RECLAMATION

Managing Water in the West

Water Resources Research Laboratory

Self-Guided Tour:

Overhead West Walkway, Station 1

U.S. Department of the Interior
Bureau of Reclamation

Physical Hydraulic Scale Modeling

Why do we conduct model studies?

Much of the world's engineering knowledge base is the result of trial and error - i.e. items learned from past failures

Photo: 1995 Folsom Dam Spillway Gate Failure

To the extent that trial and error testing can be carried out in a controlled environment and at a scaled size, the costs of developing knowledge and the risks associated with failures can be greatly reduced.

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Physical Hydraulic Scale Modeling

How do we know that observations from a scale model will apply to the full (or prototype) scale?

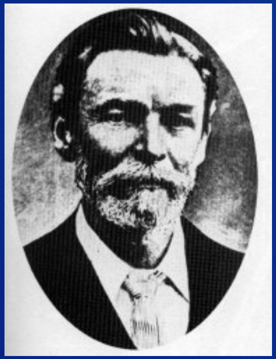
We can readily scale the geometry of a structure being studied. Scaling other aspects, in particular fluid properties such as density and viscosity, is more problematic. Fluids with suitably scaled properties simply do not exist.

In the 19th century, researchers in the field of fluid mechanics recognized that when ratios of types of forces were the same for both scale model and prototype, performance of a scale model would closely mimic that of the prototype.

Physical Hydraulic Scale Modeling

What "force ratios" are of concern in a scale model study in this laboratory?

For studies conducted in this laboratory, we are most frequently affected by the ratio of the inertial forces (momentum) to gravitational forces – known as the Froude Number – and the ratio of inertial forces to viscous forces – known as the Reynolds Number. [Fluids like motor oil or syrup that exhibit sluggish flow are more viscous than water.]



William Froude

Osborne Reynolds

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Physical Hydraulic Scale Modeling

How do the Froude number and Reynolds number ratios affect model design?

- Most of our models are designed for Froude numbers of model and prototype to be the same.
- At prototype scale, turbulent flow conditions almost always exist. (Turbulent flow is a condition where the flow field – particularly along boundaries – is rolling or multi-directional, as opposed to laminar flow where all motion is in generally the same direction.)
- Under turbulent conditions, the effects of viscous forces are greatly diminished. If flow is turbulent for both model and prototype, viscous effects will be small.
- We attempt to select a model scale that will ensure turbulent conditions.
- For some studies, limited space availability will necessitate a sectional model, or two models. The Folsom Dam study discussed at a subsequent station is an example.

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Environmental Modeling

In recent years much of Reclamation's work has shifted from designing and building projects to facility operation and maintenance.

Among the operational issues being addressed is identifying impacts Reclamation projects have on fish and other aquatic species, and devising methods for mitigating these impacts

As a result, a growing percentage of our recent model studies include tests with live fish.

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WRRL Laboratory:
On-going and Recently Completed Model Studies

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Wilkins Slough Positive Barrier Fish Screen Model, near Grimes, California

A hydraulic model study to assist with the design of a fish exclusion screen for an irrigation diversion on the Sacramento River

