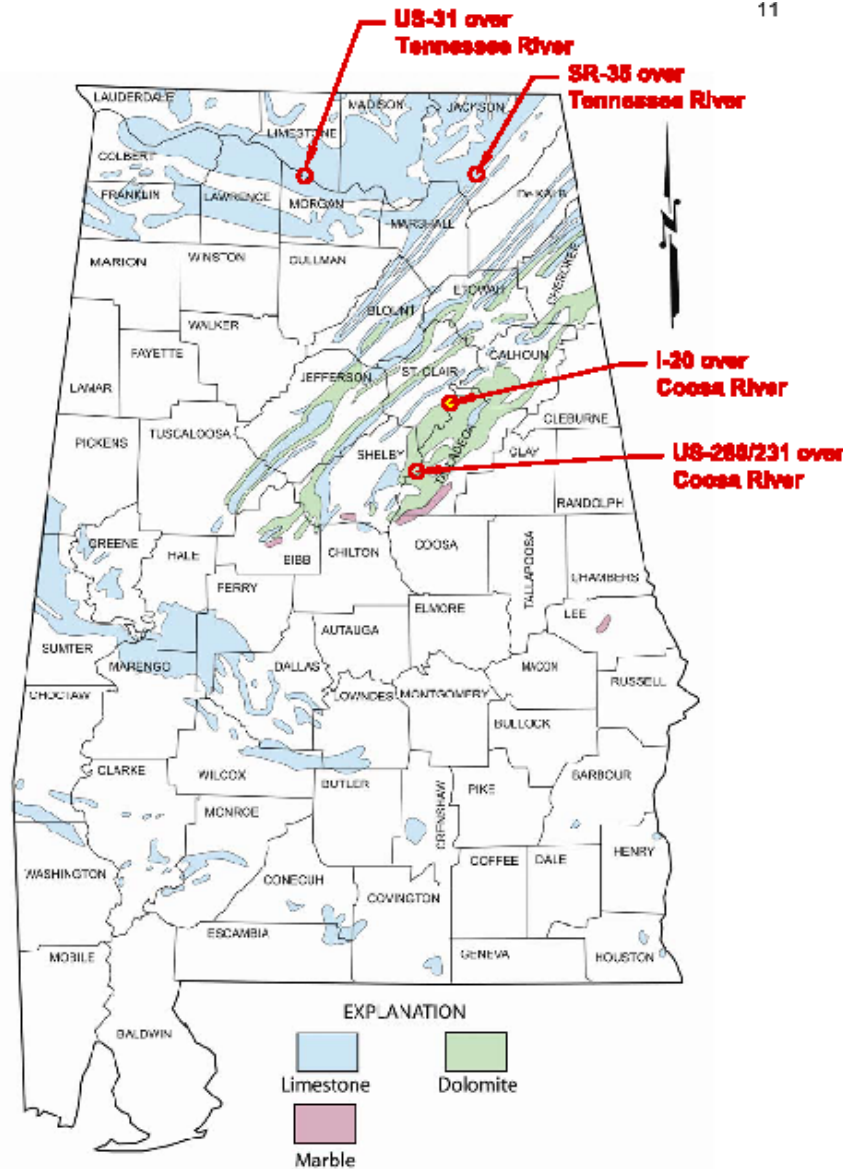


PROPOSED NEW BRIDGES FOR I-20 OVER THE COOSA RIVER

**(A CASE STUDY OF A GEOTECHNICAL EXPLORATION FOR
BRIDGE FOUNDATIONS IN KARST CONDITIONS)**

CARBONATE BEDROCK AREAS IN ALABAMA

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Source:
Dean, Lewis S., (2007).
Minerals in the Economy of Alabama (Geologic Investigations Programs, Information Series 64R).
Tuscaloosa, AL: Geological Survey of Alabama.

