Intake Dam ADH Sediment Modeling

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US Army Corps of Engineers

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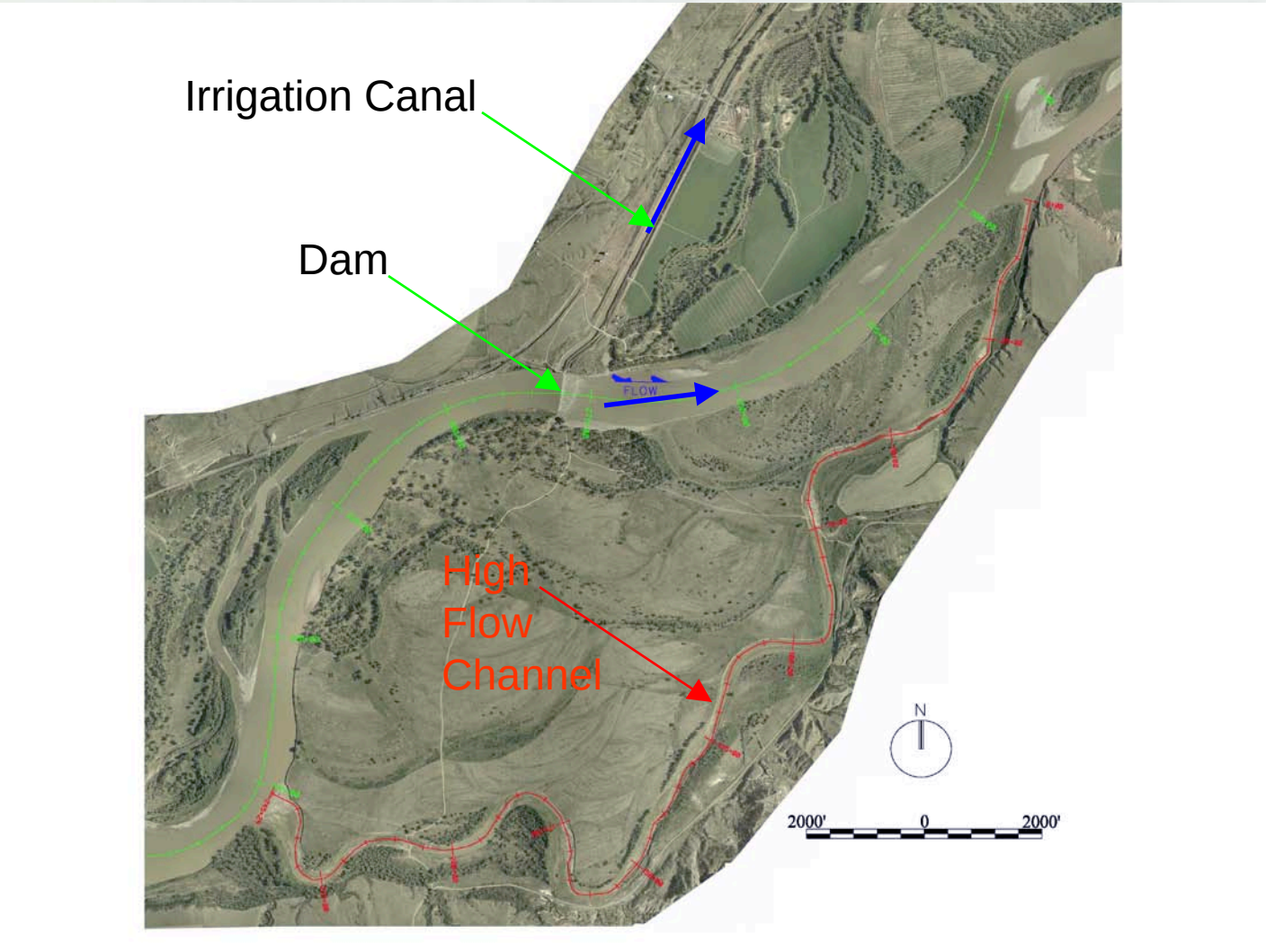
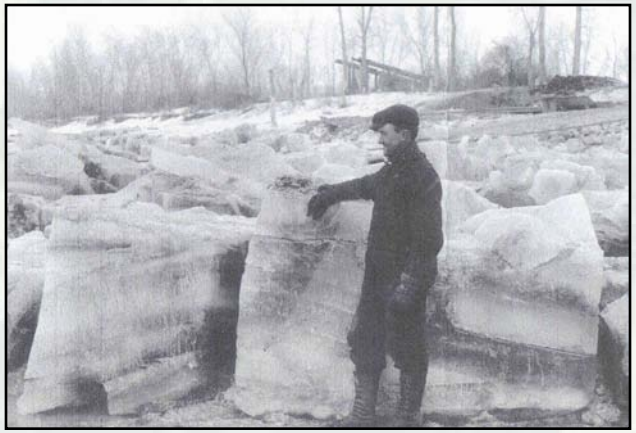
Lower Yellowstone Irrigation Project (Intake Dam)



