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Howard Hanson Dam:
Hydraulic Design of Juvenile Fish Passage Facility in Reservoir with Wide Pool Fluctuation

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Mobile District
and
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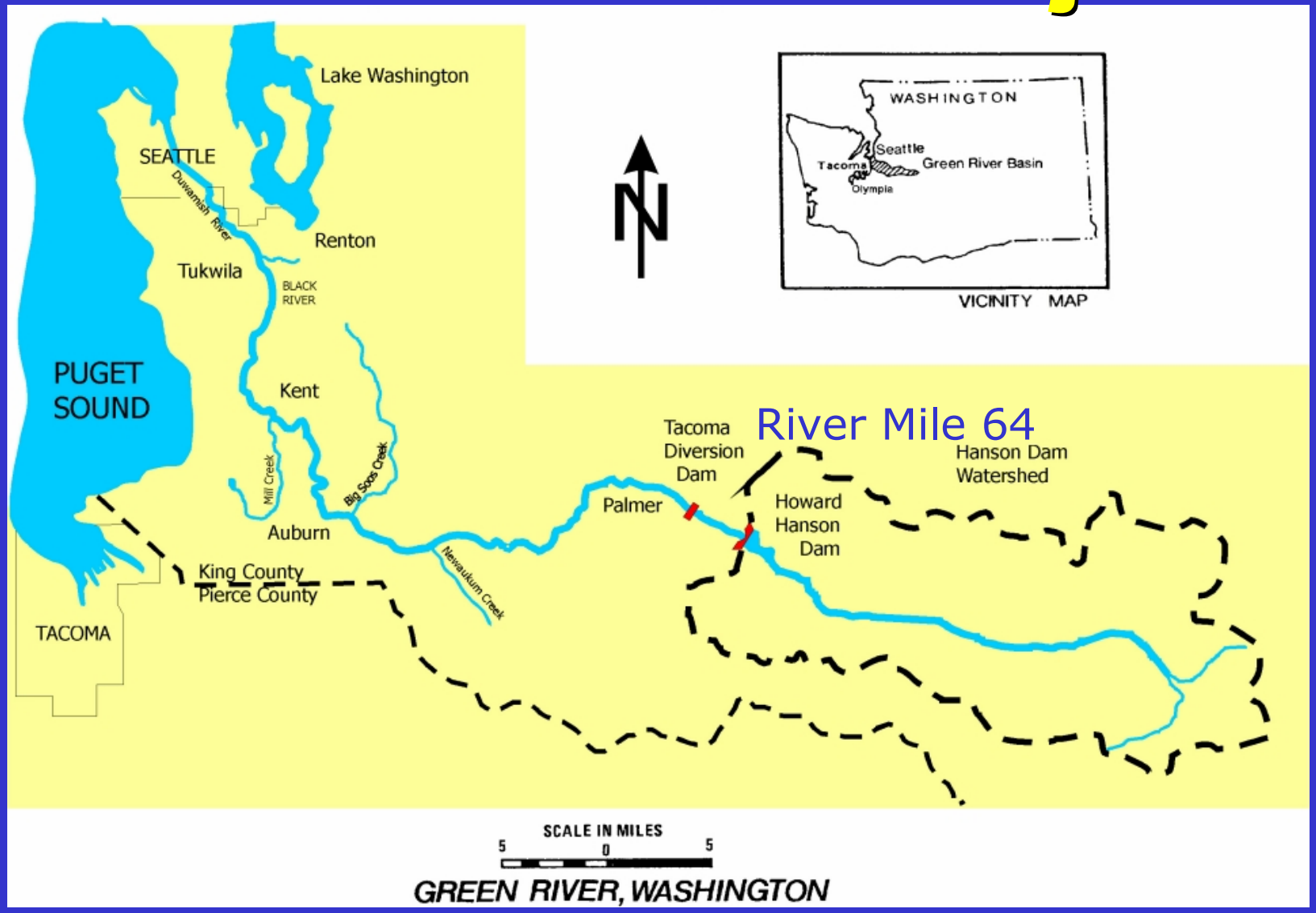
Seattle District
US Army Corps of Engineers

Howard Hanson Project



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Howard Hanson Reservoir

- **Pool Fluctuation:** 100 ft
- **Reservoir Length:** 5 miles
- **Reservoir Depth:** can exceed 140 ft. at dam
- **Fish:** Coho, Chinook, Steelhead

Howard Hanson Dam

Concrete Spillway:
Capacity 107 Kcfs

Spillway Tainter Gates:
45 x 30 ft

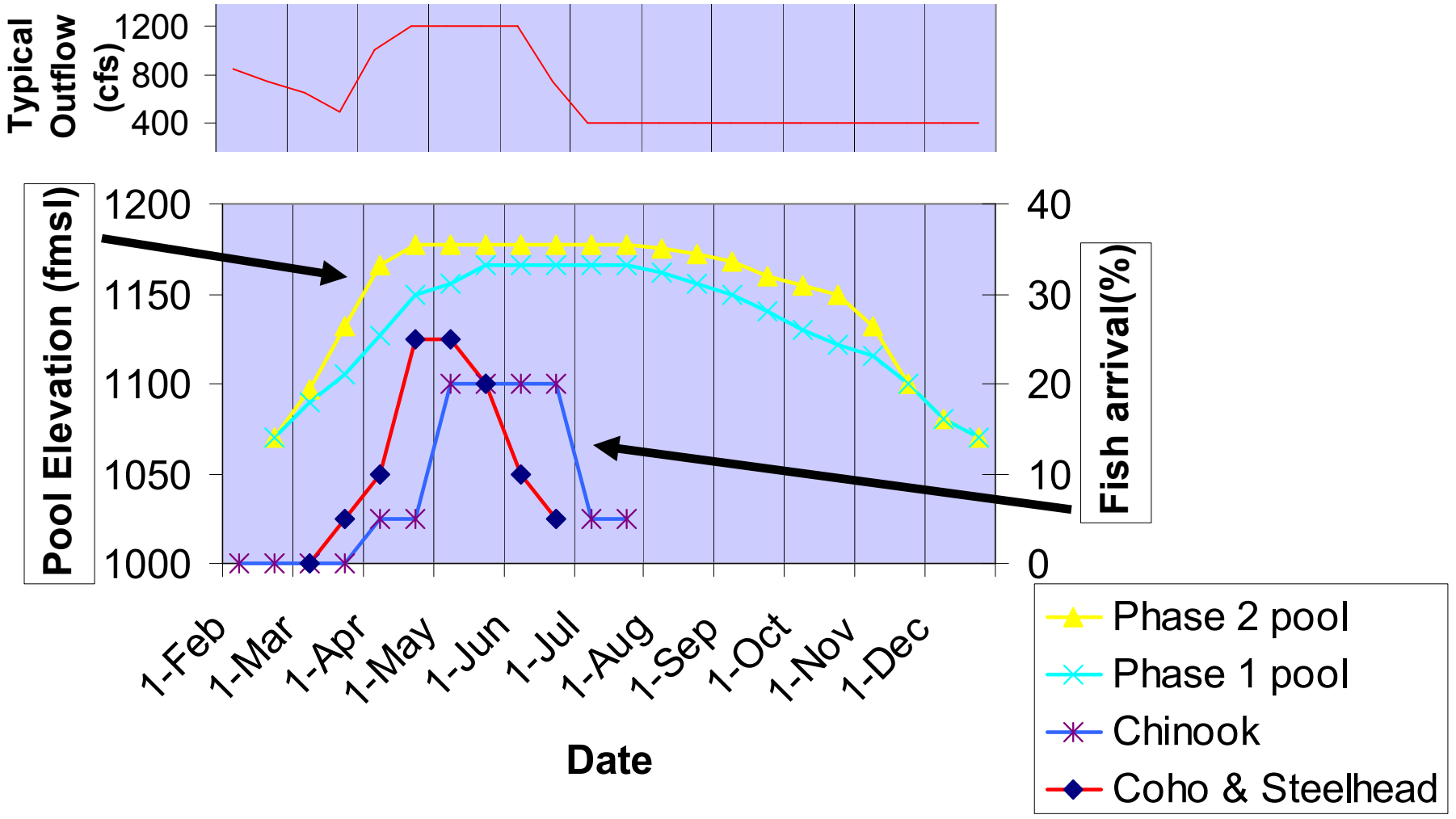
Length at Crest: 450 ft

Outlet Tunnel:

- 19 ft wide x 900 ft long
- 2 Tainter Gates, 10 x 12 ft
- Normal Capacity: 10 kcfs
- Auxiliary low-flow tunnel (0.5 kcfs)

Tailrace Features

Typical Project Operations & Timing



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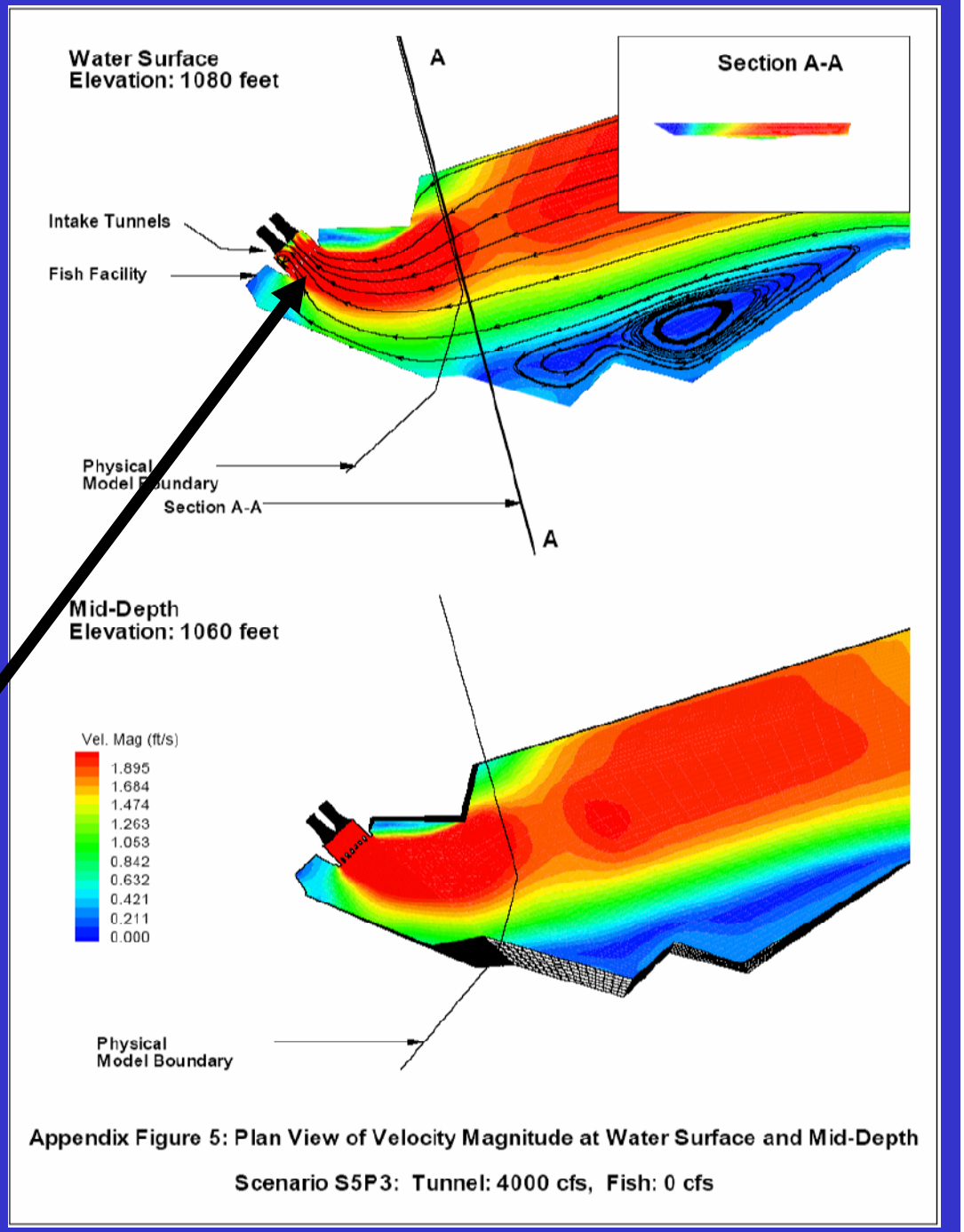
Howard Hanson Forebay

- **Without Fish Facility**
- **Existing Tunnel Only**
- **Low Pool**

- **Note Strong Surface Current at Low Pool**



Appendix Figure 5: Plan View of Velocity Magnitude at Water Surface and Mid-Depth

Scenario S5P3: Tunnel: 4000 cfs, Fish: 0 cfs

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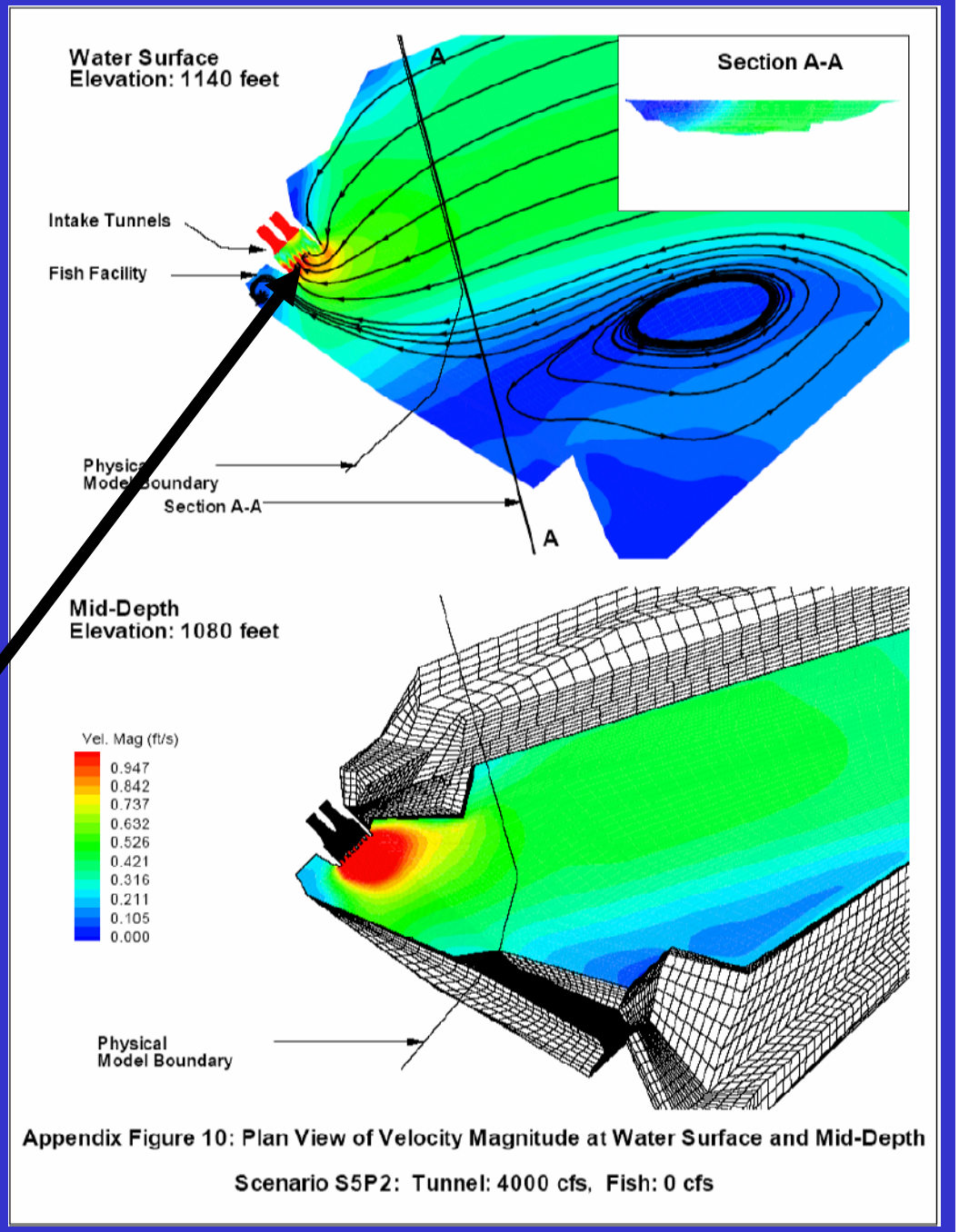
Howard Hanson Forebay

- **Without Fish Facility**
- **Existing Tunnel Only**
- **High Pool**

Note Weaker Surface Current at High Pool



Appendix Figure 10: Plan View of Velocity Magnitude at Water Surface and Mid-Depth

Scenario S5P2: Tunnel: 4000 cfs, Fish: 0 cfs

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Howard Hanson juvenile fish facility

Primary Project Goals

- Reduce juvenile passage delay
- Improve juvenile passage survival
- No impact on existing project function

Specific Design Goals

- Operating Range: 97 feet
- Facility Flow: 400 cfs to 1200 cfs
- Meet appropriate velocity, velocity gradient, energy dissipation, and screen criteria

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What is the best design alternative?