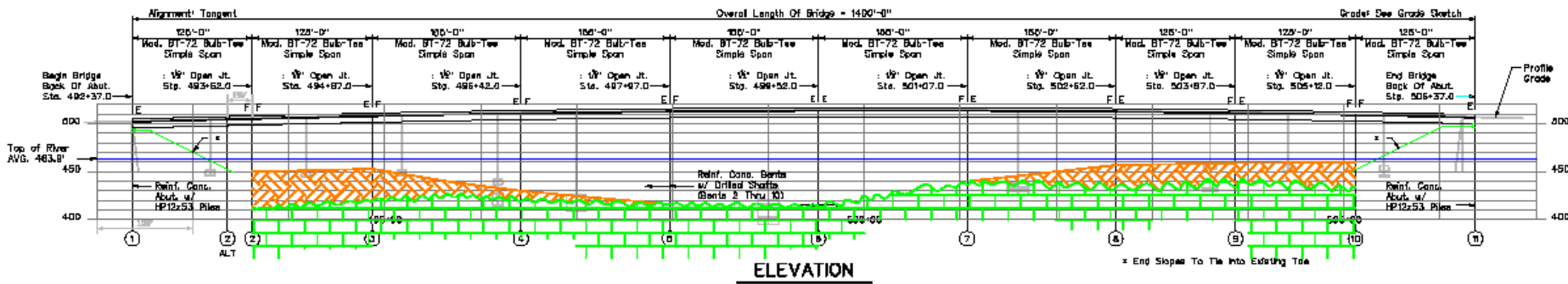
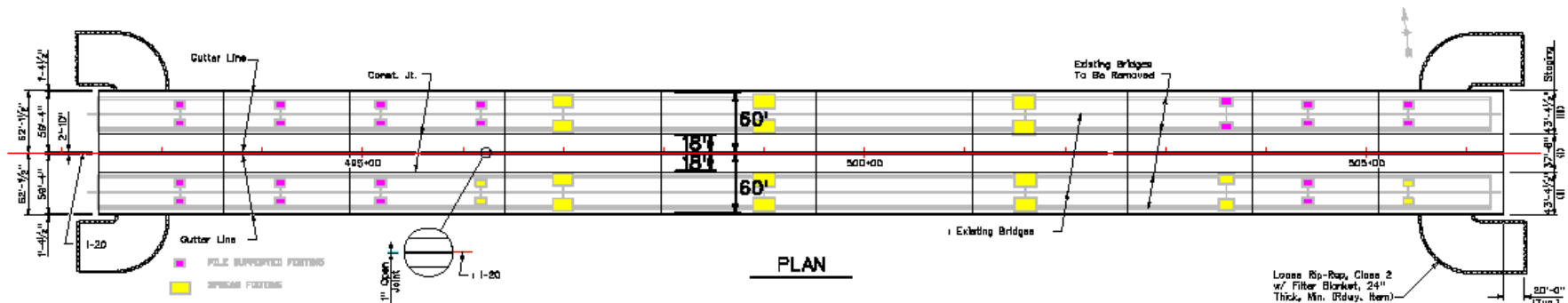


ORIGINAL BRIDGE FOUNDATIONS

1. Built before Lake Logan Martin was impounded.
2. Driven pile foundations constructed from dry ground.
3. Footings excavated up to 21 feet into bedrock in the river bed itself. Probably used sheet pile and/or embankment cofferdam.
4. There were several borings, but no rock recovery/RQD data from the rock core.

NEW BRIDGE PLAN (PRELIMINARY)

1. 1400 feet long (13'-6" longer than the existing bridge).
2. 10 spans varying from 125 to 155 feet long.
3. New bent locations have been chosen to miss existing pile caps/footings.
4. 2 supports per bent, per bridge. 700 tons per support.
5. 5 ft. to 6 ft. diameter supports at 70ksf allowable end bearing.
6. Designed using allowable stress design methods.
7. The final support arrangement may change based on the construction sequence.



POSSIBLE FOUNDATION OPTIONS

1. Spread Foundations on Rock

Advantage: Less continuous rock required due to lower bearing pressure.

Disadvantage: Rock excavation required at depth under water.

2. Piles Bearing on Rock

Advantage: Spreads load and is adaptable to poor rock conditions.

Disadvantage:

- Cofferdam, seal slab, and pile footing required.
- Must have protection from scour for the pile tips, e.g., either sufficient soil/rock penetration or set in a hole predrilled into rock.

POSSIBLE FOUNDATION OPTIONS (CON'T)

3. Drilled Shafts

Advantage:

- High single shaft bearing pressures on hard, continuous rock.
- No cofferdam required other than temporary casing.

Disadvantage: Requires continuous, high quality rock at the specific shaft footprint.

4. Combination of the above and/or specialized technique.

EXPLORATORY PLAN

FHWA Guidance for Foundations on Rock

Drilled Shafts – Borings 3D below shaft tips.

Driven Pile – Borings min. 10 feet below tip elevations.

Footings – Borings min. 10 feet below bearing elevation.

Individual Heavily Loaded Foundations

- One boring per foundation if bearing conditions may be erratic.

Set Core Recovery and RQD Guidelines

- Determine Rock Classification Requirements based on RMR for each foundation type; i.e., very good rock, good rock, fair rock, poor rock or very poor rock.
- Determine Rock Mass Rating (RMR) Requirements.
 - Unconfined core strength, q
 - Intact modulus, E_i
 - RQD (Assumes, for the most part, 100% recovery.
 - Joint condition
 - Water condition in the joints.

