Presentation
to the

# Upper Mississippi River Basin Environmental Management Program Workshop


by

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# Engineering Design Handbook

## River Training Structures

*One Team: Relevant, Ready, Responsive and Reliable*

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# Agenda

- Resource Problem
- Training Structures Overview
- List of Alternatives Covered
- Alternatives
- Questions for YOU
- Questions from YOU
- Lessons Learned (Comments from those attending)

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# Resource Problem

- Large river ecosystems support a variety of habitats, of which, backwaters are an important component.
  - Backwater habitats support many popular sport fishes, waterfowl, shorebirds and wading birds.
  - Backwaters are also quiet areas off the main channel where people and animals alike can seek refuge from the busy main channel environment.
- Many UMRS backwaters have been degraded by excessive amounts of sediment emanating from the basin, tributaries, and mainstem sources. The degradation is in the form of:
  - loss of depth
  - poor sediment quality
  - poor water quality
  - sediment re-suspension that blocks light required by aquatic plants.

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- The system that was created by the locks and dams simply was not sustainable.
- They tend to cut off flow and increase sedimentation in side channel areas. Bank revetments prevent erosion and maintain a stable channel.
- They have largely arrested new habitat creation.
- The effects of sediment deposition, loss of aquatic plant communities, shoreline erosion, and secondary channel formation has resulted in degraded habitat in the navigation pools.
- Training structures can be used to **alter hydrodynamic** conditions, the sediment transport regime, and ultimately habitat conditions on the UMRS.

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# Potential River Training Structures

| STRUCTURE | |
|---|---|
| Closure Structures | Bendway Weirs |
| Wing Dam Notching | Blunt Nosed Chevrons |
| W-Weirs | Off Bankline Revetment |
| Notched Closure Structures | Hard Points in Side-Channels |
| L-Head Dikes | Vanes |
| Spur Dikes | Cross Vanes & Double Cross Vanes |
| Alternating Dikes | J-Hook |
| Stepped Up Dikes | |

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# Closure Structures

- Used to reduce floodplain conveyance and increase main channel depths.
- Most of the land and geomorphic areas found in the river valley are affected by secondary channel closure construction.
- Secondary channel closure elevations should be constructed to the bankfull elevation or less.
  - Increases the amount of floodplain conveyance that occurs during flood events.
  - restores a more natural flow and sediment transport.
  - Secondary channels closure elevations lower than the adjacent natural levees reduce erosive forces on the natural levees during floods.

# Design Methodology: Emerged Closure Structures

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- Top elevation
  - Greater than the low water surface elevation
  - A low flow notch is often included in closure structures to allow continuous flow of water during low flow conditions and boat access.
- Significant scour holes can develop on the downstream side of closure structures, these have rarely caused a significant problem for structure integrity.
- **Rock** – Since most closure structures are designed to be overtopped, they can experience significant hydraulic forces during flood events and therefore are usually constructed of rock.
  - ♦ Constructed with enough rock so that some self-healing can occur
  - ♦ Samplers yielded nearly 27 times the number of macro-invertebrates than Ponar grab samples did from predominantly sand substrate

# Design Methodology: Submerged Closure Structures

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- Top elevation
  - Less than the low water surface elevation
- Engineering considerations regarding elevation, width, and side slope are similar to those for emerged structures
  - Calculating the flow over submerged structures is important
  - Safety for recreational craft is another consideration

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# Woody Structure

- Trees and brush can be anchored to the bottom of a channel to cause sediment deposition to occur.
  - Borrows on the technique that was developed over a hundred years ago, when pile dikes were constructed to develop a navigation channel.
  - Sand transported along the channel settled in the piles due to increased friction and decreased current velocities.
  - The main requirement for these structures to work is an adequate sediment load.

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# Wing Dam Notching

- Wing dams have long been used to guide the river and maintain the navigation channel.
- River engineers found that simply by adding notches, the dikes continue to create navigation dimensions as well as support diverse habitats.
  - Wing dams also provide flow refugia and support large concentrations of fish adapted to moderate flow.
  - The rock revetment provides structure for dense aggregation of macro-invertebrates.

