

Yellowstone River Bridge Replacement Project



Presented By: Sean McAuley, SE | March 2026

- Creating Holistic Solutions
- Building in Challenging Environments
- Fostering a Collaborative Environment of Innovation

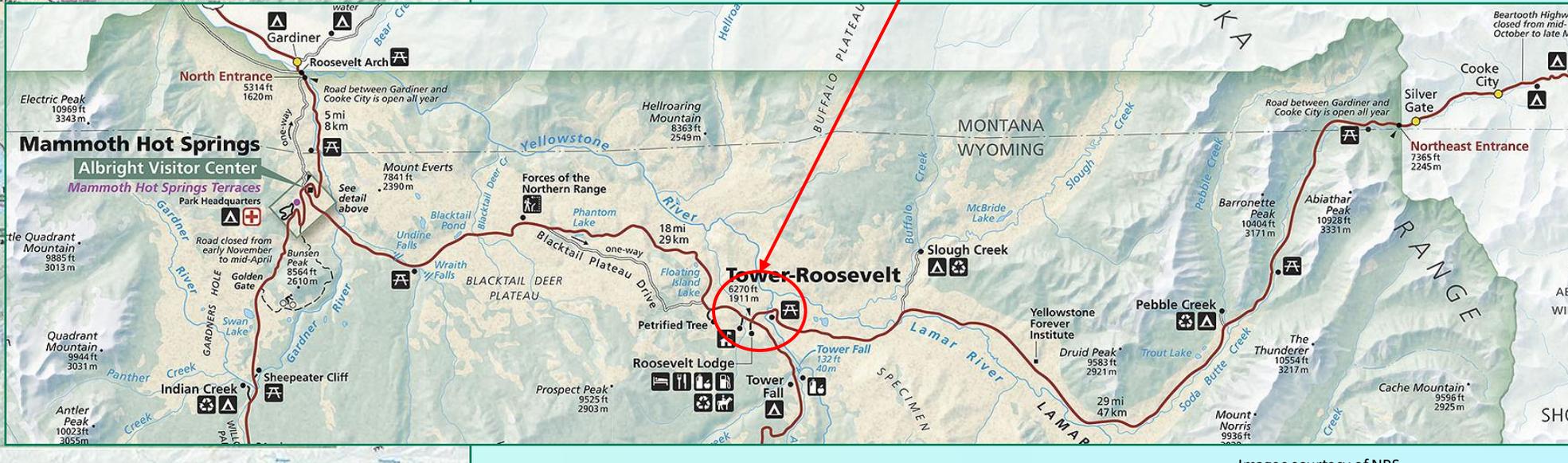
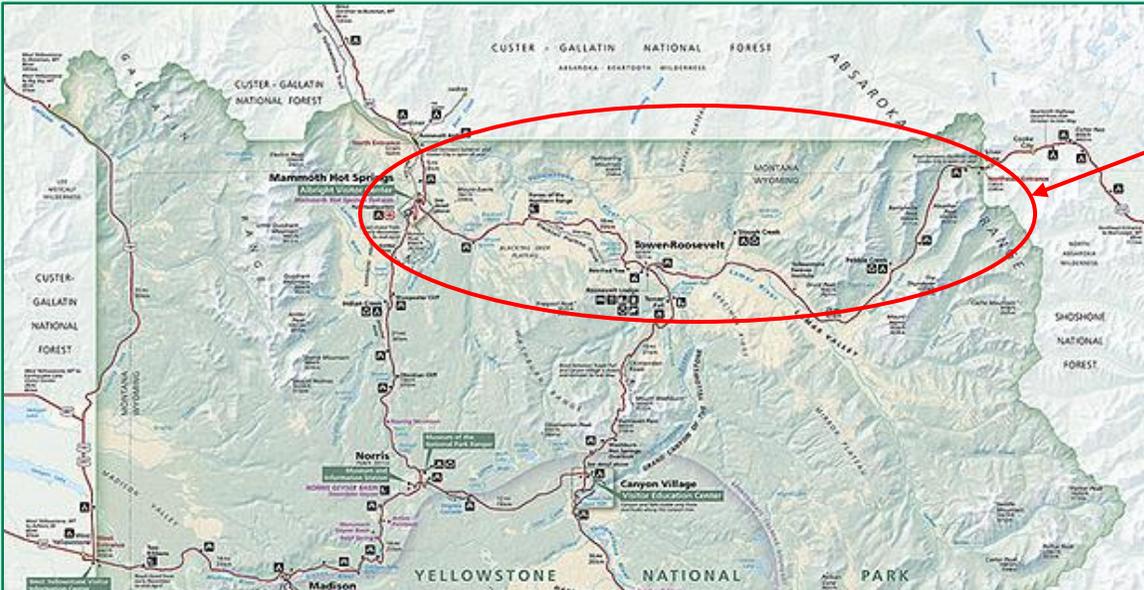


Photos courtesy of Jacobs Engineering

Yellowstone River Bridge

Northeast Entrance Road/North Loop of the Grand Loop Road

Yellowstone River Bridge



Images courtesy of NPS

Existing Bridge and Alignment

- Scour critical
- Steep alignment with sharp curves

- Deteriorating deck
- Two-girder system
- Can not be closed to public traffic



Photos courtesy of Jacobs Engineering

Preliminary Geotechnical Investigation

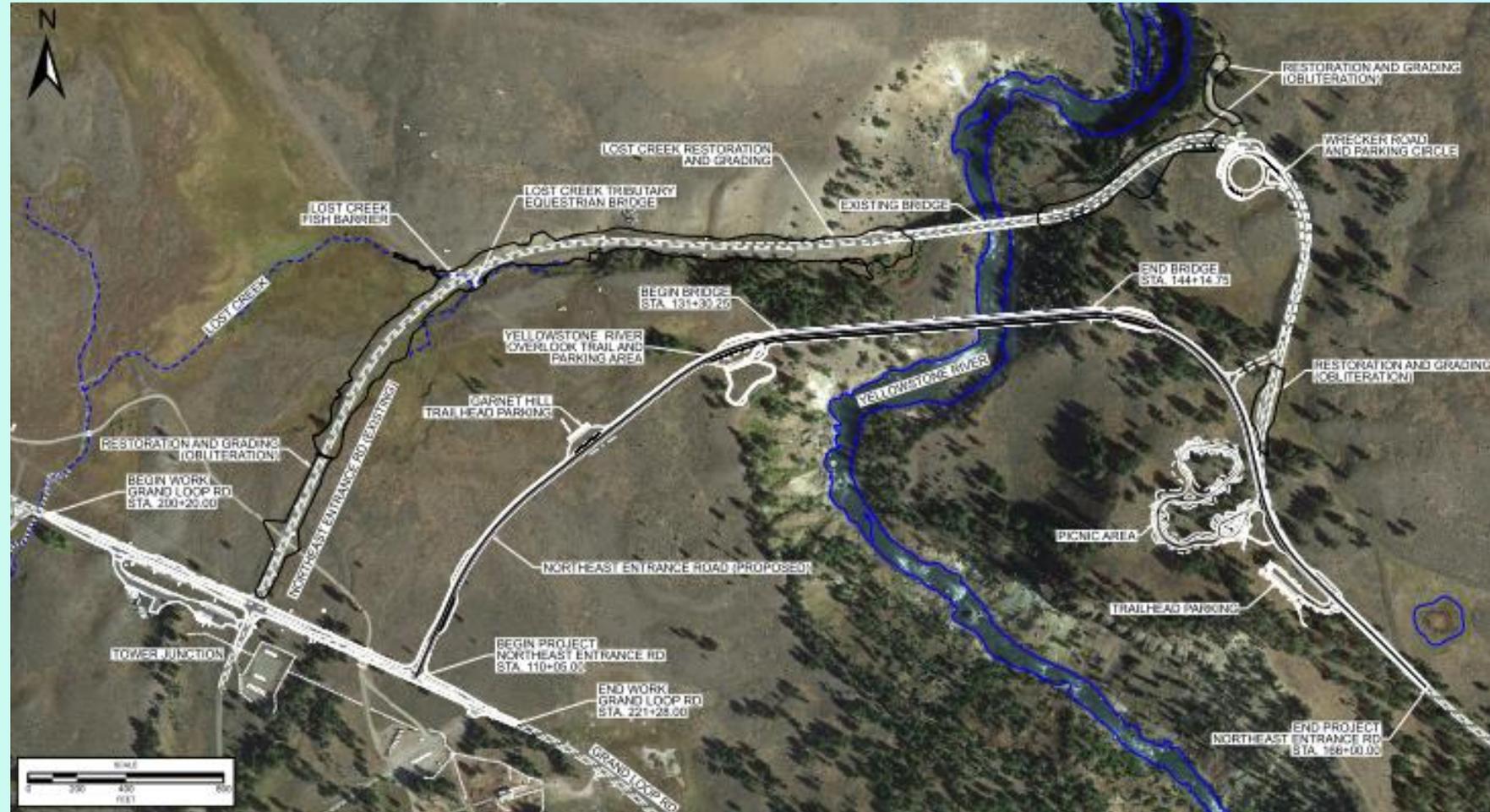
- Hot ground/hydrothermal features
- Acidic ground conditions with high sulfides