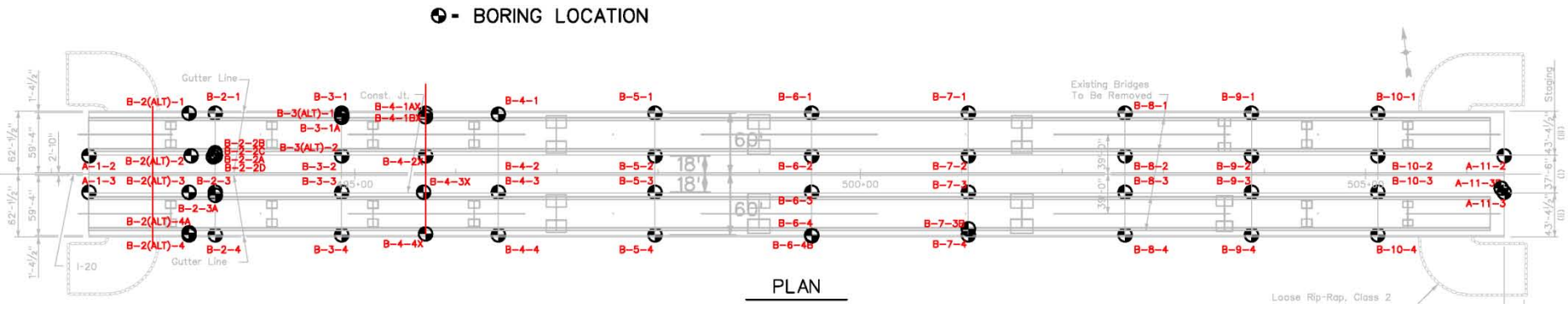
EXPLORATORY PLAN (CON'T)

- Settlement Criteria
 - Assumed to be one inch
- Drilling Criteria Developed for the I-20 Bridges was:
 - One boring per foundation
 - Drill a minimum of 5D (30 feet)
 - Must have 10 feet of min. 96% recovery and RQD 50% rock core for “fair rock”. If not, extend boring. (ALDOT requires min. 1D socket).

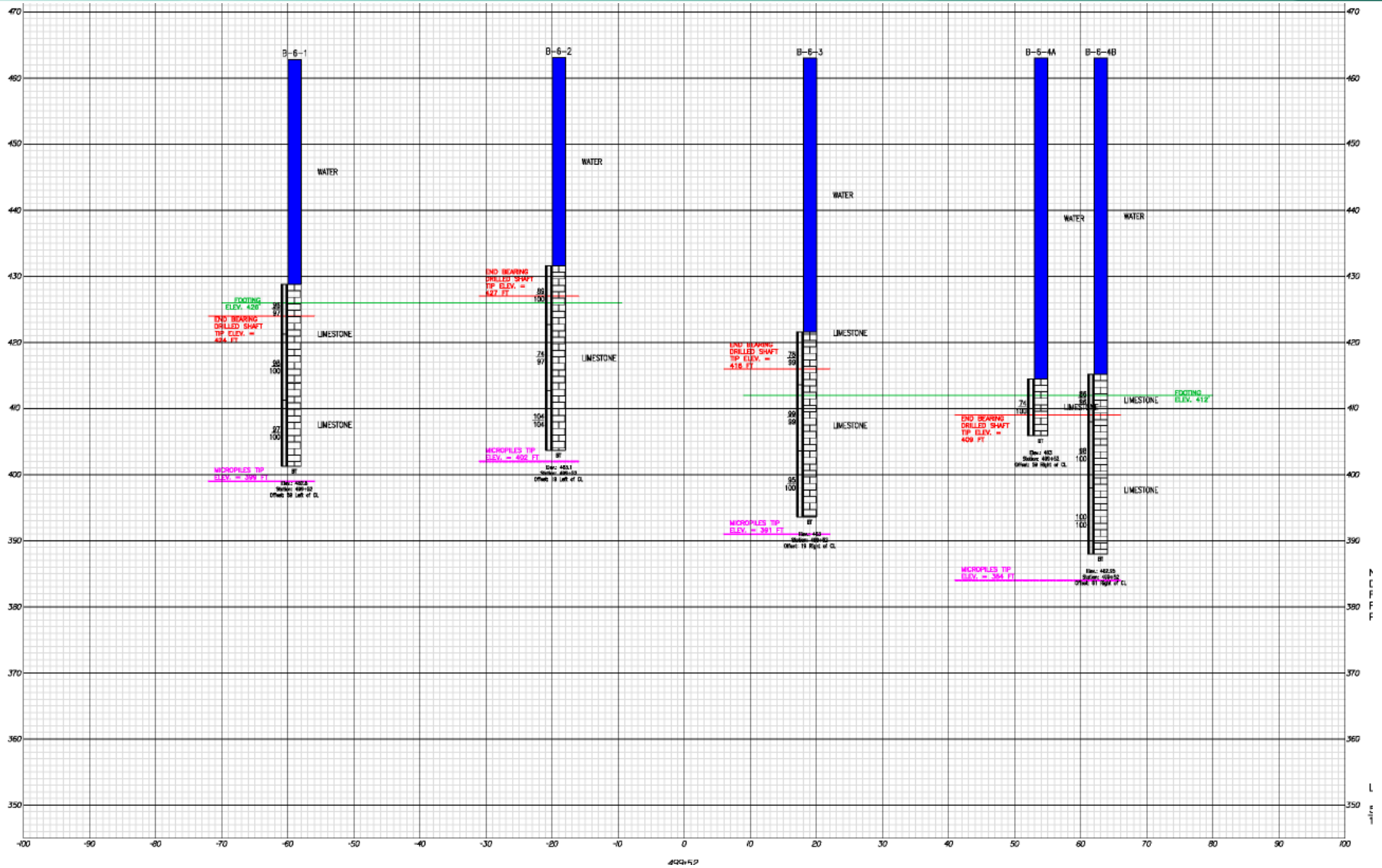
Lab Testing

- Unconfined strength and intact modulus test on rock core.