Tracy Vermeyen

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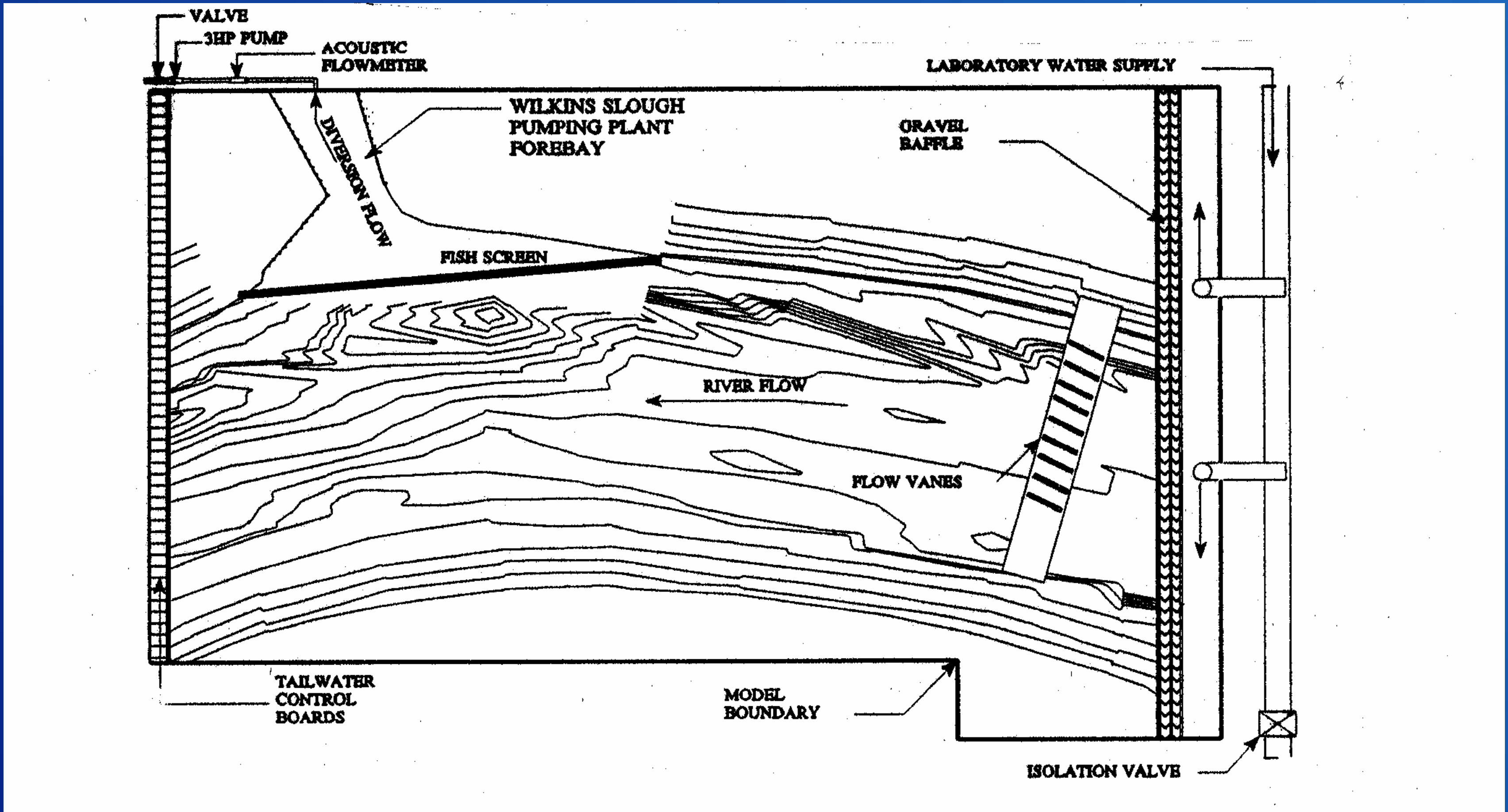
1:20 Scale Physical Model



Plan view of the Wilkins Slough positive barrier fish screen hydraulic model. The model box was 44 ft long and 28 ft wide by 4 ft deep.