Roadway Layout Features

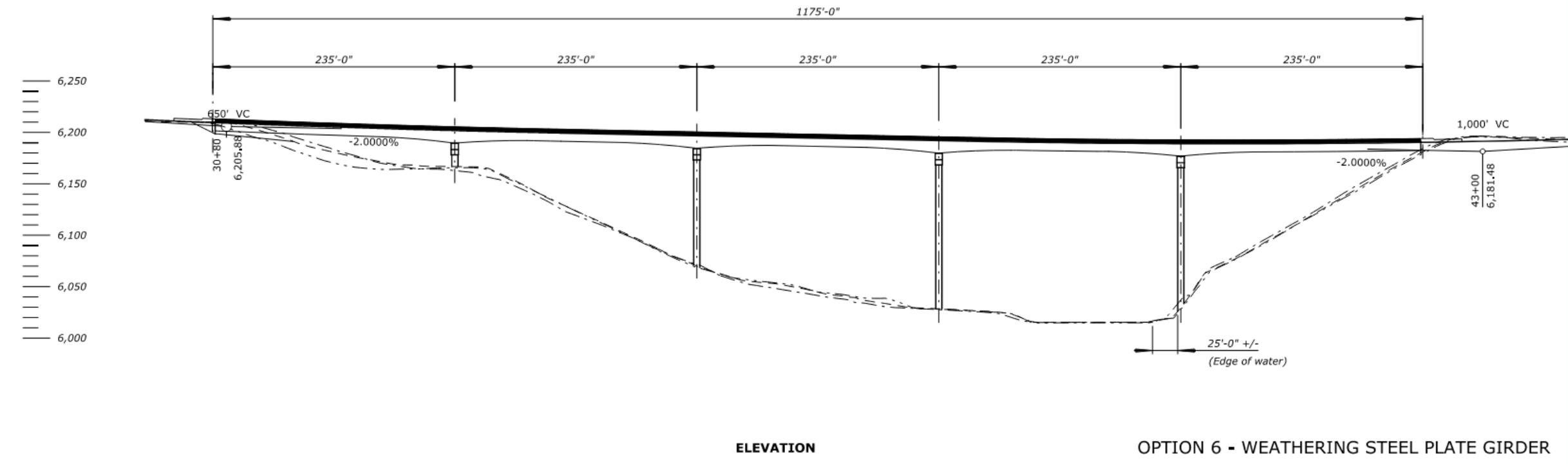
- High level crossing (175' from deck to the river)
- Mostly straight alignment with super transitions in spans 1 & 4

Constructability Challenges

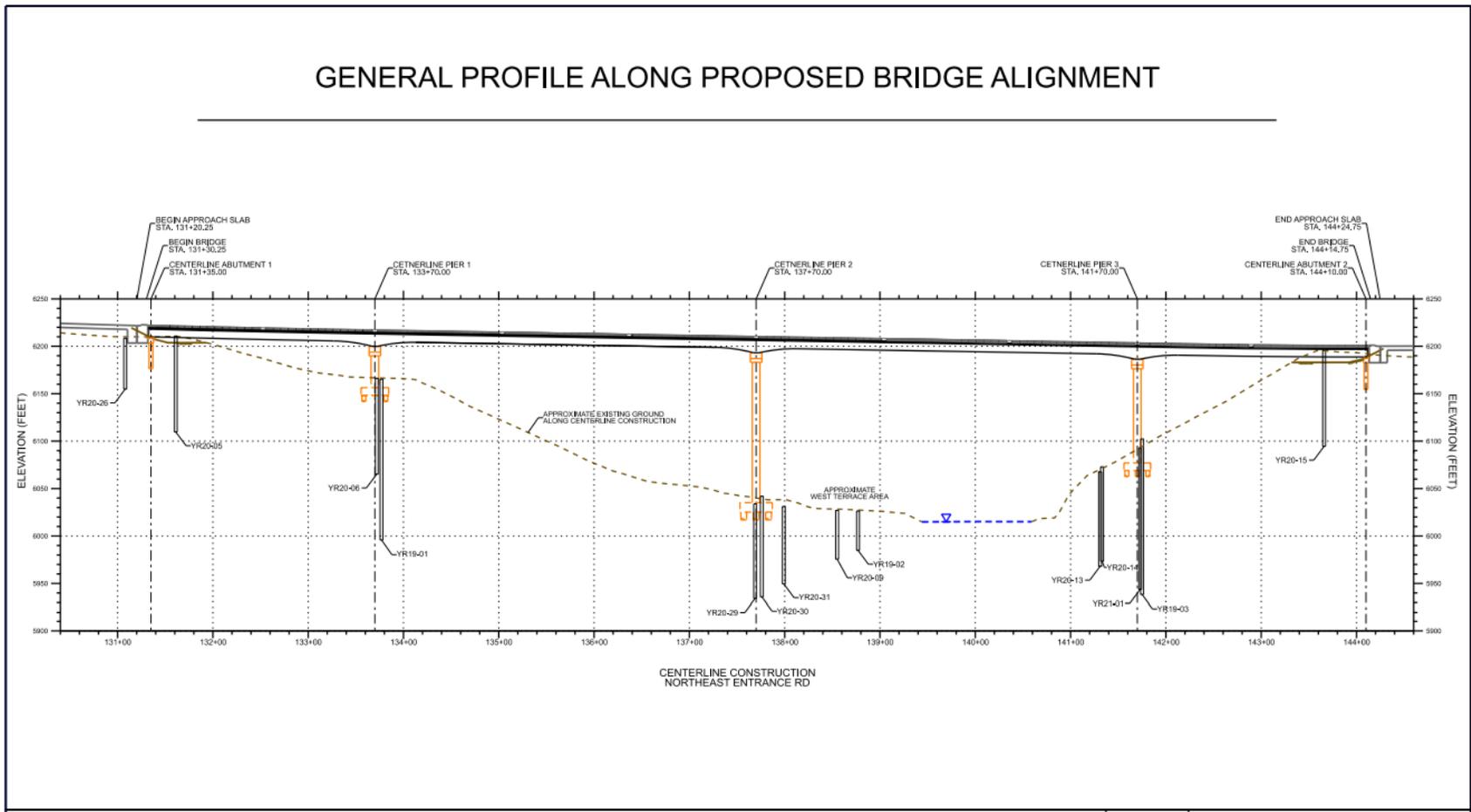
- Tall columns with challenging concrete production
- Seasonal construction windows (April-October)
- Shipping constraints