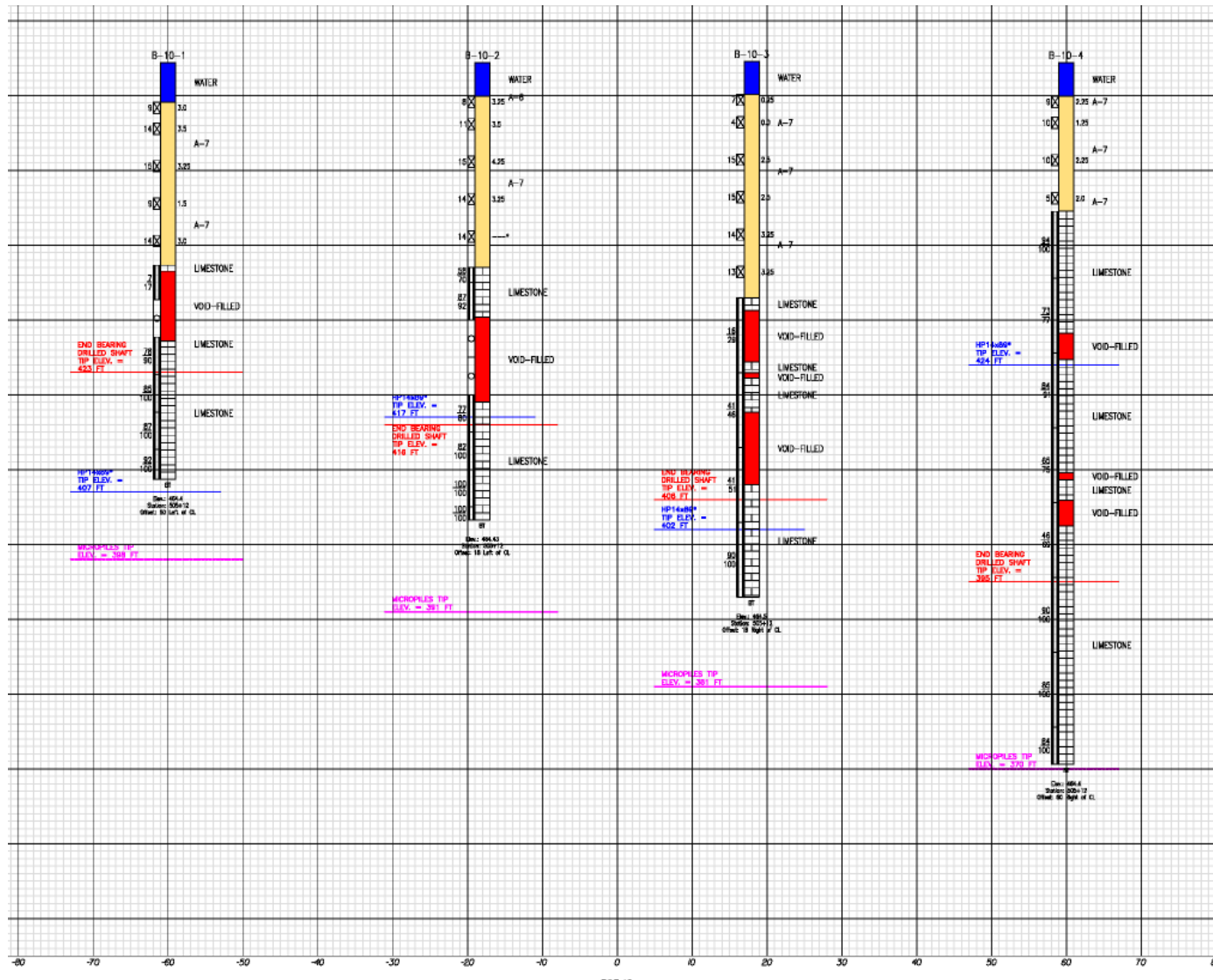
BORING LOCATION PLAN



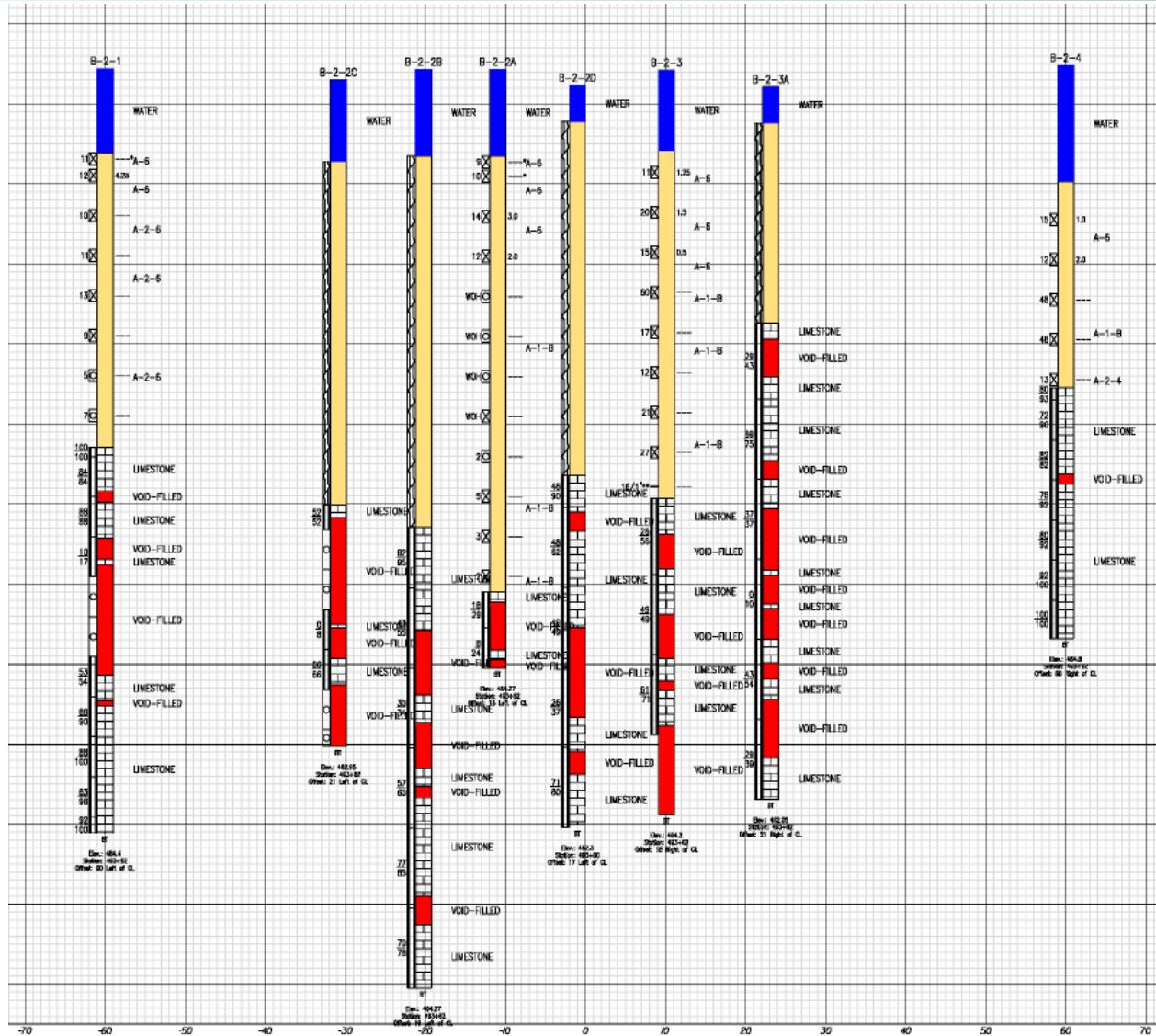
DRILLING RESULTS – GOOD (Bent 6)



DRILLING RESULTS – NOT-SO-GOOD (Bent 10)