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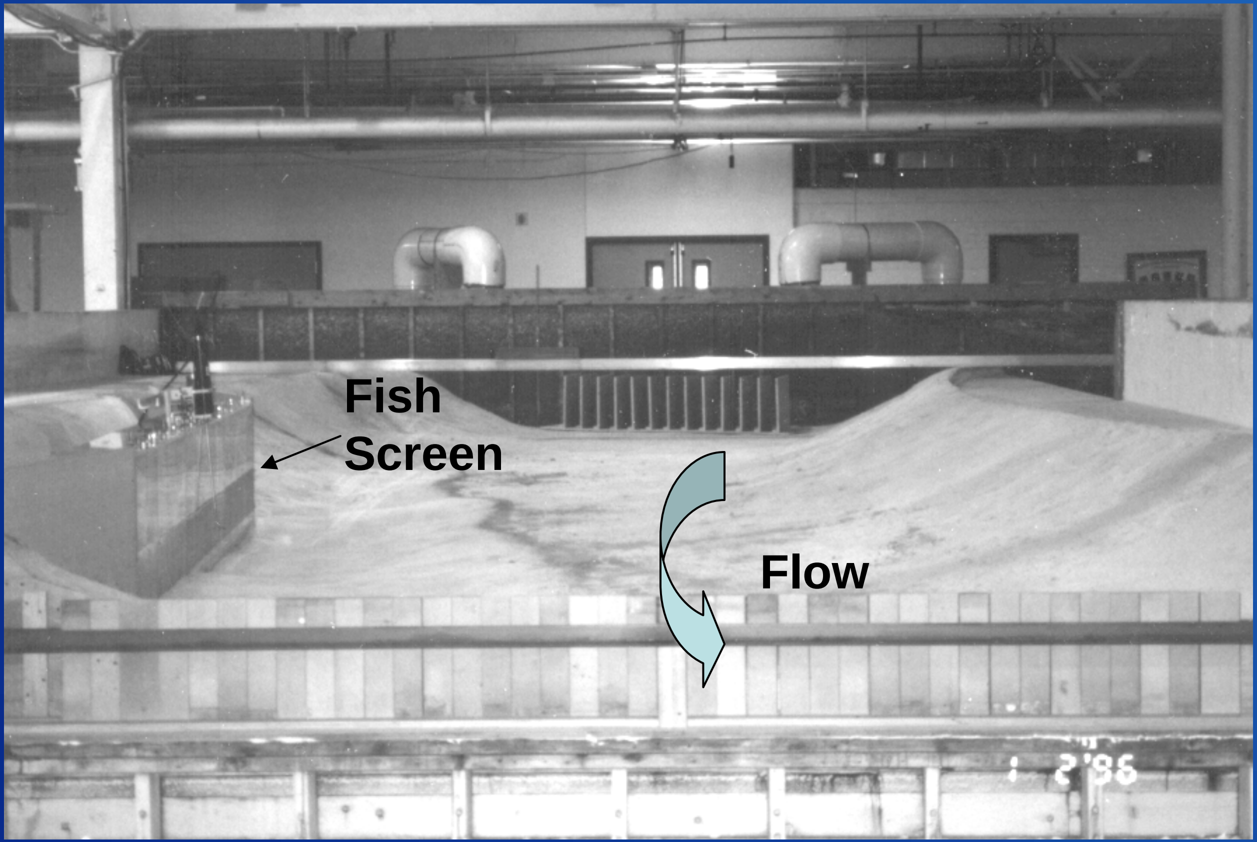
Looking Upstream at Model



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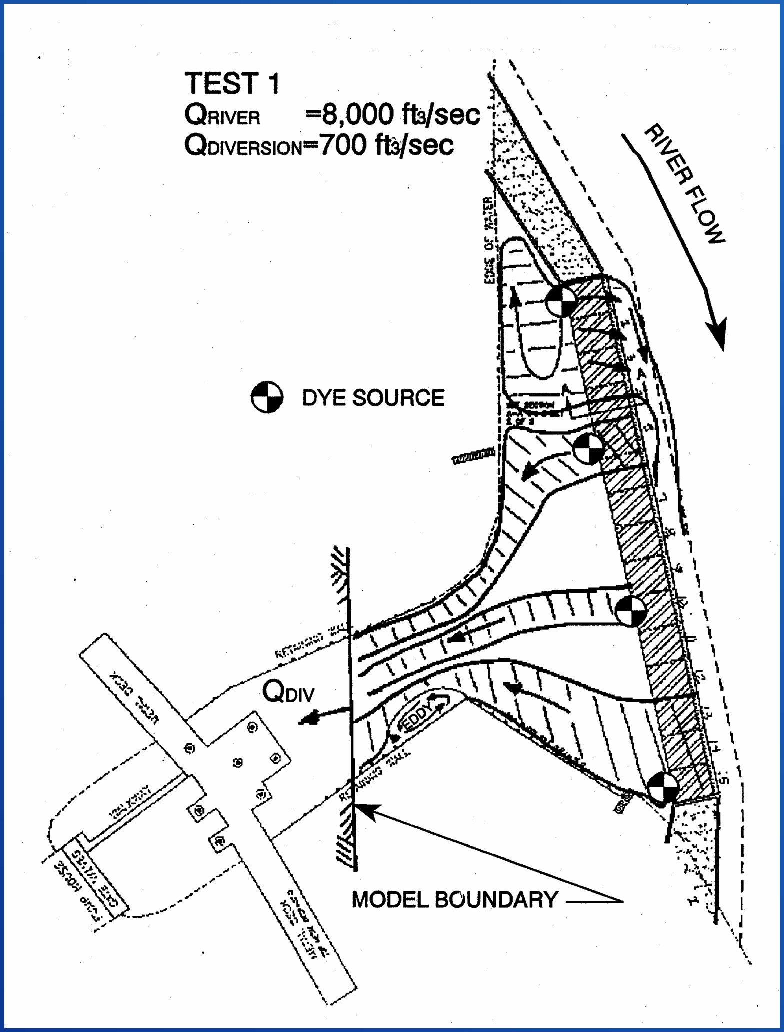
Using dye to understand flow patterns