Geotechnical Findings



Geotechnical Findings



Geotechnical Findings

2020/2021 Yellowstone River Bridge Geotechnical Investigation Soil Sample Laboratory Result Summary													
Sample Location			Moisture	Particle Size			Atterberg		R Value	Chemical Analysis			
Borehole ID	From (feet)	To (feet)	%	Fines %	Sand %	Gravel %	PL %	LL %	R	Sulfate (ppm)	Chloride (ppm)	pH	Resistivity (Ω-cm)
YR20-01	2.5	4.0	6.5	6.8	30.8	62.4	24	26					
YR20-01	5.0	6.5	11	19.8	53	27.2							
YR20-01	7.5	9.0	5.3	8.2	46.2	45.6							
YR20-02*	0.0	5.0	4.1	49.9	32.3	17.8	25	41	21				
YR20-02	7.5	9.0	13.8	7.3	56.3	36.4							
YR20-03	5.0	6.5	2.4	11.5	49.7	38.8							
YR20-03*	0.0	5.0	3.1	7.7	25.1	67.2	26	33	86				
YR20-03	12.5	14.0	5.3	9.6	57.6	32.8				66	16.5	7.7	3766
YR20-04	7.5	9.0	8	14.5	54.4	31.1				37	18	7.2	5200
YR20-04	15.0	16.5	16.9	5.8	78.2	16							
YR20-04	20.0	21.5	14.5	7.3	81.9	10.8							
YR20-05	2.5	4.0	2.7	10	64.1	25.9				28	11.3	7.8	6000
YR20-05	12.5	14.0	6.5	11.7	63.9	24.4				36	23	7.3	6000
YR20-05	45.0	45.5	13.1	40.5	43	16.5				184	60	7.1	1366
YR20-06	11.0	12.5	13.7	29.5	44.7	25.8				124	42	6.8	3192
YR20-06	31.0	31.8	14.7	49.6	37.1	13.3				1478	11	7.4	698
YR20-09	18.5	18.7	22.2	48.5	36.5	15	18	43		6595	31	6.5	326
YR20-09	2.5	4	4.3	15.2	36	48.8				257	62	7.3	2812
YR20-13	6.0	7.5	14.4	27.7	45.4	26.9				114	104.5	7.7	744
YR20-13	20.5	22.0	39.5	33.6	44.4	22				1891	300	7.1	824
YR20-13	28.0	29.5	19.7	35.9	31.3	32.8	22	44		3209	52.3	4	516
YR20-14	13.0	14.5	15	40	44.6	15.4				2460	12	7.5	962
YR20-14	30.5	32.0	27.8	74.9	16.7	8.4				Invalid*	Invalid*	2.2	206
YR20-15	7.5	9.0	8.1	47.1	40.8	12.1				222	18.8	6.8	1438
YR20-15	12.5	14.0	6.7	41.3	51.6	7.1				227	15.5	7.5	1582
YR20-15	17.5	19.0	5	41.8	41.1	17.1				156	18	7.9	1708
YR20-16	2.5	4.0	12.4	51.4	43.5	5.1	21	35					
YR20-16	5.0	6.5	9.8	36.8	44.1	19.1							
YR20-16	7.5	9.0	8.4	34.6	53.1	12.3							
YR20-17*	0.0	5.0	10.6	60.5	24.9	14.6	25	50	9				

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YR20-17	7.5	9.0	10.1	25	61.4	13.6							
YR20-17	10.0	11.5	12.7	32.3	55	12.7	19	28					
YR20-17	12.5	14.0	23.2	52.4	42.6	5	24	57					
YR20-19	0.0	1.5	2.6	41.7	48.4	9.9							
YR20-19	2.5	4.0	9	21.8	32.6	45.6	24	30					
YR20-20	0.0	1.5	13	48.4	51.6	0	32	37					
YR20-20	2.5	4.0	14.2	41	59	0	NP	NP					
YR20-20	5.0	6.5	14.2	41.7	58.3	0	23	27					
YR20-20	10.0	11.5	5.7	12.9	63	24.1							
YR20-20	12.5	14.0	10.6	9.8	48.9	41.3							
YR20-21	2.5	4.0	8.9	19.5	46.5	34				1888	44	3.4	1160
YR20-21	10.0	11.5	22.9	58.5	38.7	2.8	25	42					
YR20-21	15.0	16.5	30.4	36	62.2	1.8							

2020/2021 Yellowstone River Bridge Geotechnical Investigation Soil Sample Laboratory Result Summary													
Sample Location			Moisture	Particle Size			Atterberg		R Value	Chemical Analysis			
Borehole ID	From (feet)	To (feet)	%	Fines %	Sand %	Gravel %	PL %	LL %	R	Sulfate (ppm)	Chloride (ppm)	pH	Resistivity (Ω-cm)
YR20-30	11.0	12.5	31.1	68.2	26.9	4.9	36	59		4875	195.0	3.4	400
YR20-31	2.5	4.0	24.1	61.6	34.8	3.6	27	52		86	17.0	6.4	1212
YR20-31	7.5	9.0	21.9	57.8	41.8	0.4	24	49		2160	3.0	3.5	426
YR20-31	5.0	6.5	22.4	47	52.4	0.6	32	54		291	136.5	4.6	1760
YR20-31	10.0	11.5	17.1	68.7	31.2	0.1	23	52		970	77.0	7.0	498
YR21-01	5.0	6.5	38.1	29.1	48.7	22.2							
YR21-01	10.0	11.5	33.6	45.0	36.7	18.3							
YR21-01	17.5	18.5	26.0	52.5	43.4	4.1							
YR21-01	20.0	21.5	10	62.0	37.1	0.9	31	49					
YR21-01	28.0	28.5	17.6	28.8	58.2	13.0	35	47		5840	23.8	6.7	344
YR21-01	32.0	32.5								6386	18.3	4.1	316
YR21-01	36.5	37.0								4368	19.8	8.1	4540
YR21-01	42.1	42.9	5.5	30.1	69.9	0				658	13.0	8.2	744
YR21-01	115.5	116.2								453	29.0	7.2	1044

- Notes:
1. PL=Plastic Limit
 2. LL=Liquid Limit
 3. R Values are reported as the corrected R value at 300 psi Exudation Pressure.
 4. Resistivity is reported at the minimum resistivity (Ω-cm).
 5. The shaded gray cells indicate testing that was not conducted for that sample.
 6. * indicates a bulk sample collected from the augers at the surface.
 7. Invalid* = geochemical sample sulfate and chloride concentrations exceed the laboratory testing method (Hach Method 8051 and 8207).