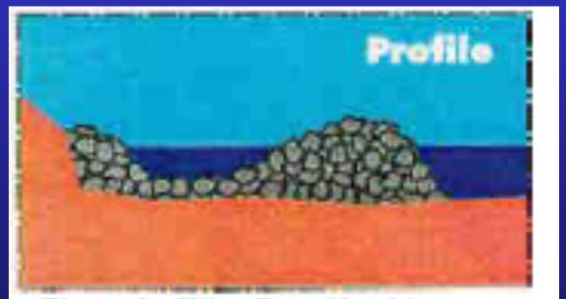

Figure 2: Wing Dam Notching

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# More Benefits

- The river moves in and out between the notches creating all four of the primary river habitats.
  - Creation of small chutes within a dike field
  - Sediment buildup forms small sandbars between each of the dikes.
  - Fish community benefits from the increased edge habitat and resulting aquatic habitat diversity
  - Macro-invertebrate community benefits from the increased edge habitat as well

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# W-Weirs

- Constructed with two (2) Rock Vanes on opposing sides of the stream channel forming the outside legs of the W-Weirs and two opposing vanes in the center of the channel to complete the W-Weir .
- May be staggered, such that one leg of the W-Weirs is offset either upstream or downstream of the opposite leg.
- The “W” shape is seen when viewing the W-Weirs from upstream looking downstream.
- Reduce shear stress on banks, controlling the grade of the streambed and establishing fisheries habitat.
- Design Considerations
  - Constructed of angular, flat or cubed rock
  - Concrete, other “debris” rock, porous rock, such as some limestone, soft rock, such as shale ,are not allowed.

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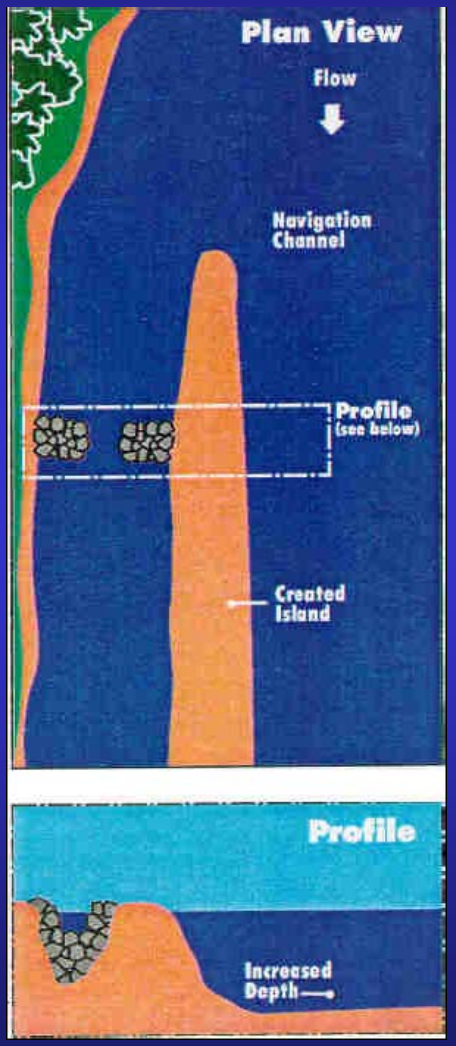
# Notched Closure Structures

- Side channels are not used for navigation, but are valuable environmental areas.
- Traditionally these side channels were closed
- with rock structures to divert the flow
- While improving navigation, this process tends to fill the side channels with sediment
- Notching a closure structure tends to keep the side channels from being filled.
- These structures form areas of deep water and shallow water creating a diversity of habitat, attracting different species of fish.



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# L-Head Dikes

- Dike fields change river morphology by:
  - Decreasing the channel width
  - Decreasing the surface area of the waterway
  - Increasing the depths through bed degradation
  - Sometimes shifting the channel position.
  - As the flow is realigned and/or constricted, the bed is scoured by locally higher velocities.
  - Decreased velocity within the dike field leads to accretion of sediment in this area.