Dye streaks were used to identify flow patterns for a wide variety of river and diversion flows



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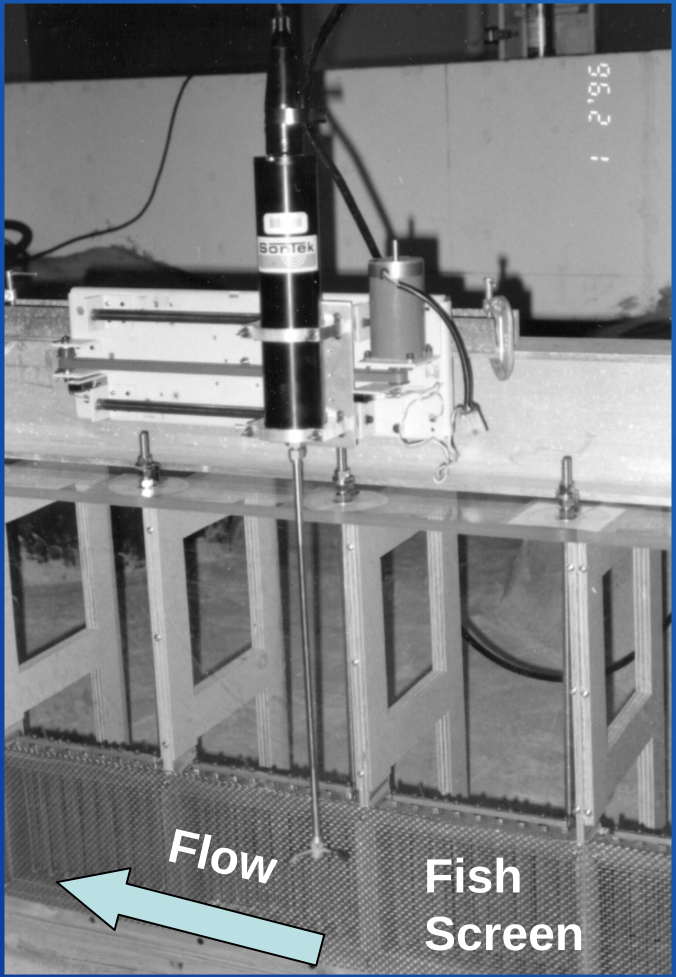
A velocity probe was used to measure velocities along the screen face

Velocity distribution along the screen face was an important aspect of this model study.

A 3-D acoustic Doppler velocimeter and a positioning table was used to measure the velocity field on all 15 screen bays.



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Photograph of the completed Wilkins Slough fish screen structure at Reclamation District 108

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Design of Boulder Weir and Rock Fishways for Native Fish Species

Taking Research from the Laboratory to the Field

Brent Mefford

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Design of Boulder Weir and Rock Fishways for Native Fish Species

The Rock Fishway with Boulder Weirs concept was developed as a mechanism for enabling two-way passage around low-head river diversion structures

Design of Boulder Weir and Rock Fishways for Native Fish Species

Laboratory Development

Scale-Model Concept

Prototype-Scale Laboratory Test Facility

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Design of Boulder Weir and Rock Fishways for Native Fish Species

Live Fish Laboratory Tests

Silvery Minnow

Shovel Nose Sturgeon

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Design of Boulder Weir and Rock Fishways for Native Fish Species

Research into fishway design resulted in the development of a standardized Boulder Weir Fishway

Boulder Weir Fishways have been constructed on a number of Reclamation and non-Reclamation diversion dams.

