Presentation
To

Society of Gas Operators

Open Cut of Lackawanna River Using Water Filled Coffer Dams

By:
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Project Background and Conditions

Replacement of the existing bridge across the Lackawanna River on State Route 3013 (S. Main St.) in Old Forge, PA


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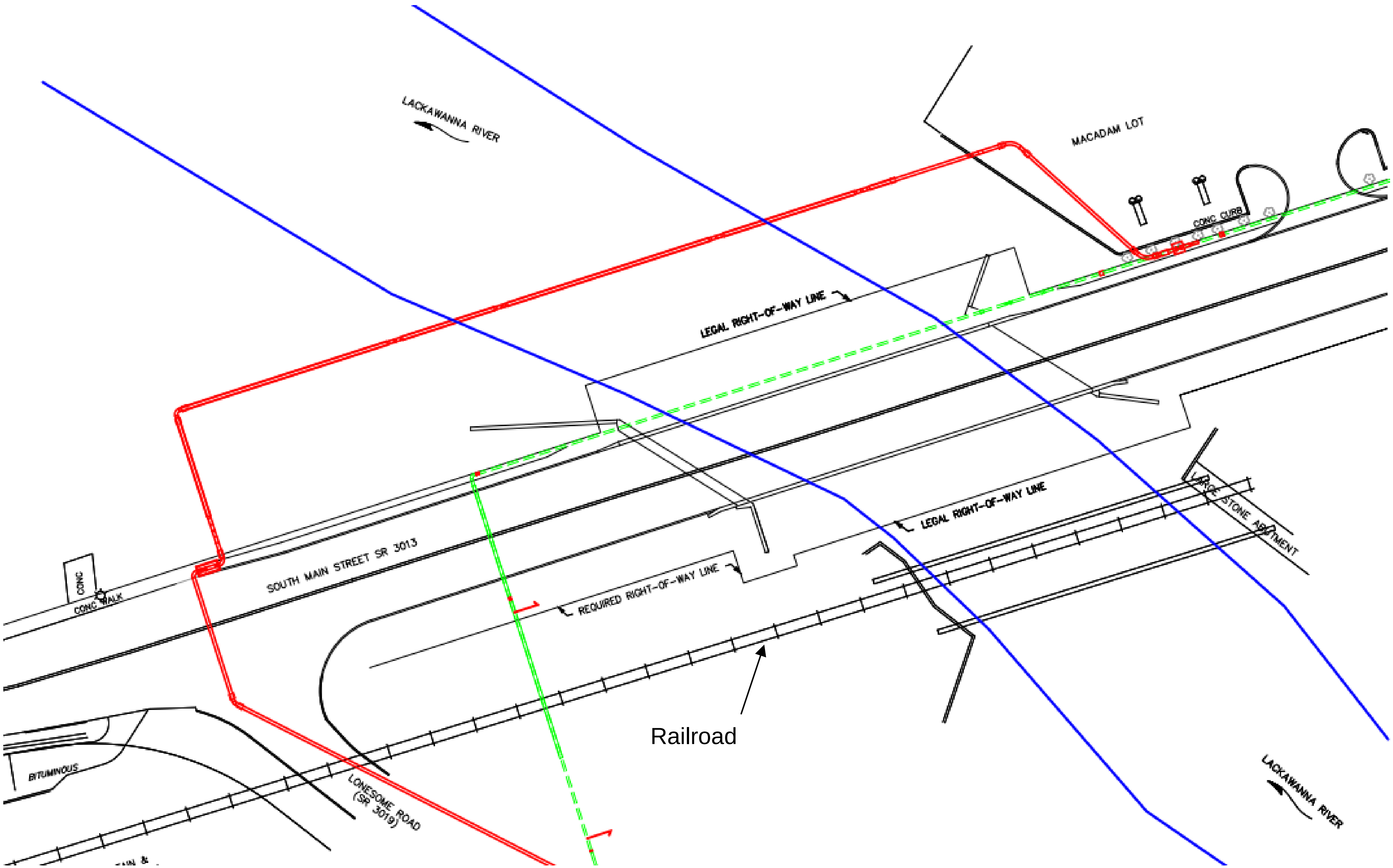

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The project background and contributing factors to the use of open cutting the Lackawanna River for the installation of replacement gas main.

The existing gas main:

Per sources at UGI the gas main was described as follows:

"Main was 12" steel, Schedule 40, Grade B, reclaimed pipe, manufactured in 1915-1920, installed and field coated in 1957. MAOP is 282 psig and operates at 282 psig. This crossing is a portion of the main installed to enable converting Wilkes Barre and Scranton from manufactured to natural gas."

UGI management decision to relocate all pipelines/mains off of bridges as standard policy where possible.

The Bridge:

The original steel truss bridge installed by PennDOT in 1940 to cross the 110 feet wide Lackawanna River with a span of 165 feet and 45 feet wide was the subject of a Time-Tribune article of which select excerpts are shown below.

The Times-Tribune.com

Main Street Bridge in Old Forge to be closed

BY MICHAEL IORFINO (STAFF WRITER)
Published: January 16, 2013

Select Excerpts:

Built in 1940, the bridge was No. 5 on a list of most structurally deficient bridges and overpasses in the Scranton/Wilkes-Barre area that carry at least 5,000 vehicles per day in a November 2010 report prepared by TRIP, a national transportation research group based in Washington, D.C.

