

Yellowstone River Bridge Replacement Project



Presented By: Sean McAuley, SE & Andrew Wahr, SE | September 2026

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Challenging today.
Reinventing tomorrow.

Overview

- Yellowstone National Park and the Yellowstone River Bridge Replacement
- Foundations challenges in a Super volcano
- Why precast segmental
- Strength and Service Design Challenges
- Seismic design of precast segmental substructures
- Detailing for constructability
- Thanks, Questions, and Shameless Plugs



Photos courtesy of NPS

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Tower Junction

- Bozeman – 100mi
- Billings – 200mi
- Salt Lake City – 375mi
- Boise – 450mi
- Denver – 600mi

Seasonal Access

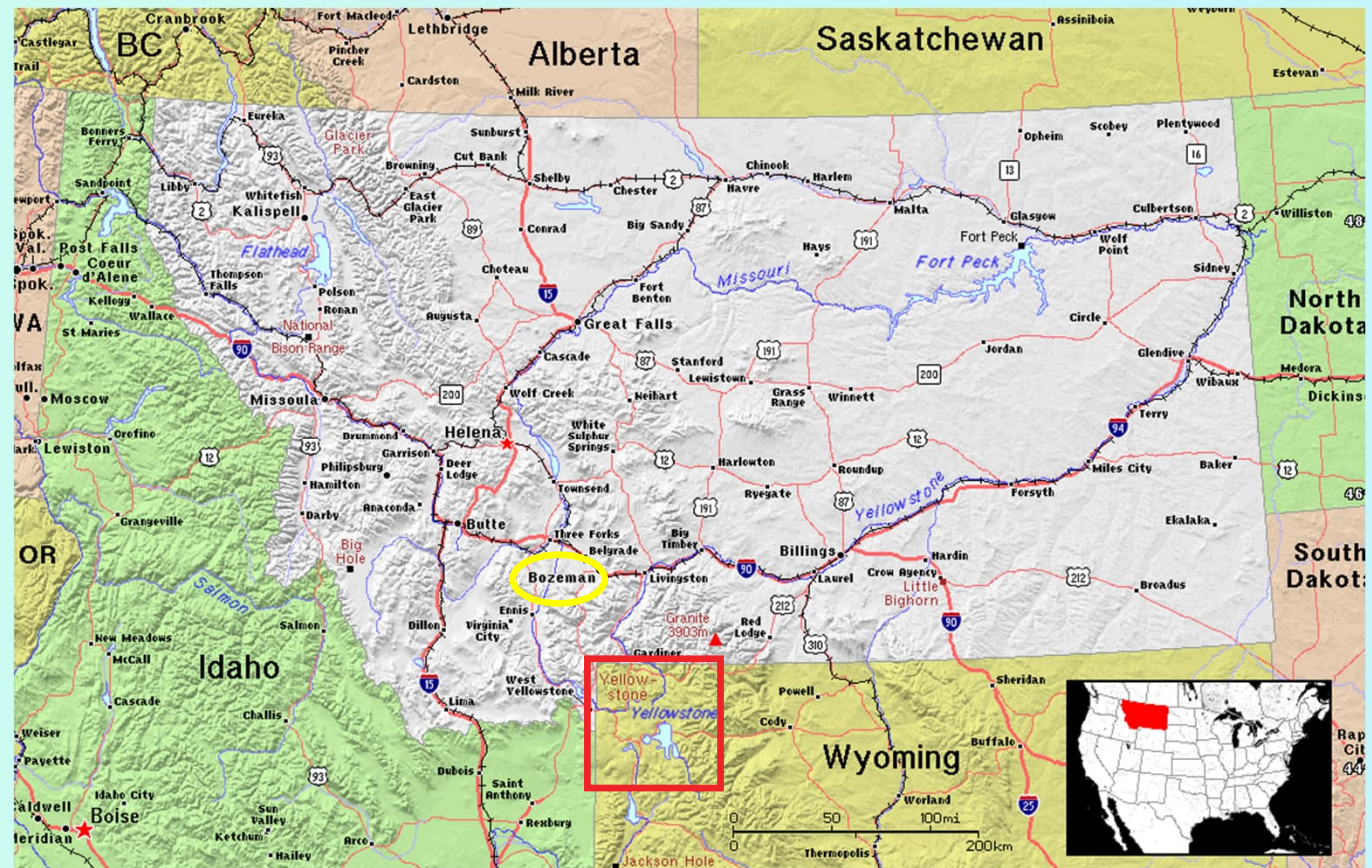
- Grand Loop Rd – June to November
- Beartooth Pass – June to November
- Chief Joseph Pass – April to December

