ENGINEERING
RESOURCE ASSOCIATES

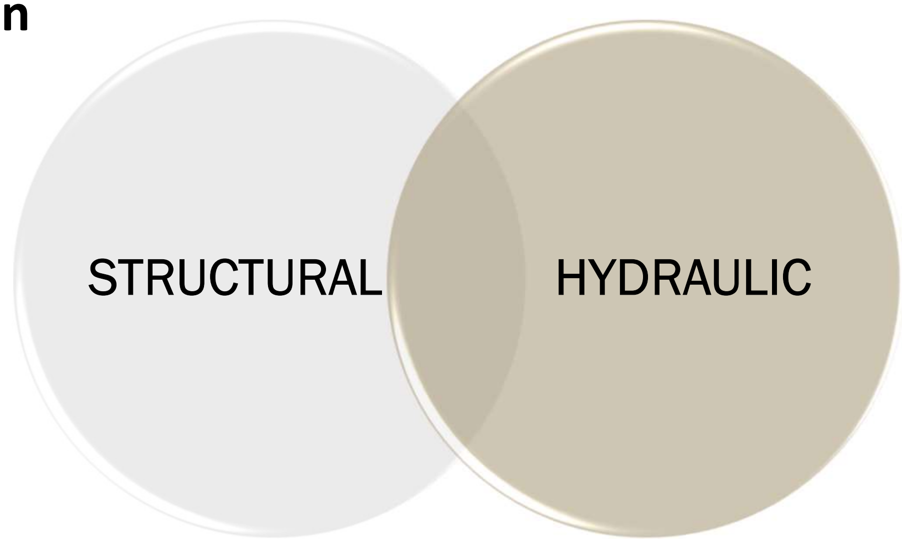
Bridging the Communication Gap between Structural and Hydraulic Engineers

IAFSM Presentation

Wednesday, March 14, 2018

Why is this important?

- **Bridging the Communication gap between two technical disciplines.**
  - Best Designs are Iterative
  - Communication throughout Design Process
  - Prevents errors and re-work
  - Achieves a product that is cost-effective