On a scale of one to nine - with lower scores indicating a greater level of deficiency - the bridge's substructure received a grade of five, while the bridge's deck and super-structure received a grade of three, according to the report.

January 14, 2013 Channel 16 WNEP news report by Stacy Lange

The deck of the bridge had deteriorated to the point that holes in it gave views of the river below.

The Times-Tribune.com
BY MICHAEL IORFINO (STAFF WRITER)
Published: January 16, 2013

Crumbling deck had rebar exposed to the elements and deteriorating

The River:

The Lackawanna River at bridge crossing location:

- River is acid mine drainage river from local coal mines
- No fish or plant life
- Hard shale river bed
- 110 feet span
- Normal river depth 3.5 feet and velocity 2.4 MPH (3.5 ft/sec)
- 25 year flood level is 9.0 feet and velocity 8.8 MPH (12.9 ft/sec)

The Coal Mining Industry in the area…the BIG PROBLEM

The coal mining that had occurred over the years had a large impact on the necessity for the open cut river crossing for the pipeline.

- Abandoned coal mine tunnels of unknown locations and depths in the area of the river crossing present a danger in using HDD drilling technology. If the HDD drilling were to penetrate into an abandoned coal mine tunnel, it was feared that an incident similar to the Knox Mine disaster that occurred in 1959 would develop:
    - The Knox Mine disaster was a mining accident on January 22, 1959, that is widely credited with single-handedly killing the mining industry in the Northern Anthracite Region of Pennsylvania. The Susquehanna River broke through into the many interconnected mine galleries in the Wyoming Valley.
    - The River Slope Mine, an anthracite coal mine owned by the Knox Coal Company, flooded when coal company management had the miners dig illegally out under the Susquehanna River. Tunneling sharply upwards toward the river bed without having drilled boreholes to gauge the rock thickness overhead, the miners came to a section with a “roof” thickness of about 6 feet (1.8 m) and 35 feet (10.6 m) was considered the minimum thickness for safety. The insufficient "roof" thickness caused the waters of the river to break into the mine tunnel.
    - It took three days to plug the hole in the riverbed, which was done by dumping large railroad cars, smaller mine cars, culm, and other debris into the whirlpool formed by the water draining into the mine.

The Coal Mining Industry in the area…the BIG PROBLEM (cont.)

- The presence of culm piles next to the river bank gave radical elevation changes on the east side of the river which would require longer HDD bores to maintain the angle of attack with further complications due to the presence of a 24 inch diameter forced sanitary sewer main being present in the river near the east river bank at a depth of 12.5 feet below the river bed.

Other complicating factors that drove the construction technique to open cut:

- Needed easement(s) from property owners on both sides of crossings. One was a car wash on the east river bank, which imposed numerous conditions and restrictions on construction activities.

- The 24 inch dia. forced sanitary sewer embedded 12.5 feet into the river bed on the river's east side further complicated any proposed HDD drilling of the proposed replacement main beyond the complications of the unknown locations of coal mine tunnels in the area of the crossing.

Manhole for 24” dia. forced sanitary sewer running with the river at a depth of 12.5 feet into the river bed

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In summary and order of importance the reasons for choosing the open cut method for the river crossing:

- The fact of known coal mines in the area and lack of information regarding their location and depths coupled with the concern of a Knox Mine type incident was the largest factor.
- The 24 inch dia. forced sanitary sewer main embedded 12.5 feet into the river bed on the east side of the river.
- UGI's preferred policy for removing pipelines from bridge structures.
- River being an acid mine drainage river with no plant or fish life with hard shale river bottom which lends itself to an open cut type crossing.
- The elevation change of 30 feet from the one side of the crossing to the other side of the crossing would require a relativity long HDD boring length in hard shale and culm piles that would have complicated an HDD drill.
- Complicating factors created by demands of landowners for the granting of easements.

The Engineering and Design

The damming of the river in sections to allow open cut construction technique for pipeline installation:

- The river has a depth range of 3.5 feet to 9 feet depending on seasonal and storm conditions, although typical range of depth was 2.5 feet to 4.0 feet, excluding major storm events.

- The velocity of the river ranges from 2.4 MPH (3.5 ft/sec) @ 3.5 feet depth up to 8.8 MPH (12.9 ft/sec) @ 9 feet depth
  - When portions of the river are dammed off for the open cut construction technique the discharge of the river will increase the river's depth and velocity in the remaining flowing section and will increase the demands placed on the damming system.

- The water filled cofferdams chosen for the project were determined to be capable of with standing a river velocity of 7.6 ft/sec at a maximum water depth of 6 feet. Based on the seasonal river depth records there were years where the river never exceeded 4 feet in depth for the entire year. Usually when a significant storm event occurred (many times associated with the remnants of a hurricane) the river's depth would exceed 4 feet.
  - The capacities of the water filled cofferdams were based on calculations to determine whether or not the dam could slide on the hard shale river bottom or overturn based on the combination of buoyancy and river forces acting on the coffer dams.