Proposed Facility...

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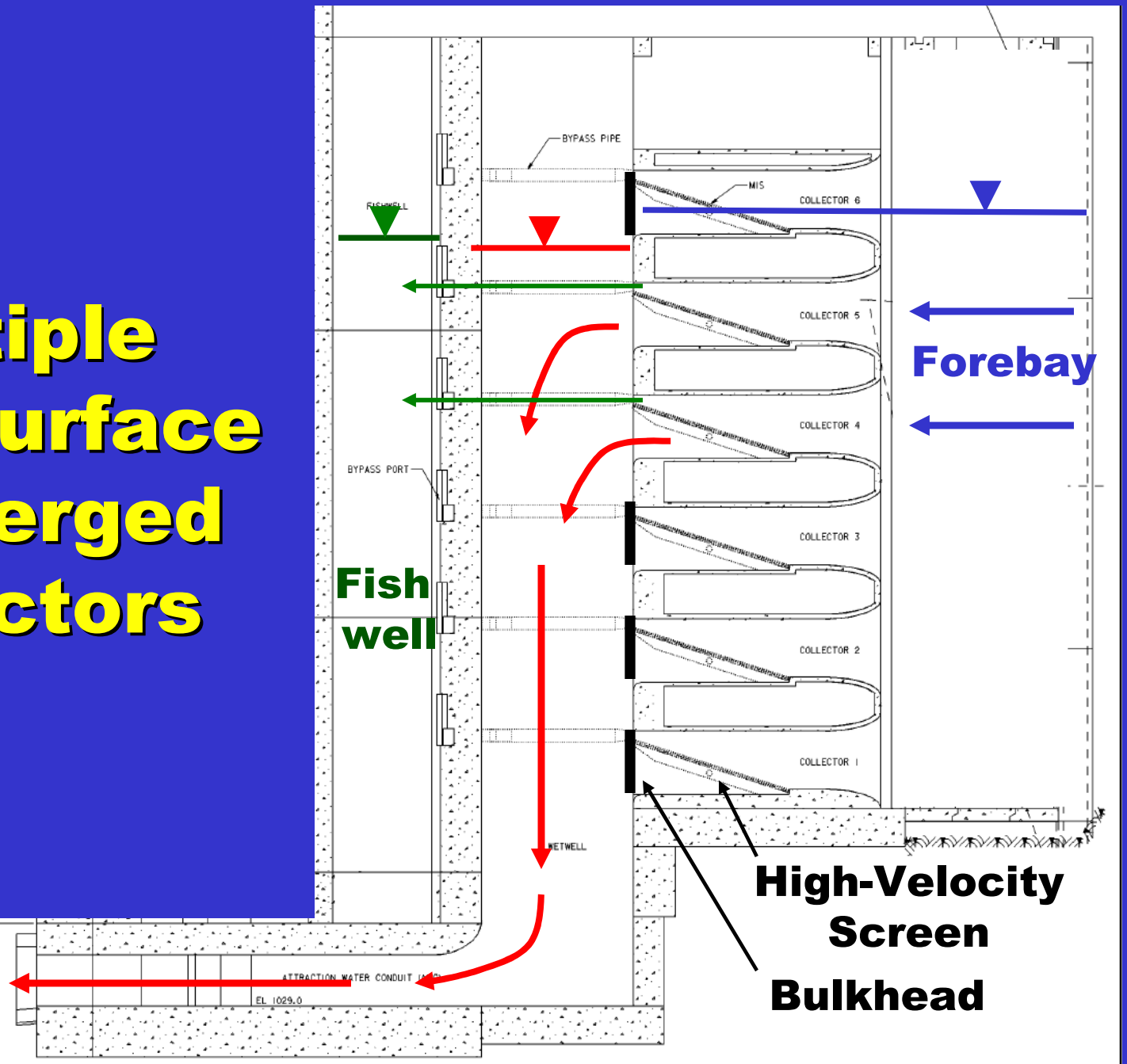
Multiple Near-Surface Submerged Collectors



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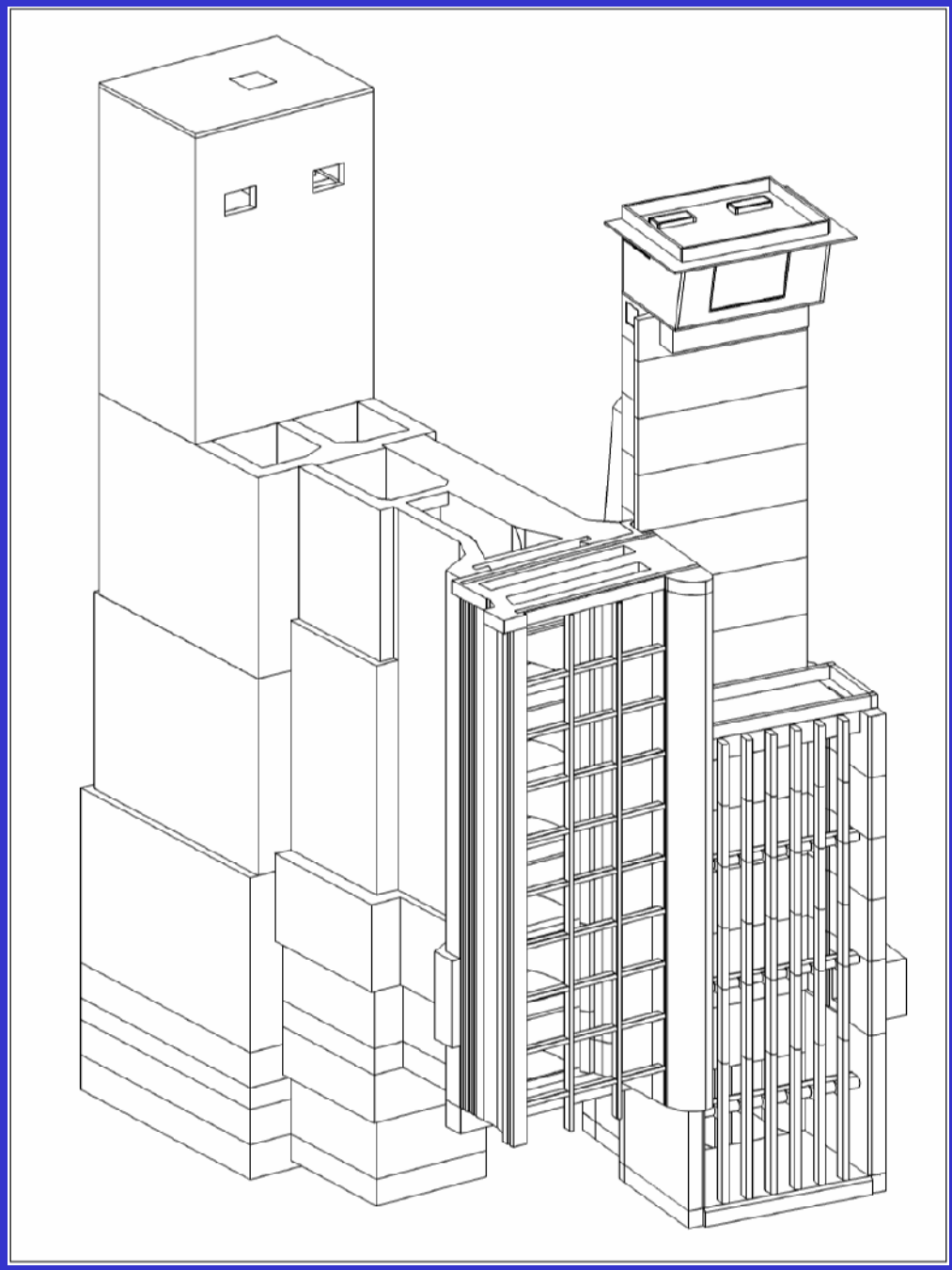
Goal:
No impact on existing function

Junction with adjacent flood-control tunnel...



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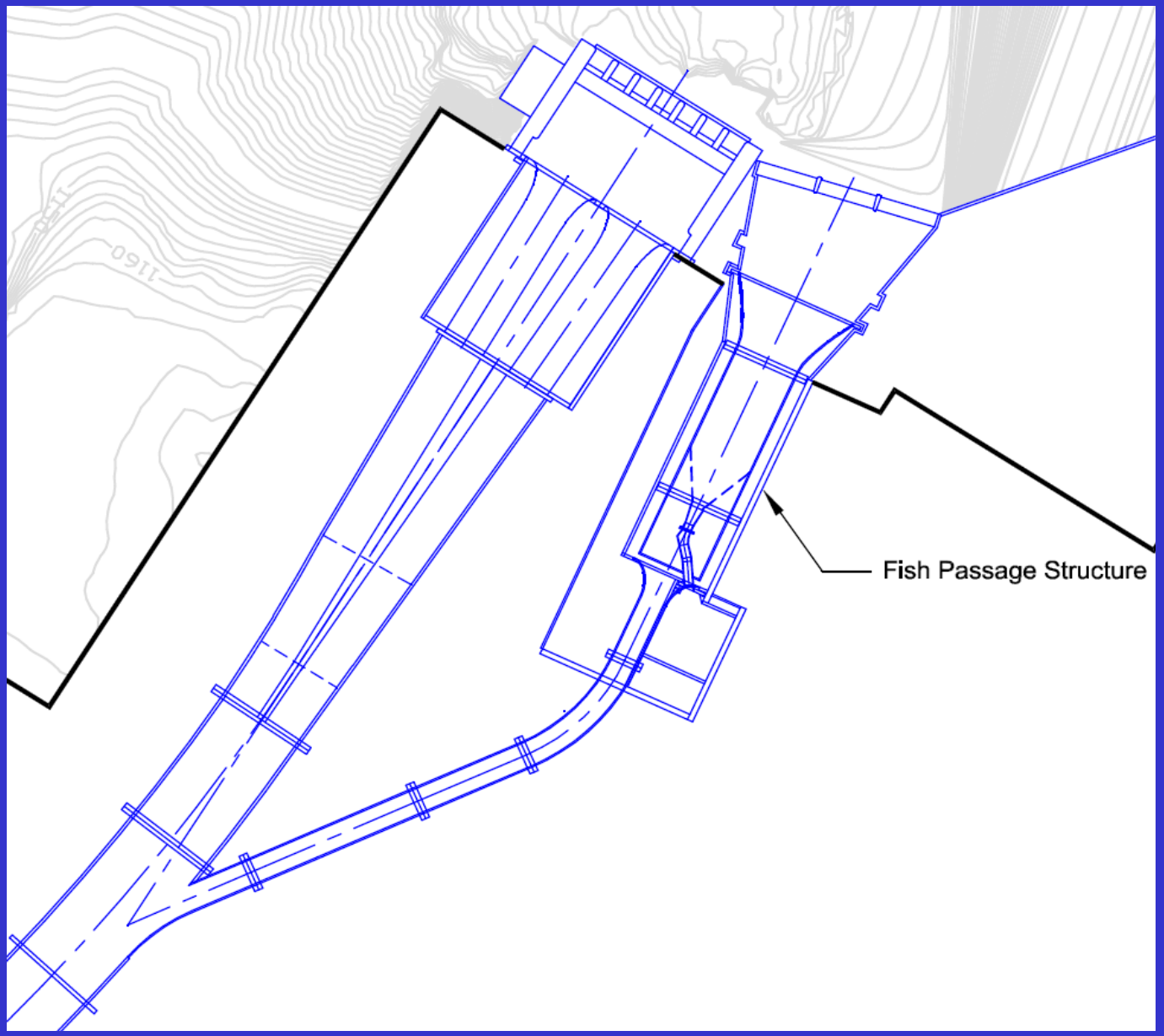
Plan View of tunnel junction