Geotechnical Findings

YR20-09 Downhole Temperature vs. Time Plot

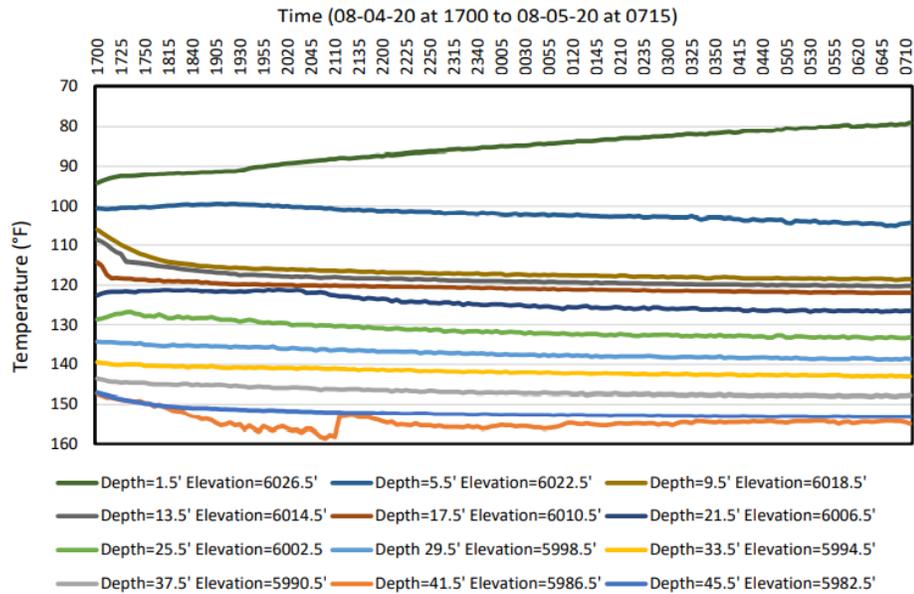
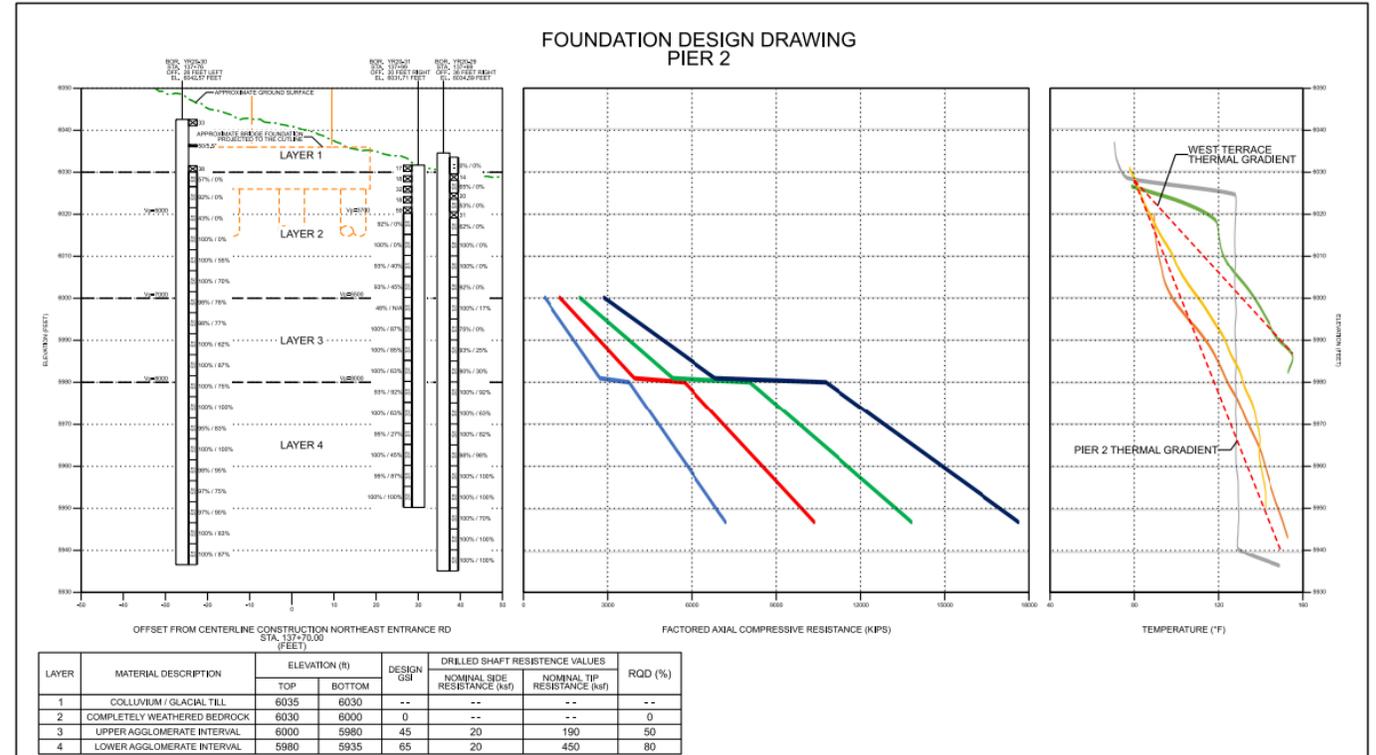


Figure C-7: Plot of temperature with time following the completion of drilling at borehole YR20-09. For clarity, only certain selected depths are displayed.



Holistic Solutions

- **How to Deal with Ground Conditions:**

1. Deeper = Hotter
2. Keep foundations shallow
3. Shallow foundations require:
 1. Keep deadloads low
 2. Alternative seismic solutions
4. Use steel and hollow columns for dead loads
5. Use isolation and limited ductility for seismic demand
6. Use microcrystalline wax for duct filler

- **How to Deal with Constructability Issues:**

1. Precast columns
2. Steel erection analysis and detailing
3. Precast deck panels



Photo courtesy of NPS/Jacob W. Frank

General Corrosion Guidelines

- **Sulfide resistance:**
 - Sulfide concentration >1500ppm considered corrosive (YRB – 6500ppm)
 - Type V cement (high sulfide resistance)
 - Dense concrete preferred
- **Acid Resistance:**
 - Anything < pH of 6.5 considered acidic
 - ACI recommendation for < pH of 3.5 is non-contact

Concrete deterioration increases as the pH of the acid decreases from 6.5. In fact, **no hydraulic cement concrete**, regardless of its composition, **will hold up for long if exposed to a solution with a pH of 3 or lower**. To protect concrete from such severely acidic environments, surface treatments are often used.