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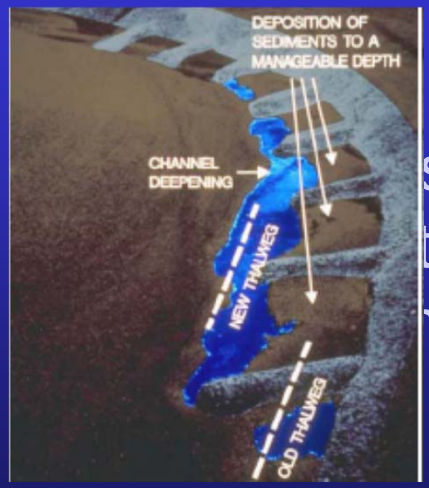
# Spur Dikes

- Used in river training as contraction works to;
  - establish normal channel width
  - to direct the axis of flow
  - to promote scour and sediment deposition
  - trap bedload to build up new banks.
  - Less effective than training walls in rivers with steep gradients and swift currents, they are often more economical than longitudinal works since material is required to protect the bank.




spacing is critical. If the spacing is to close, tional areas will not form and if the spacing is nk erosion is possible between the structures.

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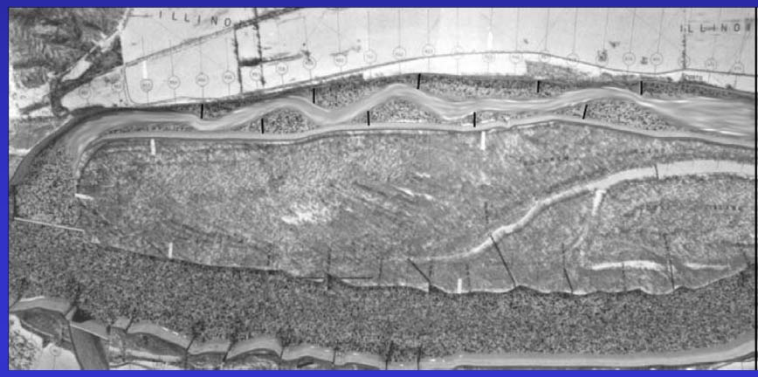
# Alternating Dikes

- Alternating dikes can typically be used in side channels that are long and straight.
- Creates a sinuous flow pattern in areas that previously had homogeneous flow.
- Scour holes off the ends of each dike and sand bars along the banklines upstream and downstream of each structure.



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# Remember…..

- Additional flow along the bankline, opposite each dike which could induce erosional tendencies.
- Privately owned banklines should be armored with stone.
- If the land is publicly owned, lateral movement of the bankline could produce a sinuous planform if allowed to erode naturally.

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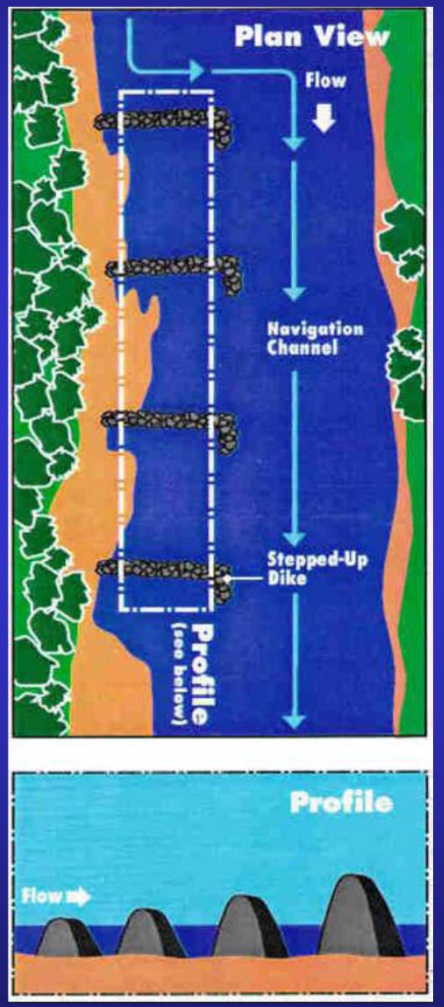
# Stepped Up Dikes

- Provide an additional element of diversity.
- Prevents the conversion of aquatic environment into terrestrial.
- This approach utilizes the river's energy to change the sediment deposits as the water level changes.
- Beneficial environmental effects are related to the diversity of substrates, depths, and velocities created by the dike fields and often provide a diverse habitat with a relatively high biological activity.