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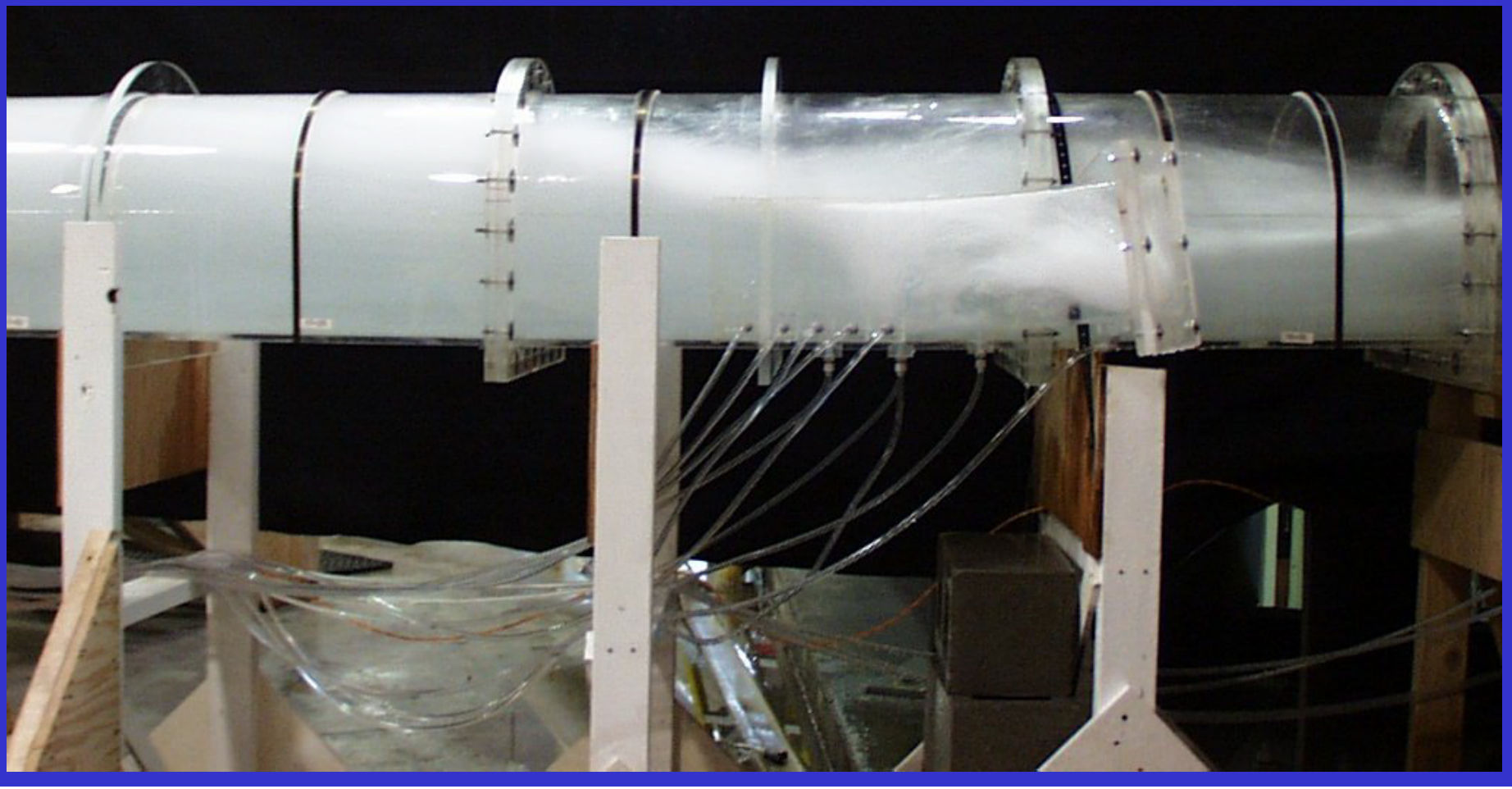
Tunnel Junction Concerns

- Highly Supercritical Flow
- Cavitation
- Stability of Water Surface
- Air movement



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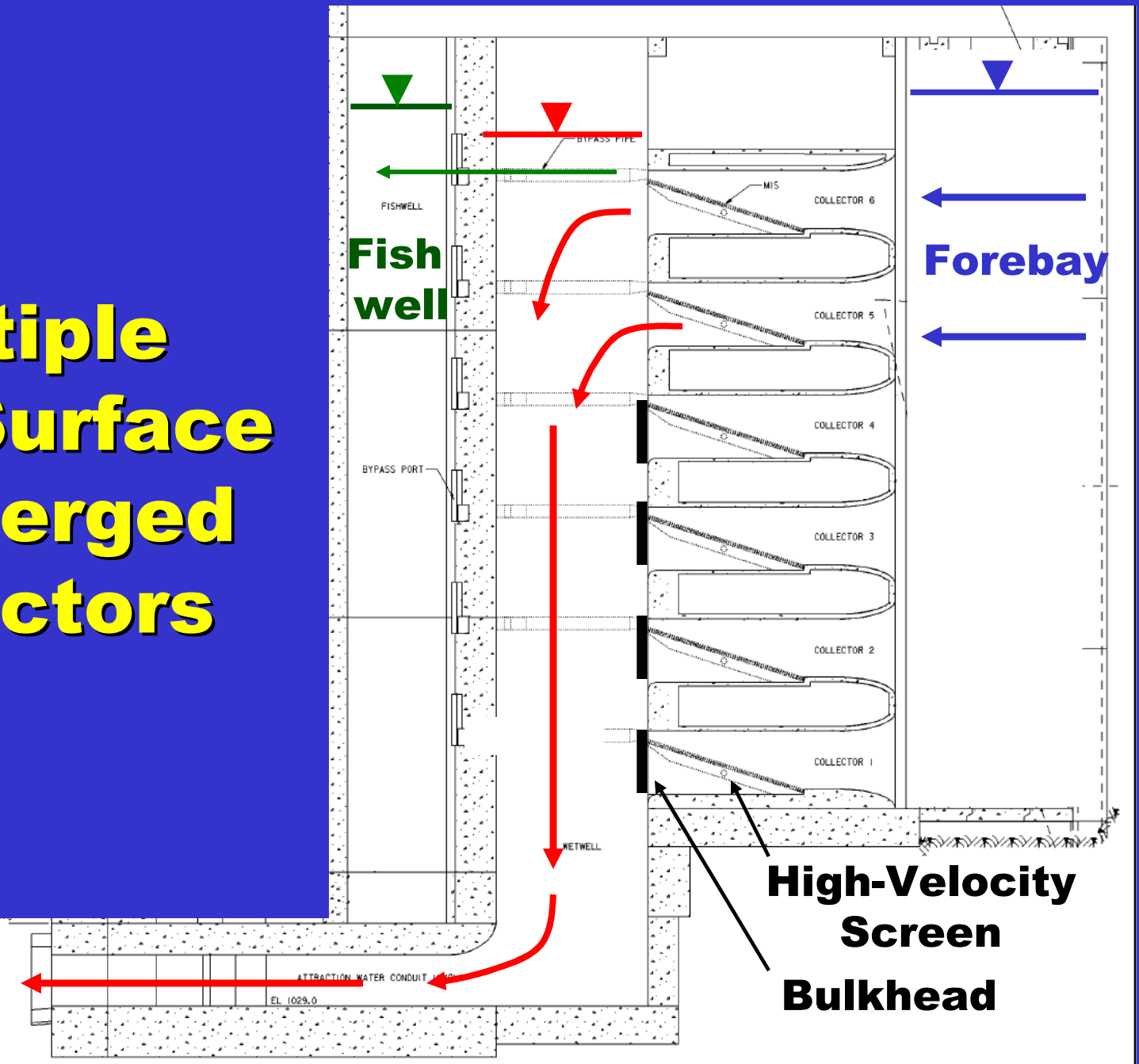
Multiple Near-Surface Submerged Collectors



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Goal:

Reduce Delay...

Plan view of collector entrance

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Goal:
Reduce Delay

High Forebay with Juvenile Fish Facility

Low-level outlet closed

Note Strong Surface Current at High Pool

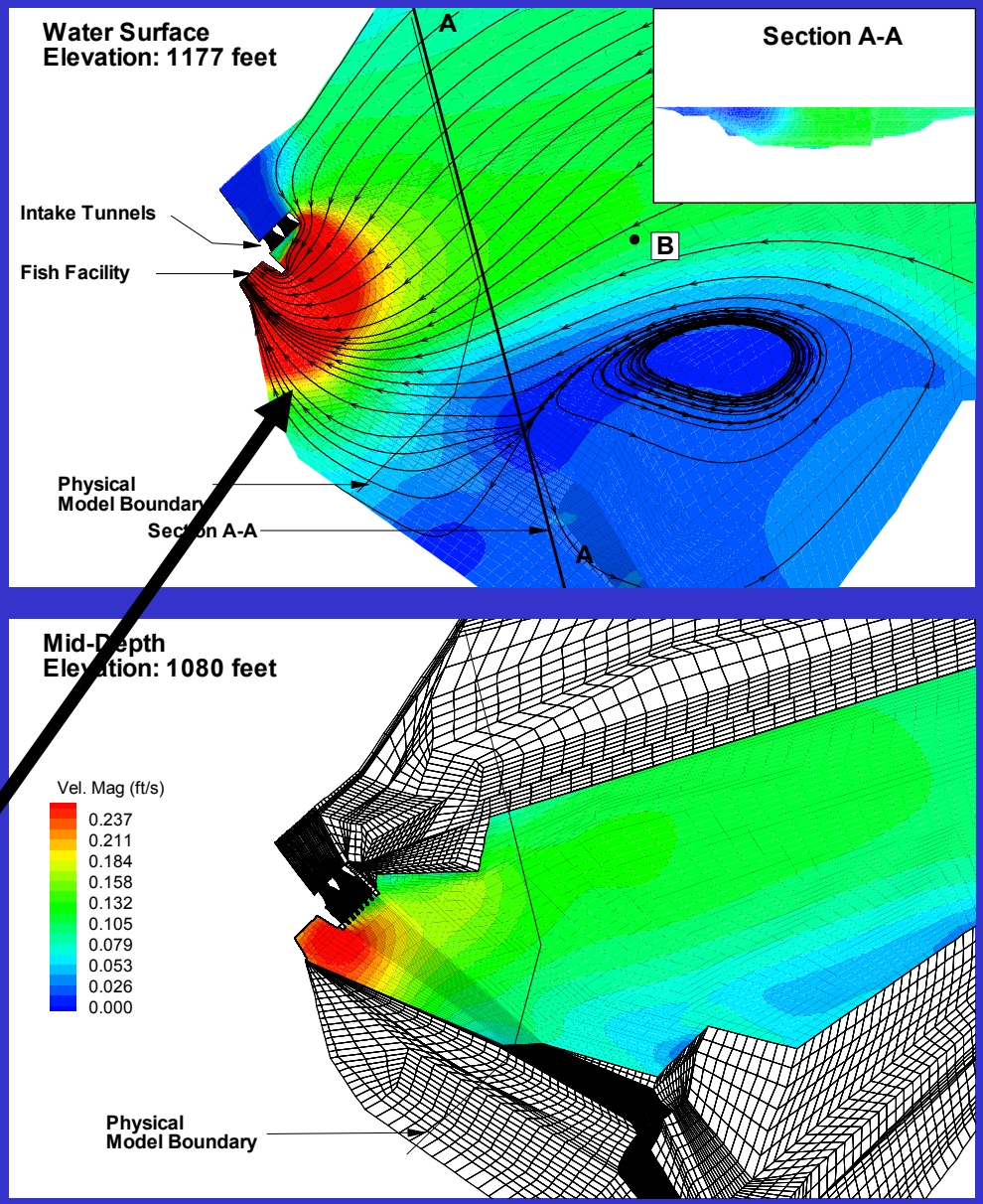

Figure 5: Plan View of Velocity Magnitude at Water Surface and Mid-Depth

Scenario S4P1: Tunnel: 0 cfs, Fish: 1300 cfs

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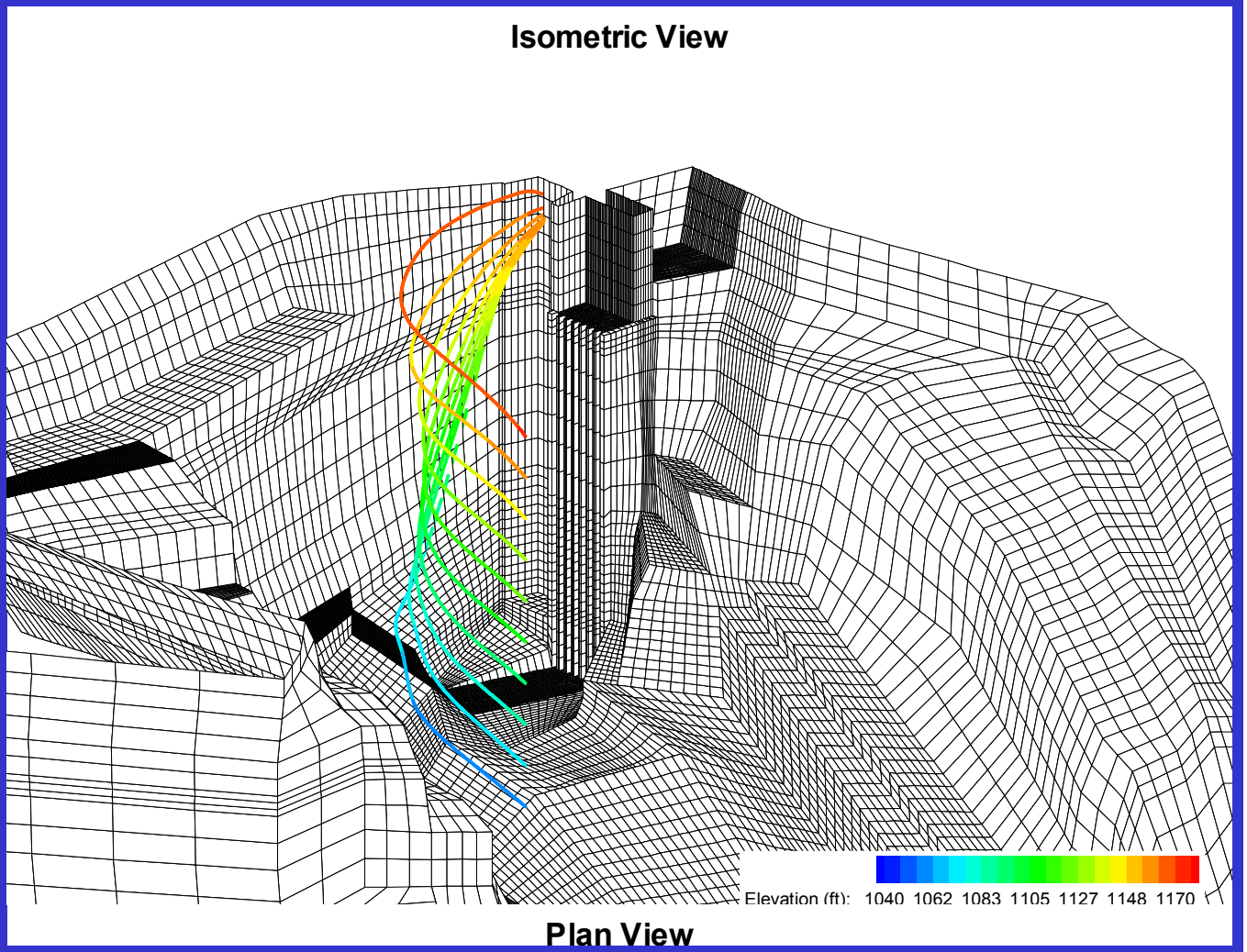
Goal:
Reduce Delay

High Forebay with Juvenile Fish Facility

Low-level outlet closed



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Goals: Reduce Delay and Improve Survival