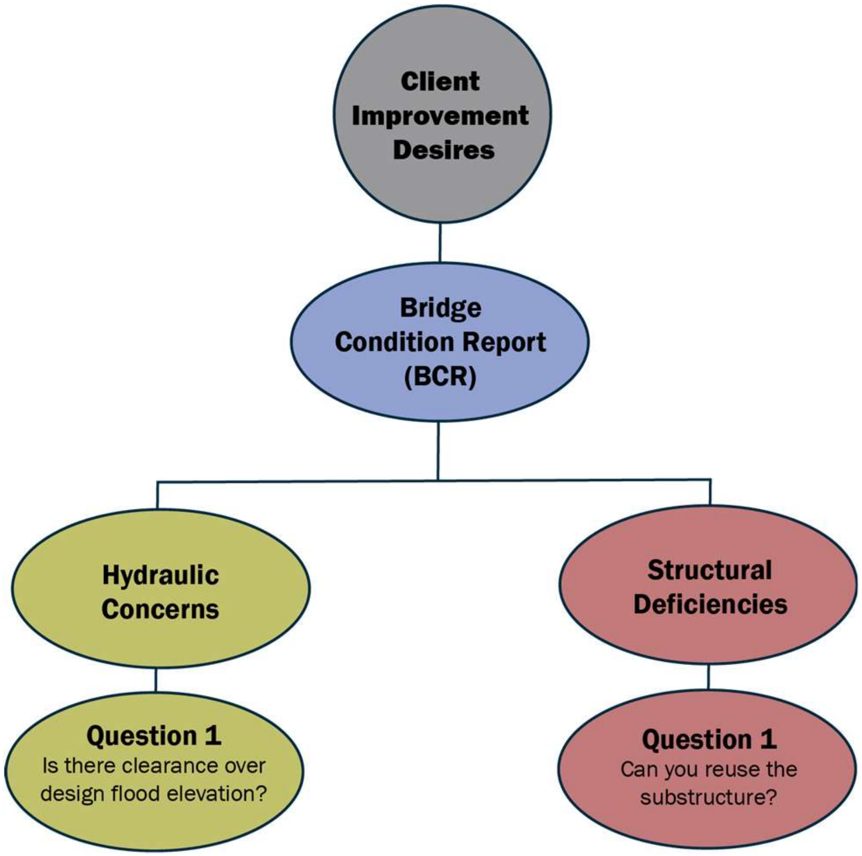
Presentation Setup

- “Rounds” of Iterative Phase I Planning
  - Round 1: Project Goal
  - Round 2: Site Hydraulics
  - Round 3: Structural Planning
  - Round 4: Capacity
  - Round 5: Bridge Condition Report (BCR)
  - Round 6: WIT
  - Round 7: Scour Analysis | Foundation Design
  - Round 8: Submittal Requirements
- Point of Coordination
  - Critical Design Components
- Communication Pitfalls

Round One - Project Goal | Structural Engineer

- **What's the goal of the project?**
  - Does the client want to widen the bridge?
  - Is the bridge deficient?
  - Is there Hydraulic concerns?
  - Are there site constraints?

- **Point of Coordination**
  - Request from Hydraulic Engineer the design flood elevation based on the Highway Classification.



Round Two - Site Hydraulics | Hydraulic Engineer

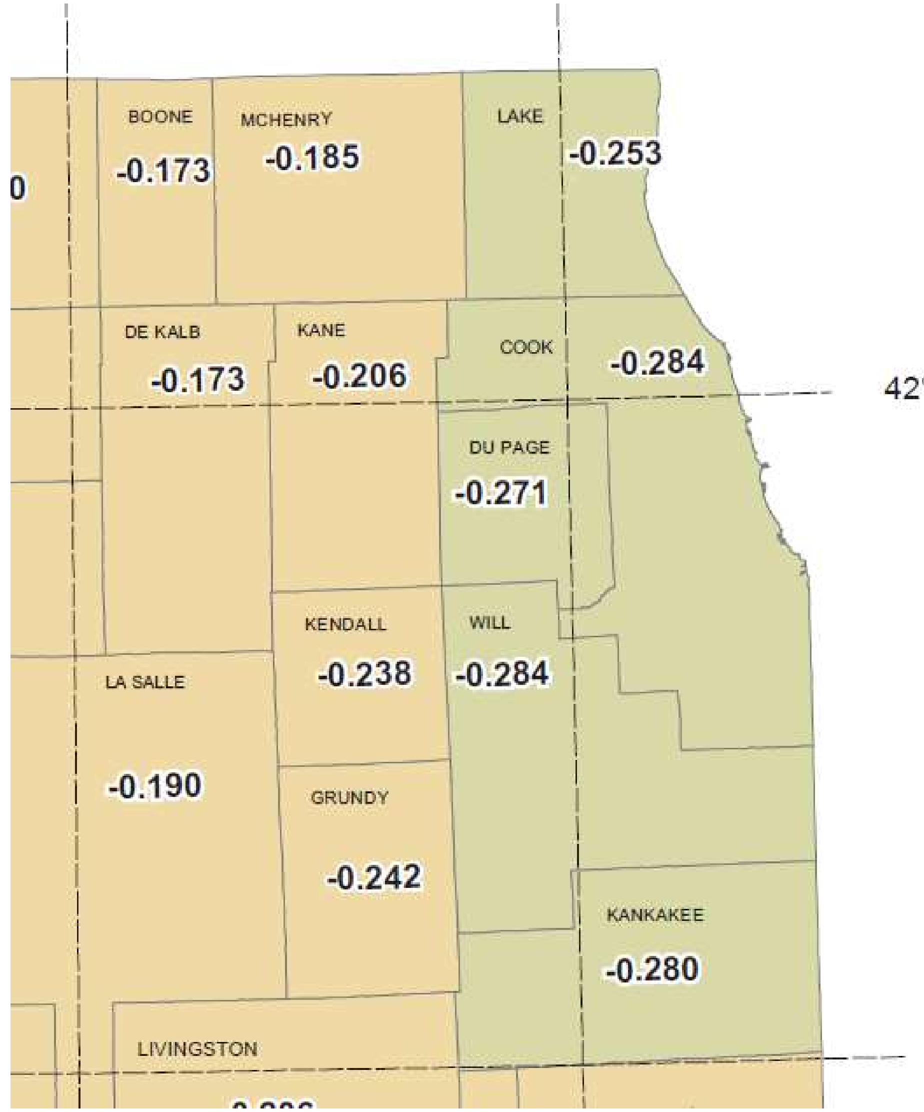
- Existing Drainage Report
  - PBDHR, Local Drainage Studies
- Topography
- Regulatory Flood Elevations
  - FEMA maps
    - 100-yr Flood plain delineation
    - Floodway delineation
  - Flood Insurance Studies
    - Flood Profiles
    - Floodway Data Table
    - Summary of Discharges Table