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# Environmental effects

- Diversities created by the dike fields;
  - Substrates
  - Depths
  - velocities
- Provide a diverse habitat with a relatively high level of biological activity.

- Sediment accretion
- Alterations in river depth and stage
- Reduction in wetted edge
- Locally increased main channel velocities, and a reduction in slack water habitat caused by closure and subsequent sedimentation

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# Bendway Weirs

- Totally submerged rock structure that is positioned from the outside bankline of the riverbend and angled upstream toward the flow.
- These underwater structures extend directly into the navigation channel underneath passing tows.
- Wider and safer navigation channel through the bend without the need for periodic maintenance dredging.
- It is critical to place the structures at an upstream angle of 30°.

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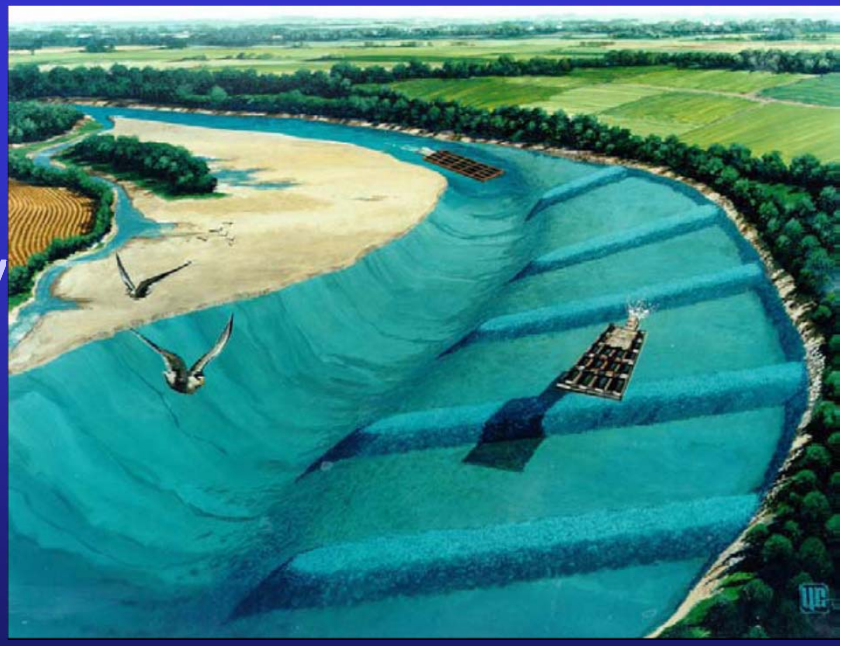
# Terrestrial Effects

- A wider and more smoothly aligned navigation channel has resulted so that traditional above-water dikes will no longer be built on the sandbars.
- Nesting Habitat for the Least Tern, an endangered bird species is thus left largely undisturbed.



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# Aquatic Effects

- Also proven to provide habitat for a number of fish species.
  - Environmental reefs have created diversity in the river bed and flow patterns in areas that were once narrow, deep, and swift.
  - Monitoring efforts have shown that the federally endangered Pallid Sturgeon uses the weir fields significantly for their habitat.

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# Blunt Nosed Chevrons

- Provide nose protection for islands while providing slower moving waters for fish habitat.
- Improve river habitat and to create beneficial uses of dredge material.
- Small islands encourage the development of all four primary river ecosystem habitats.

- In addition, various microorganisms cling to the underwater rock structures, providing a food source for fish.
- Larger rock provided habitat for a greater number of fish than either small stone revetment or the natural river bank.