2022 Flooding

- North Entrance (Mammoth to Gardiner) reroute

Bridge Permitting

- Gardiner River High Bridge
- Madison River Bridge

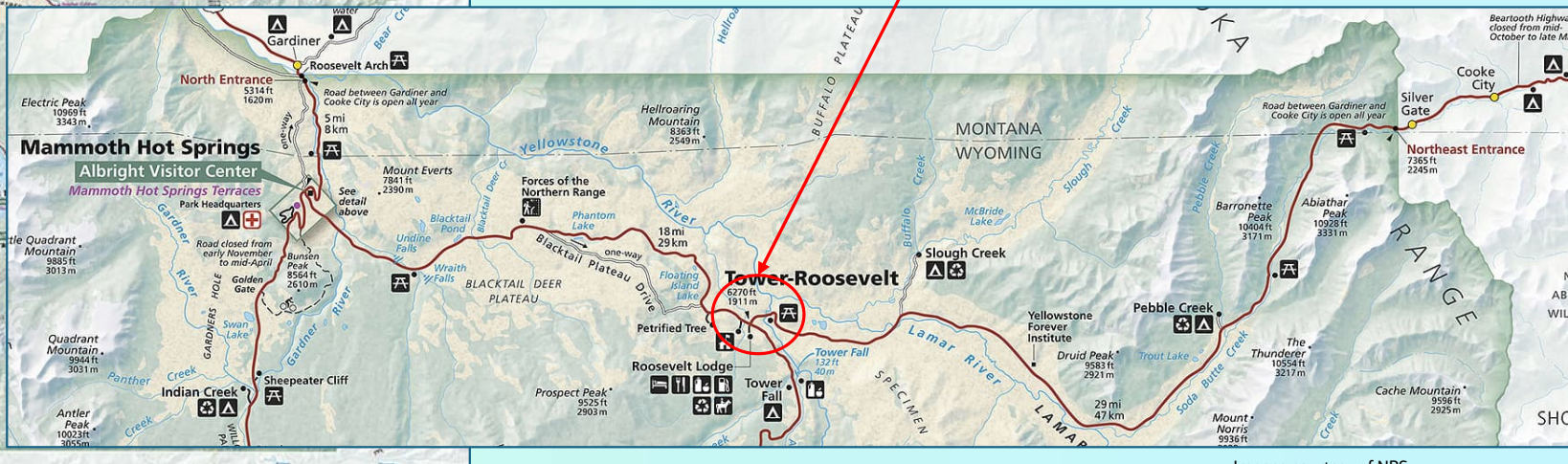


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Northeast Entrance Road/North Loop of the Grand Loop Road

Yellowstone River Bridge



Images courtesy of NPS

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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

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Preliminary Geotechnical Investigation

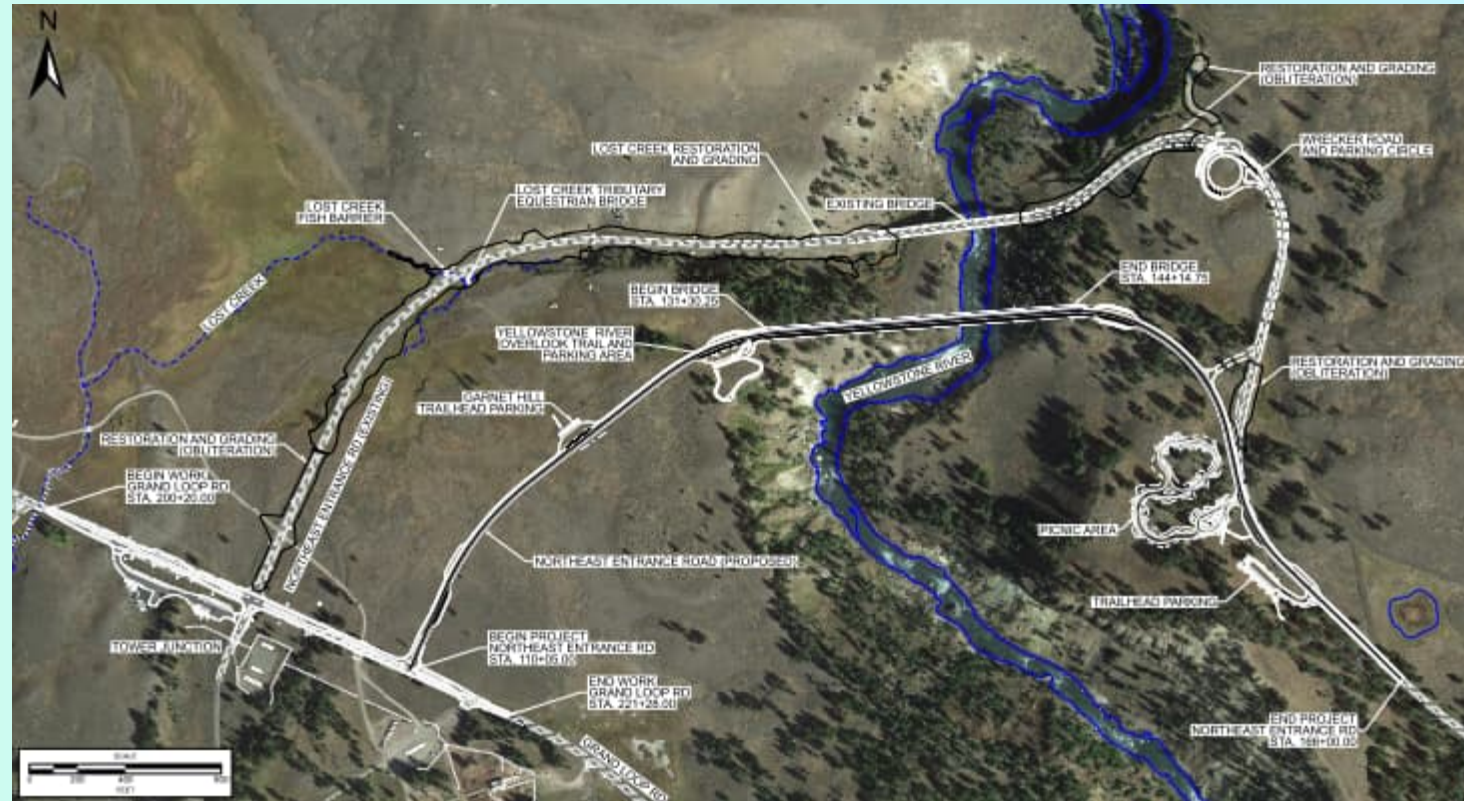
- Hot ground/hydrothermal features
- Acidic ground conditions with high sulfides