Side View of Fish Passage Facility

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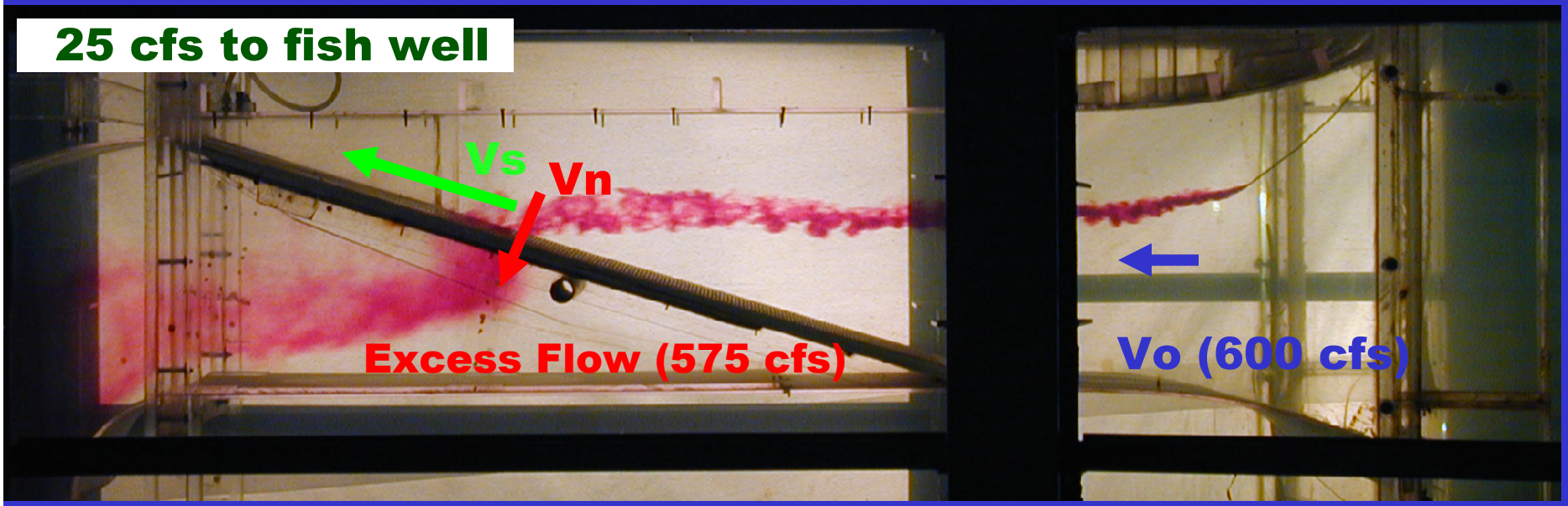
Fish Screen in Normal Operation

Fish Capture Criteria
6 to 8 fps

25 cfs to fish well



High Velocity Screen Criteria
- Vs / Vn > 2.2
- Vn / Vo < 0.45

Entrance Criteria
- Velocity Gradient < 0.3 fps / ft
- Design Vo = 6 fps @ 600 cfs

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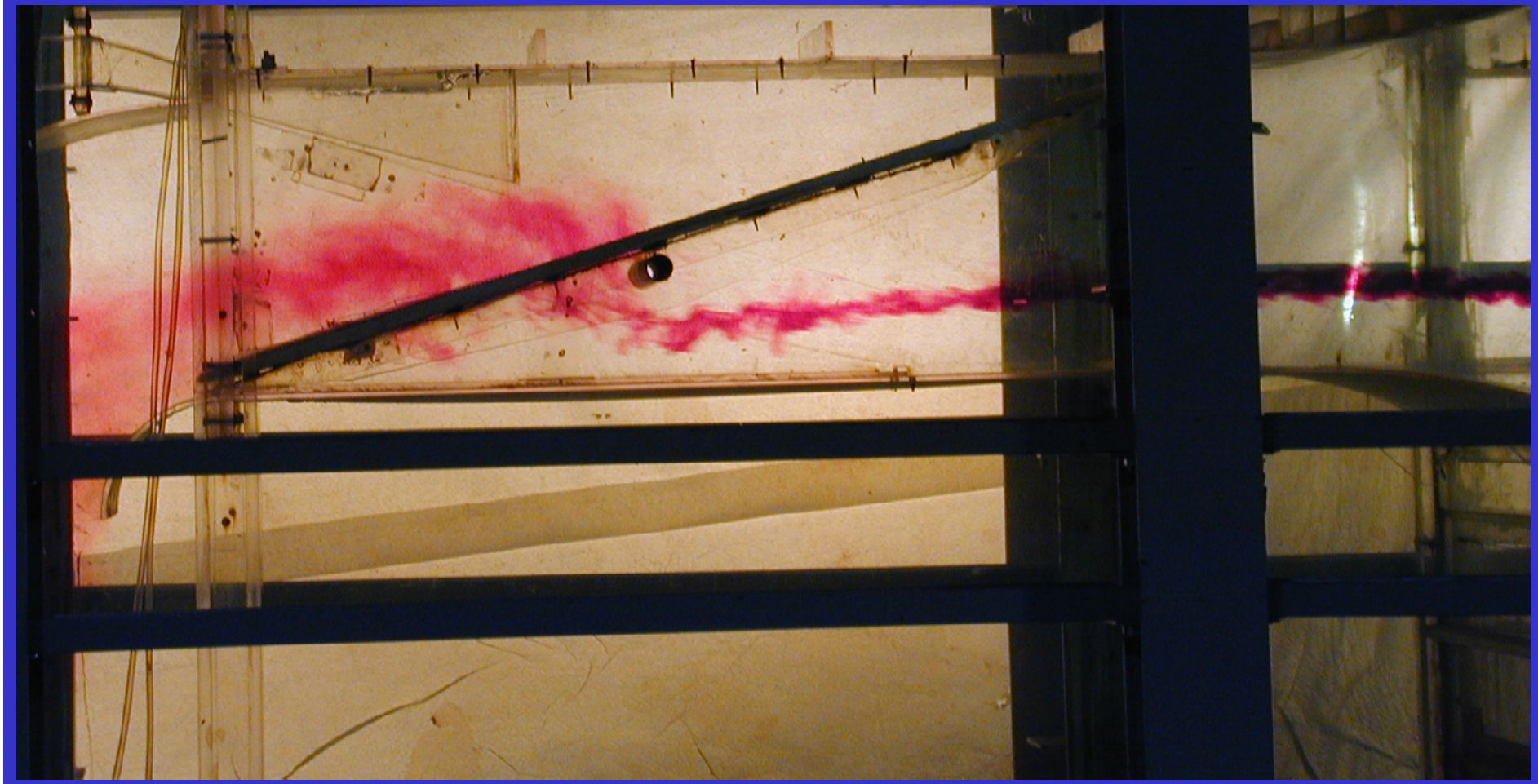
Debris

Fish Screen in Backflush Operation



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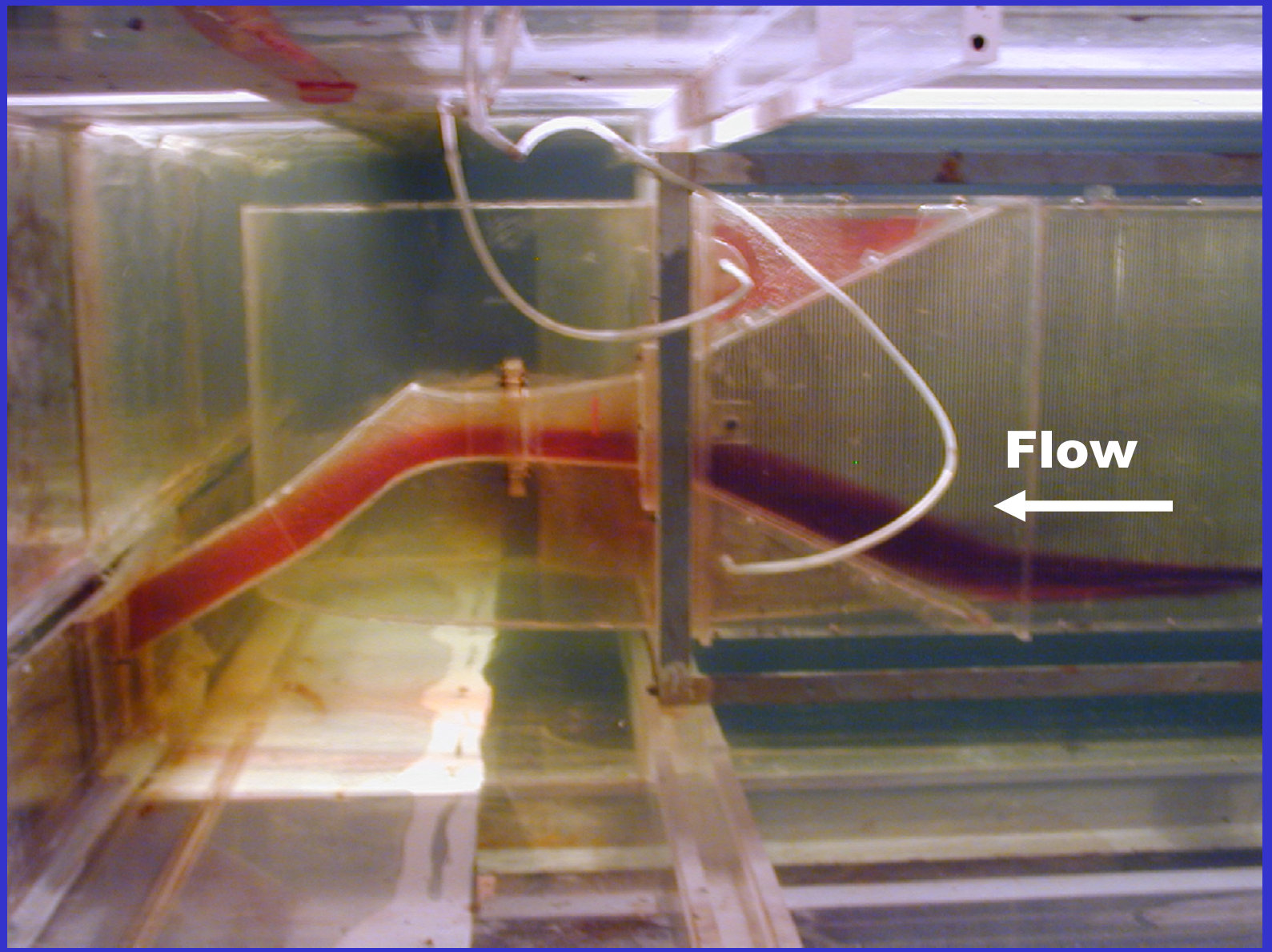
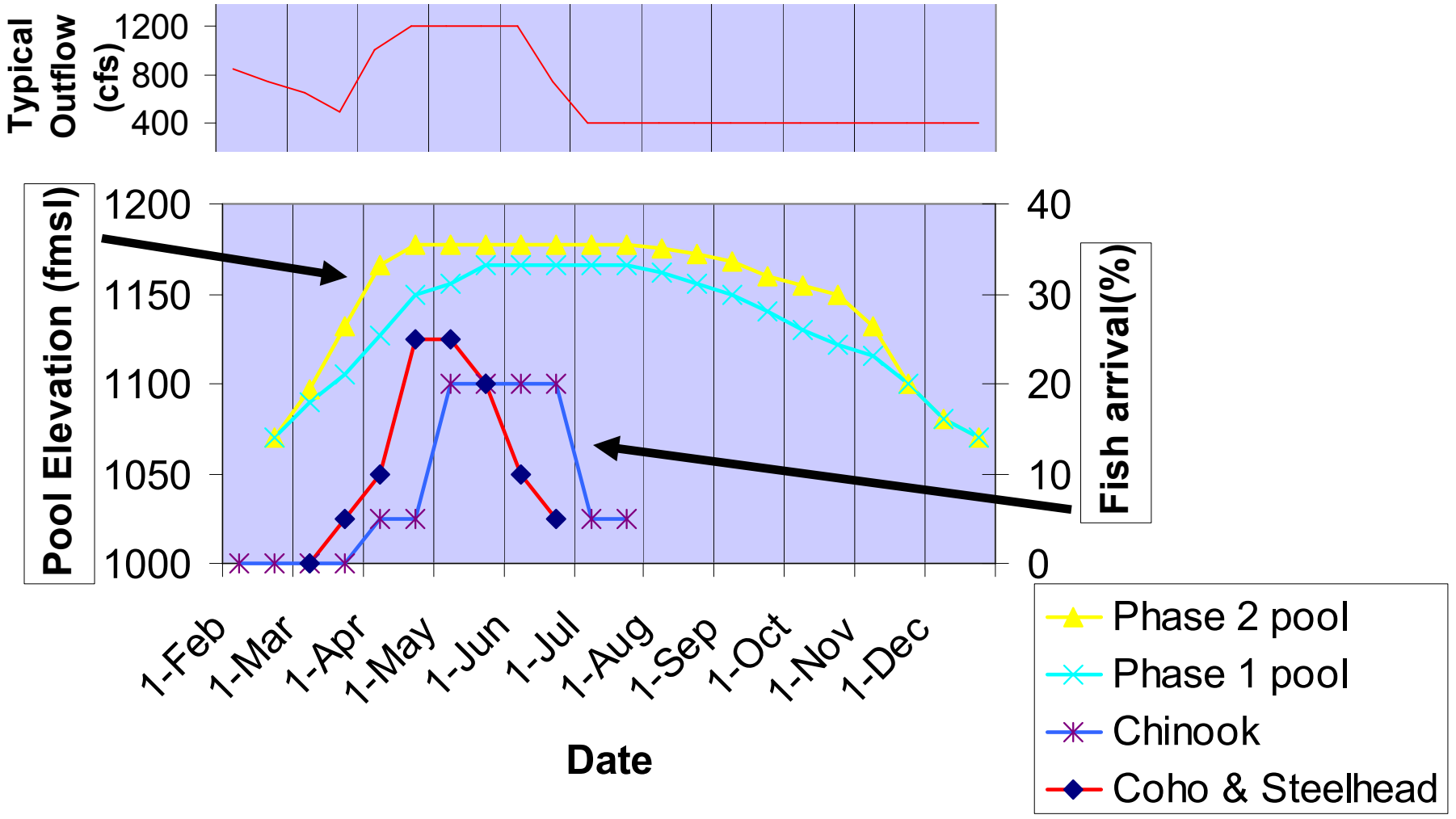
Pathway to fish well along screen and screen enclosure (Plan View)



Velocity and energy dissipation in fish lock

A Remaining Concern.