Photo: Recently constructed Rock Fishway at Derby Dam near Reno Nevada

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City of Albuquerque Drinking Water Project

Sediment Management Model

Tom Gill
Brent Mefford
Rudy Campbell

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Sediment Management Model

Model Design Considerations:

Sediment Transport Similarity – Initiation of motion for bed sediment particles must occur at corresponding model and prototype discharges.

To achieve this condition in the model, special adjustments were needed:

- A slope distortion of 6.5(model):1(prototype)
- Use of coal as model sediment (specific weight = 79 lbs/ft^3 vs sand specific weight = 165 lb/ft^3)

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Sediment Management Model

Data Acquisition Method:

Overhead Photography tracking floating objects
to determine surface velocity

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Sediment Management Model:
Sediment Exclusion Tests

An array of sediment exclusion structures installed in front of the diversion were tested.

The three most effective systems from initial tests were re-tested with multiple intake configurations.

Sediment Management Model

Bed-Load Diversion Limiting Tests:

No sediment exclusion system installed

Sediment is carried at an appreciable rate into the downstream diversion bay (seen in the lower half of the photo)

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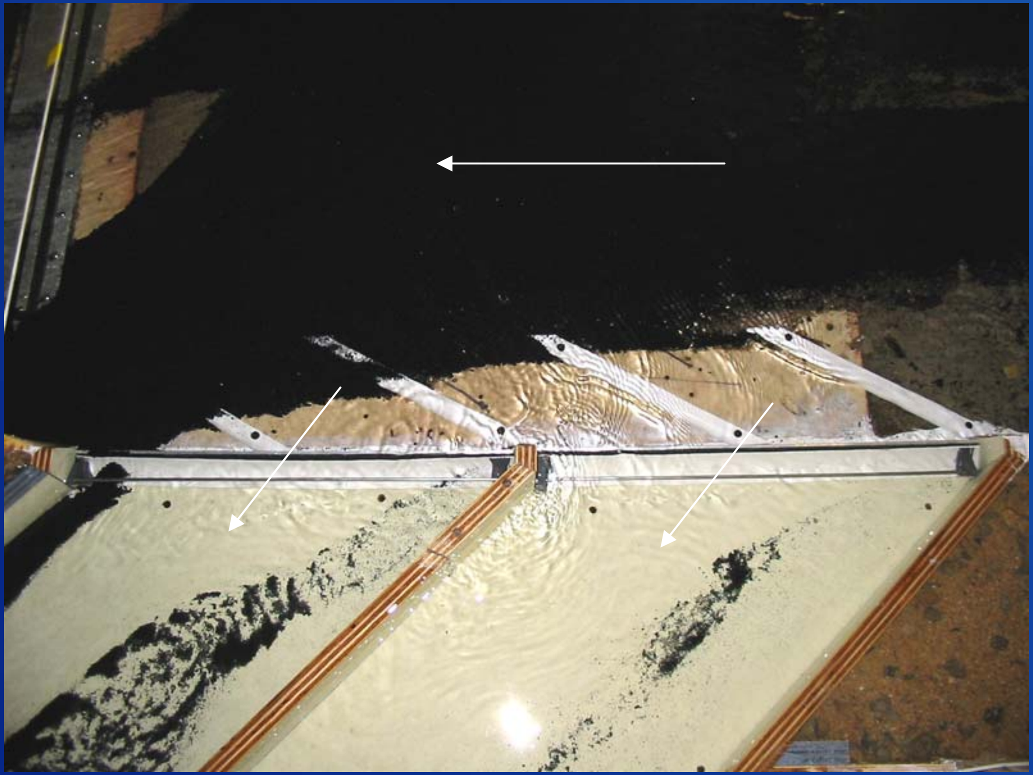
Sediment Management Model