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

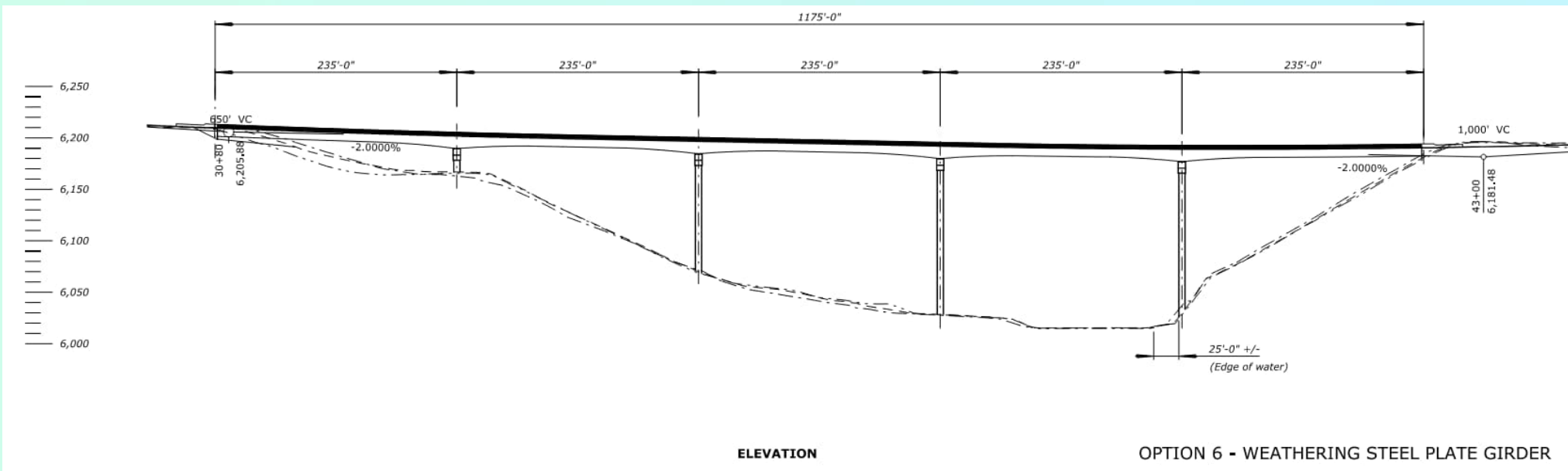


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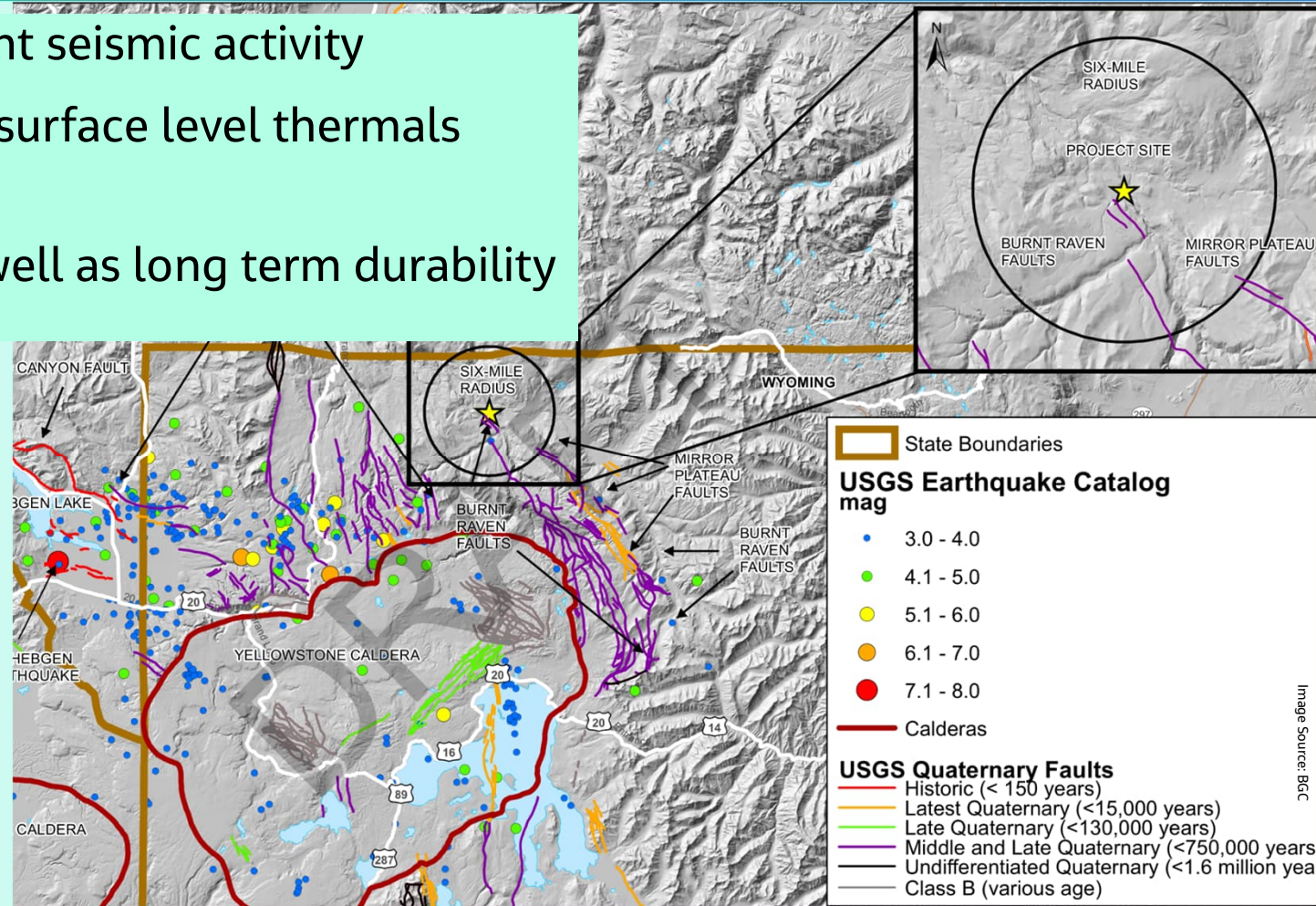
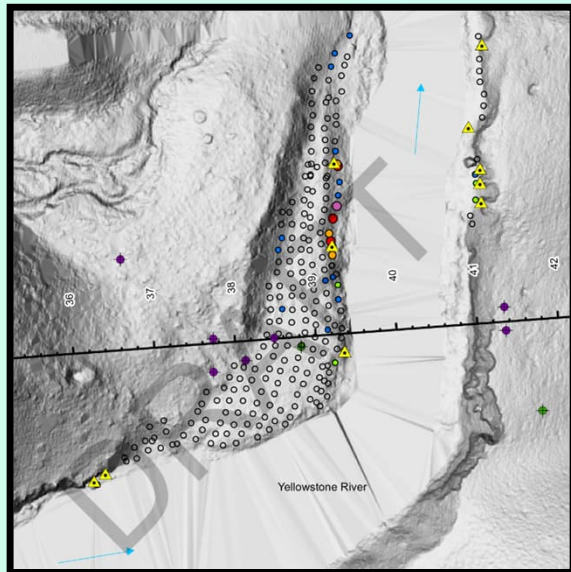
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15% Structural Concept



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- Yellowstone has significant seismic activity
- Which is also paired with surface level thermals activity
- Safety of the workers as well as long term durability need to be considered