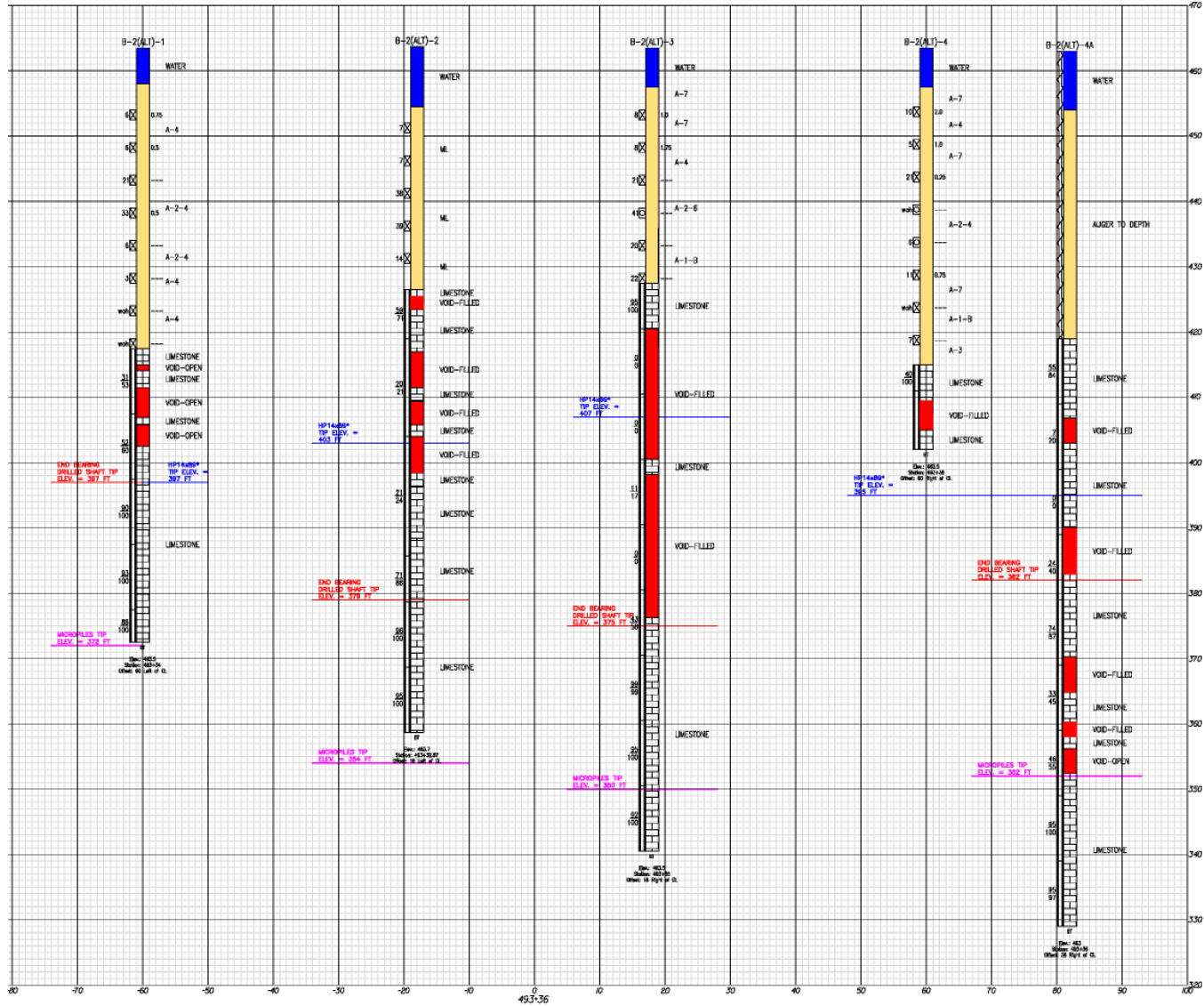
DRILLING RESULTS – UGLY (Bent 2)



MODIFIED DRILLING PLAN

- Contacted Bridge Bureau to investigate ways to avoid the Bent 2 Location.
- Shortened the first span on the west end from 125 to 95 feet.
- Lengthened the second span from 125 to 155 feet.
- Remobilized and drilled Bent 2 (Alternate) Location.
- Conditions are somewhat better.

BENT 2-ALT



RECOMMENDATIONS

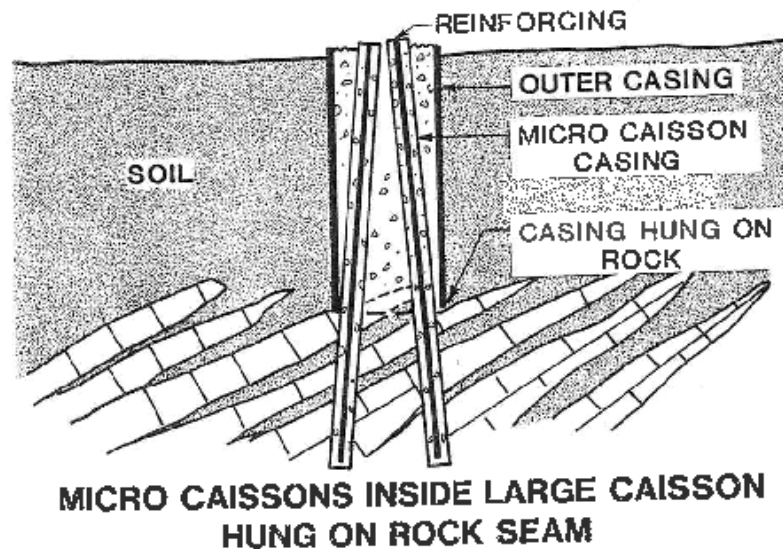
DRILLED SHAFTS – END BEARING

- Drilled shafts are useable at all river bents except Bents 2A and 3 and are preferable at Bents 4 through 7 in the old river channel.
- The recommended installation procedure is to :
 - Excavate minimum one diameter into bedrock
 - Drill 2 core borings to a min. of 4D feet below the casing.
 - Once a section of rock a min. of 10 feet long with 96% recovery and 50% RQD is identified, the drill shaft should be completed to the top of that section.