Corrosion Protection from Acids and Sulfates

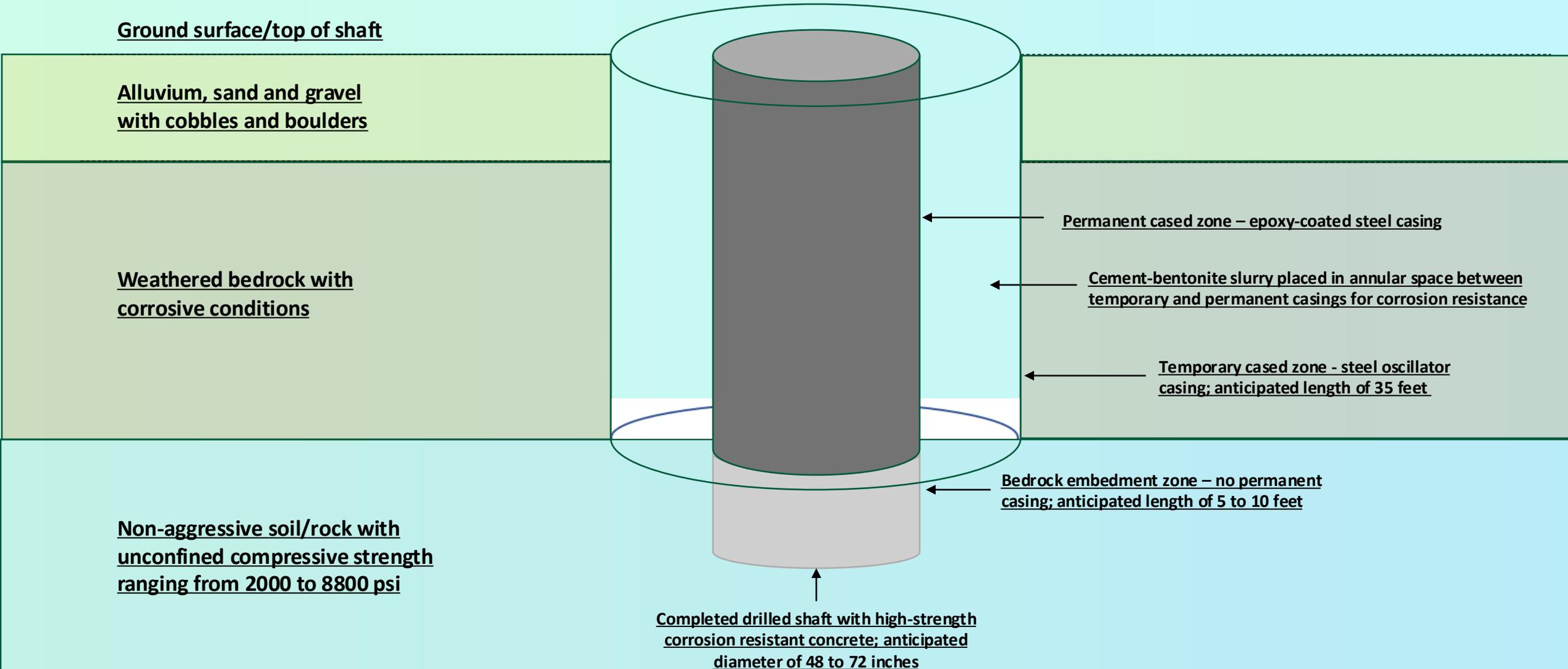
Sections 5.12.4 and 5.12.5 of Caltrans Amendments to LRFD Specifications provide guidance on protection against acids and sulfates. Acids and sulfates have a detrimental effect on concrete and can adversely affect the performance and/or service life of a structure. The acidity of soil/water is determined by its pH value. If the bridge site data / foundation report indicates that the pH value of the soil/water is between 3 and 5.5 or that its sulfate concentration is between 2000 ppm and 15,000 ppm, then CRC will be required. This information should be conveyed to the Specifications Engineer.

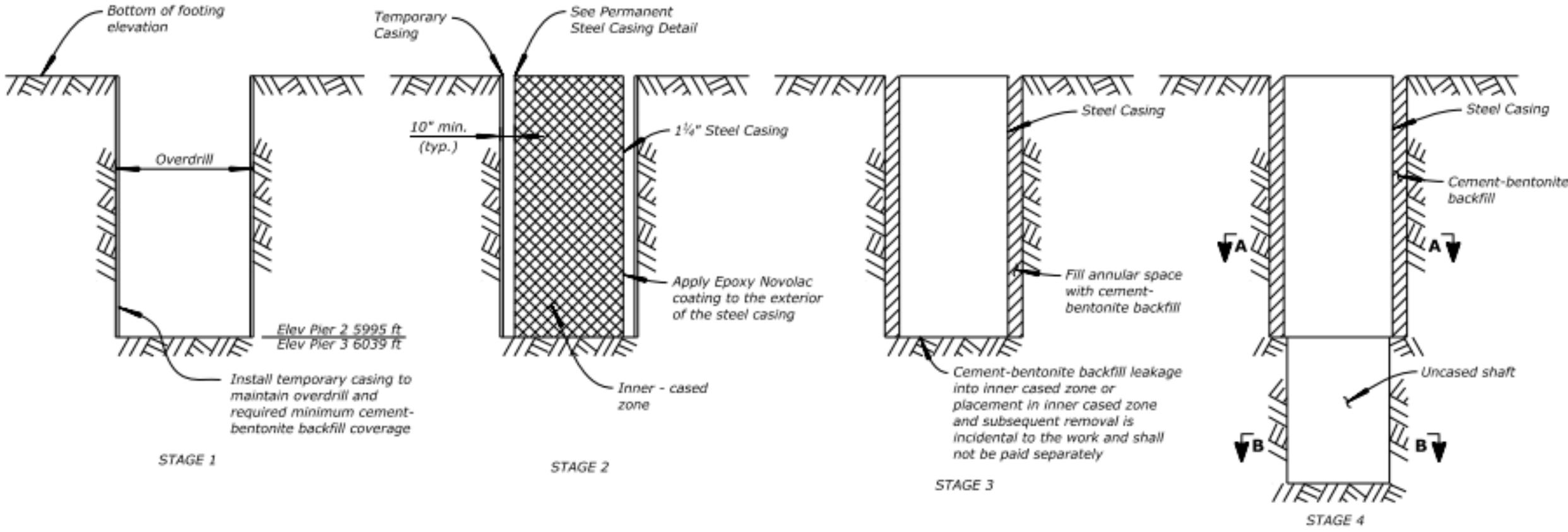
When the pH of soil/water at the bridge location is less than 3.0 or when the sulfate content exceeds 15,000 ppm, contact the Corrosion Technology Branch.