Intake Dam-Overview



Authorization:
- Reclamation Act of 1902

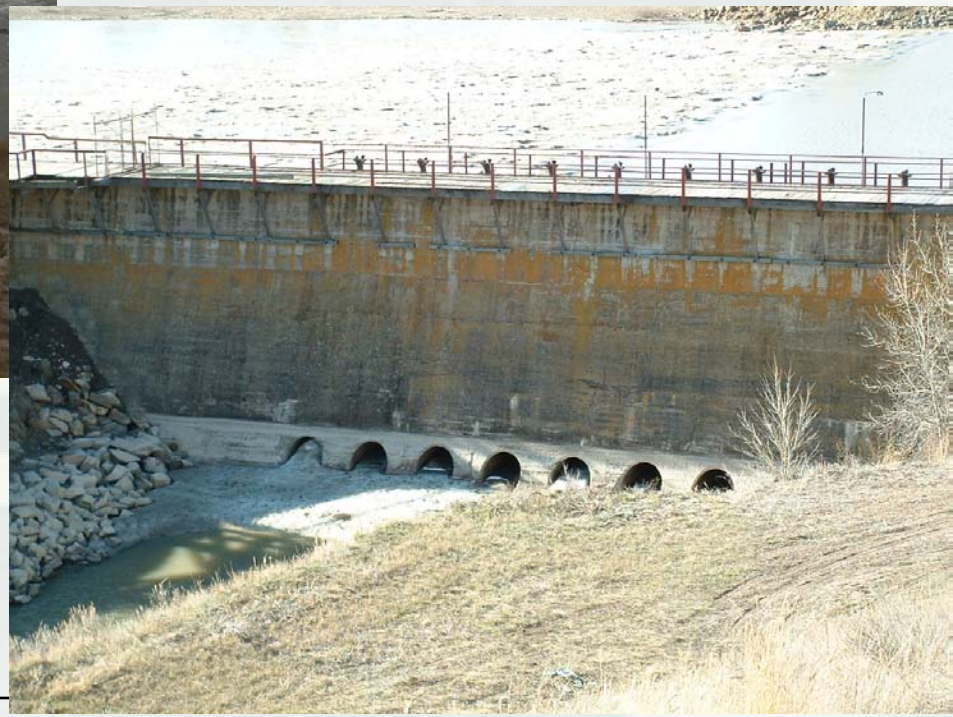
Construction:
- 1905-08 by Reclamation

Operation:
- Diverts ~1,400cfs into Main Canal for delivery to ~52,000 acres

Maintenance:
- Placement of rock on the crest of dam to maintain head and replace rock washed downstream by high flow and ice

