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MODELING A ZERO SLOPE CHANNEL IN HEC-RAS; APPLICATION OF IDNR REGULATIONS TO CONCURRENT / CONTINGENT RAILROAD BRIDGE PERMITTING
Background

- As part of upgrades to a coal-fired power plant, two new rail spurs were constructed:
  - One over an intake channel that conveys cooling water to the plant
  - One over Lost Creek
Cooling Lake

Intake Crib

Intake Channel

Intake Channel Bridge
Cooling Lake

Intake Channel

Connection Bridge over Lost Creek

Mainline Bridge over Lost Creek
HEC-RAS used to determine hydraulic impacts of proposed intake channel bridge.

Since channel bottom has zero slope, slope required to convey peak flow was calculated using Manning’s equation.

\[ Q = \frac{1.486}{n} \times A \times R^{2/3} \times S^{1/2} \]

Channel geometry was known from design plans.

Water surface elevation/depth at bridge location known from survey.

Peak flow taken from information on pumps in crib house.
Model Calibration

- Water surface data at cooling lake and intake crib was provided by plant operator for various pumping rates (discharges)
- Using theoretical channel slope from Manning’s equation, drop in water surface between cooling lake and intake crib was estimated
- For peak flow, observed elevation differences from plant records correlated well with predicted drop
- Therefore method employed to back calculate theoretical channel slope proved valid
- Slope calculated using Manning’s was then used in HEC-RAS to calculate head created by proposed bridge
Modeling the Skewed Bridge

- Since bridge is skewed to channel, contemplated whether to skew bridge and adjacent sections. This approach did not seem correct given trapezoidal channel geometry.
- Also considered turning cross sections at bridge to be parallel/tangent to bridge but results were very suspect.
- Eventually piers designed to have single round shaft so bridge modeled as perpendicular to channel, but pier projection used to establish pier stations.
Intake Channel
Looking Upstream from Near Crib House
Since flow in channel is actually suction induced (by pumps at the downstream end of channel), head created by bridge actually represents lowering of water at downstream end of channel /crib house.
Effects on Pumps

- Effects on Net Positive Suction Head (NPSH) and associated margin ratios were calculated to ensure risk of cavitation not significantly increased
  - \[ \text{NPSH} = \frac{P_{\text{atm}}}{\gamma} - \frac{P_{\text{vapor}}}{\gamma} + \Delta Z - h_{fs} \]
  - NPSH Margin Ratio = \( \frac{\text{NPSH}_A}{\text{NPSH}_R} \)
- Lower water surface elevation meant reduction in submergence, therefore submergence checked
- Reduced water depth translated to increase in static head, corresponding reductions in discharges from pumps estimated from pump curves
- This information provided to plant operators to assess economic impacts of reduced pumping rates
CURVES SHOW APPROXIMATELY THE CHARACTERISTICS WHEN PUMPING CLEAR WATER. NO GUARANTEE IS MADE EXCEPT FOR THE WATER POINT.

PERFORMANCE CURVE NO. 854-576-A

CIRCULATING WATER PUMPS #51, #52, #53

PERFORMANCE CURVE FOR PUMP SER. NO.

MINIMUM AVAILABLE NPSH

3 Pumps @ 115 KGPm

3 Pumps @ 115 KGPm

CWP = 36.3

Total 345 KGPm CRITICAL NPSH (FT)

BHP @ 10 SGR

10,000 U.S. GALLONS PER MINUTE

100 200 300 400 500 600 700 800 900 100 110 120 130

105° X 54° TYPE YAV CENT. PUMP

115,000 G.P.M. 38 FT. HD. 254 R.P.M.

ALLIS-CHALMERS

MILWAUKEE, WISCONSIN 53221

PATRICK ENGINEERING
Lost Creek Bridges

Mainline Bridge over Lost Creek

Connection Bridge over Lost Creek
Mainline Bridge over Lost Creek

Connection Bridge over Lost Creek
The Lost Creek Bridge

- New bridge over Lost Creek 900’ downstream of existing, restrictive mainline railroad bridge.
- IDNR Part 3700 Rules Applied (Increase up to 1.0’ at structure and 0.5’ 1000’ upstream).
- Additionally IDNR would not allow any additional created head upstream of the existing mainline railroad bridge resulting from construction of a new bridge.
Old Mainline Bridge
• The owner of the existing mainline railroad bridge was planning on replacing their bridge.
• Under the 3700 Rules, existing mainline bridge could be replaced with a structure just as restrictive as the existing bridge. The existing bridge was “using up” all of our client’s allowable created head and as a result they effectively could not construct a new bridge.

**Section 3700.70 Special Provisions for Bridges and Culverts**

b) General Standards for Bridge and Culvert Reconstruction
A bridge or culvert reconstruction project which would meet the following provisions will be permissible. A reconstruction project which would not meet these provisions must comply with the general standards for new bridges and culverts.

1) **The reconstruction (including approach roads) shall be no more restrictive to normal and flood flows than the existing bridge or culvert crossing**; and

• The new bridge is slightly skewed: Pier projections were modeled in HEC-RAS.
Mainline Bridge

Existing Water Surface
Success

- Unique opportunity:
  - Modifying the railroad’s replacement bridge to make it less restrictive
  - Permitting the two bridges in tandem for no net increased flood elevations upstream of the existing bridge
  - Patrick sized two bridges using an independent HEC-RAS model constructed from surveyed cross sections and flood insurance study discharges
  - Successfully permitted the bridges with IDNR and both bridges were constructed in the second half of 2009
New Mainline Bridge
New Connection Bridge