Bed-Load Diversion Limiting Tests:

Straight vanes, angled away from the diversion mouth

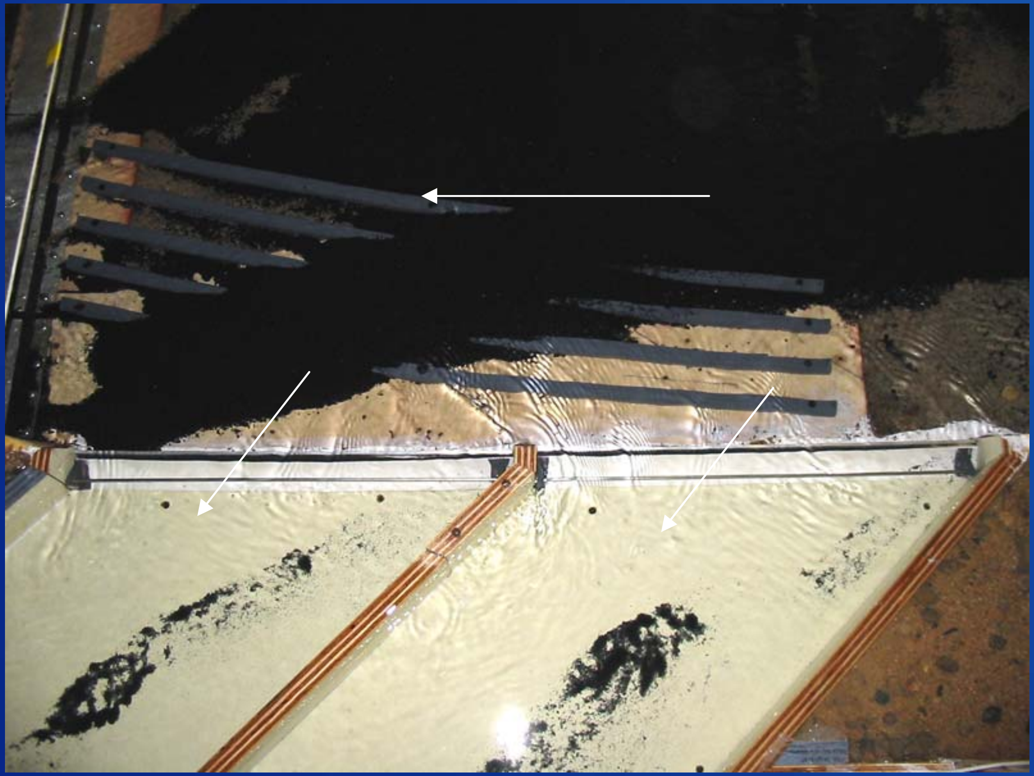


A reduced, but still significant rate of sediment diversion is observed entering the diversion bays

Sediment Management Model

Bed-Load Diversion Limiting Tests:

Long, curved vanes were installed on the channel bed in front of the intake mouth



Rate of sediment diversion observed is comparatively less than seen with straight vanes

Sediment Management Model

Bed-Load Diversion Limiting Tests:

A field of 16 “Iowa Vanes” is shown installed in front of the diversion.

The vane field is effective at directing sediment laden flow near the bed away from the diversion