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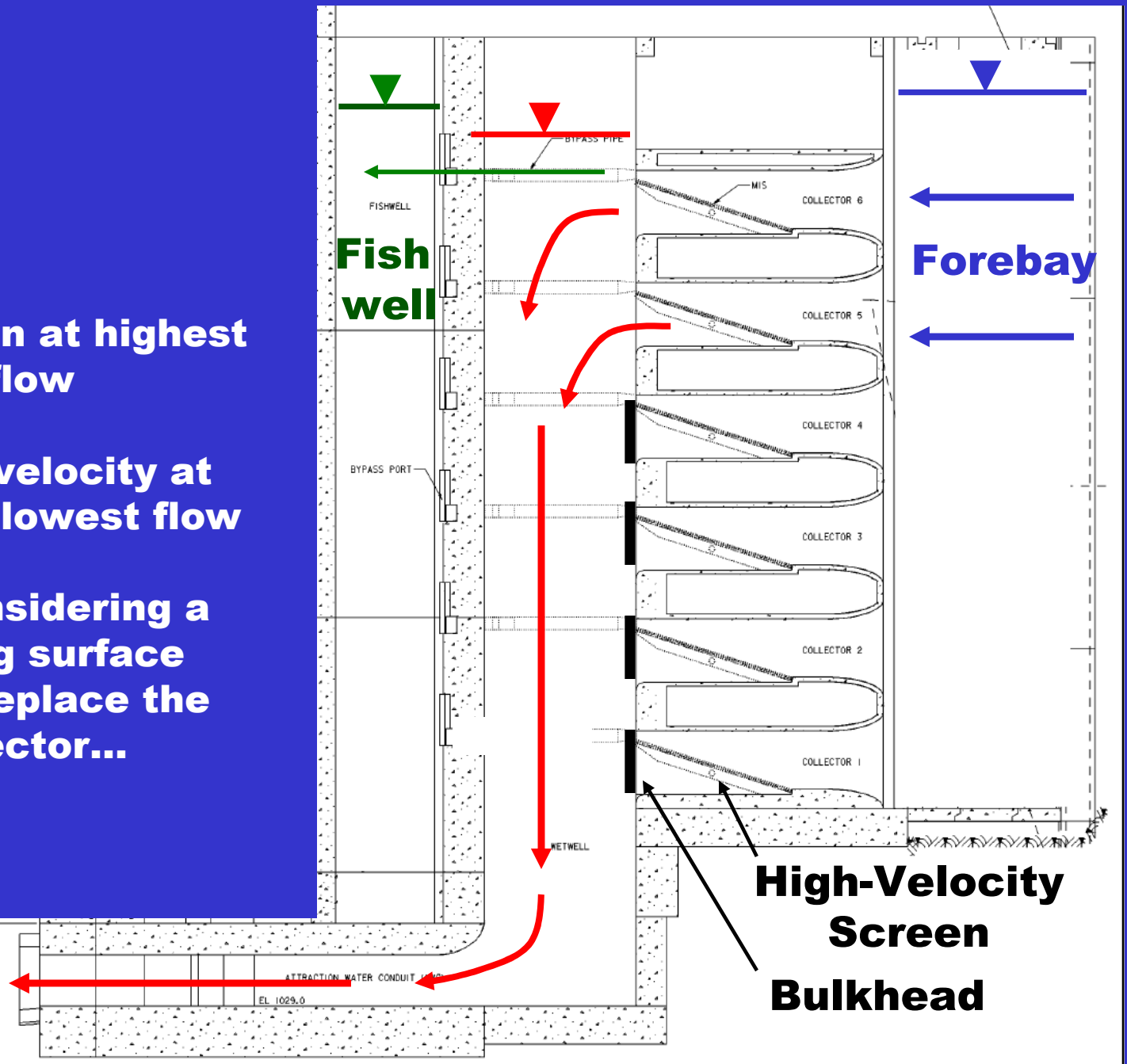
Fish attraction at highest pool, lowest flow

Fish capture velocity at highest pool, lowest flow

Presently considering a small, floating surface collector to replace the topmost collector…



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Questions?

Sample Surface Collector Design

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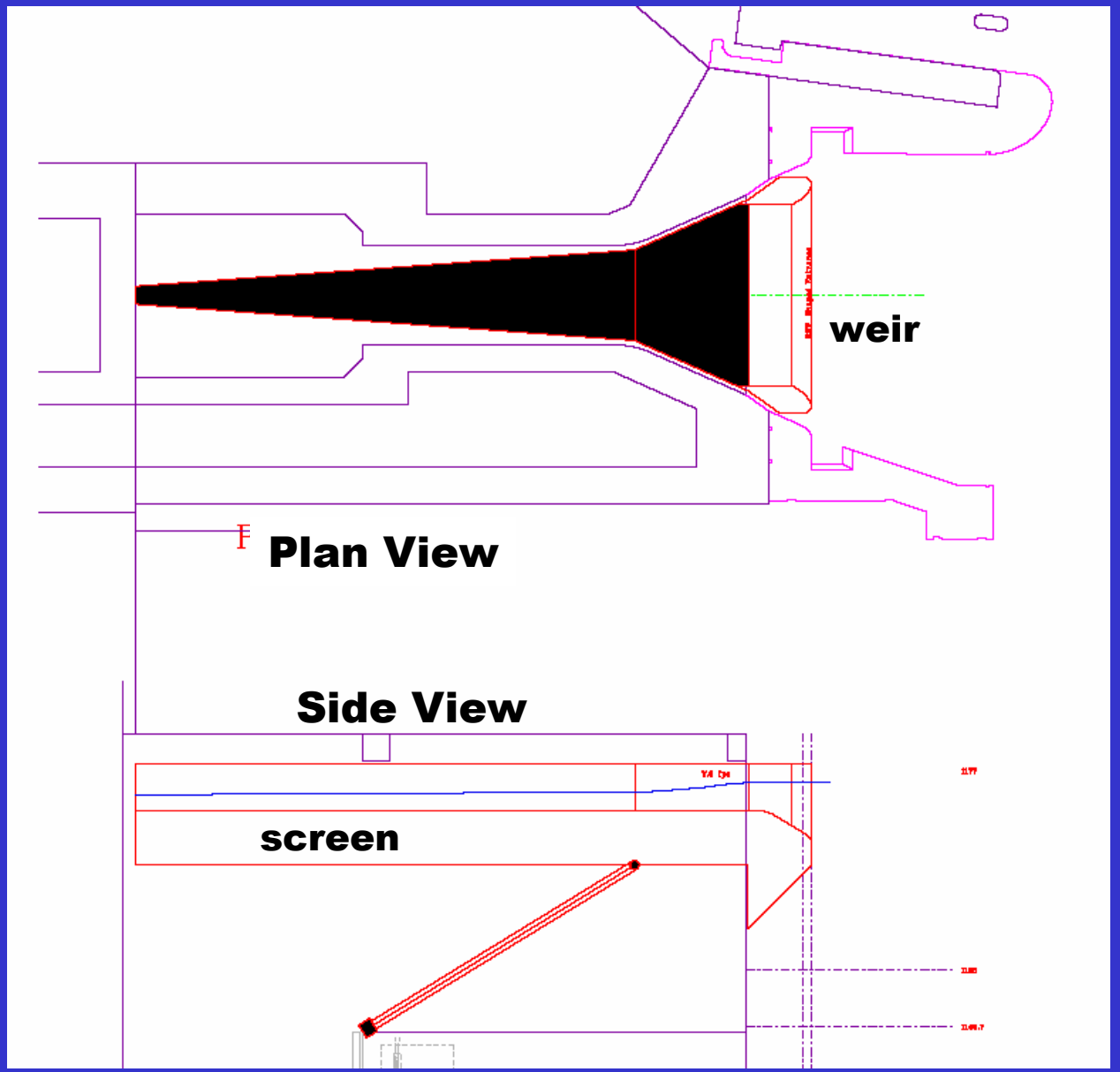
- **Issues:**

Operational complexity
Compatibility with existing design
Cost
Is it necessary?



Howard Hanson fish facility: hydraulic design considerations

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- High head radial gate and vertical emergency gate
- Highly supercritical confluence
- Constant dv/dx intake
- Screen enclosure
- Fish-friendly bypass
- Wet well size
- Fish bypass system to pool below
- PHYSICAL MODELING
  - 1:? Scale forebay and stilling basin model
  - Sectional model (approach flow, wet-well, conduit intake, flood control tunnel)
  - Screen model
  - Physical/biological fish well model
- NUMERICAL MODELING
  - Forebay (to set BC's for sectional model)
  - 3-D fish well model (I did this on the side)
- Modeling of new conduit and junction with existing tunnel.
- Flow Control and AWC.

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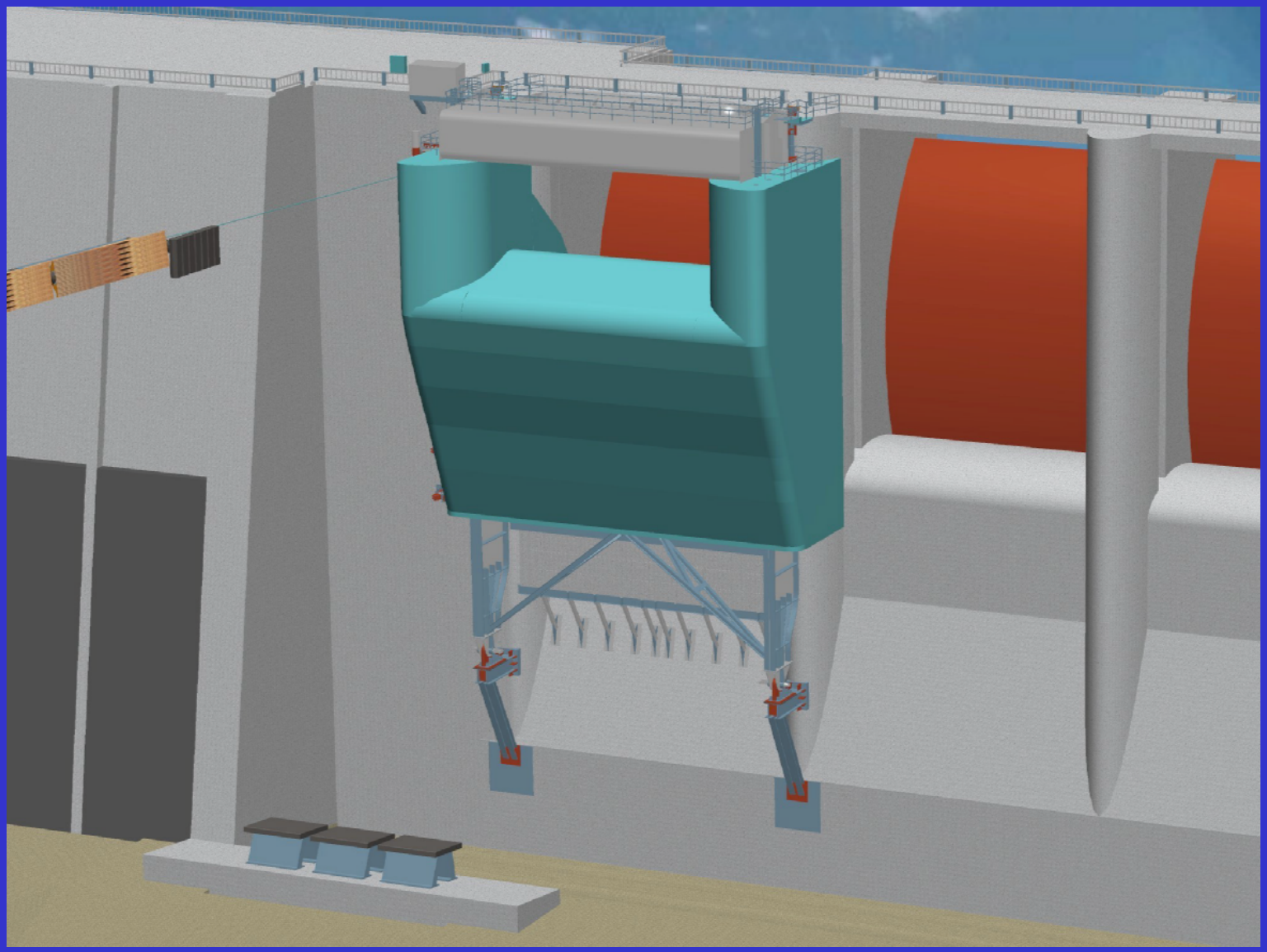
Removable Spillway Weir

Typical Snake River Project



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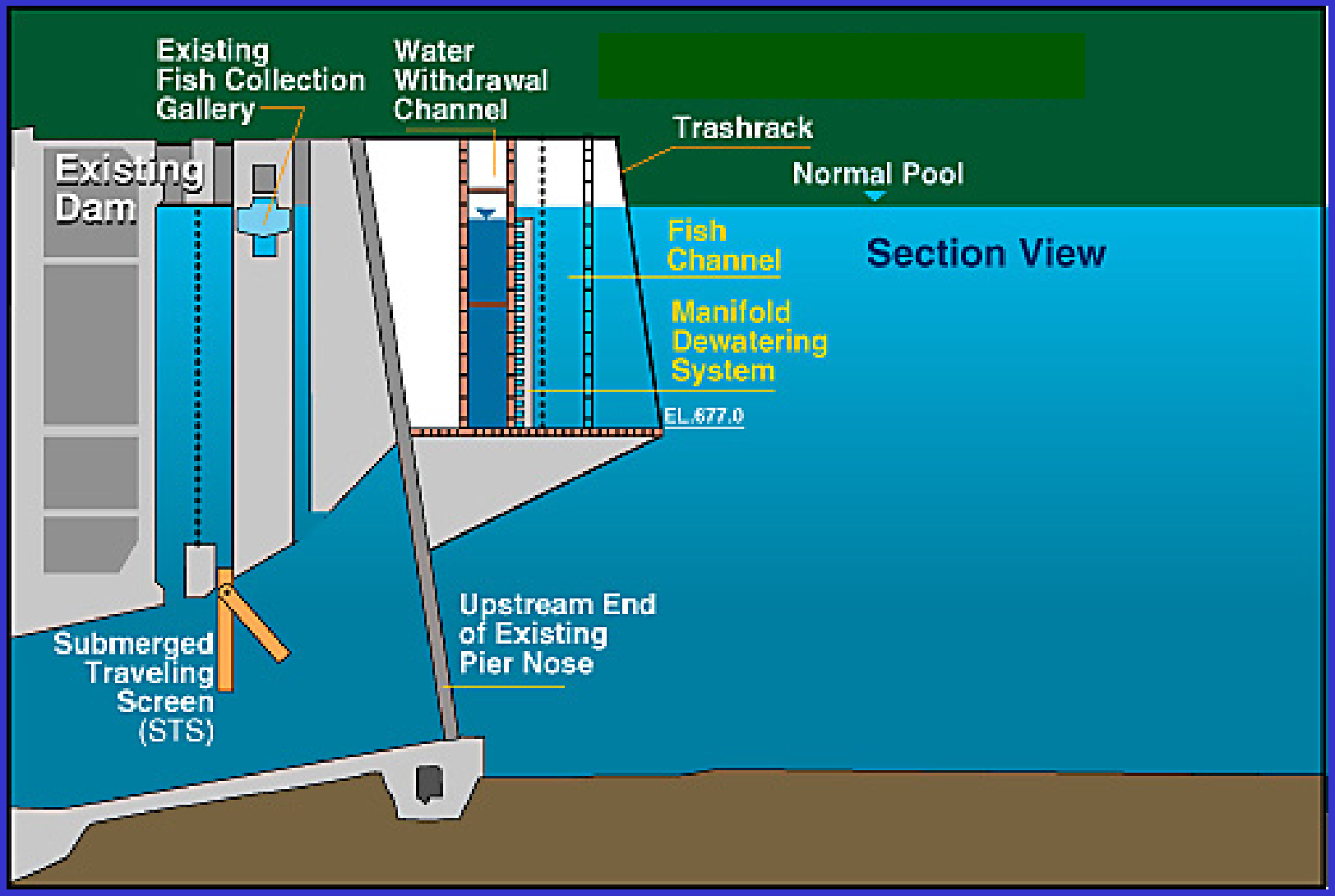
Powerhouse Passage
Typical Snake River Project