- Flooding Observations
  - High Water (River Stage)
  - Overtopping Events (existing bridges)
  - Peak Streamflow

- **Point of Coordination**
  - Info Used for General Span Requirements
  - Info Used for Abutment Type and Location

Pitfall – Vertical Datum!

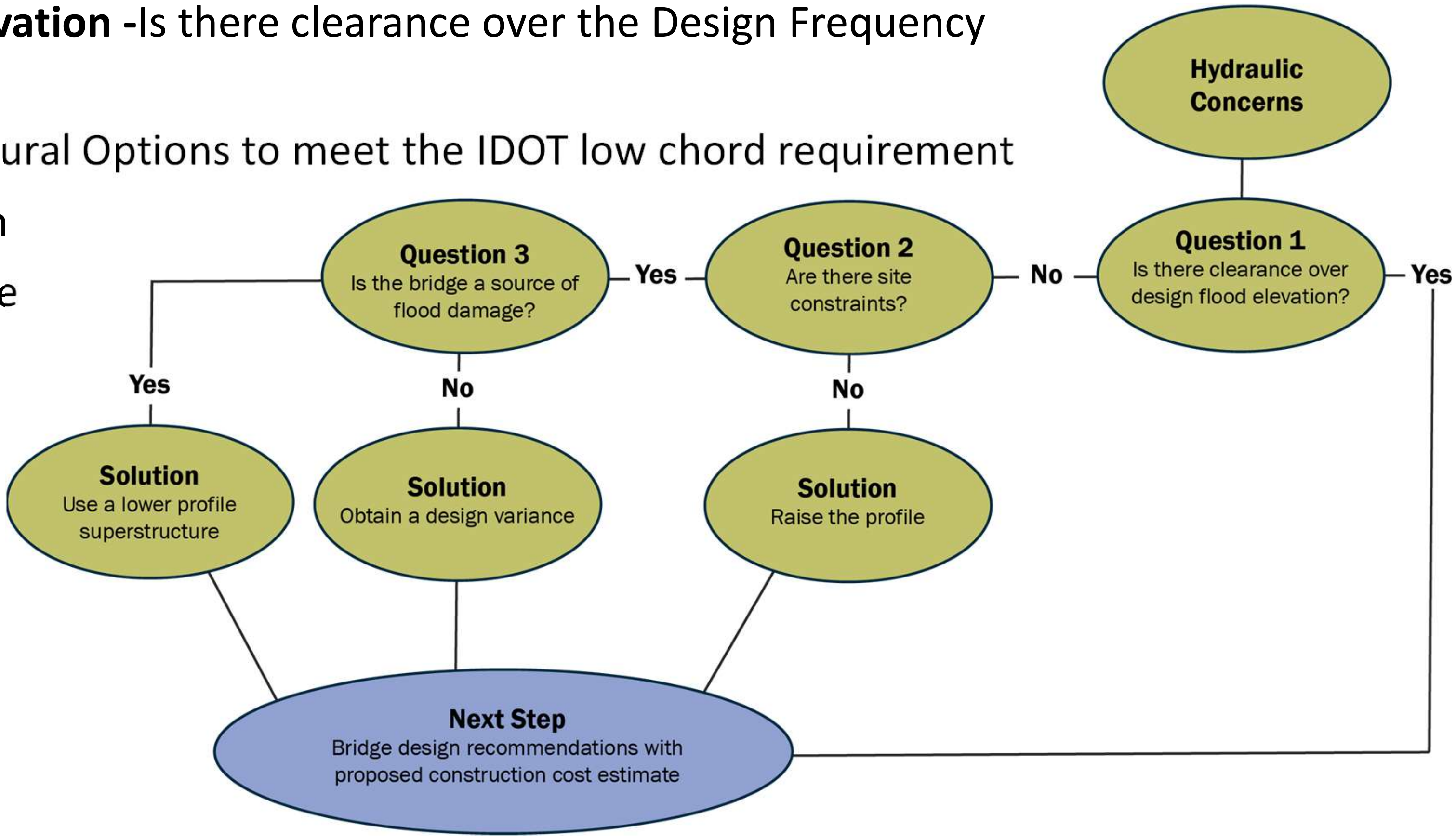
- Site specific survey in NAVD 88
- FEMA Models in NGVD 29
- FIS in NAVD 88 or in NGVD 29
- Converting from NGVD 29 to NAVD 88 ranges throughout Illinois from -0.4' to 0.3'