The damming of the river in sections to allow open cut construction technique for pipeline installation:

- Alternative stackable concrete barriers and cabling were incorporated into the design as secondary barriers to take the brunt of the river's velocity and/or to counteract the loss of buoyancy if river depth exceeded 6 feet. If conditions during construction were such that the 6 feet water depth and 7.6 ft/sec capacity of the water filled cofferdams were to be exceeded, the secondary barriers were an alternative option. The construction contractor also had the option to suspend construction and remove the coffer dams if weather conditions would lead to the capacity of the cofferdams being exceeded.

- The contractor was responsible for determining the size of the dammed area relative to anticipated weather conditions and corresponding river depth to stay within the water filled coffer dams' capacity during construction.

- Additionally, it was the contractor's decision whether or not they chose to utilize the secondary barrier system during the construction period.

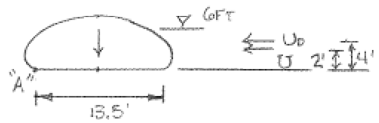
- Contractor was responsible for safety plans, weather condition monitoring and evacuation/emergency plans for the construction project.

- During the entire 120 day construction period no major storms occurred and normal rain events had no negative effects on construction.

OVERTURNING

OVERTURNING SHOULD NOT REALLY BE AN ISSUE SINCE THE SYSTEM WOULD LIKELY DEFORM SHAPE OR ROLL. HOWEVER, TO BE CONSERVATIVE, MODEL AS A RIGID WALL SYSTEM.

USE 6 FT RIVER HEIGHT TO CHECK



$$FS_{OT} = \frac{\Sigma M_{(RESIST)}}{\Sigma M_{(DRIVE)}} \geq 2.0$$

$\Sigma M_{\text{"A"}} = 0$:

RESISTING $\quad \Sigma M_{(R)} = W(13.5/2) = 7446.8\,(6.75) = 50{,}265.9 \ \frac{lb\text{-}ft}{ft}$

DRIVING $\quad \Sigma M_{(D)} = U_D(4) + U(2) = 167.9(4) + 1123.2(2) = 2918 \ \frac{lb\text{-}ft}{ft}$

$$FS_{OT} = \frac{50{,}265.9}{2918} = 17.2 \gg 2 \quad ✓ \text{ O.K.}$$

BY INSPECTION, BEARING ON SANDSTONE MAKES BEARING CAPACITY AND GLOBAL SLOPE STABILITY UNNESSESARY TO EVALUATE. THE FS WILL BE MUCH GREATER THAN REQUIRED

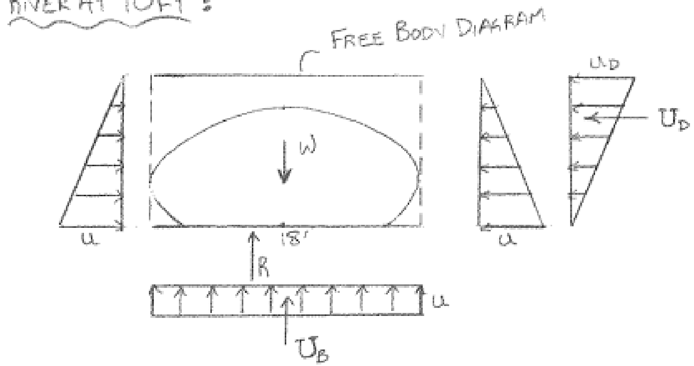
$FS_{BC} \geq 3$

$FS_{GS} \geq 1.3$

Calculations showed that at 6 feet river depth would have the water cofferdams remain stable and not overturn.

CHECK IF SUBMERGED

RIVER AT 10FT:



$u = 624$ PSF

$u_D = 161.2$ PSF

$W = 10(18)62.4 = 11{,}232$ lb/FT

$U_B = 624(18) = 11{,}232$ lb/FT

$\Sigma F_y = 0 : \uparrow$

$R = W - U_B = 0$

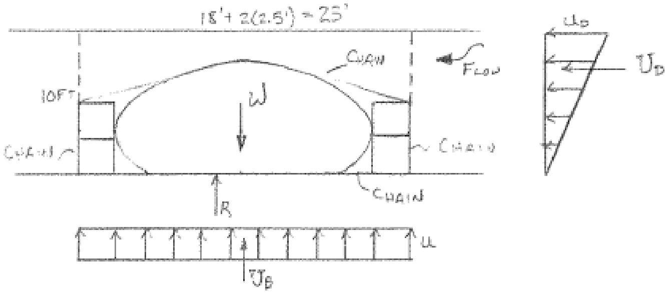
THE TUBE BECOMES BUOYANT & THE RESISTANCE BETWEEN THE TUBE AND BEDROCK APPROACHES ZERO WHEN WATER OVERTOPS THE TUBE (IGNORING WEIGHT OF TUBE LINER).

THE CURRENT CAN THEN PUSH THE TUBE DOWNSTREAM.

Calculations showed that at 10 feet river depth the water cofferdams would reach neutral buoyancy and be capable of sliding down the river.