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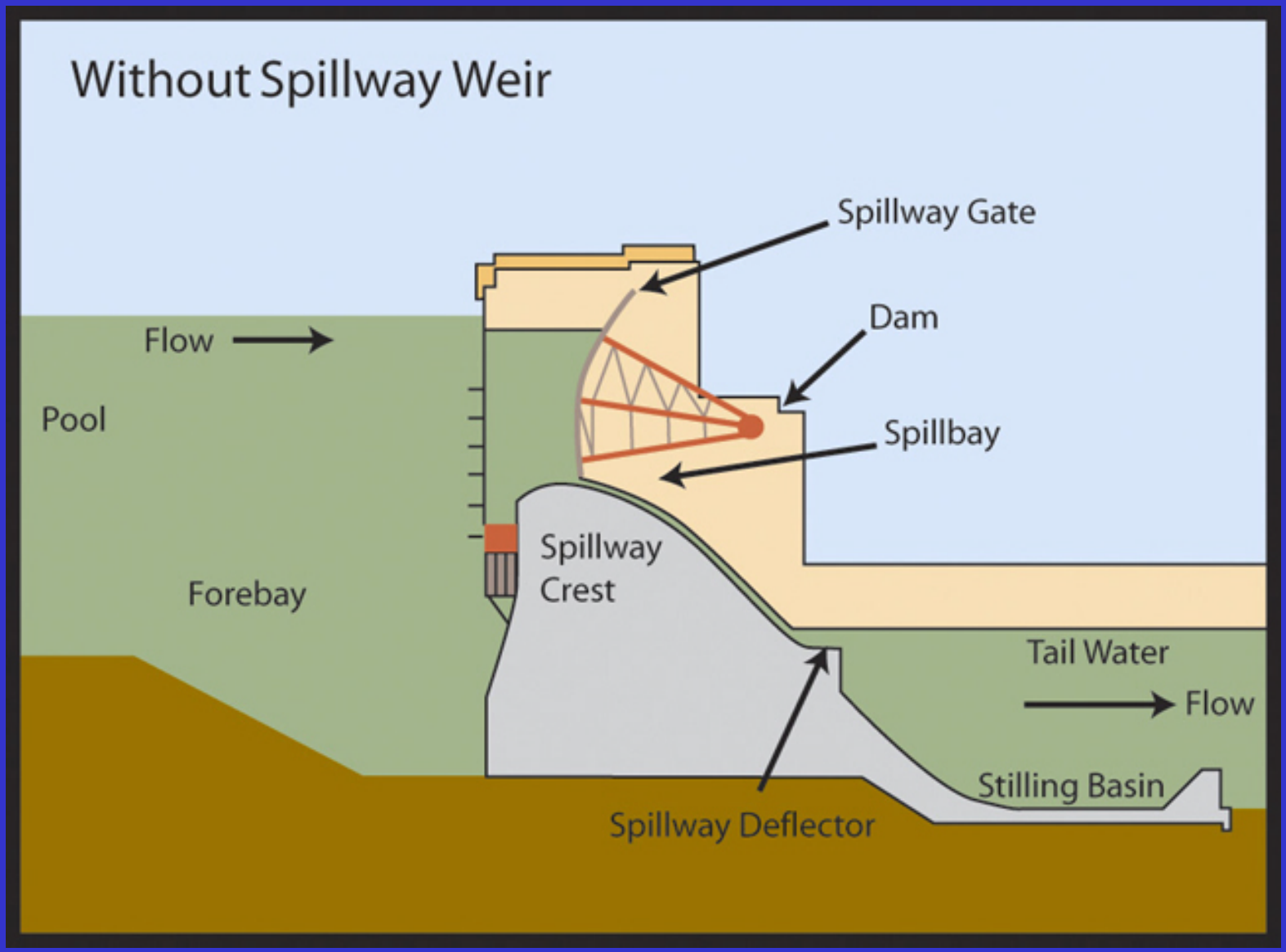
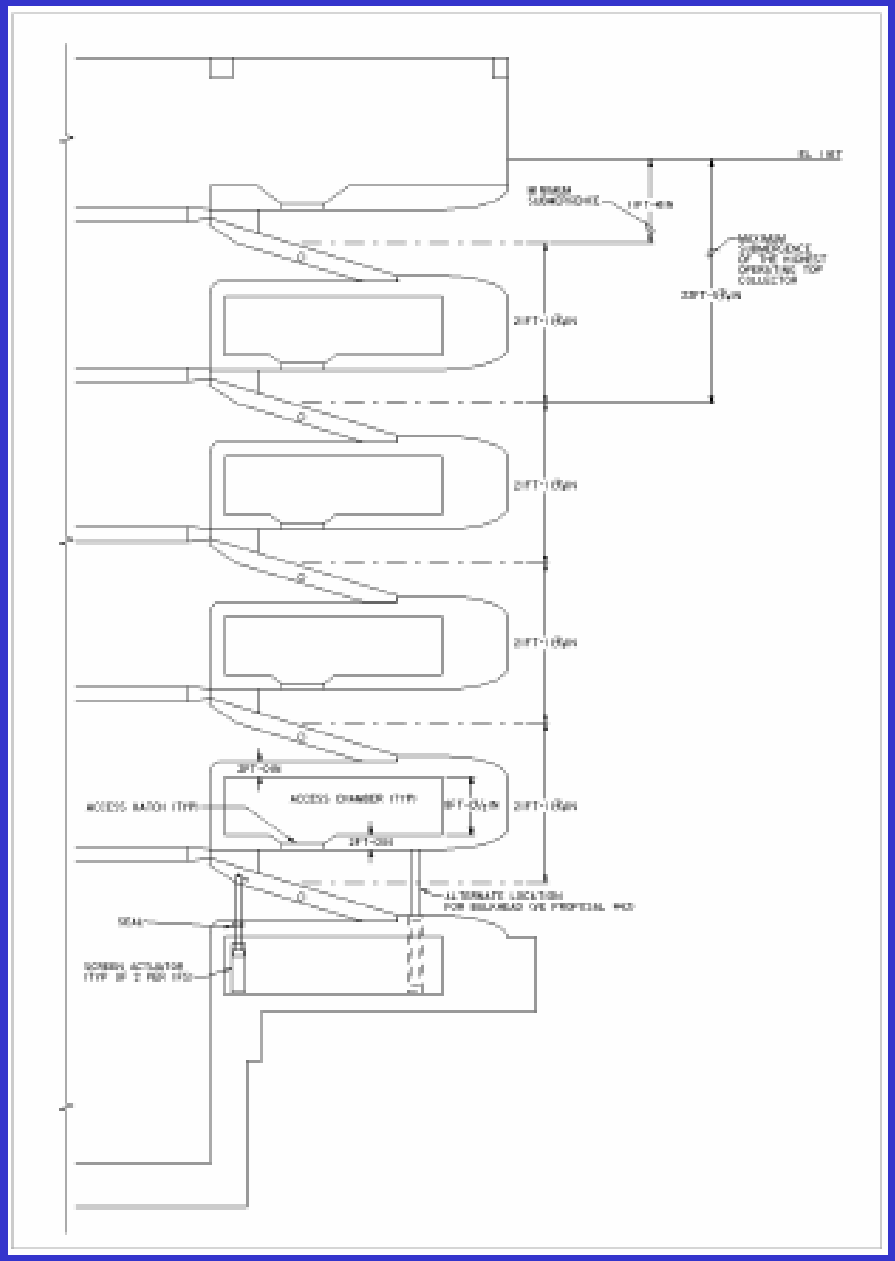
Spillway Passage
Typical Snake River Project





Howard Hanson

Juvenile Fish Facility

Current Design without Surface Collector

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Howard Hanson fish facility: hydraulic design features

Fish Entrance Horn

Overhead Oblique View

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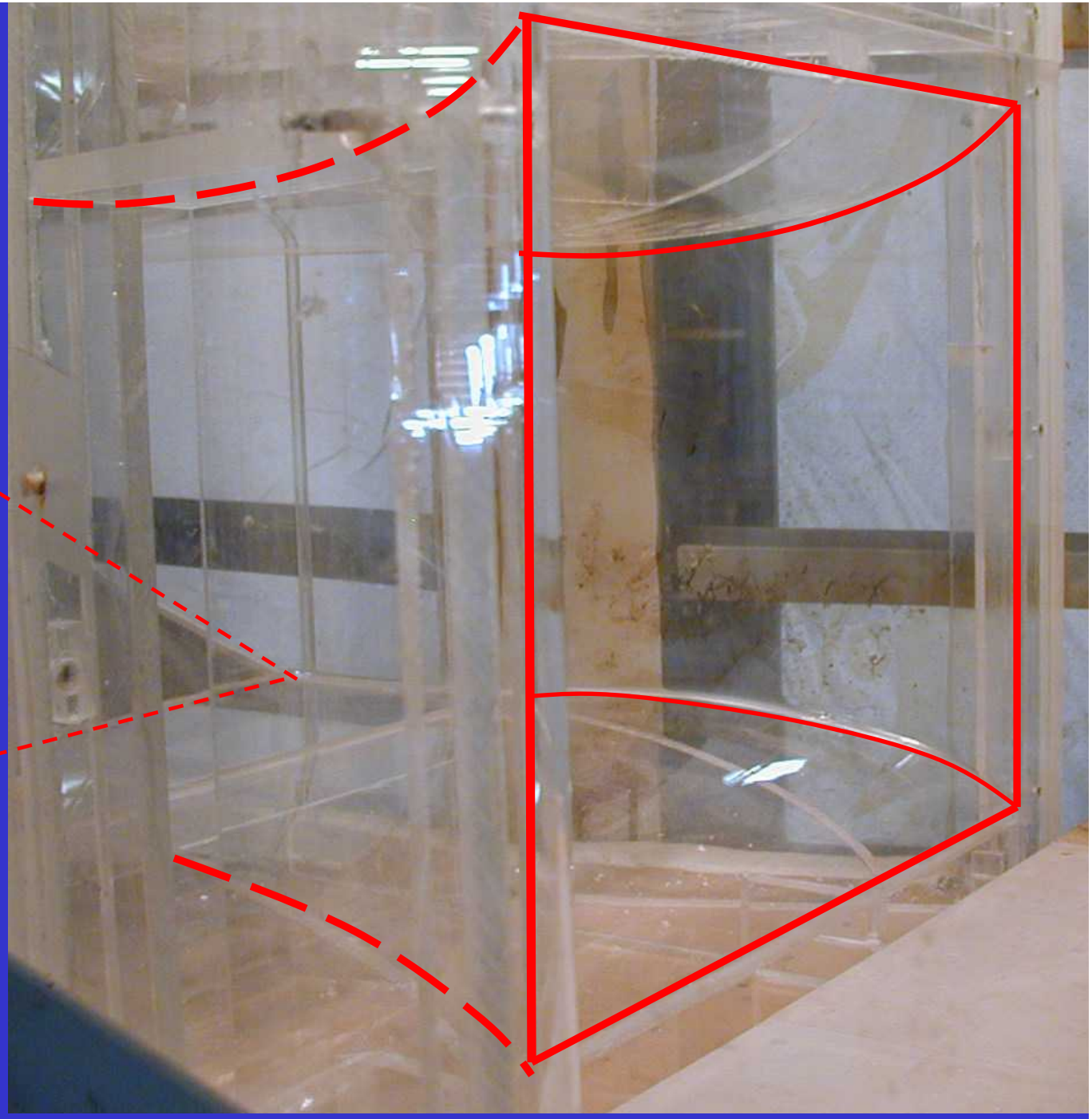
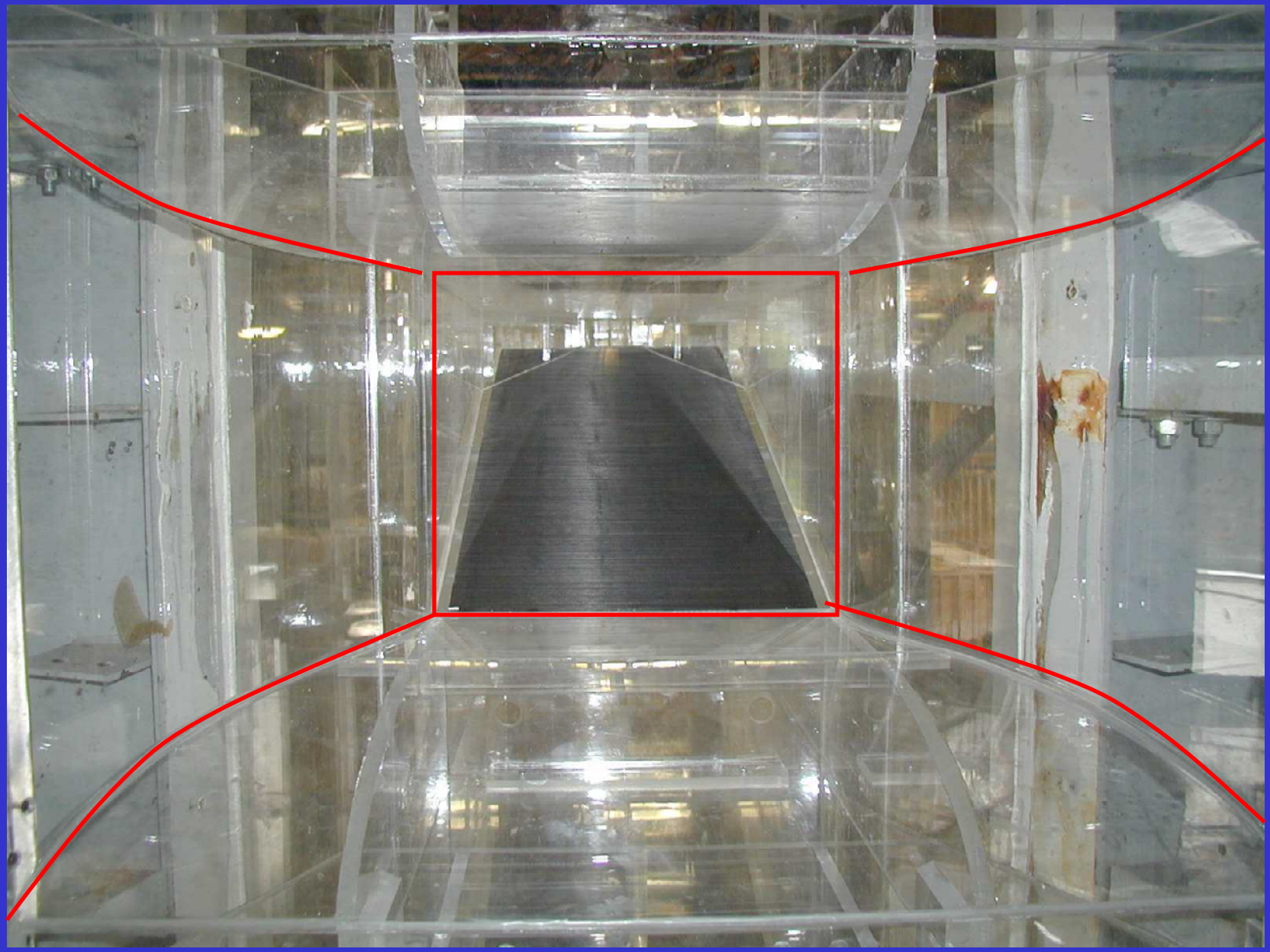
Howard Hanson fish facility: hydraulic design features