http://www.sws.uiuc.edu/iswsdocs/maps/ISWSMS2007-01.pdf

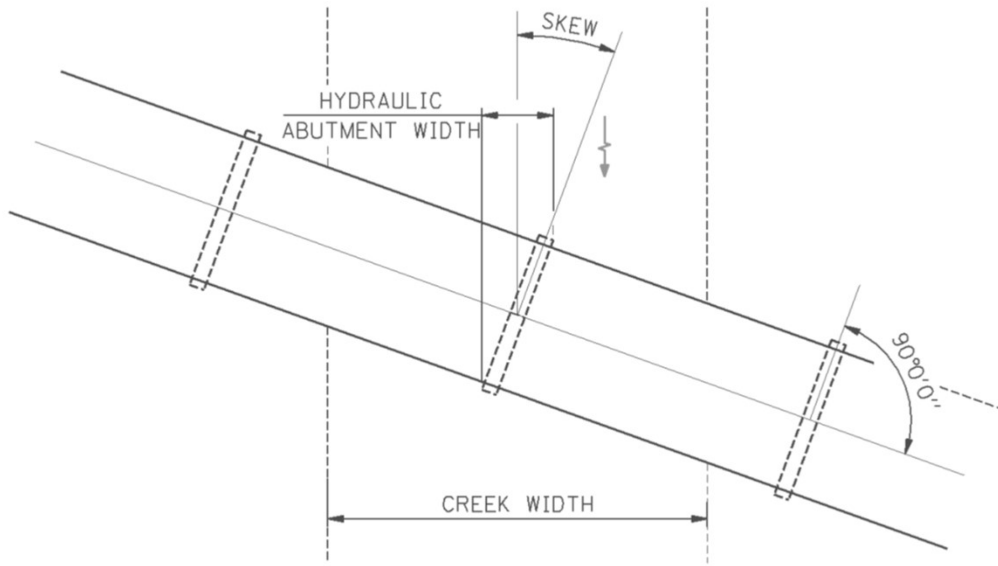
Round Three - Structural Planning | Structural Engineer

- **Design Flood Elevation -**Is there clearance over the Design Frequency elevation?
- **Planning** – Structural Options to meet the IDOT low chord requirement
  - Rehabilitation
  - New Structure



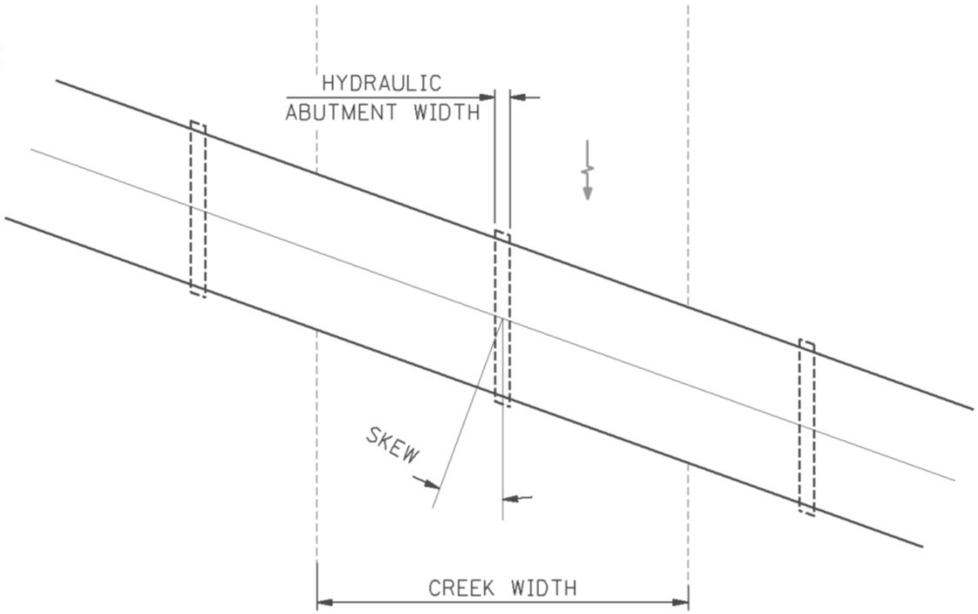
Round Three - Structural Planning | Structural Engineer