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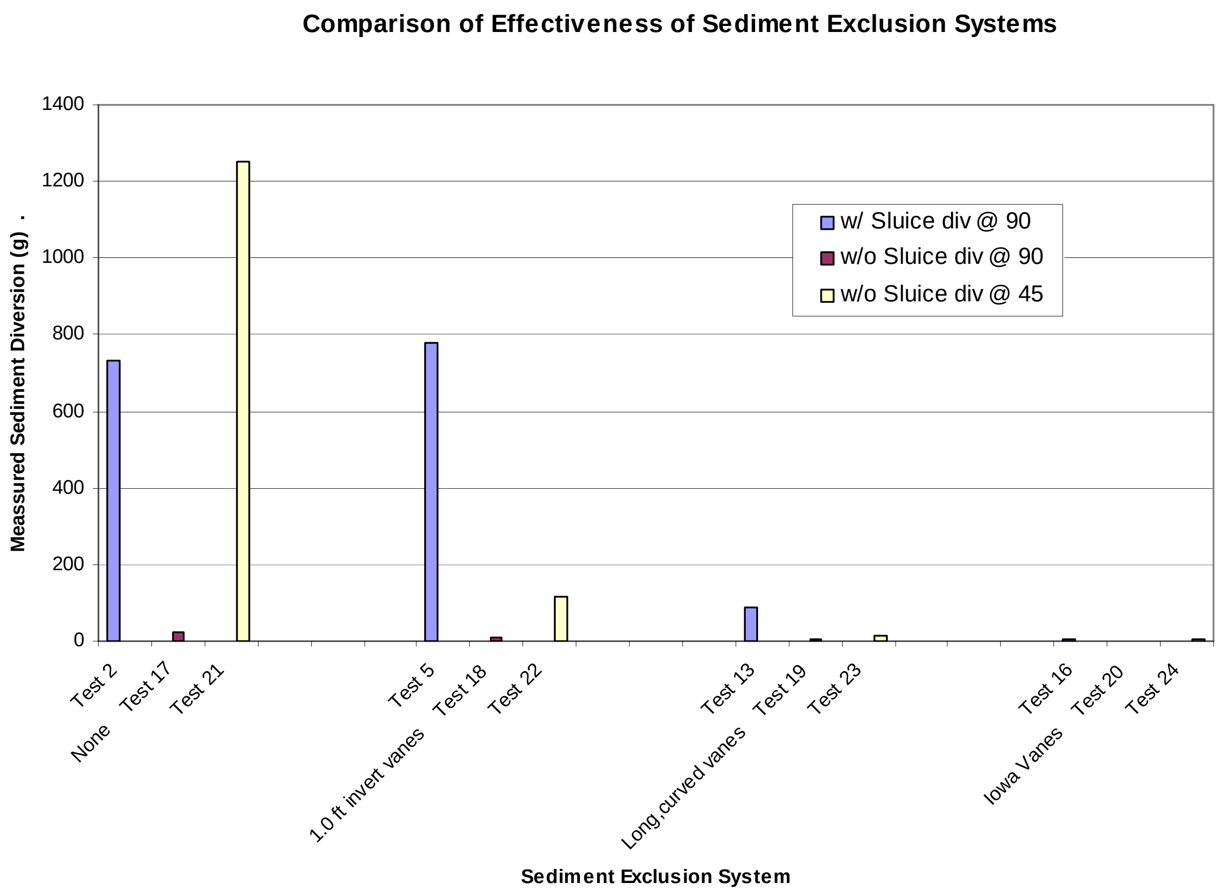
Sediment Management Model

Comparative sediment exclusion effectiveness of tested alternatives



City of Albuquerque Drinking Water Project

Design modifications identified and tested in the Sediment Management model study were incorporated into the design of the Rio Grande diversion structure, shown here under construction in Spring of 2005

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Rio Grande Silvery Minnow Sanctuary

Rio Grande River near
Albuquerque NM

A current laboratory model study is playing an integral role in Reclamation's efforts to support recovery of the endangered Rio Grande Silvery Minnow species

Brent Mefford
Joe Kubitschek

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Rio Grande Silvery Minnow Sanctuary

Project Goals:

Develop viable constructed habitat that combines flow and structure to:

- Maximize egg and larval retention
- Provide larval guidance to rearing habitat
- Accommodate sediment transport