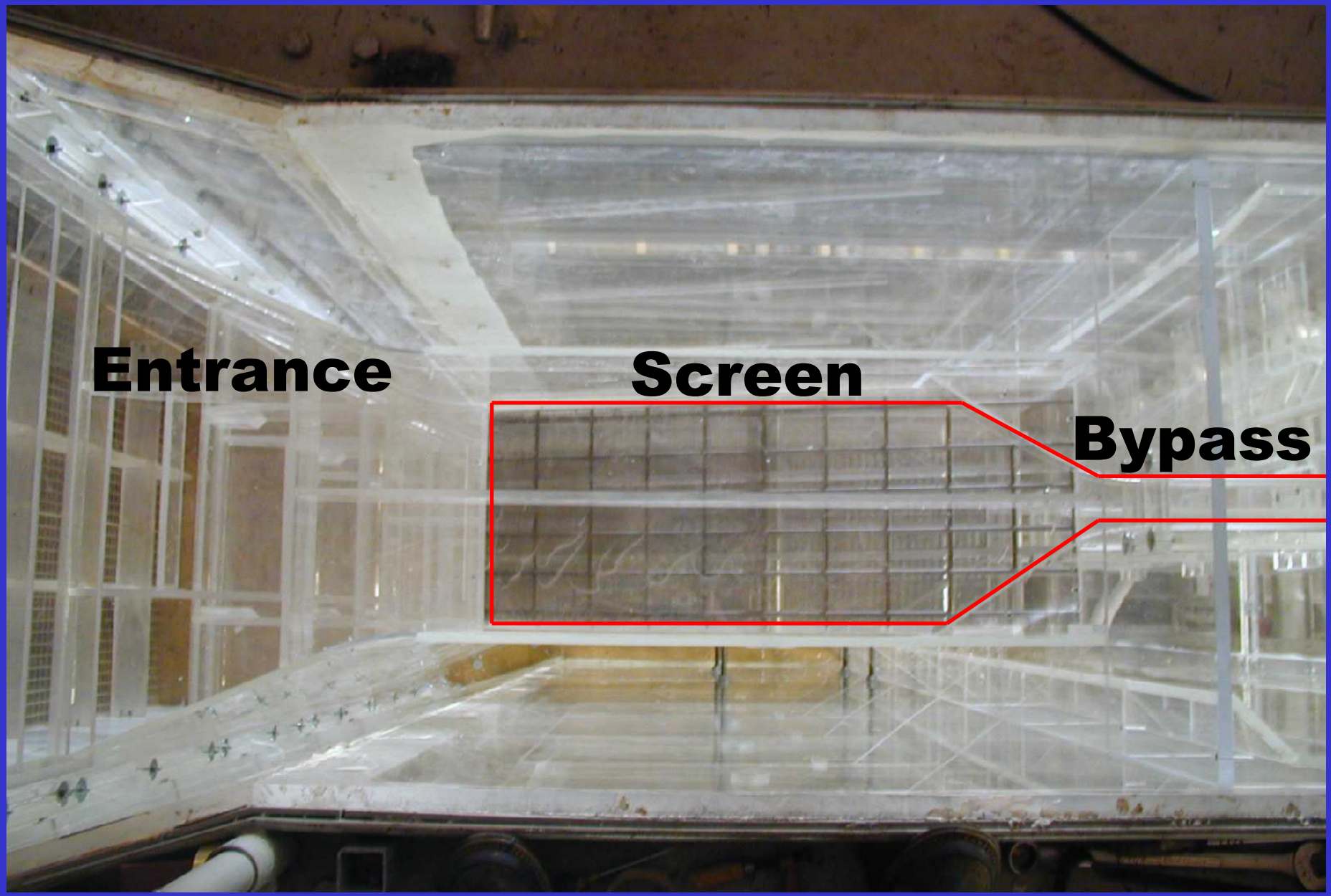
Entrance Horn



Conclusions.



Fish screen and screen enclosure



Overhead view of bypass conduit and wet well

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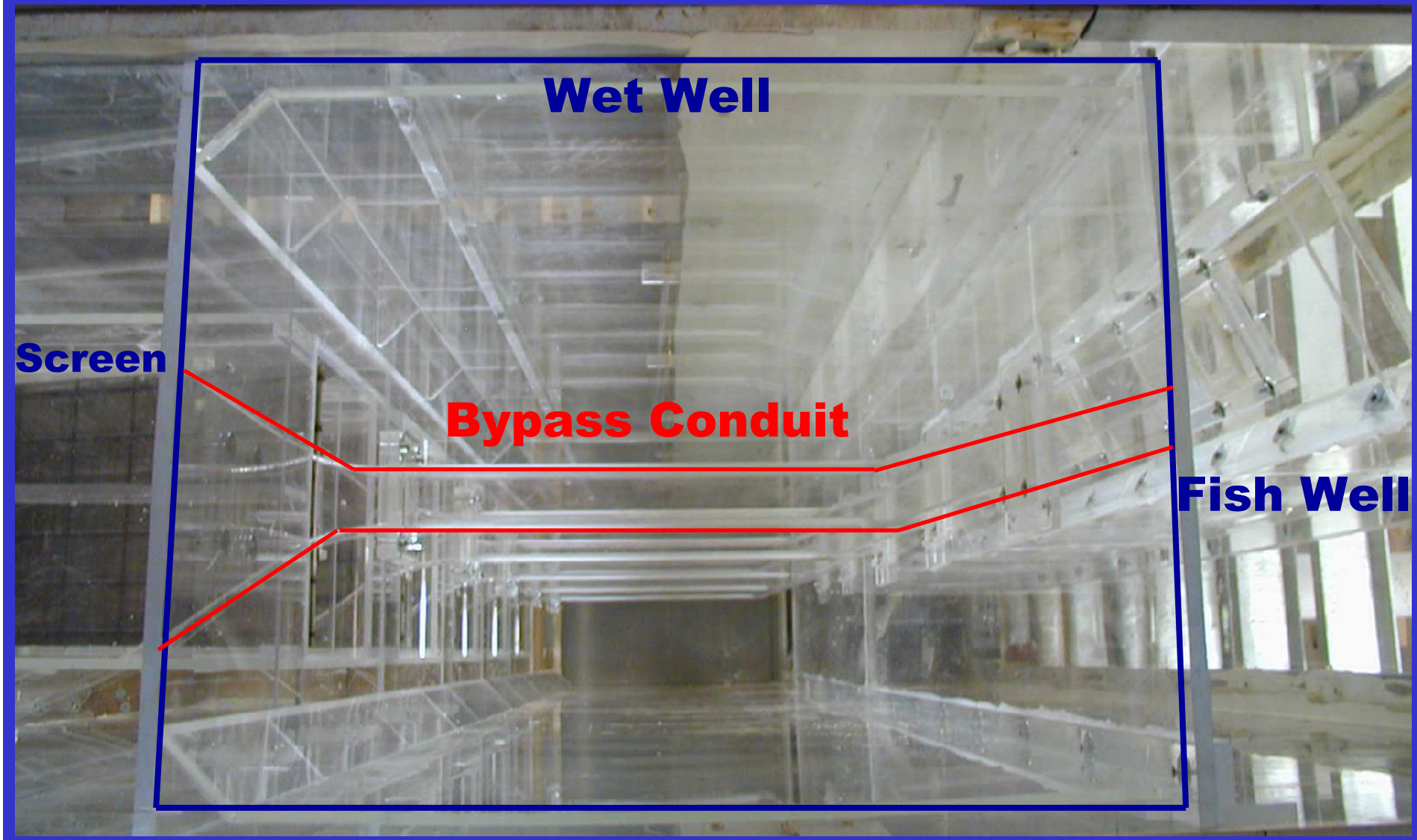

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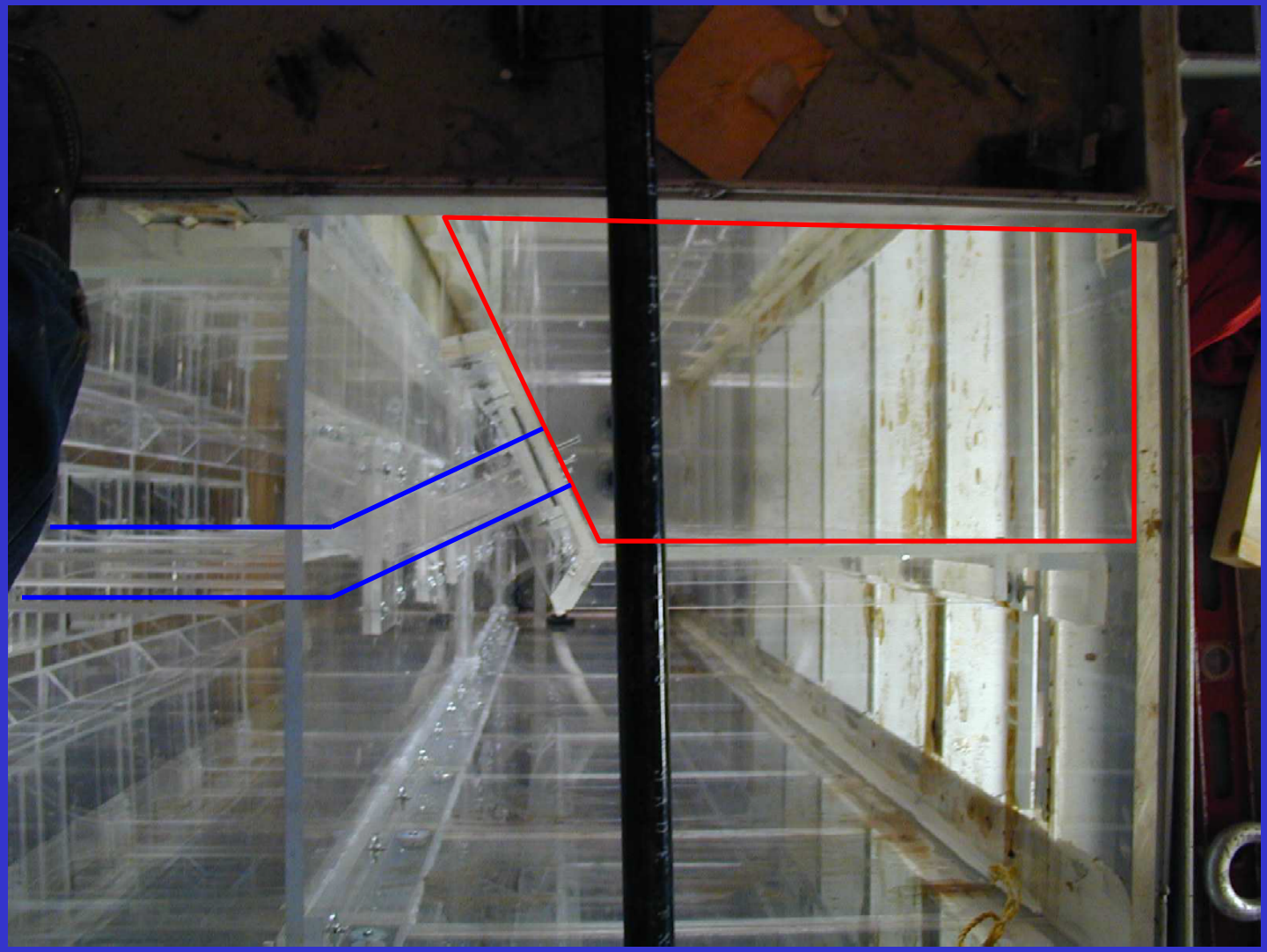
Plan View of Wet Well