- **Geometry Layout of Substructure**
  - Hydraulic Skew and NO structural skew
    - Structural Advantages:
      - Smaller bridge spans
      - Smaller Superstructure Depths
      - Lower Construction Cost
    - Hydraulic Disadvantage:
      - Not best solution for the hydraulics
      - Potential increase in scour
      - Potential increase in water surface elevation



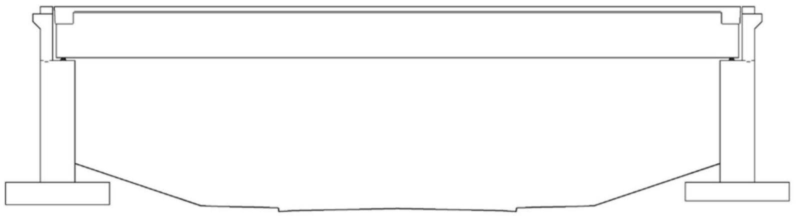
Round Three - Structural Planning | Structural Engineer

- Geometry Layout of Substructure
  - Structural Skew and No Pier Hydraulic Skew (Still Deck Skew)
    - Structural Disadvantage:
      - Longer Spans
      - Deeper Structural Depths
      - Higher Construction Cost
    - Hydraulic Advantages:
      - No Pier Skew
      - Potentially Less Scour



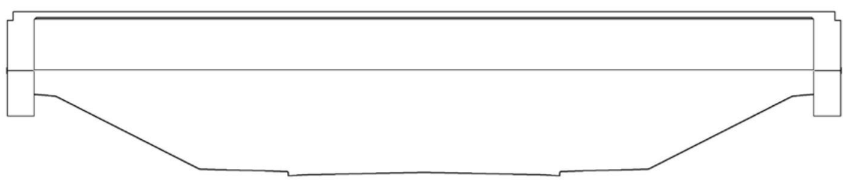
Round Three – Structural Planning | Structural Engineer

- **Substructure Types for Hydraulic Engineers**
  - High Wall Abutments
    - Advantages
      - Used in tight site constraint areas
      - Allow for shorter spans
    - Disadvantages
      - Expansion Joints
      - Higher substructure element costs
      - Smaller waterway opening



Round Three – Structural Planning| Structural Engineer

- **Substructure Types for Hydraulic Engineers**
  - Integral Abutments
    - Advantages
      - Increased waterway opening
      - No expansion joints
      - Potential lower scour depths
    - Disadvantages
      - Longer Spans
      - Deeper structural depths
      - Potential higher superstructure construction cost



Point of Coordination

Bridge Geometry

Round Four - Capacity | Hydraulic Engineer

- **Modeling Preliminary Bridge Geometry**
  - No increase in flood elevations
  - Clearance for design storm
  - Freeboard for design storm

- **Point of Coordination**
  - Feedback on Geometry
    - Slack in span
    - Low Chord/Structural Depth