TRY STACKABLE CONCRETE BLOCKS AS BALAST

- USE INTERBLOCK 2.5' × 2.5' × 5' AT 4320 lb -OR- $\frac{4320}{5} = 864 \frac{lb}{FT}$



WEIGHT OF BLOCKS = 864 (4) = 3456 lb/FT

AREA OF BLOCKS = [2.5(2.5)]4 = 25 FT^2

FREE BODY AREA = 23(10) = 230 FT^2

AREA OF WATER = 230 − 25 = 205 FT^2

W = 205(62.4) + 3456 lb/FT = 16,248 lb/FT

U_B = 62.4 (23) = 14,352 lb/FT

$\Sigma F_Y = 0 : \uparrow +$

$R = W - U_B$ = 16248 − 14,352 = 1896 lb/FT

CHECK SLIDING

$$FS_S = \frac{R \tan(\delta)}{U_D} = \frac{1896(0.42)}{806.2} = 0.99$$ (THEORETICALLY UNSTABLE)

HAVE THE CONTRACTOR SUBMIT THEIR PLAN FOR SECURING THE TUBES FOR FLOOD EVENTS, THEY MAY ALSO DECIDE TO DEFLATE TUBES.

The alternative barriers were offered in case the river exceeded 10 feet in depth or the velocity of 7 ft/sec when the contractor choked down the river flow with the water filled cofferdams.

iNTER-BLOCK
RETAINING SYSTEMS, INC.
MANUFACTURER OF THE ENVIRO-BLOCK ™

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Press Release

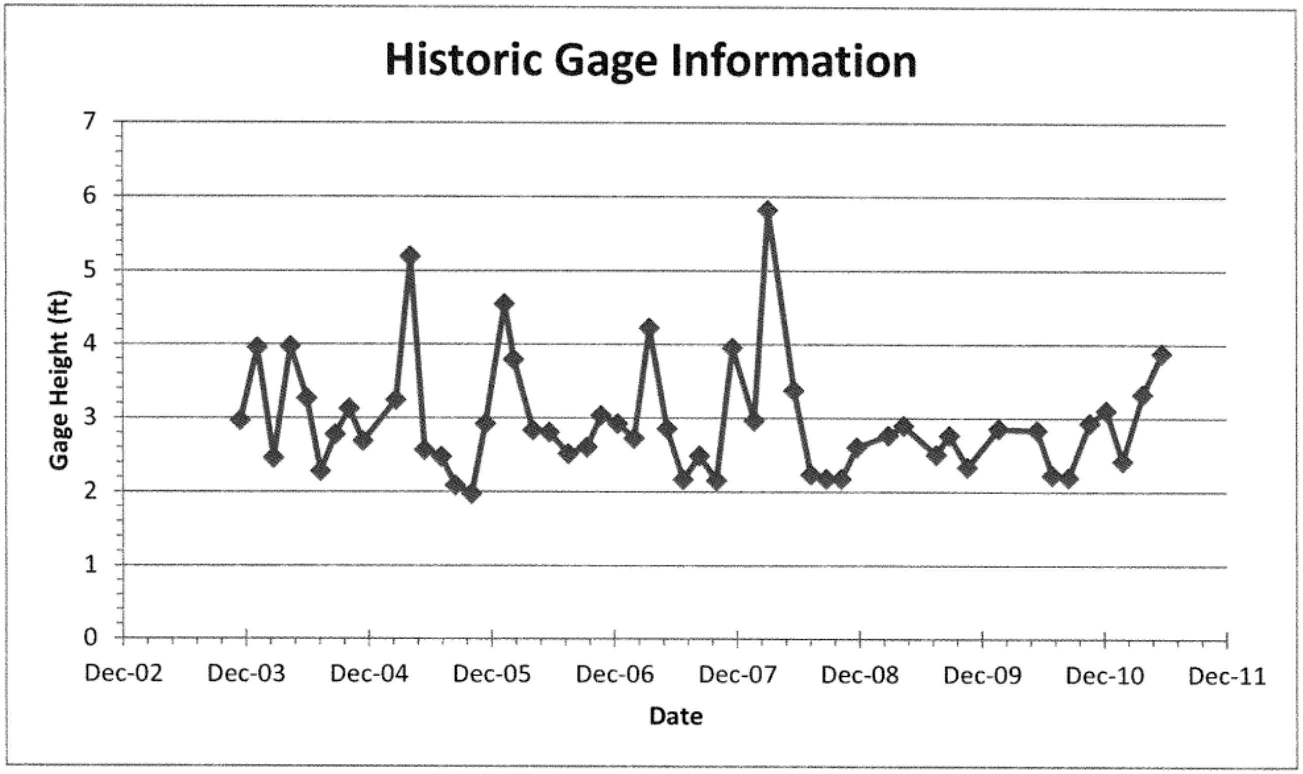
Video

Photographs

Block Specifications

Size	29.5"x 29.5"x 59", (750mm x 750mm x 1500mm) approx. 2.5'x 2.5'x 5'
Weight	1960 kg (4320 lbs.)
Clearance around key	1/2" (12mm). The chamfered corners provide approximately 8 square inches of drainage area per block.
Lifting provision	A standard 7 strand steel loop at top center of each block.
Minimum radius of curvature	23mm (75') for walls one block thick
Surface finish	Standard Grade: 1 full face without large blemishes
	Utility: All faces may contain large surface blemishes such as honeycomb, chips, etc.
	Rock Faced: inset granite with rustic trowel joints.
Concrete strength	Blocks are manufactured with return concrete and strength levels will vary. Extra charges will be quoted for guaranteed concrete strength, if required.
Average placing time	10 blocks per hour (bottom row), 20 blocks per hour (other rows)