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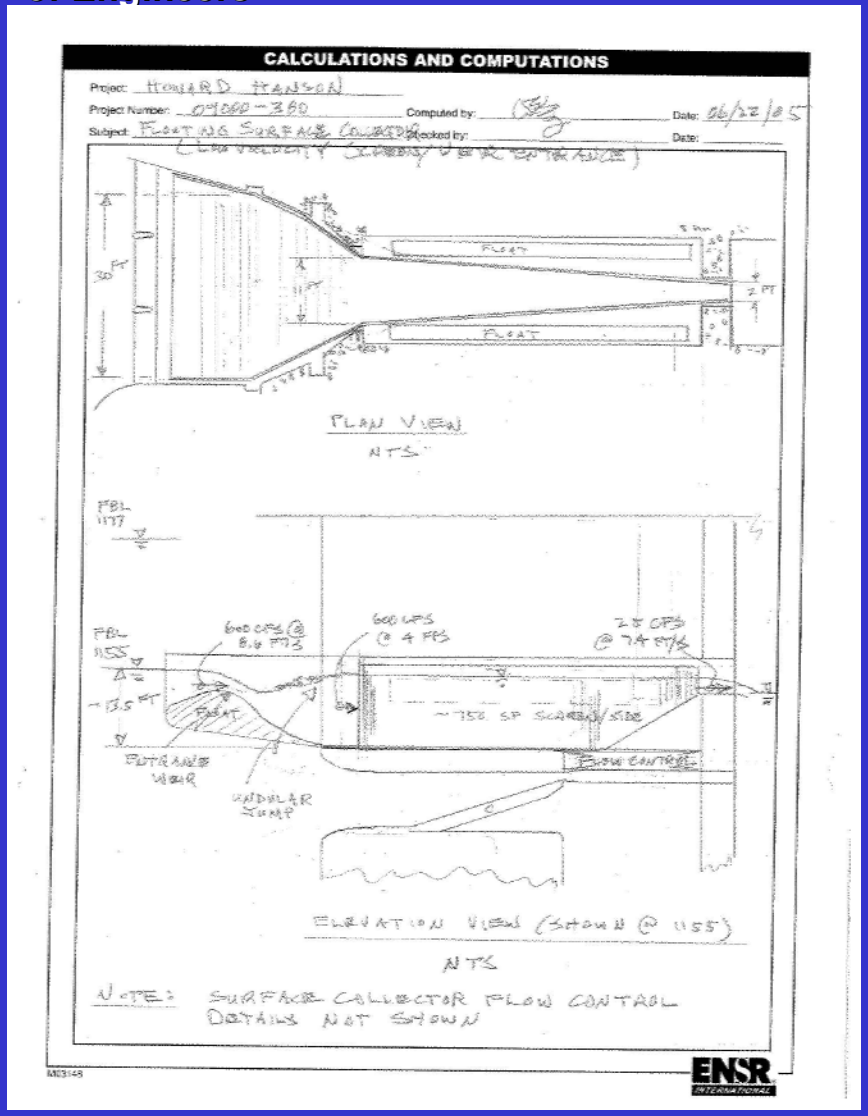
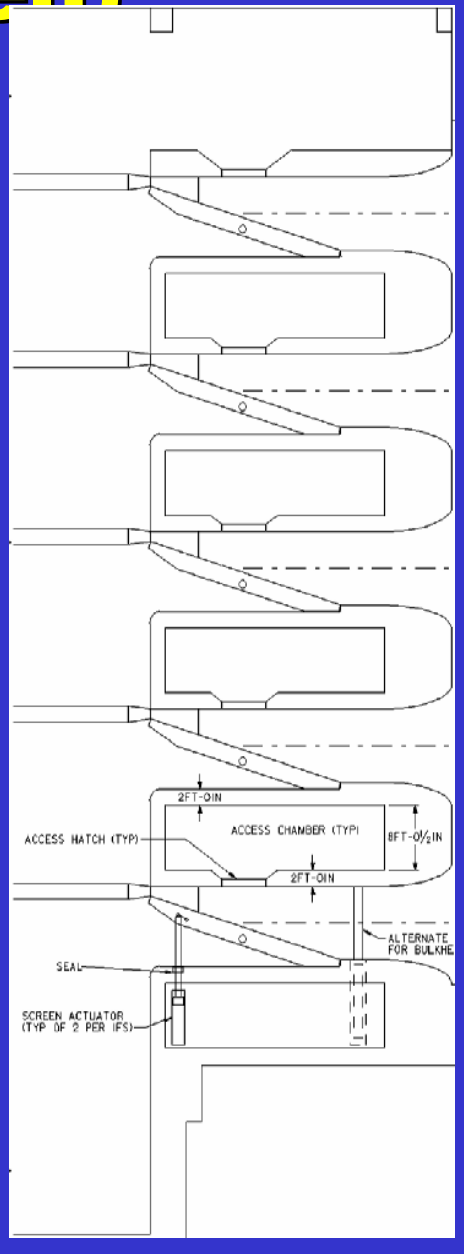
Floating Surface Collector (Low Velocity Screen)





Howard Hanson site limitations

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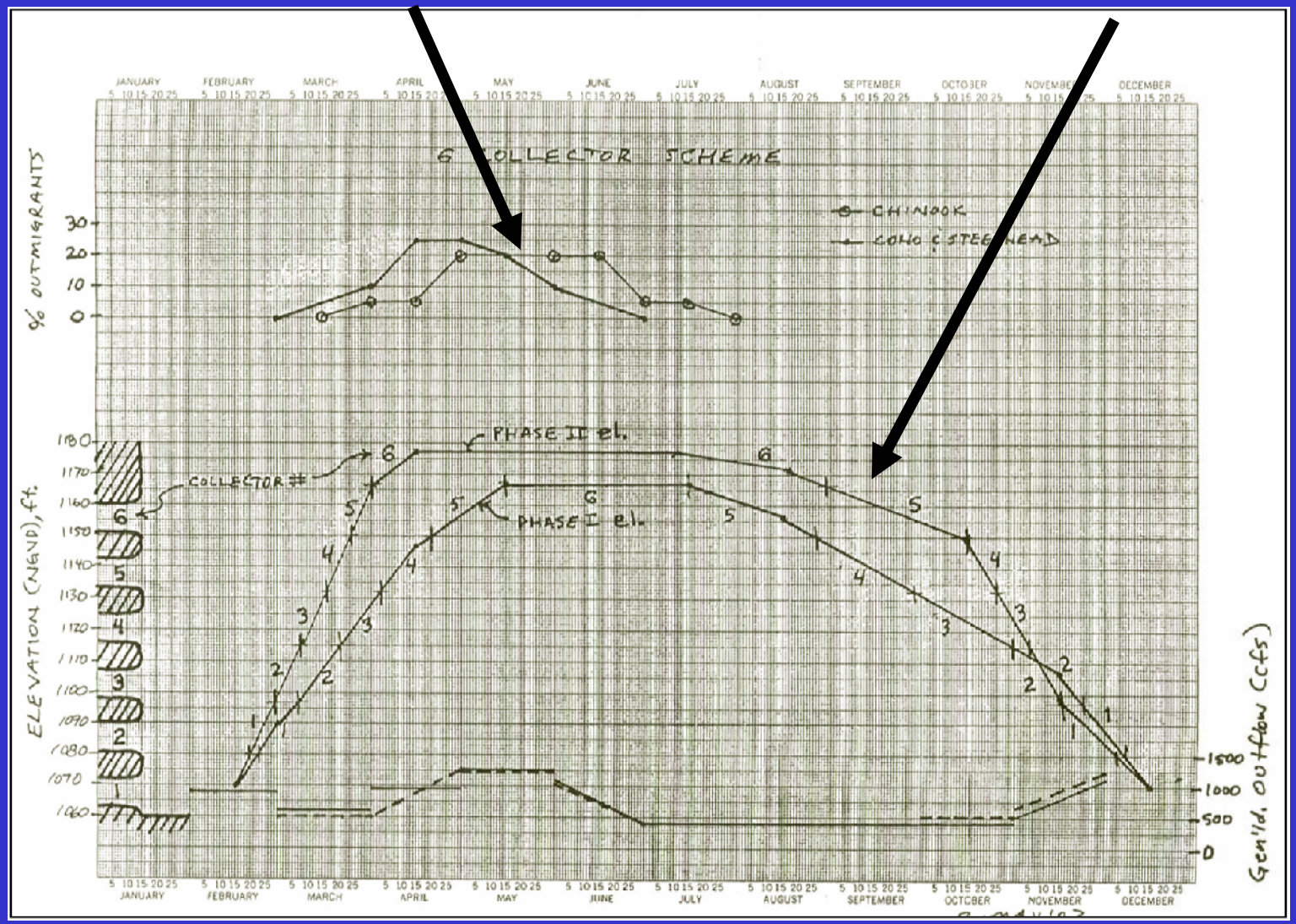
- **Expected fish timing**

•Wide pool fluctuation



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Goal:
Reduce Delay

High Forebay with Juvenile Fish Facility

Low level outlet open

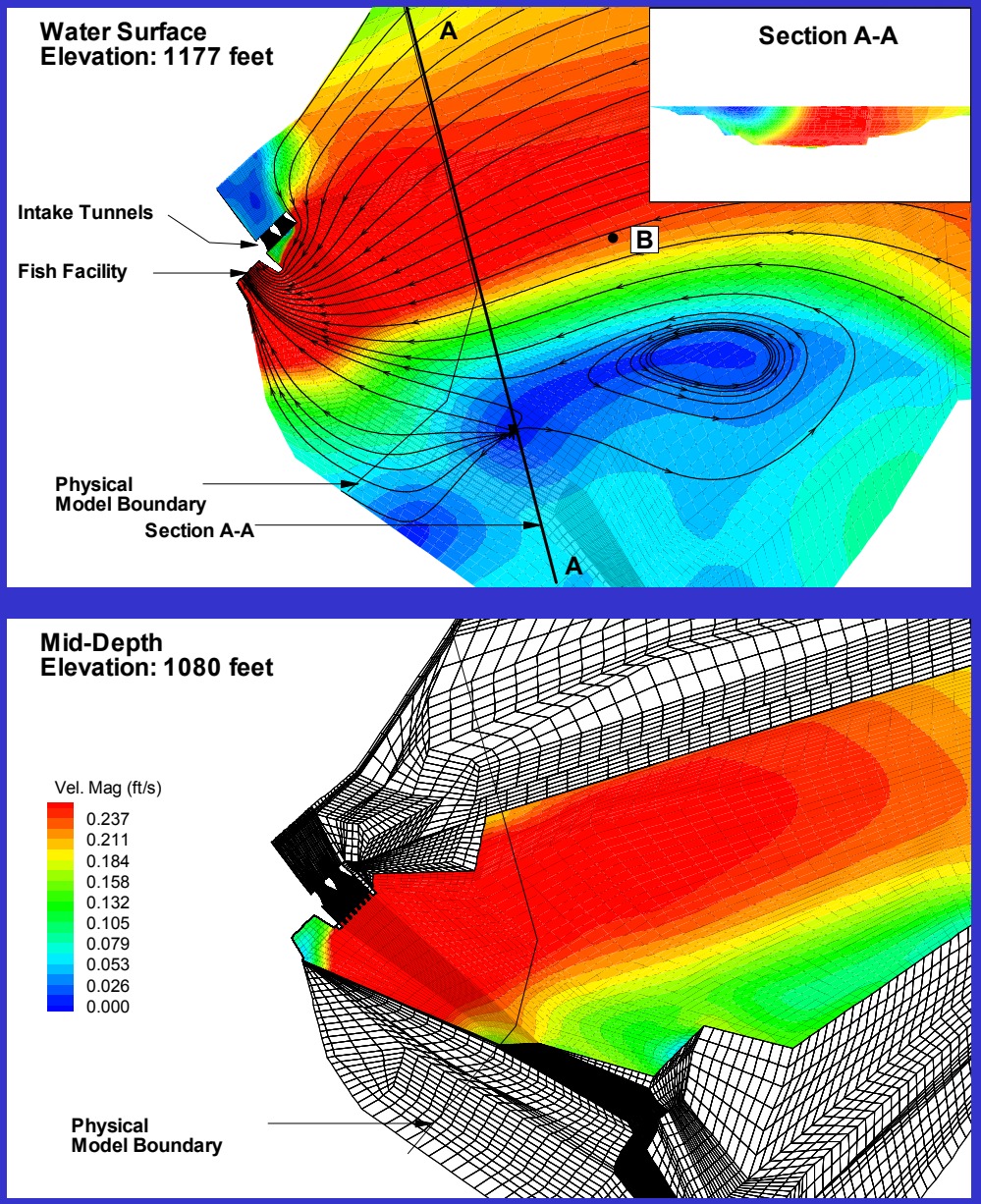

Figure 3: Plan View of Velocity Magnitude at Water Surface and Mid-Depth

Scenario S1P1: Tunnel: 2700 cfs, Fish: 1300 cfs

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Goal:
Reduce Delay

High Forebay

with Juvenile Fish Facility

Low Level Outlet Open

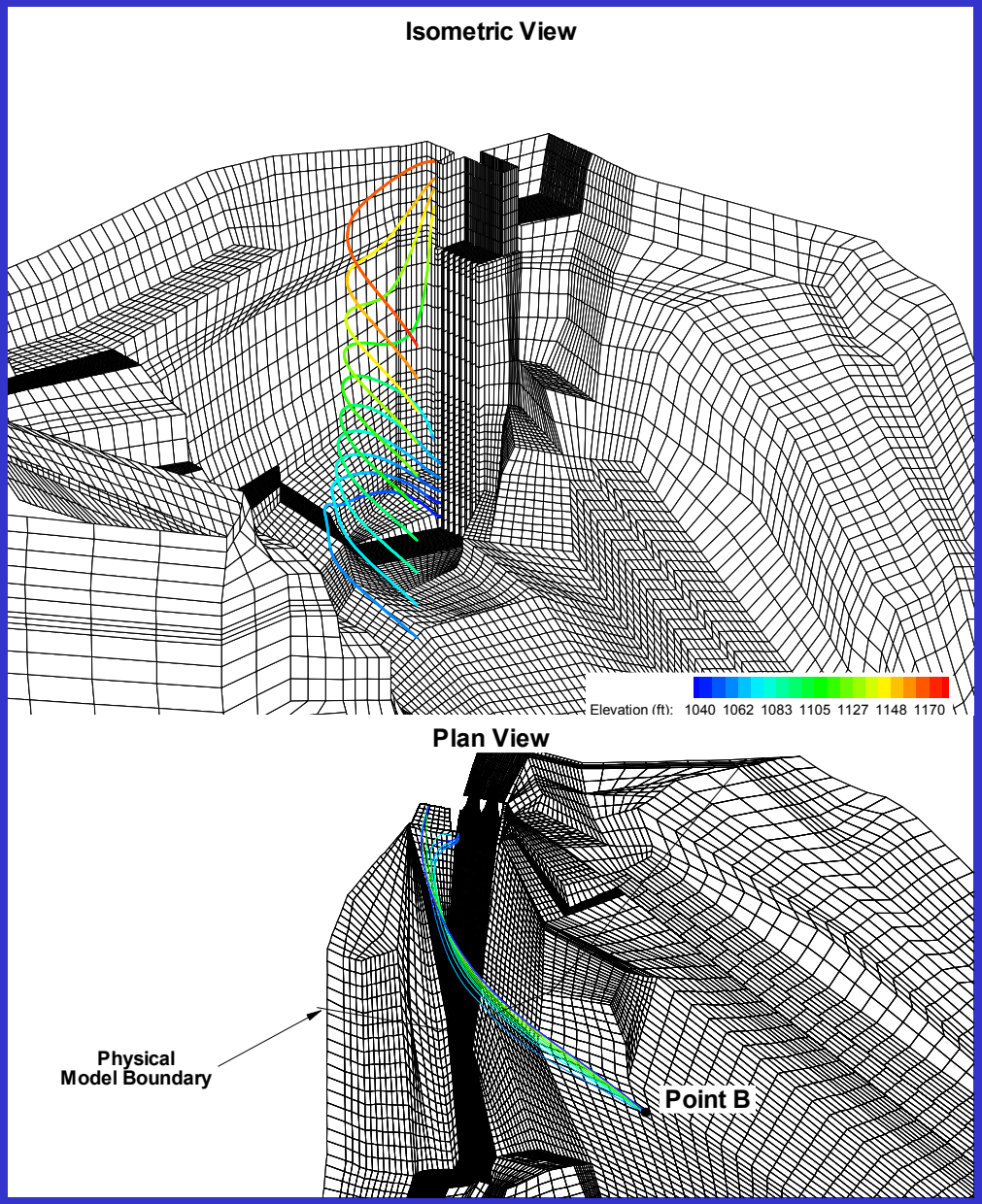

Figure 4: Flow Path From Point B to Tunnel and Fish Facility

Scenario S1P1: Tunnel: 2700 cfs, Fish: 1300 cfs

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Overview of Fisheries Design Criteria

- Operating Range: 97 feet
- Collector Design Flow: 200 - 600 cfs
- Facility Flow: 400 cfs to 1200 cfs
- Velocity gradient and screen criteria
- Bypass discharge: 25 cfs at all times
- Limitations on screen angle, flow depths in bypass conduit, energy dissipation in fish lock, maximum velocities, valve operations, pipe r/d ratios, etc.