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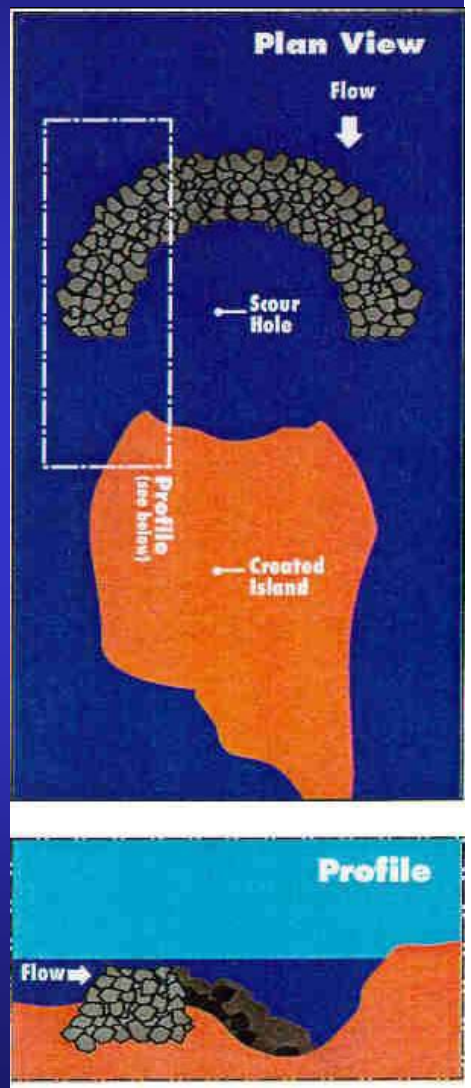
# Habitat Benefits

- A large scour hole is created inside of the chevron just downstream of the structure's apex.
- Downstream of this area, the reshaped material deposits and creates a shallow bar.
- After the flows drop below the crest of the structure, the scour hole formed at high flow becomes an area of deep slack water. Which is very conducive to the needs of overwintering fish and provides the ideal conditions for a nursery for juvenile and larval fish.
- The plant life that establishes along the wetted edges provides good cover and habitat for young fish.



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# Off Bankline Revetment

- Erosion is reduced and diverse habitats are maintained.
- In some areas, the revetment is notched allowing fish to move between the fast water and the slow water easily.
- The areas between the revetments and the bank line are considered to be prime fishing locations by both commercial and recreational fisherman.

# Hard Points in Side-Channels

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- Notching a closure structure tends to keep the side channels from being filled with sedimentation.
- These structures form areas of deep water and shallow water creating a diversity of habitat, attracting different species of fish.

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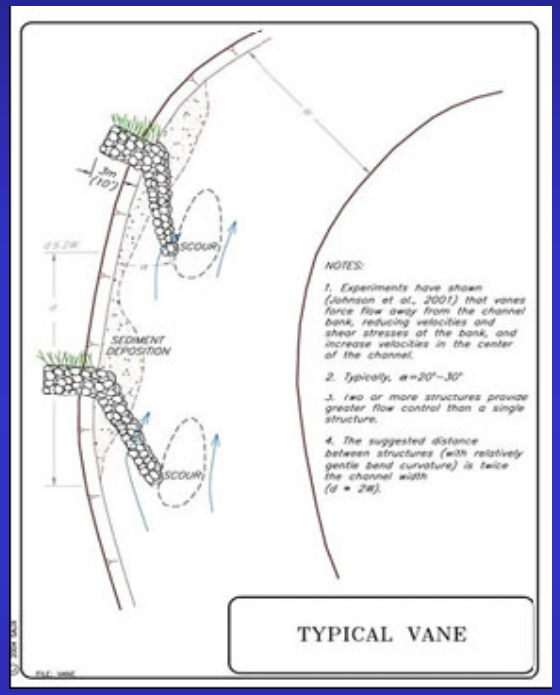
# Vanes




- They are designed to protect stream banks from erosion, maintain navigation depth and flood-flow capacity in rivers, and control sediment at diversions and water intakes.
- Rock be of sufficient hardness to resist weathering and shall be free of cracks and other blemishes. Porous rock such as some limestones and soft rock as shales are not allowed.
- J-Hook Vanes