Photo courtesy of NPS/Jacob W. Frank

Drilled Shaft Corrosion Protection Scheme





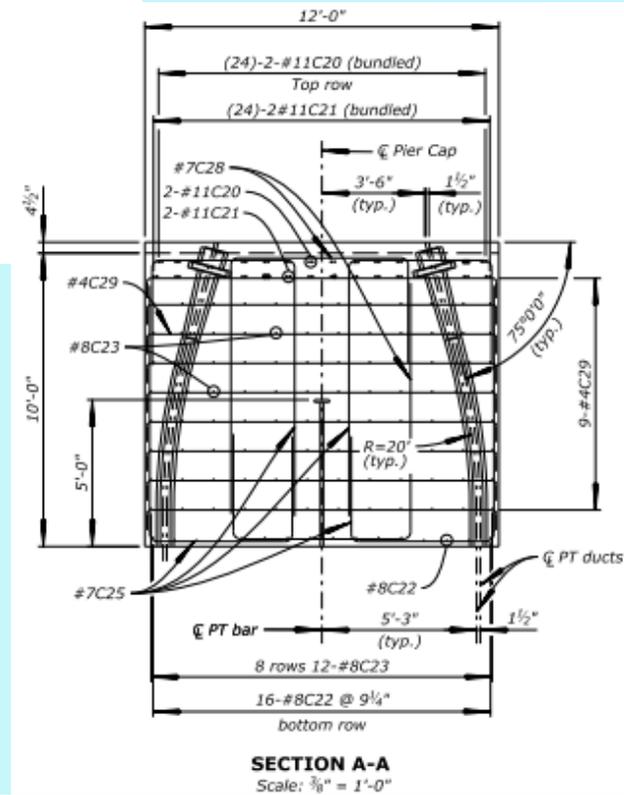
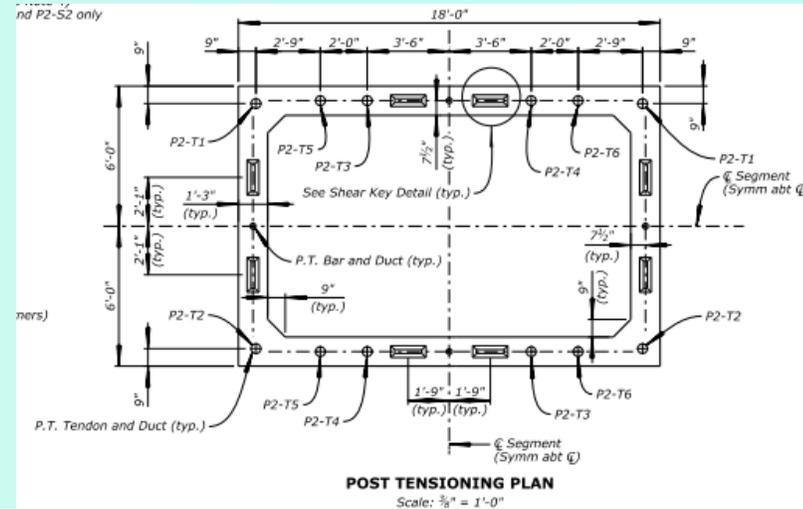
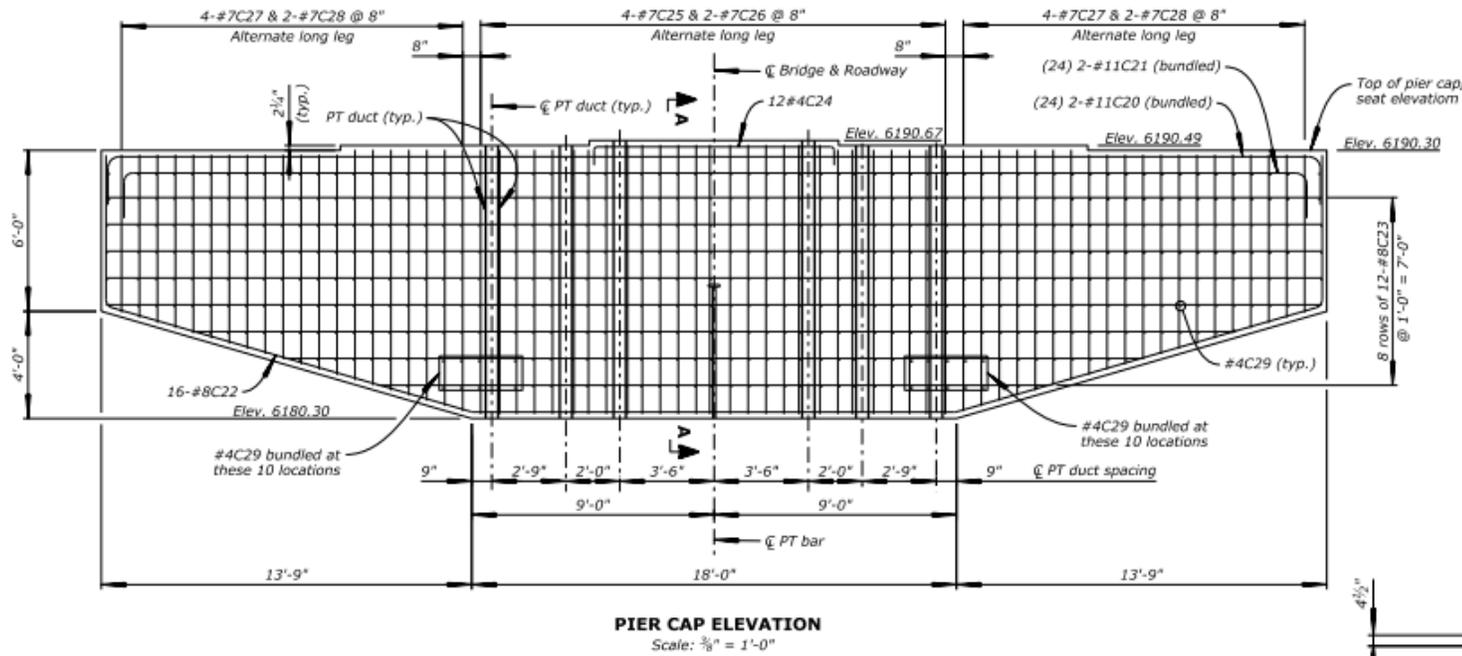
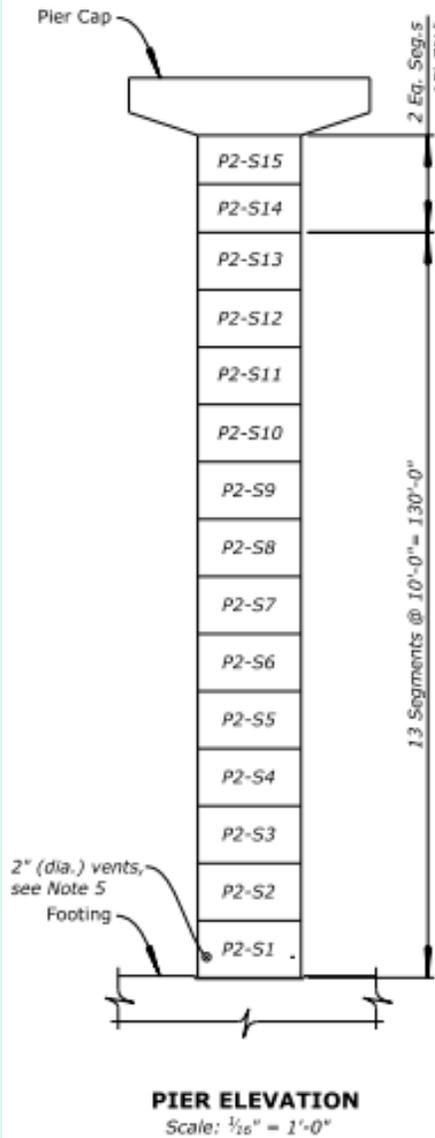
ELEVATION - CONSTRUCTION STAGING

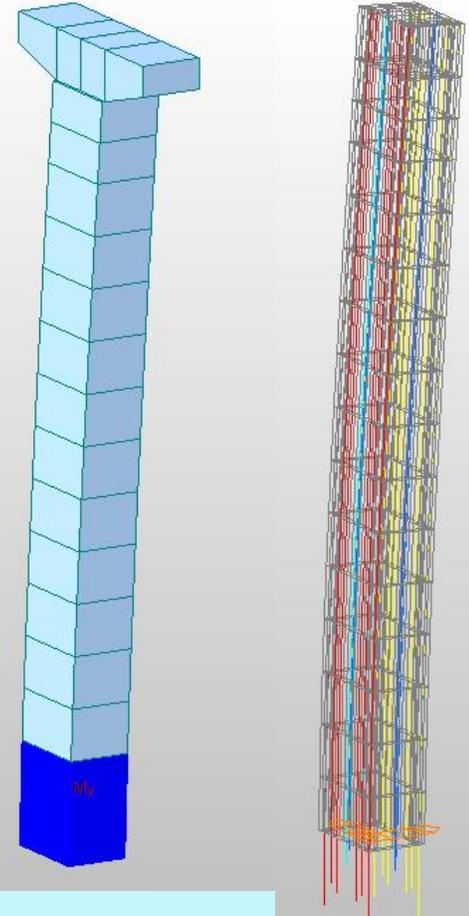
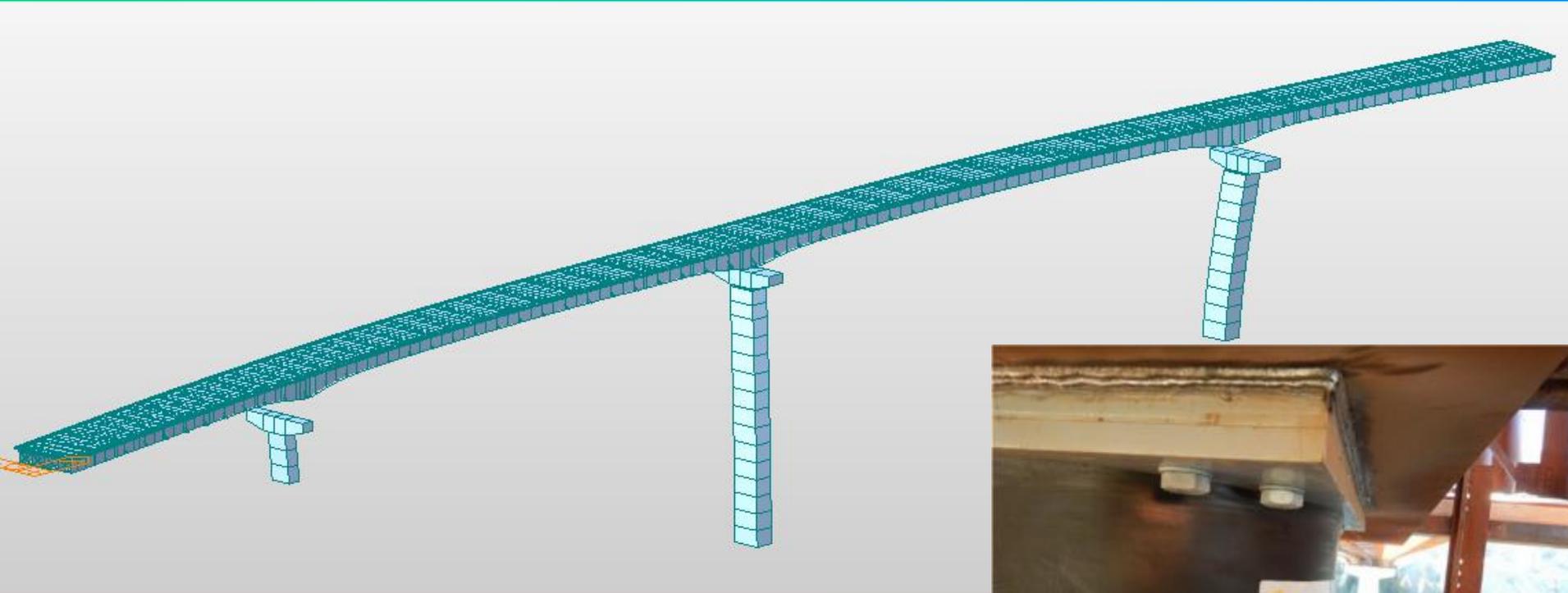
Precast Segmental Piers