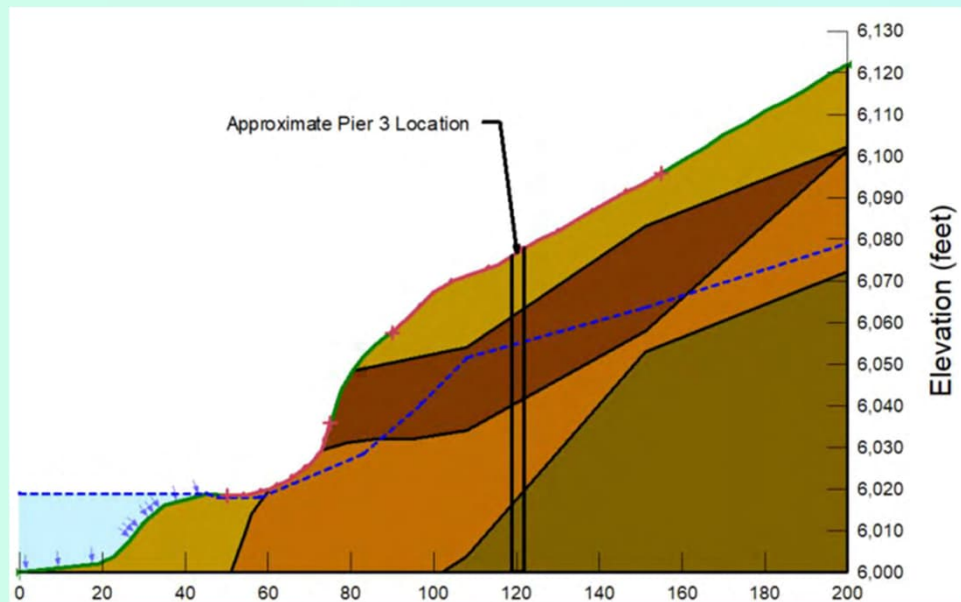


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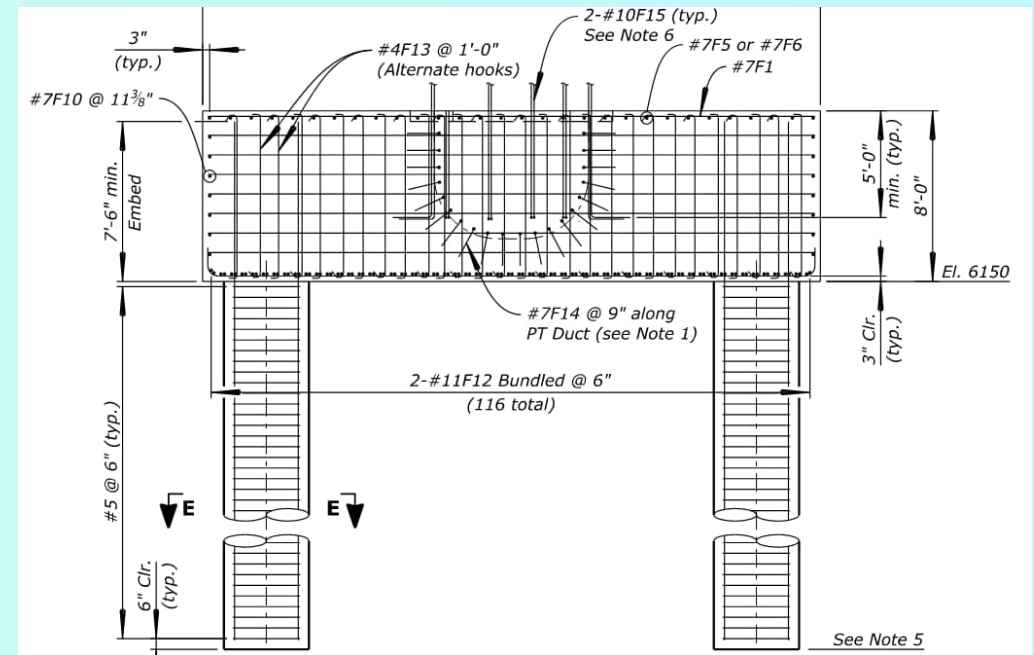
Geologic Profile