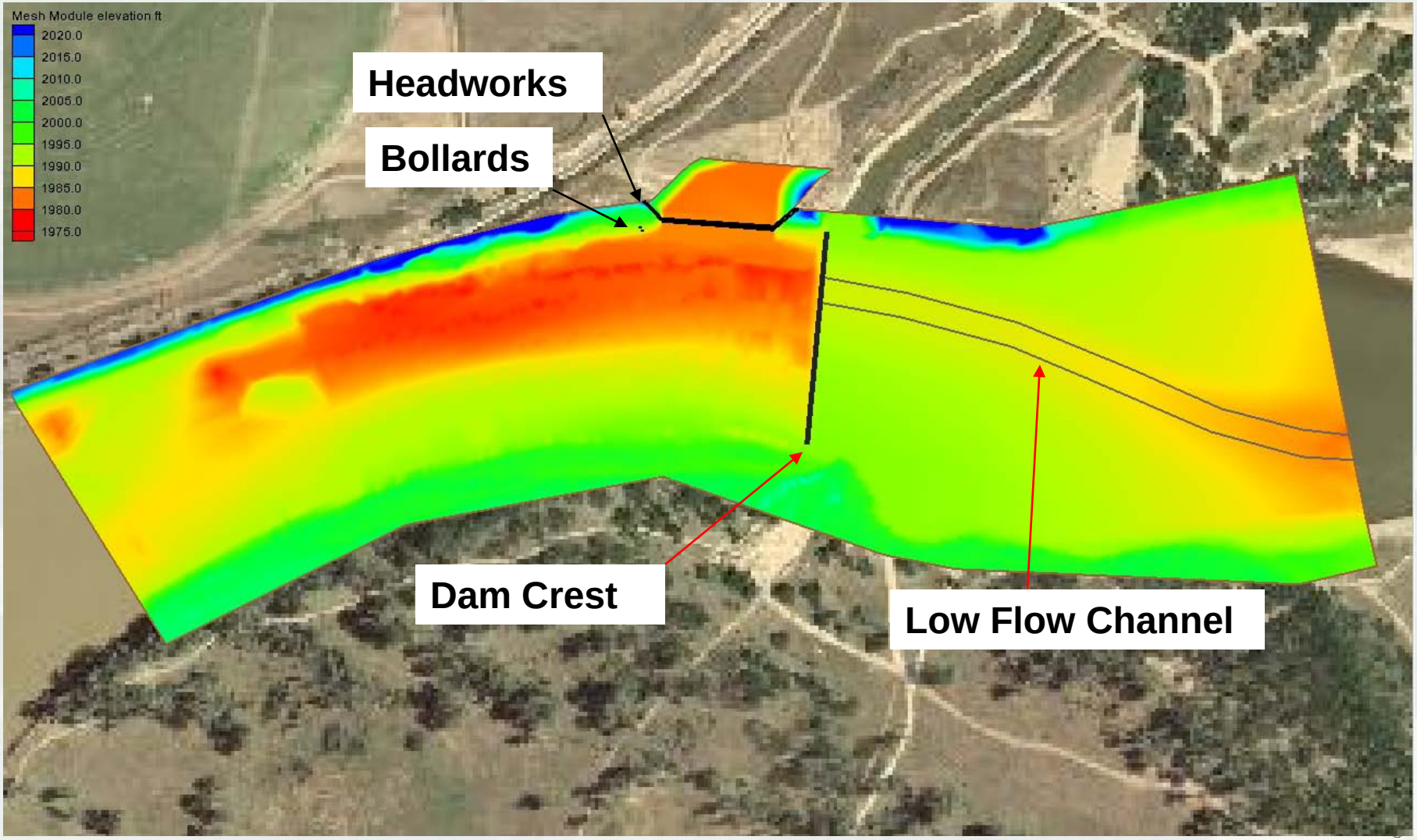
Issues: Fish Passage and Entrainment

Fish Passage Issue



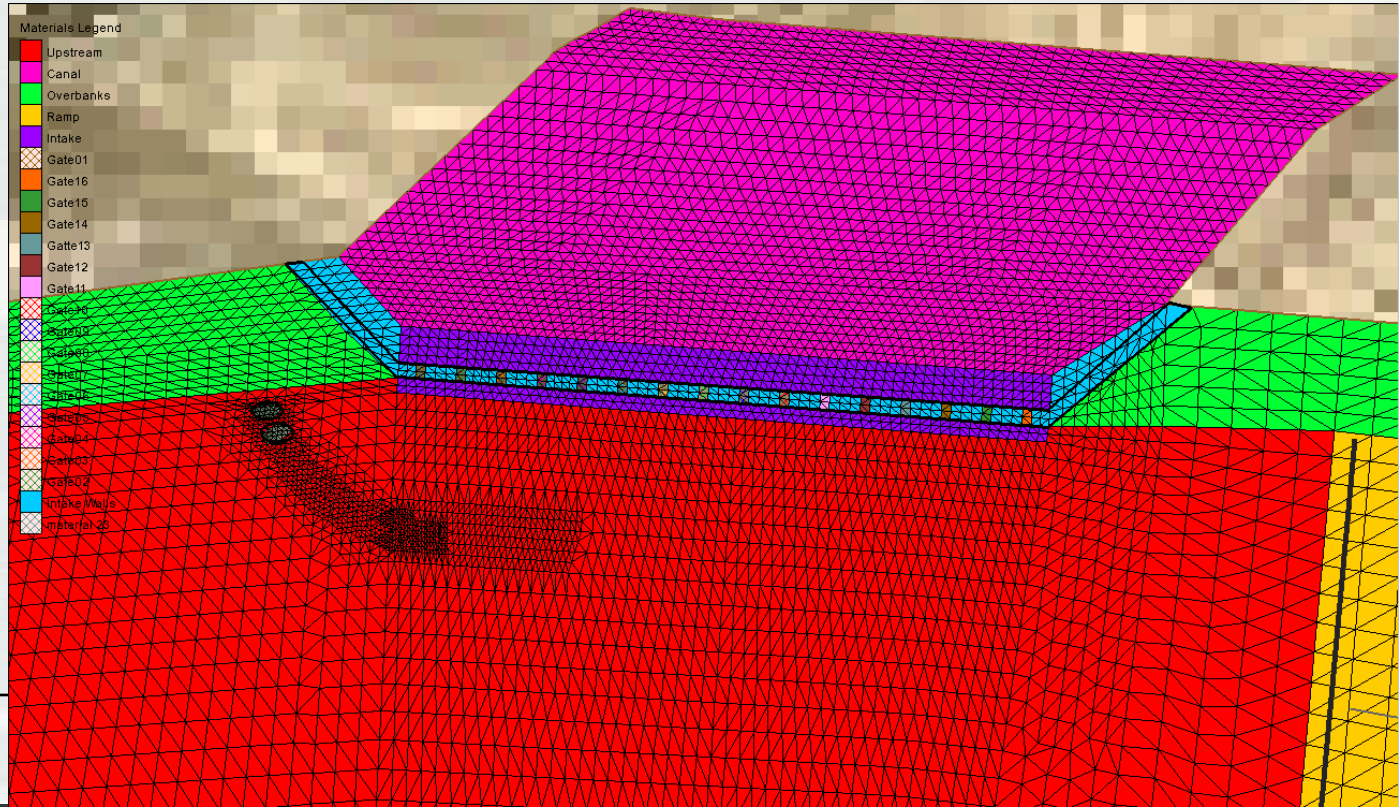
Entrainment Issue

Geometry