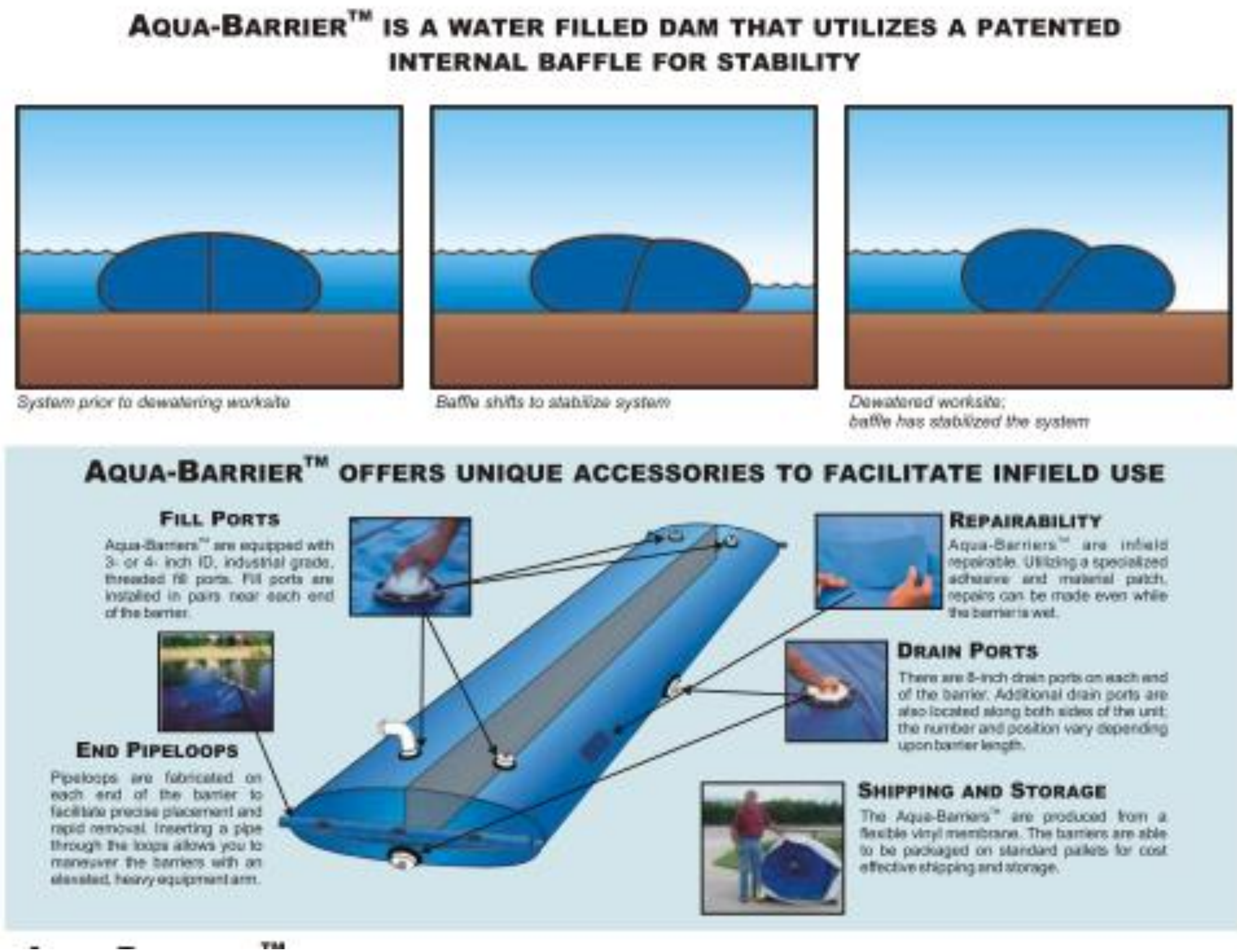
Specified stackable concrete specified for alternative barrier system.



Based on data obtained from a USGS river monitoring station located up stream of the bridge crossing site,
a correction factor was established that translated the river gage information on depth at the site of the USGS
station and our river crossing location.