DRILLED SHAFTS IN DISCONTINUOUS ROCK

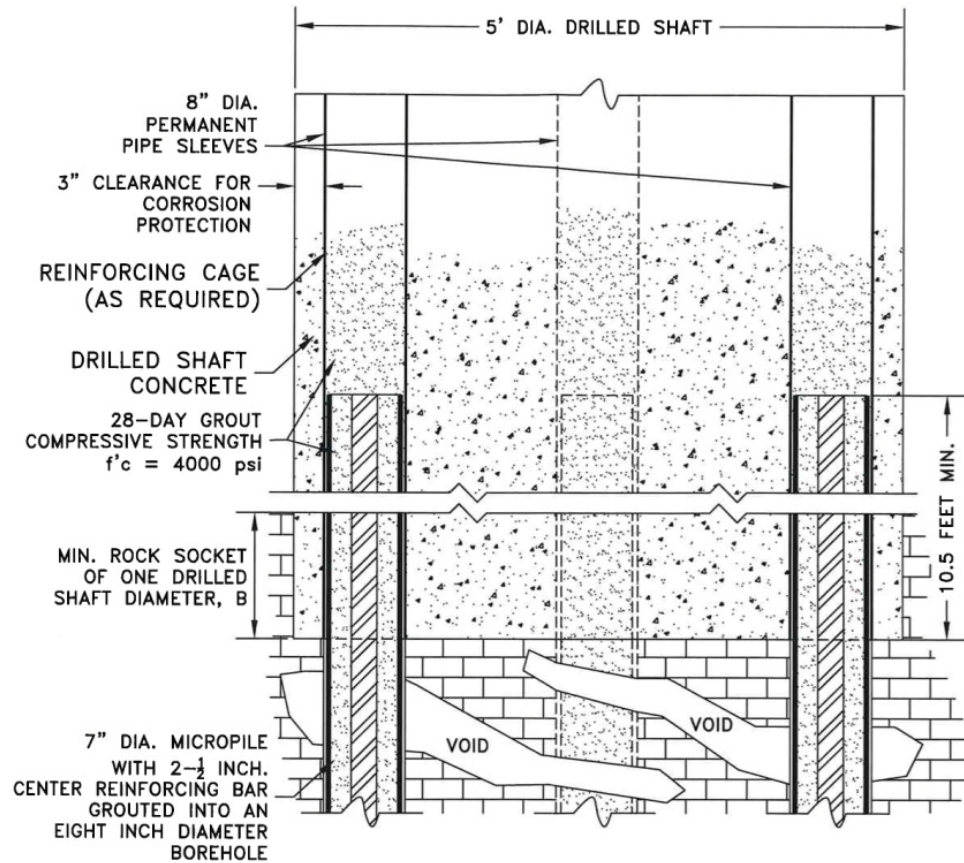
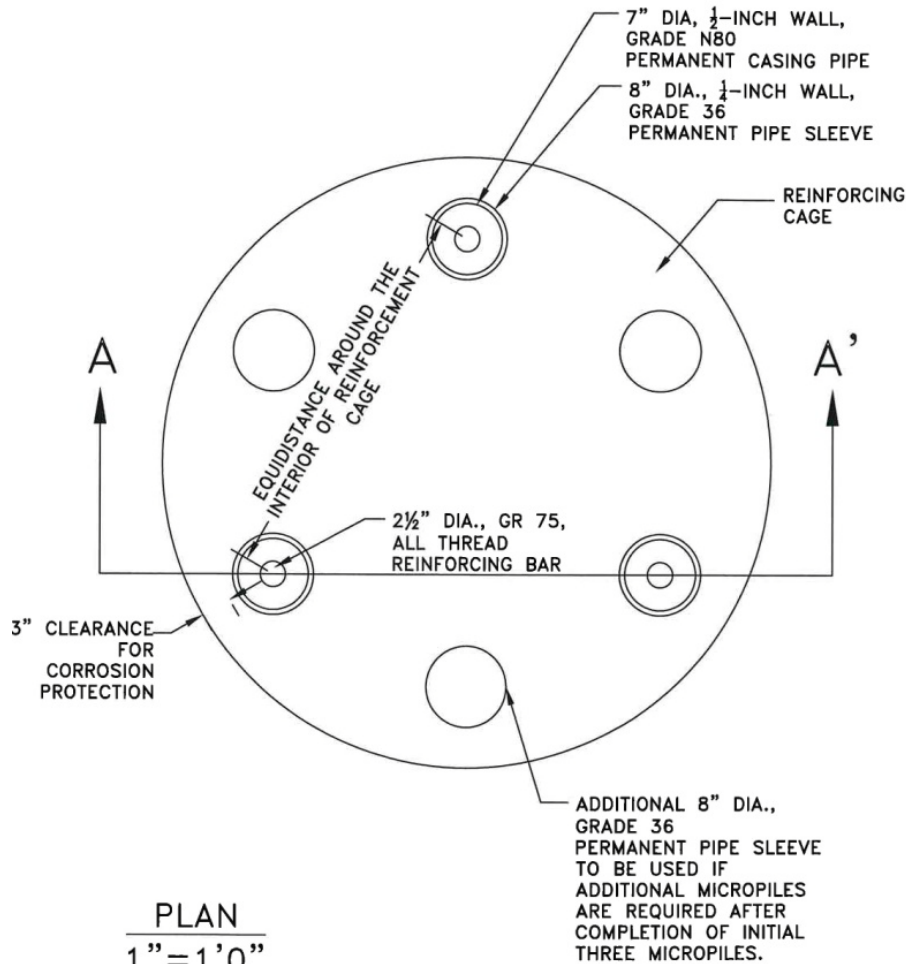
1. Supplemented by Micropiles

- Suggested by Sowers (1996).
- Specialty contractors have some recent experience in this application.