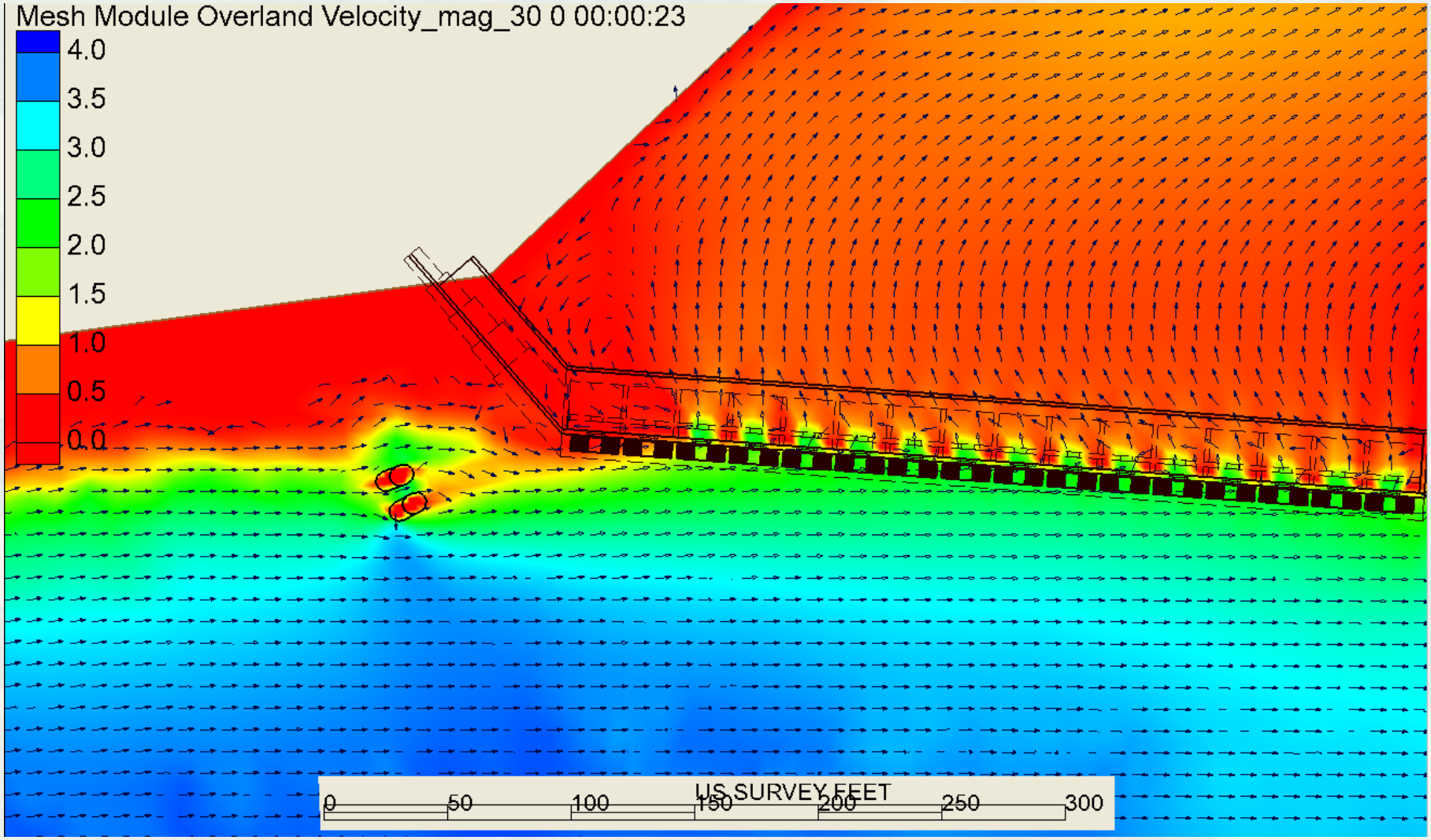

Mesh Module elevation ft
2020.0
2015.0
2010.0
2005.0
2000.0
1995.0
1990.0
1985.0
1980.0
1975.0
Headworks
Bollards
Dam Crest
Low Flow Channel

Mesh

- 28,000 elements; 14,000 nodes
- Diversion gates modeled using DB LDE card (stationary lid)
- Bollards and headworks structure materials turned off