Rock relatively close to the surface



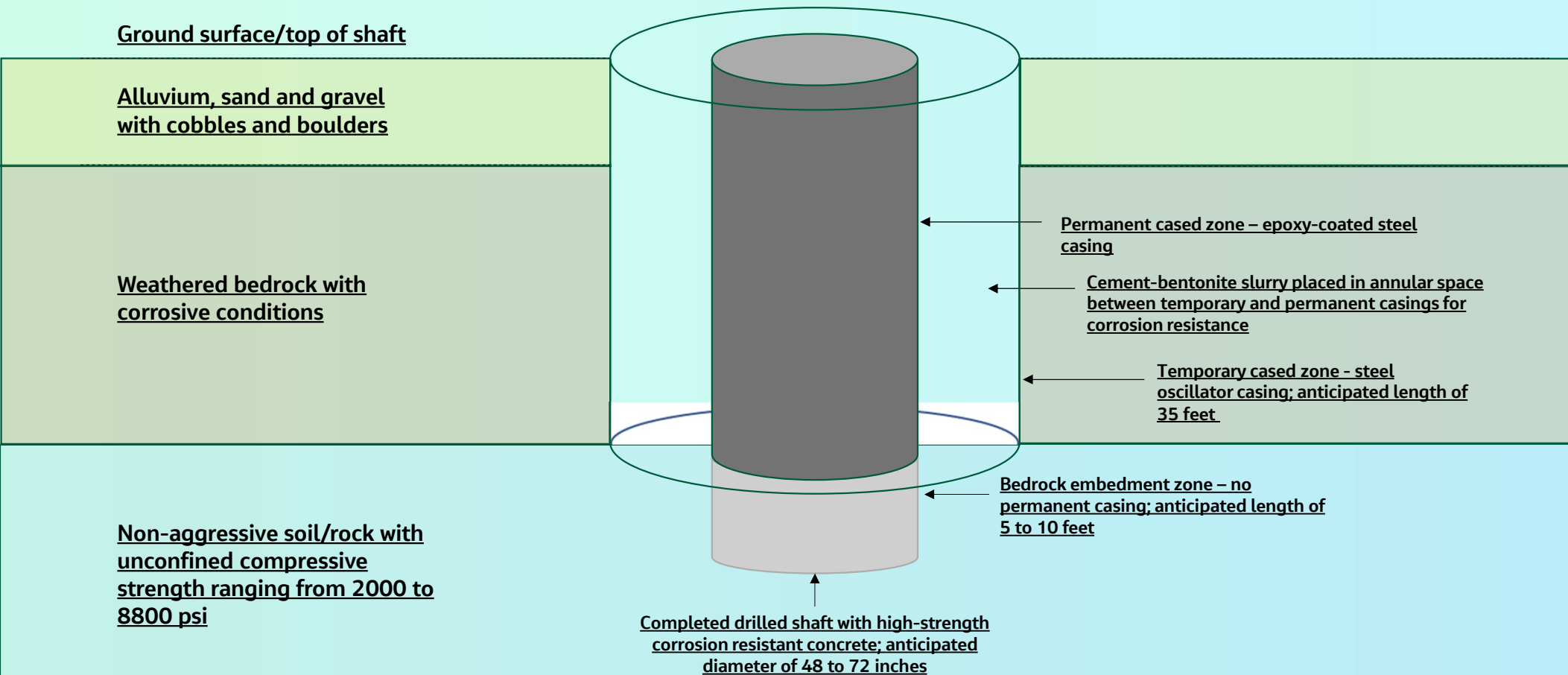
Chosen Solution

More access prep & footing on drilled shafts



Images Source: BGC (Left), Andrew Wahr (Right)

Drilled Shaft Corrosion Protection Scheme



11

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- Why not just “normal” columns?
- This is not the traditional application of precast
- But this is not a traditional bridge (or location!)

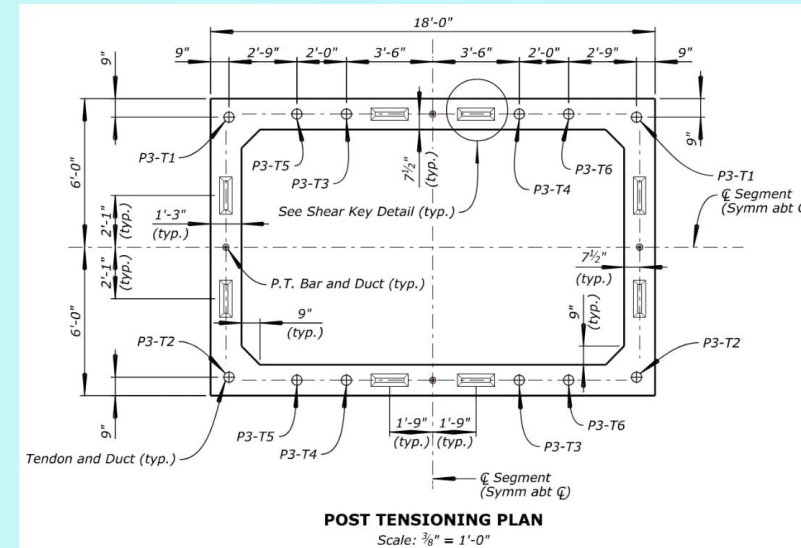


Image Source: Andrew Wahr

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- The usual contract delivery mechanism is unusual
- They will have to be driven a long distance
- But maybe there are some advantages to the situation?

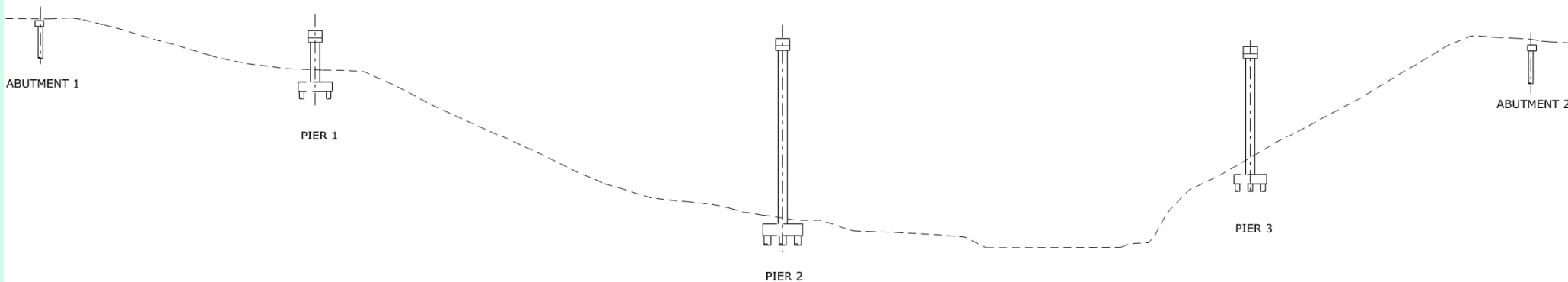