- Seasonal Construction Work Windows
 - April 1st through October 31st
- Pier Heights
 - Pier 1 ~30' (40' with cap)
 - Pier 2 ~148' (158' with cap)
 - Pier 3 ~97' (107' with cap)
- Long spans = large loads
- Precast Pier Advantages
 - Significant construction schedule savings (offsite/offseason construction)
 - Higher quality materials, tighter tolerances
 - Potential cost savings



Photo courtesy of NPS/Jacob W. Frank





- Seismic Isolation
 - Elastic Response
 - Energy dissipation through hysteric behavior
 - Upperbound/Lowerbound analysis
- Limited Ductility Response
 - Very little design guidance on precast segmental columns response in seismic zones
 - Need to rely on research and sound analytical approach
 - Traditional M-C analysis and pushover analysis to validate capacity
 - Energy dissipation reinforcement fully grouted in the first 2 segments
 - Unbonded tendons (microcrystalline wax duct filler – one of the first uses in vertical construction)
 - Nonlinear static pushover using spine + linear time history model using solids/bricks

Photo courtesy of FHWA



Photo courtesy of Jacobs Engineering

■ Seismic Strategy

- Energy dissipation reinforcement
 - Debond at joints to prevent premature rupture
 - Grout in corrugated ducts for high bond strength
 - Template to avoid conflicts with precast columns
- PT Tendons and Bars
 - Smooth ducts with microcrystalline wax flexible filler designed to distribute strain
 - Increased area to prevent rupture
- Stiffness balancing
 - For elastic analysis send as much demand as possible to stiffest elements (abutments/Pier 1)
 - Balance by adjusting isolation bearing parameters (characteristic strength/yield displacement)

Superstructure

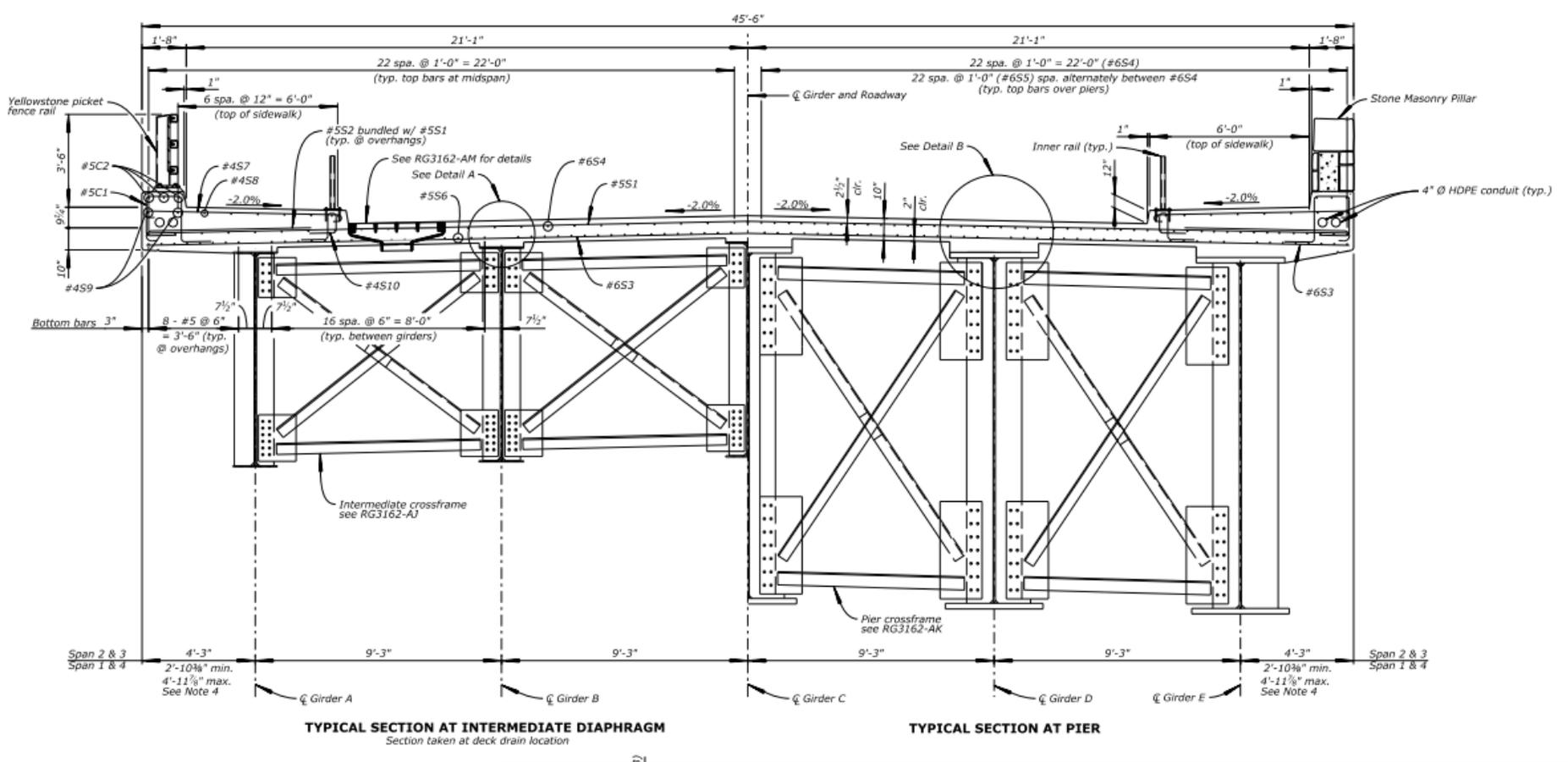
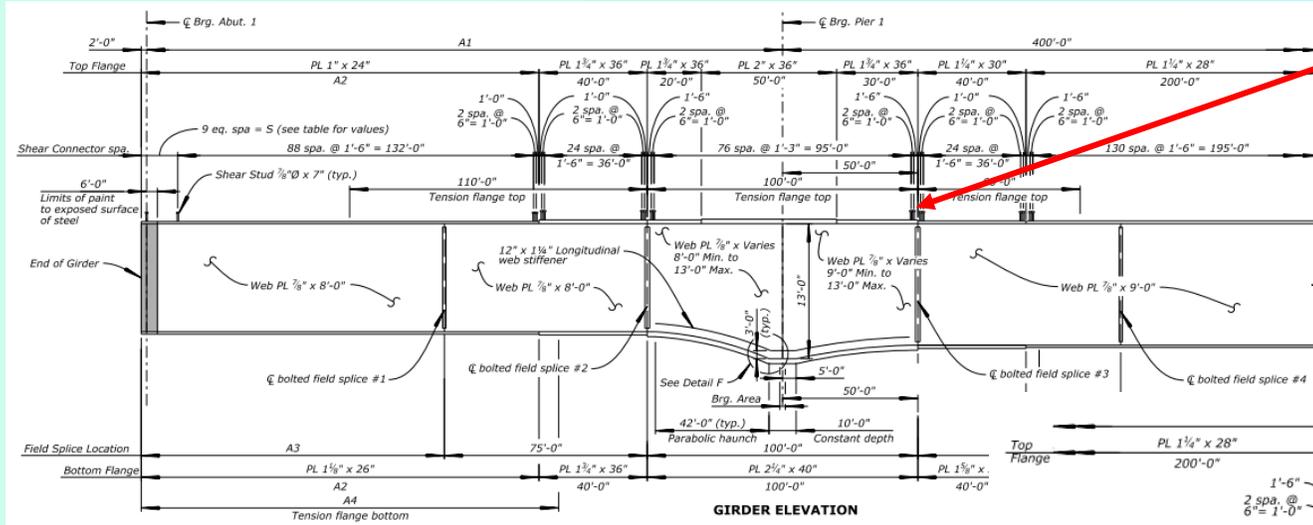