Pitfall – Not Optimizing Structural Design

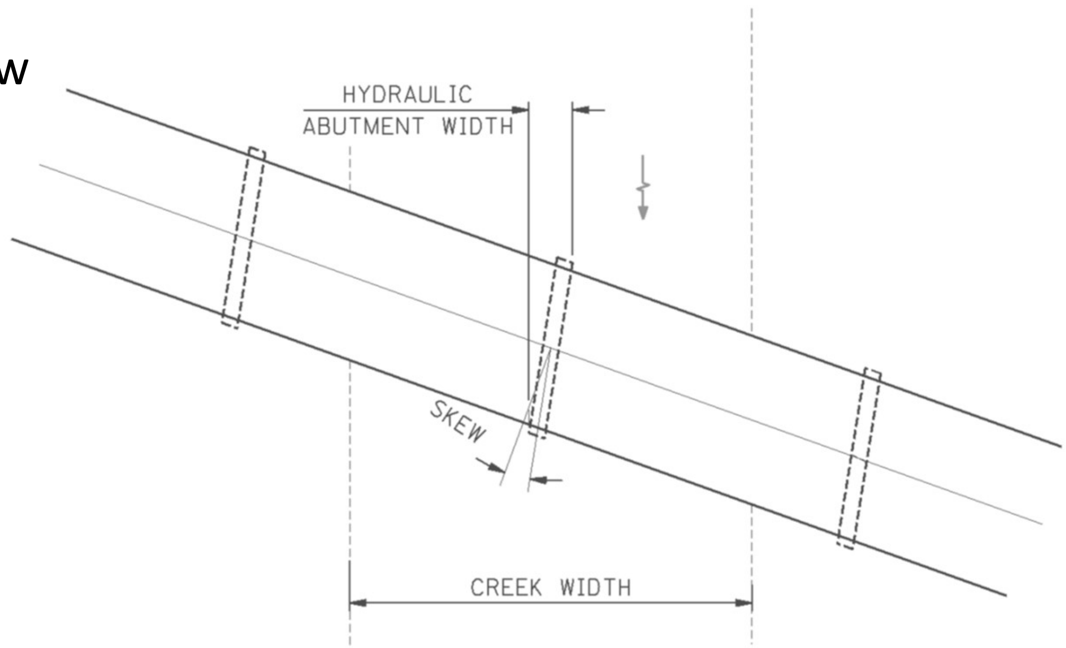
- Hydraulic Analysis shows "over" capacity
  - Iterate back through general span and abutment location design (Round 3 and Round 4)
- Ultimately Reducing Span Length is Lower Construction Cost and Less Maintenance

Round Four - Capacity | Structural Engineer

- **Modifications to Superstructure**
  - Preferred Superstructure Type for Stream Crossings:
    - Precast Prestressed Concrete/ Cast-in-Place (CIP)
    - Advantages: Low Maintenance and generally cheaper than steel
    - Disadvantages: Deeper structural depths
  - Alternative to Concrete is Steel
    - Advantages: Shallower Structural depths
    - Disadvantages: Higher long term maintenance, Potentially higher initial construction cost

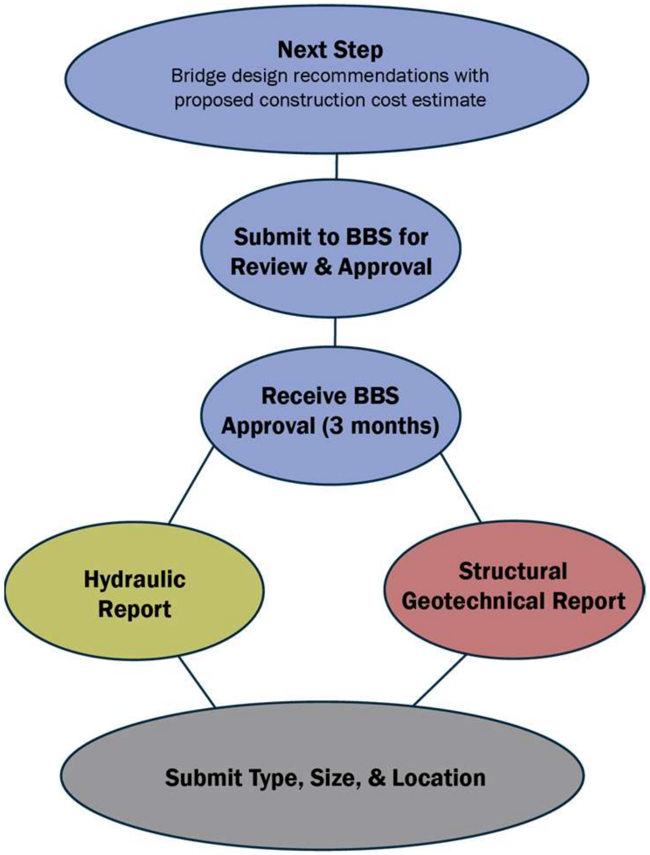
Round Four - Capacity| Structural Engineer