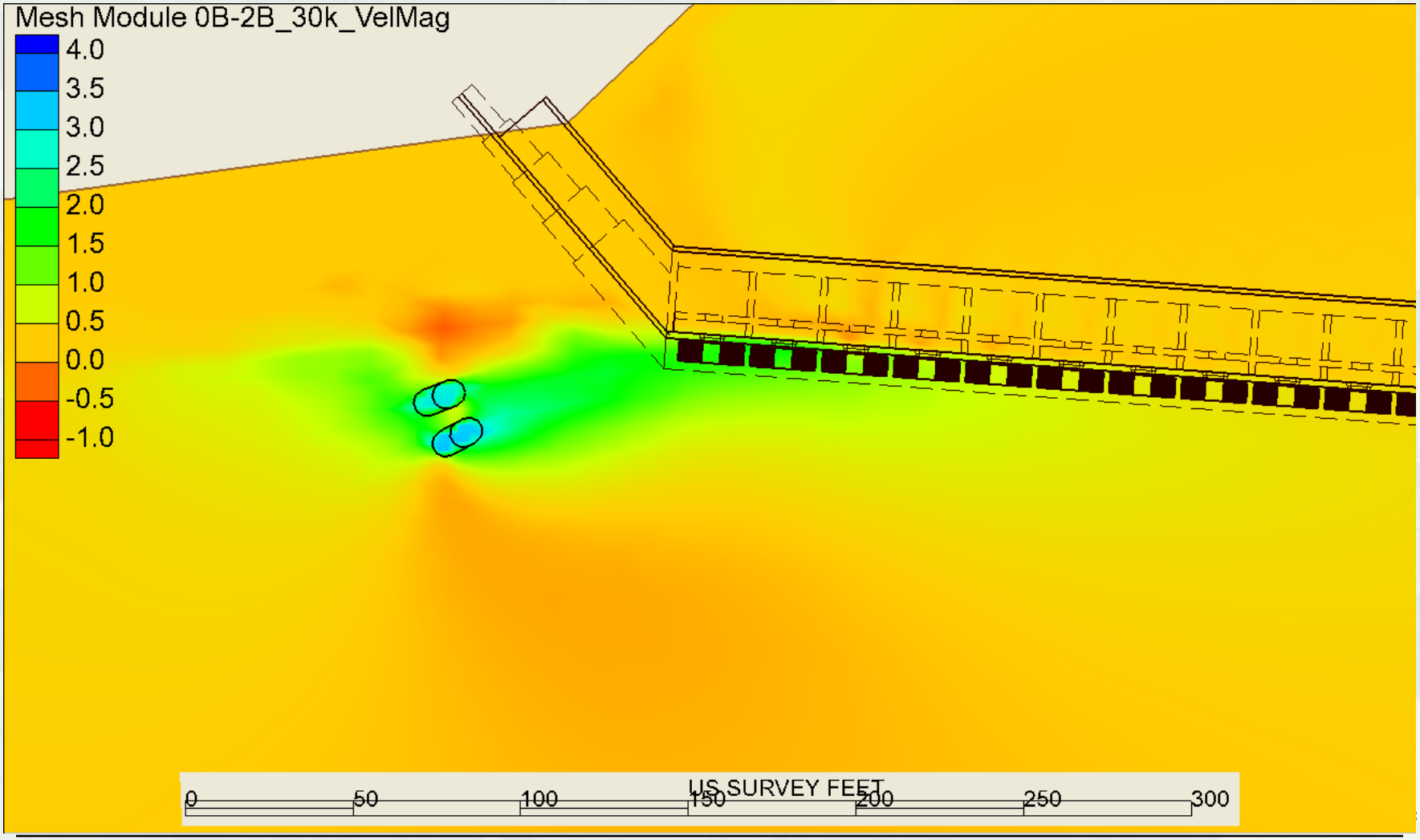


Hydrodynamics



Hydrodynamics (cont'd)