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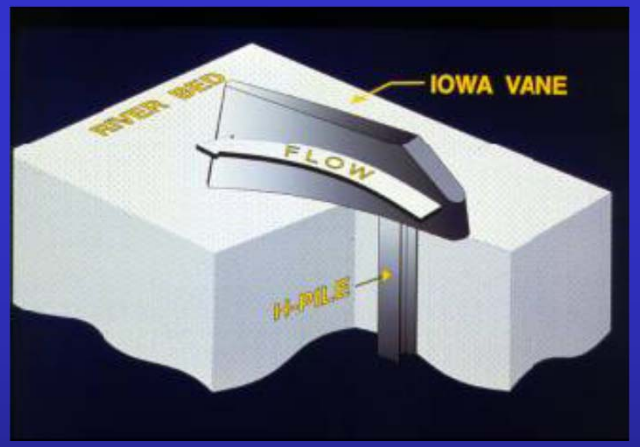
# Iowa Vanes

- Small, submerged flow-training structures or foils designed to modify the near-bed flow pattern and redistribute flow and sediment transport within the channel cross section.
- Generate secondary circulation in the flow. The circulation alters magnitude and direction of the bed shear stresses and causes a change in the distribution of;
  - velocity
  - Depth
  - and sediment transport in the area affected by the vanes.




- As a result, the riverbed aggrades in one portion of the channel cross section and degrades in another.
- Vane-generated secondary current eliminates the centrifugal induced secondary current, which is the root cause of bank undermining.

# Cross Vanes & Double Cross Vanes

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- The objectives of this structure are to:
  - Create instream cover/holding water
  - Take excess shear stress from the “near bank” region and direct it to the center of the stream to maintain later stability
  - Increase stream depth by decreasing width/depth ration
  - Increase sediment transport capacity
  - provide a natural sorting of gravel (where naturally available) on the up-welling portion on the downstream side of the structure

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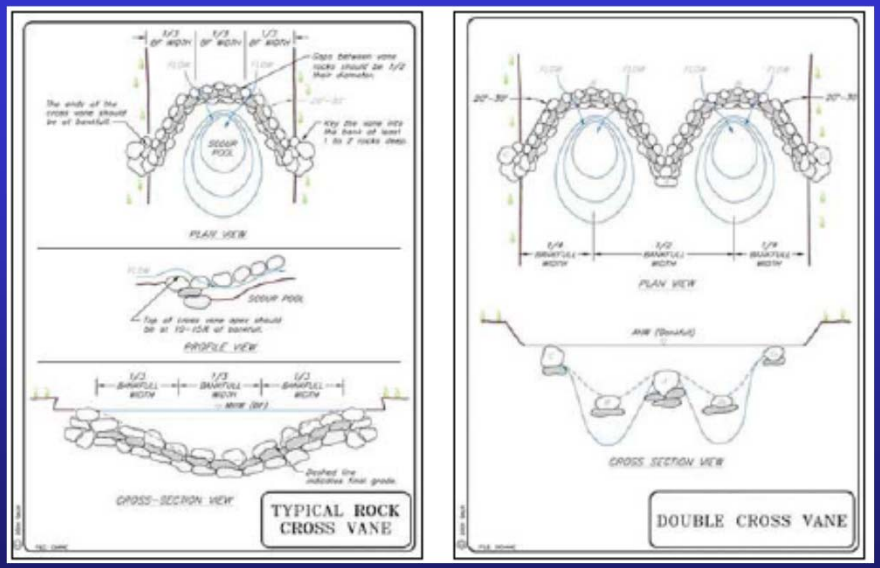
# W-Shaped Weir?

- When the rock is placed, make sure that the footer rocks are working in compression with flow or the integrity of the structure will be compromised.
- When building the structure, alternate the size of the stone, allowing voids in the structure to allow for fish passage.
- If used as a grade control structure and the head cut is relatively high, use a series of structures instead of one large structure to allow for fish passage.



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# Questions for YOU

- How many people have constructed River Training structures based on habitat benefits?
- How close is the in field operation to that expected in the design?
- How is habitat responding?
- What are some of the best things built for you?
- What are some of the hardest things to operate or maintain?

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# and more……

- Does the structure respond to a flood or drought as designed?
- What would you change in building another similar structure?
- What other features in any did we not mention?
- What features should we expand upon?
- Would the Chapter Description in the Design Handbook help a PDT start the design process?

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# Questions from YOU

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# Lessons Learned