- **Modifications to Substructure**
  - Both Structural and Hydraulic Skew
    - When and Why would you have a structural and hydraulic skew?
      - Balancing span length
      - Minimize Structure depth with the design flood elevation
      - Optimize construction cost



Round Five - BCR | Structural Engineer

- **Bridge Condition Report (BCR)**
  - Structural Document
    - Discuss Deficiencies of the Structure
    - Roadway Geometry
    - Hydraulic concerns
    - Concept sketches of (3) alternatives along with associated cost estimates and recommendations



Round Six – WIT| Hydraulic Engineer

Illinois Department of Transportation

Bridge Waterway Information Table

Route:
Waterway:
Section:
County:

Existing SN:
Proposed SN:
Prepared by: Date:
Checked by: Date:

Drainage Area = square miles

Existing Overtopping Elev. = at Sta.
Proposed Overtopping Elev. = at Sta.

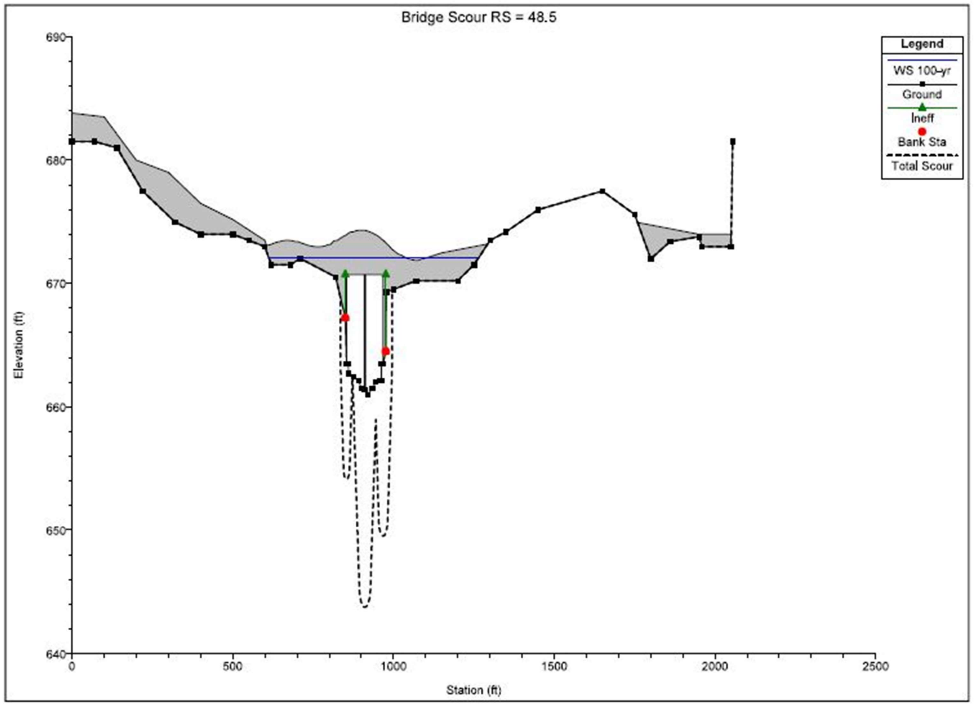
Flood Event	Freq. Yr.	Discharge ft^3/s	Waterway Opening - ft^2		Natural H.W.E. - ft	Head - ft		Headwater Elevation – ft	
			Existing	Proposed		Existing	Proposed	Existing	Proposed
Design									
Base									
Scour Design Check									
Overtop Existing									
Overtop Proposed									
Max. Calc.									

Datum:
All-Time H.W.E. & Date: ft
Surveyed Normal Water Level: ft

10-Year Velocity through Existing Structure = ft/s
10-Year Velocity through Proposed Structure = ft/s
2-Yr. Flow Rate = ft^3/s

Round Seven – Scour Analysis | Hydraulic Engineer

- **Bridge scour, the erosion or removal of sediment due to flowing water around piers or abutments.**



Round Seven – Foundation Design | Structural Engineer

- Point of coordination with Geotechnical Engineer
  - Provide Design Loads and Geometry
  - Provide Theoretical Scour Depths
  - Scour Type Reductions
    - Limestone – 100% reduction in scour depth
    - Shale and Sandstone – 90% reduction
    - Stiff to Hard Cohesive soil (Qu>1.5TSF)- 50% reduction
    - Soft to Stiff (0.5 TSF < Qu <1.5 TSF) - 25% reduction
    - Qu < 0.5 TSF – 0% reduction