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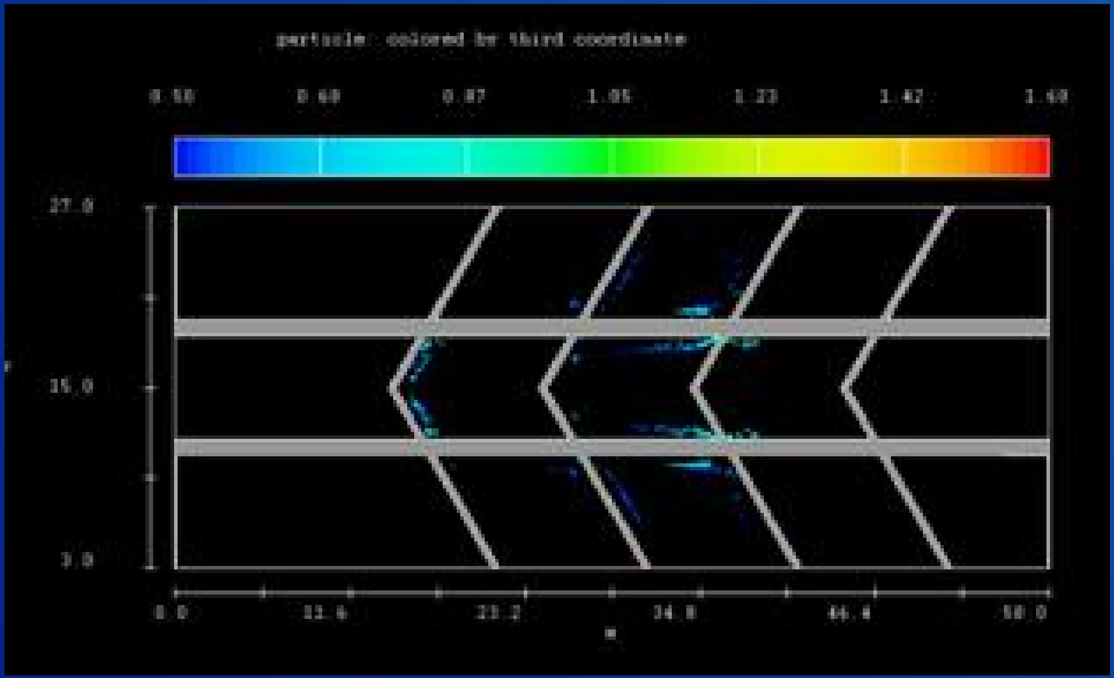
Rio Grande Silvery Minnow Sanctuary

Laboratory Study:

Computational Fluid Dynamics (CFD) Modeling



CFD modeling was conducted as the initial phase to "pre-screen" alternatives

It is expected CFD modeling can be used to fine tune the field-constructed habitat

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Rio Grande Silvery Minnow Sanctuary

Laboratory Study:

A physical model was built to develop and demonstrate concepts that:

- Maximize egg and larval retention
- Provide guidance to rearing habitat
- Exhibit suitable sediment transport characteristics
- Minimize maintenance requirements

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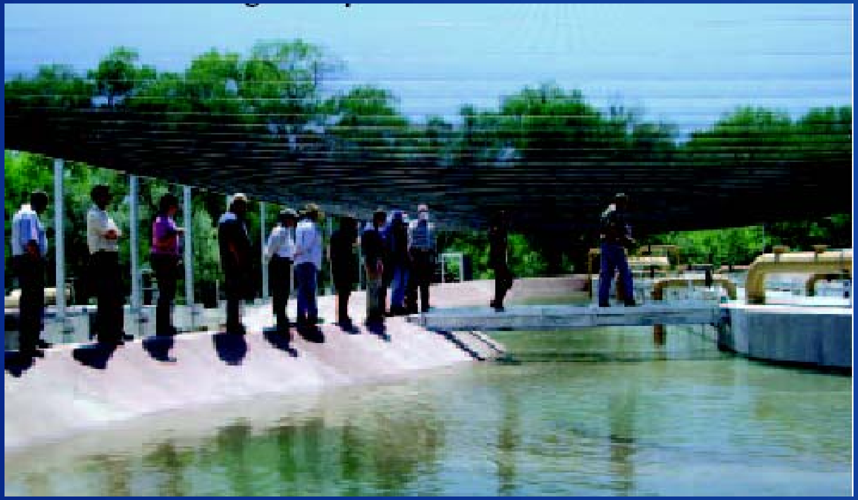
Rio Grande Silvery Minnow Sanctuary

Associated Field Projects



An off stream Silvery Minnow Refugia has been established at Albuquerque's Biological Park

Start of construction is planned for Fall of 2005 for a Silvery Minnow Sanctuary to be located in the Albuquerque vicinity within the river levee

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End of Station 1 presentation

Please proceed south to Station 2

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