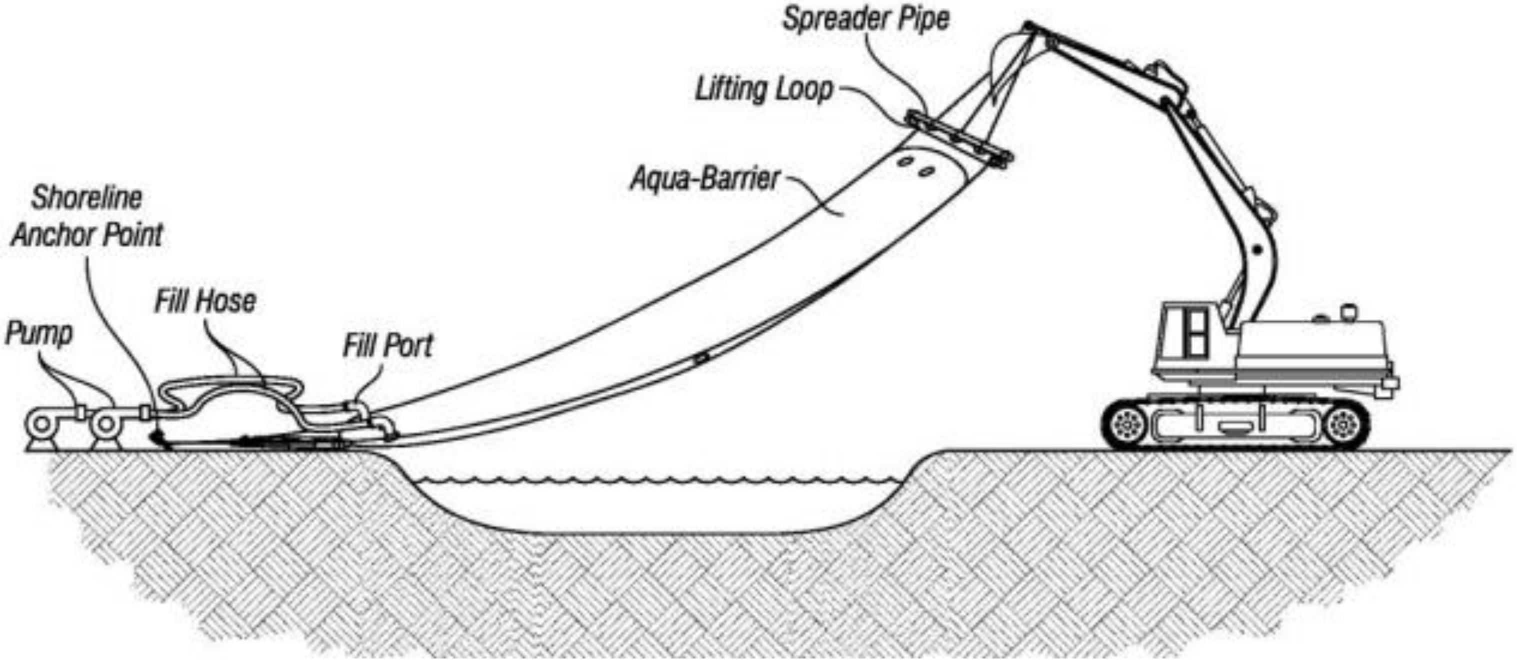
Please note that the data shows stable river depths between 2.5 feet and 4 feet for months at a time.

Best method for damming off portions of the river for open cut construction technique