Sowers, 1996

DRILLED SHAFTS IN DISCONTINUOUS ROCK



SECTION A-A'
SCALE: NTS

DRILLED SHAFTS IN DISCONTINUOUS ROCK (CON'T)

INSTALLATION PROCEDURE FOR MICROPILE

- Set casing and drill a minimum of one shaft diameter into bedrock.
- Drill minimum one core boring to establish approximate tip depth.
- Set reinforcing cage with guide sleeves attached and place drilled shaft concrete.
- Drill micropile boring into a suitable bond zone and then lift micropile casing to the top of the zone.

DRILLED SHAFTS IN DISCONTINUOUS ROCK (CON'T)

INSTALLATION PROCEDURE FOR MICROPILE (CON'T)

- The recommended bond length for the 250 ton micropile is 25 feet of rock with no discontinuity over 5 feet and with no significant discontinuities in the bottom 10 feet.
- Grout with fill grout if significant voids are encountered in the bond zone.
- Redrill micropile borings to the required depth and construct the micropile.

DRILLED SHAFTS IN DISCONTINUOUS ROCK (CON'T)

ADVANTAGES:

- Saves extensive rock excavation, telescoping of drilled shaft casing (most likely permanent), etc.
- Micropiles in production shafts can be proof loaded in uplift to confirm capacity.

DISADVANTAGES:

- Introduces another level of complexity to the construction process.
- A prototype shaft with micropile installation would have to be constructed and load tested to confirm design assumptions.

DRILLED SHAFTS IN DISCONTINUOUS ROCK (CON'T)

2. Drilled shafts with side shear plus end bearing or side shear support only.

ADVANTAGES:

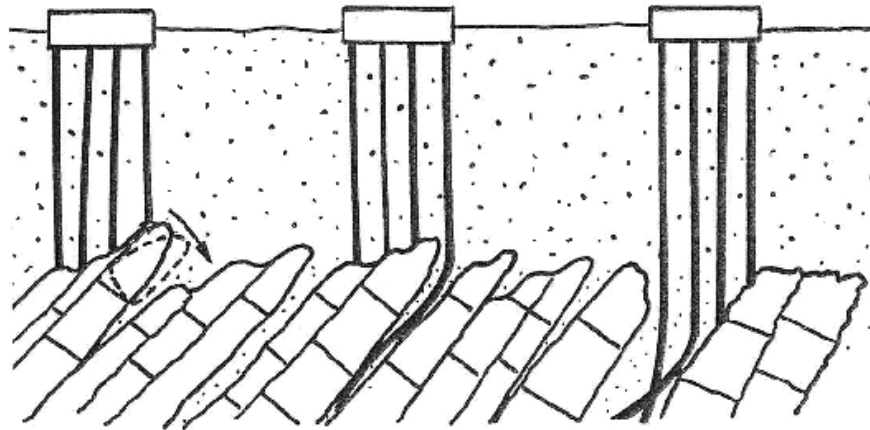
- Uses same equipment as already on site for the conventional end bearing drilled shafts.

DISADVANTAGES:

- Assessing the friction factor between the rock and concrete would require a prototype load test.
- Some method would have to be developed to determine how much rock was present.
- No way of easily proof loading the shafts to verify capacity.

DRIVEN PILES

- The recommended driven pile section at the river bents is a H14x89 with maximum allowable load of 105 tons.
- At Bents 2 and 3 and possibly Bents 9 and 10, the design pile capacity should be reduced by as much as 50% to compensate for piles that will not reach the refusal criteria.



(Sowers, 1996)

DRIVEN PILES (CON'T)

- Installation procedure is anticipated to be:
 - Install the cofferdam sheet piles;
 - Excavate to the bottom of the seal slab;
 - Install the driving template for the piles (Note: Only practical where cofferdam sheet piles can achieve adequate embedment);
 - Drive the piles to refusal criteria;
 - Install seal slab, dewater; and
 - Construct pile footing.

SPREAD FOUNDATIONS

Not considered viable due to the depth of water and soil to the bearing elevation and the difficulty of excavating the highly fractured rock to reach the bearing elevation under 50+ feet of head of water.

FINAL RECOMMENDATIONS

- Driven Pile Supported Abutments
- Driven Pile Support for Bents 2, 3, 9 and 10 using a reduced pile capacity.
- Drilled shaft or driven pile support (whichever is more economical) at Bent 8 where sufficient soil is available for cofferdam construction.
- Drilled shaft support at Bents 4, 5, 6, and 7 in the old river channel where little or no overburden is present.

LESSONS LEARNED

1. Conduct the geotechnical exploration early in the design process so modifications to the planned structure/foundation system can be made, if necessary.
2. Be flexible and evaluate as many options as appear practical.