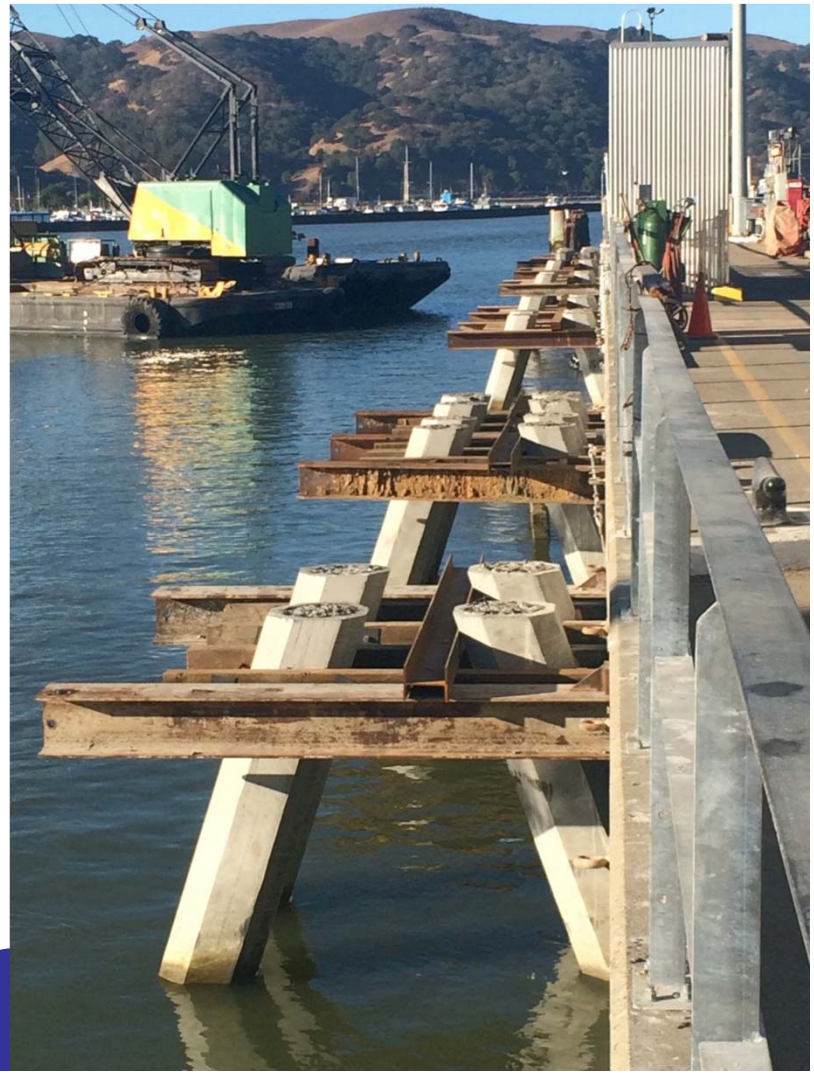
- Template → Falsework • Rebar Pre-fab



Finished Dolphins

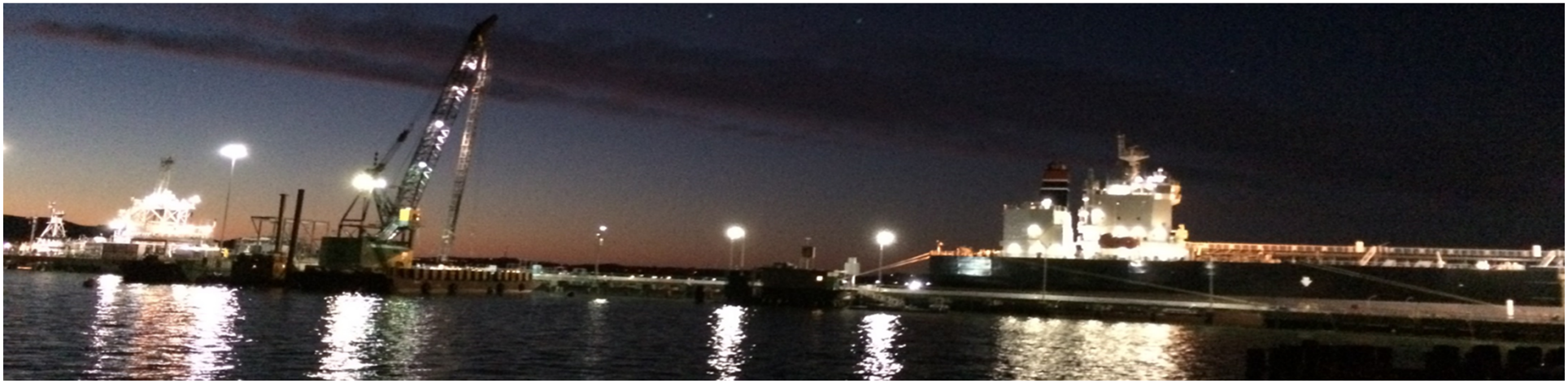
Project Status Today

- Berth 2 completed
- All FRP work completed
- Berth 1 pile driving underway
- Expect full operations to be maintained during Berth 1 construction



Additional Lessons Learned

- Good Owner-Contractor-Engineer team = Project success!
- Good geotechnical data improves pile design
- Contractor needs well defined work rules/limits/boundaries
- Be flexible – Vessel traffic is fickle



Thank you!