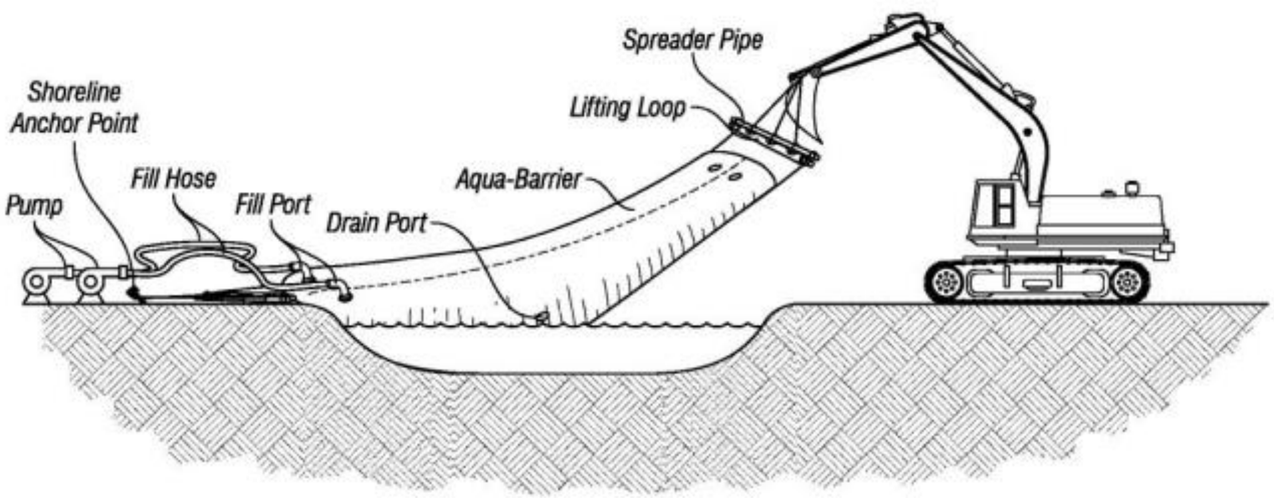
Aqua-Barrier Deployment Method

Using one track hoe and shoreline anchor
Phase 1



Aqua-Barrier Deployment Method

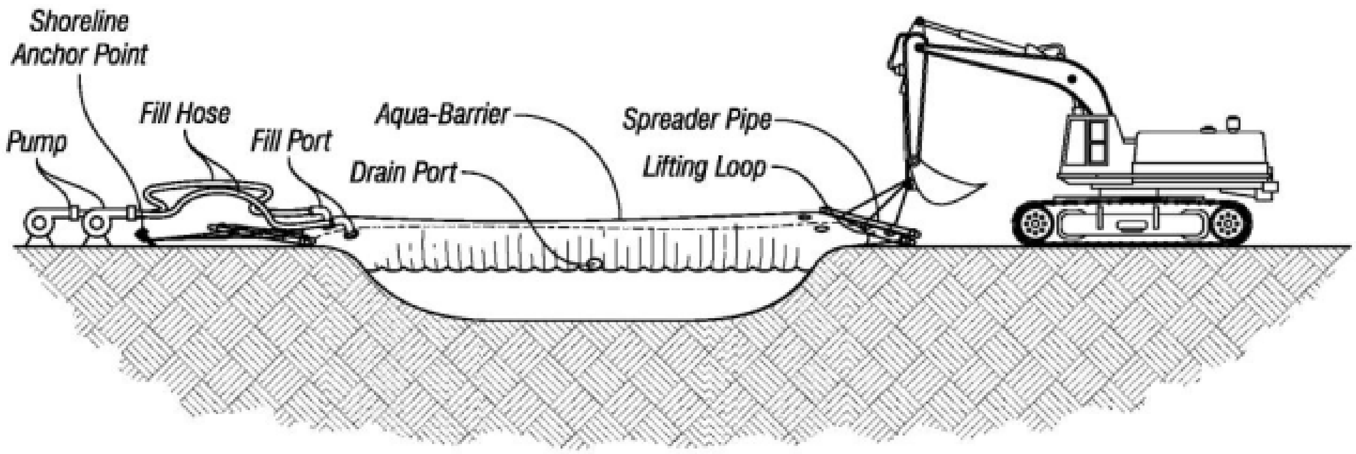
Using one track hoe and shoreline anchor
Phase 2

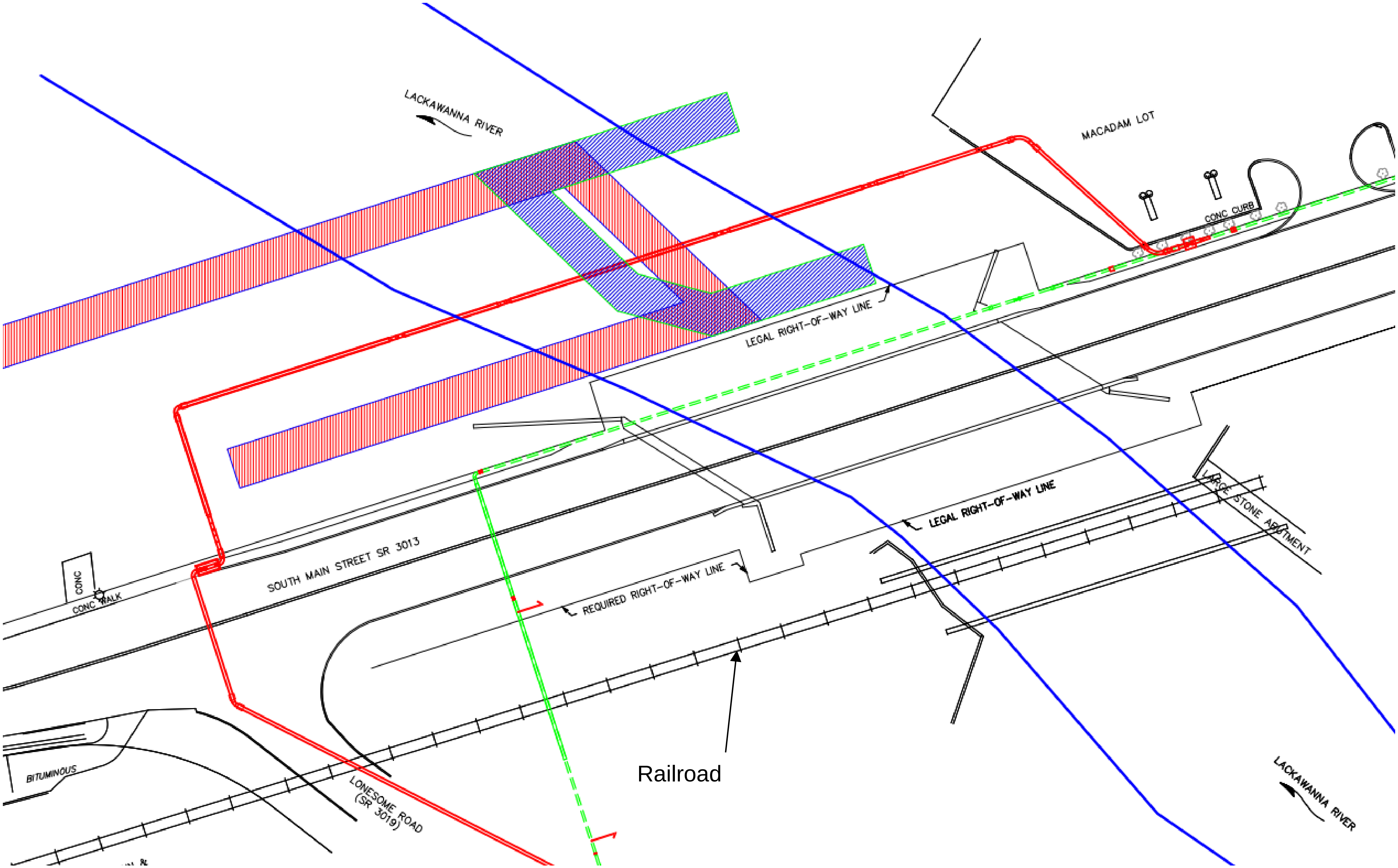


Aqua-Barrier Deployment Method

Using one track hoe and shoreline anchor

Phase 3





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Permitting

PA-DEP-BWEW GP-5 was granted within 42 days of application.