Round Seven – Foundation Design| Structural Engineer

- **Pile Capacity Table**

Illinois Department of Transportation

IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

SUBSTRUCTURE======================================	west abut.	
REFERENCE BORING ==================================	2	
LRFD or ASD or SEISMIC ================================	LRFD	
PILE CUTOFF ELEV. ==================================	446.00	ft
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVING ====	444.00	ft
GEOTECHNICAL LOSS TYPE (None, Scour, Liquef., DD) =======	None	
BOTTOM ELEV. OF SCOUR, LIQUEF., or DD ================	424.00	ft
TOP ELEV. OF LIQUEF. (so layers above apply DD) ==========	434.00	ft
TOTAL FACTORED SUBSTRUCTURE LOAD ================	1245	kips
TOTAL LENGTH OF SUBSTRUCTURE (along skew)===========	34.00	ft
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE =========	1	
Approx. Factored Loading Applied per pile at 8 ft. Cts ============	292.94	KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts ============	109.85	KIPS

<u>*MAX. REQUIRED BEARING & RESISTANCE for Selected Pile, Soil Profile, & Losses*</u>

Maximum Nominal Req'd Bearing of Pile	Maximum Nominal Req.d Bearing of Boring	Maximum Factored Resistance Available in Boring	Maximum Pile Driveable Length in Boring
335 KIPS	**335** KIPS	**184** KIPS	**60** FT.

Print Input Sheet

Print Pile Design Table

Clear Input Cells

Print Bearing Graph

PILE TYPE AND SIZE ============== Steel HP 10 X 42

Plugged Pile Perimeter==========================	3.300	FT.	Unplugged Pile Perimeter==============	4.858	FT.
Plugged Pile End Bearing Area====================	0.680	SQFT.	Unplugged Pile End Bearing Area=========	0.086	SQFT.

Round Eight – Submittal Requirements

- **Submittal Requirements for BB&S**
  - Type, Size & Location Drawing
    - General Plan & Elevation of Proposed Bridge
    - Waterway Information Table (W.I.T.)
    - Design Scour Table
    - Substructure Sketch
  - Bridge Hydraulic Report
    - Design Scour Depths
  - IDOT Form BLR 10210
  - Soil Geotechnical Report (SGR)
    - Pile Capacity Sheets

Pitfall – Forgetting about other Disciplines

- Environmental
- Utilities
- Roadway

Coordination "Cheat" Sheet Handout

Hydraulic Structure Coordination Data Sheet

Project: ______

Project No: ______

Hydraulic Engineer Contact: ______

Structural Engineer Contact: ______

Geotechnical Engineer Contact: ______

Project Scope/Goal: ______

- ☐ Complete Replacement
- ☐ Superstructure Replacement
- ☐ Superstructure Widening; Length of pier
- ☐ Bridge
- ☐ Culvert
- ☐ New

Study: ☐ YES ☐ NO

Floodway: ☐ YES ☐ NO

Drainage Area to Structure (sq. mi.): ___

- ☐ Urban
- ☐ Principal Arterial
- ☐ Minor Arterial
- ☐ Collector
- ☐ Local

Design Flood Frequency: ☐ 30-year ☐ 50-year ☐ Other: ______

Design Storm WSEL and Datum: ______

Datum of FIS Profile: ______

Datum of FIS Model: ______

Boundary Condition Location and Elevation(s): ______

Tailwater or Backwater on Structure: ______

History of Flooding or Overtopping problems: ______

Sources and Dates of Observed Highwater: ______

Sensitive Flood Receptors

Clearance: ______

Preliminary Proposed Structure Information

☐ YES ☐ NO

Low Beam Elevation: ______

Width of Deck: ______

Total Length from face to face abutment: ______

Abutment type: ______

Skew (structural): ______

Skew (hydraulic): ______

Number of Spans: ______

Culvert: ☐ YES ☐ NO

Type and Size: ______

US Invert elevation: ______

DS Invert elevation: ______

Length: ______

Entrance Type: ______

Wing walls: ______

http://bit.ly/IAFSM-2018_Handout

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