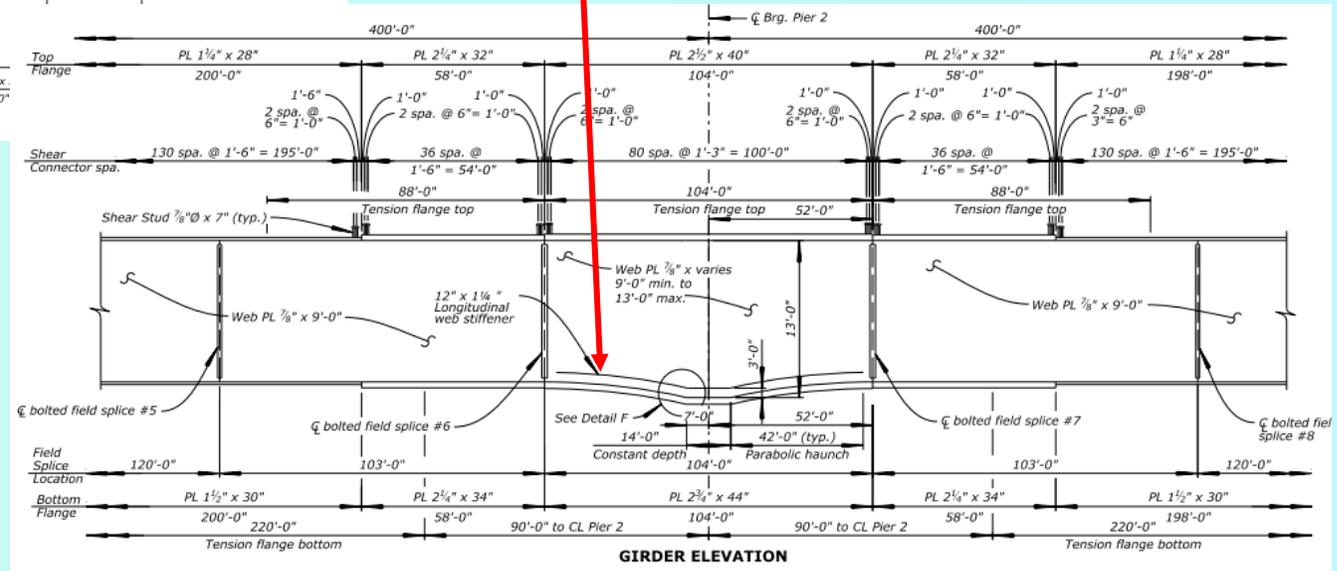
Photo courtesy of Jacobs Engineering

Superstructure

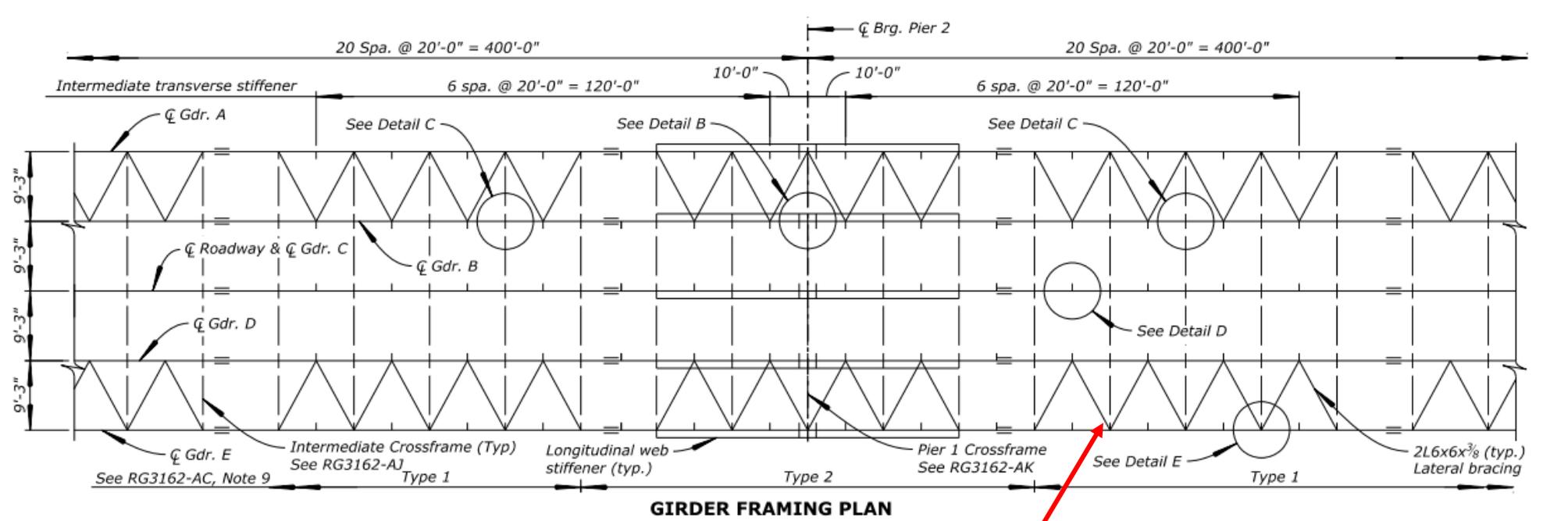


100' to 104' parabolic haunched piece

Longitudinal stiffener kept webs to 7/8"



Superstructure



Lateral bracing in exterior bays only



Photo courtesy of NPS/Jacob W. Frank



Photo courtesy of NPS/Jacob W. Frank

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Photo courtesy of NPS/Jacob W. Frank

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Questions & Answers