Only requested change was from rock back fill to flowable fill in the river bed area

Construction

Contractor Leeward Construction
Honesdale, PA

Budget $ 2.5M
Duration 120 days

Filling and placing water filled coffer dams

Water filled coffer - dams being filled with water

West bank dams in place and drilling underway

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Dewatering behind coffer-dams

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East bank dams in place and excavation of trench underway

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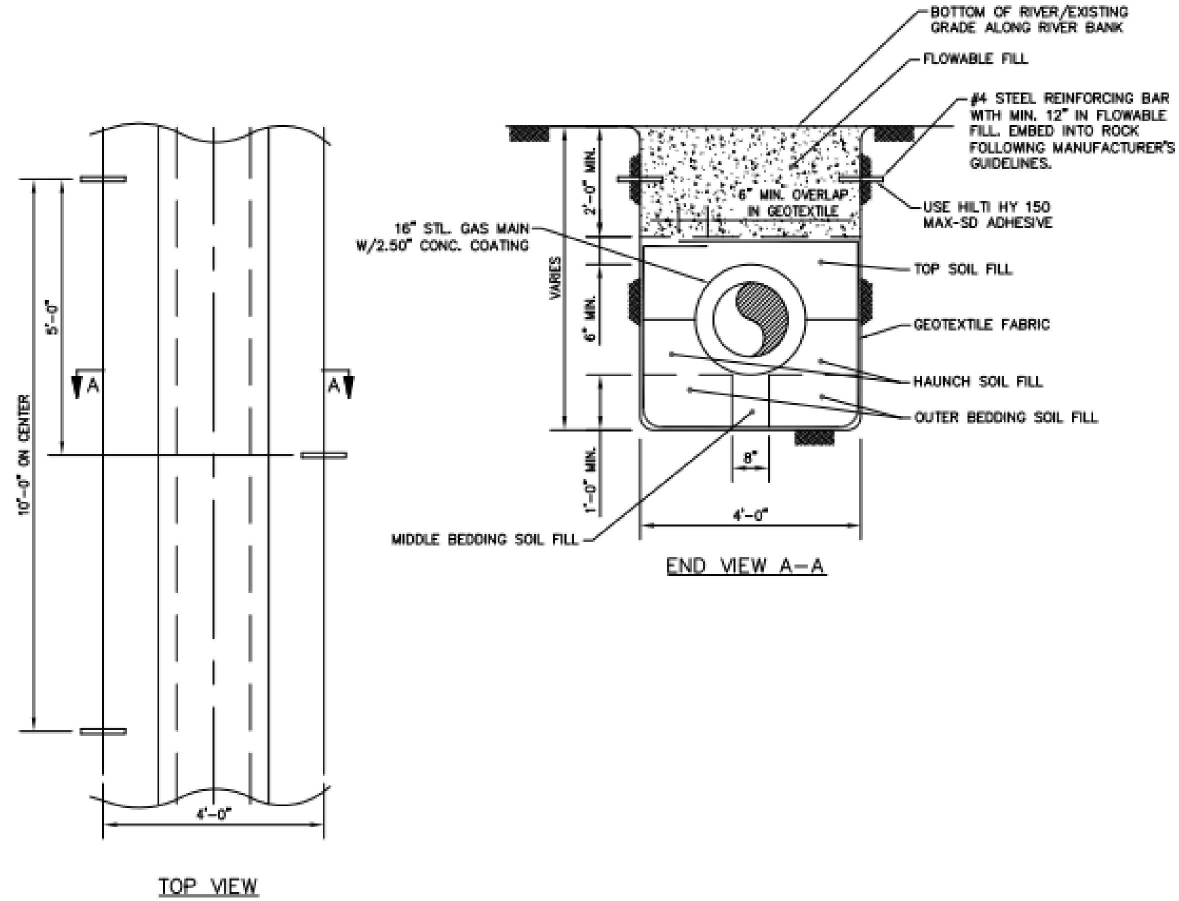
Rock drilling machine drilling trench for subsequent breaking and removal with excavator

Excavating drilled trench in preparation for pipe installment

Pipe installed and trench backfilled with flowable fill as specified by GP-5 permit. Original design called for rock backfill from excavating

Pipe installed in trench. Note rebar placed into sidewalls of trench as reinforcement and to resist lift out of pourable fill by river current.



Design detail of pipe installed in trench. Note rebar placed into sidewalls of trench as reinforcement and to resist lift out of pourable fill by river current.

DETAIL "D"

TRENCH EMBEDMENT DETAIL BENEATH RIVERBED AND UPWARD ALONG RIVER BANK BELOW 100 YR FLOOD WATER SURFACE ELEVATION

(FROM SHEET P4)

New pipe:

16” dia., x 0.375” WT API-5L X-42 with 2.5” concrete coating mill applied

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Sandbags were adjusted at base of water filled cofferdams to minimize leakage under cofferdams due to river bed surface irregularities.

The final product.

Before

After

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Thank you for your time and allowing me to make this presentation.

Charlie Brown

I will now attempt to answer any questions you may have.