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- Should the size scale to the pier?
- It needs to fit on a truck
- Cost is a factor, but speed is less important (than normal)
- This is a National Park, so aesthetics play more of a role

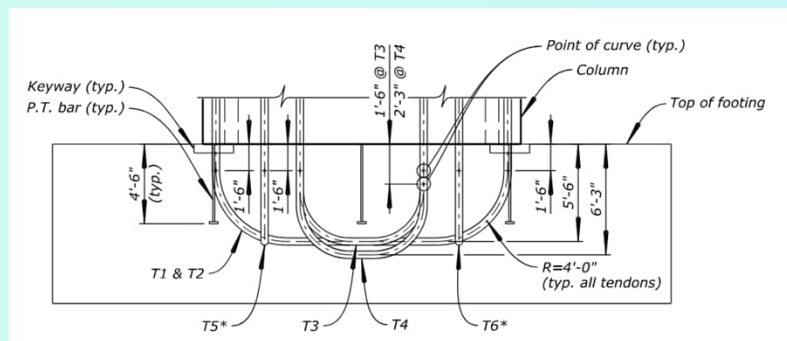


Image Source: Andrew Wahr



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- Construction means and methods, and to some extent: sequencing, is left up to the contractor as much as is possible.
- The scale is small enough that reuse of material is less critical, and special equipment less likely to be used or built.
- Modeling must account for ordering and deformations appropriately as well as allow for stability during construction.
- Allow for fit-up & adjustments in field



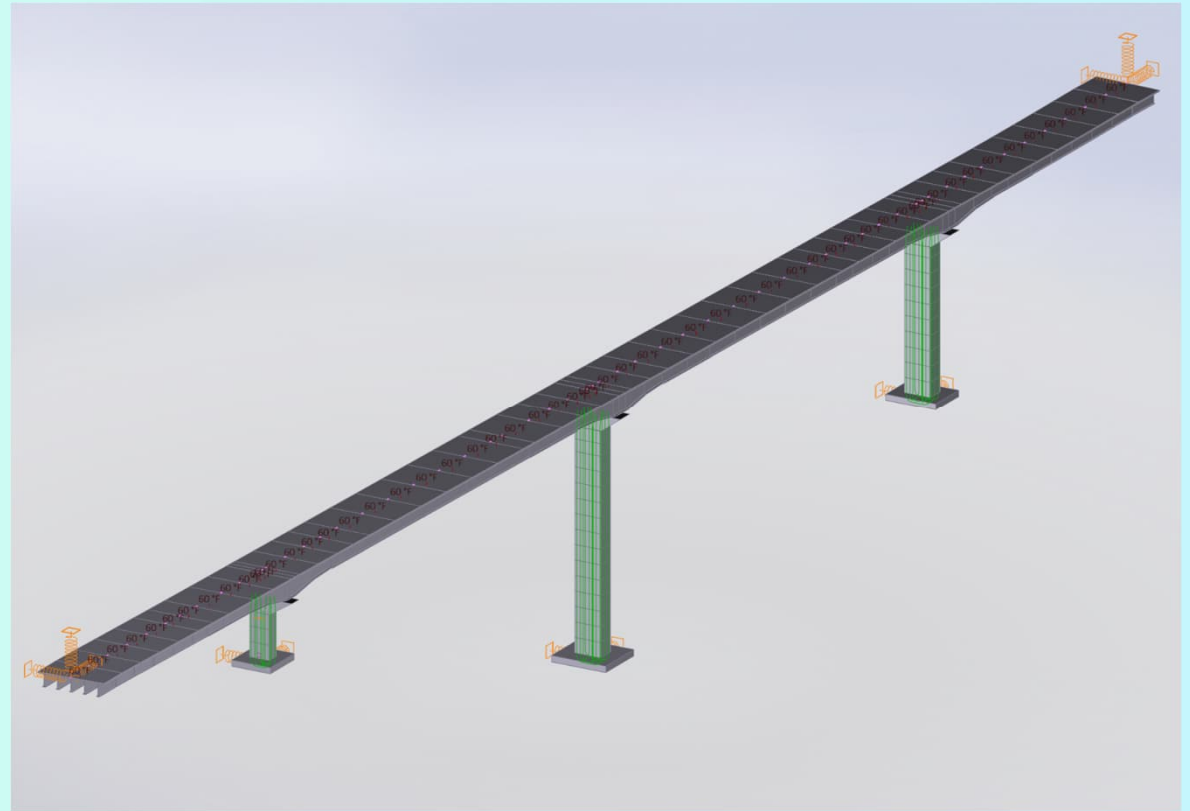
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- A precast pier cap would be even faster
- But it's also heavy and large
- A precast "topper" (SIP form) can ease the process, but a CIP is simpler and allows for final adjustments
- Post-tensioning from the cap rather than top of column simplifies details and creates a continuous, structural unit.



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- Determining the short and long term behavior was done with a finite element model using LARSA 4D
- The “stick” model and the time-dependent behavior were wrapped into a single model for simplicity
- Construction staging, including variable concrete modulus and age were considered
- Foundations were modeled using springs from geotechnical analysis



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- It was still desirable to tune the different piers
- Isolation bearings for elastic design?
- Isolation bearings for elastic design!



Image Source: Andrew Wahr

SEISMIC ISOLATION BEARING PROPERTIES

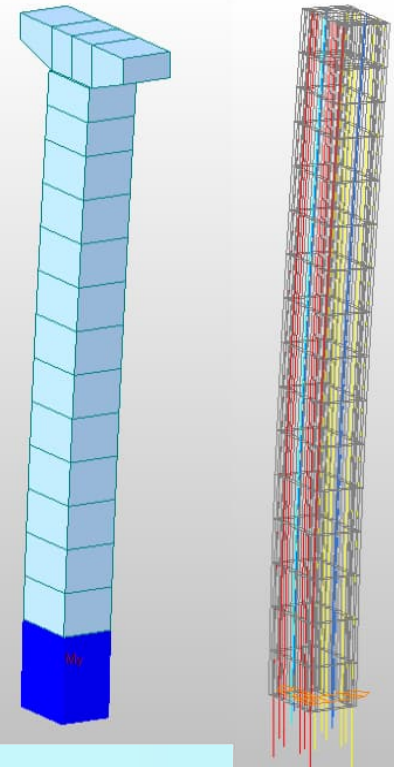
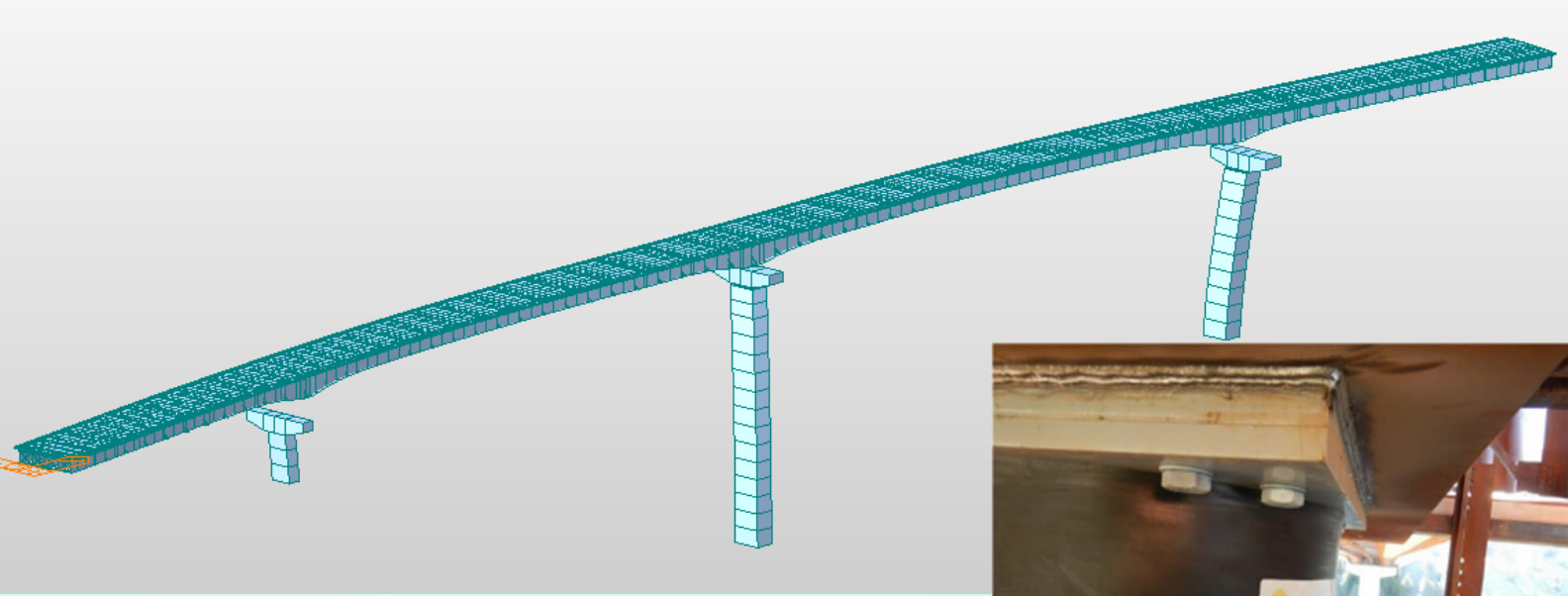
LOCATION	Characteristic Strength	Post-Elastic Stiffness	Initial Stiffness
	Q_d kips	K_d kip/in	K_i kip/in
Abutment 1	40.5	4.7	47
Pier 1	11.7	11.8	118
Pier 2	37.35	8.95	89.5
Pier 3	11.7	11.8	118
Abutment 2	40.5	4.7	47

■ Seismic in Precast Segmental Columns

- Applicability
 - Non-conventional structure types (AASHTO Guide Specification for LRFD Seismic Design)
 - Hollow piers for substructures
- Ductility
 - Type 1 Seismic Design Strategy
 - Design a ductile substructure with essentially elastic superstructure
 - “The ability of a material to have its shape changed without losing strength or breaking.”
 - “Experimental Study of Precast Segmental Columns with Unbonded Tendons under Cyclic Loading” by Li et al.
 - “Segmental columns showed much better ductility compared with monolithic column.”
- Energy Dissipation
 - “The ERS shall provide a reliable and uninterrupted load path for transmitting seismically induced forces into the surrounding soil and sufficient means of energy dissipation and/or restraint to reliable control seismically induced displacements.”

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- 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

■ Seismic Strategy for the Yellowstone River Bridge Columns

- Primary Earthquake Resisting System is seismic isolation
- Secondary Earthquake Resisting System is ductile substructure response
 - 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
 - 0.3% of A_g
 - PT Tendons and Bars
 - Smooth ducts with microcrystalline wax flexible filler designed to distribute strain
 - Increased area to prevent rupture

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Thank You!

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Thanks and Appreciation

- National Park Service
- Yellowstone National Park
- Federal Highway Administration
- Western Federal Lands Highway Division
- Jacobs Engineering
- BGC Engineering
- RESPEC



U.S. Department
of Transportation
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- HK Contractors
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- McNary Bergeron & Johannesen
- Dynamic Isolation Systems
- Contech Engineered Solutions
- Hamilton Form Company

Questions & Answers