- Velocity magnitude comparison: zero bollards minus two bollards



Hydrodynamics (cont'd)

- Time step = 10 seconds from 0-10,000 sec, then to 5,000 or 10,000seconds
- Downstream boundary set based on ADH model of entire ramp
- Canal outflow set to $\approx 40\ m^3/s$ (1400cfs), flow through each gate is reasonable
- IP NTL and ITL set to 0.05 m
- Upstream and canal elements = 1 level of refinement, error tolerance = 0.50
- Wetting and drying, from 0.2/0.6 to 0.38/0.42, trying to determine sensitivity and impact on run time
- Currently using Manning's roughness, equivalent roughness height is being considered

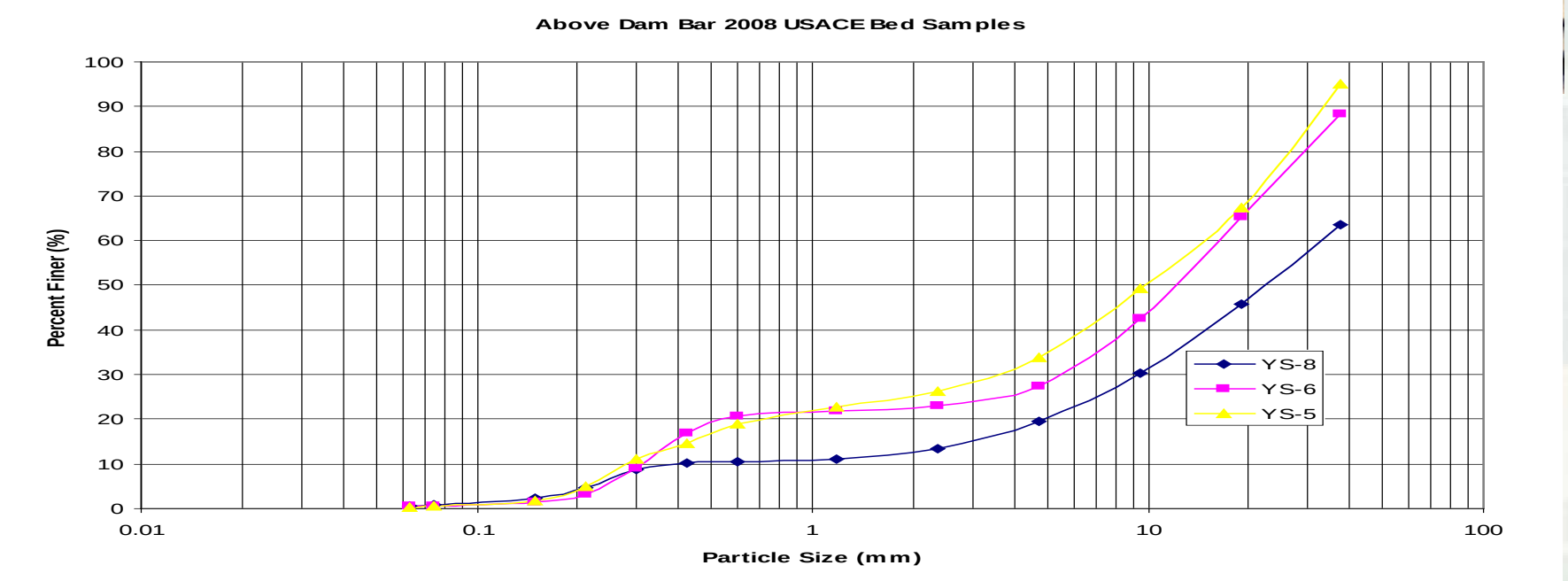
Purpose of Sediment Modeling

- Current diversion configuration requires only minimal maintenance
  - Requires very little sediment removal from canal
  - No current sediment issues in river
- Proposed design must not impose O&M burden on irrigation district
- Need for debris protection presents sediment challenges

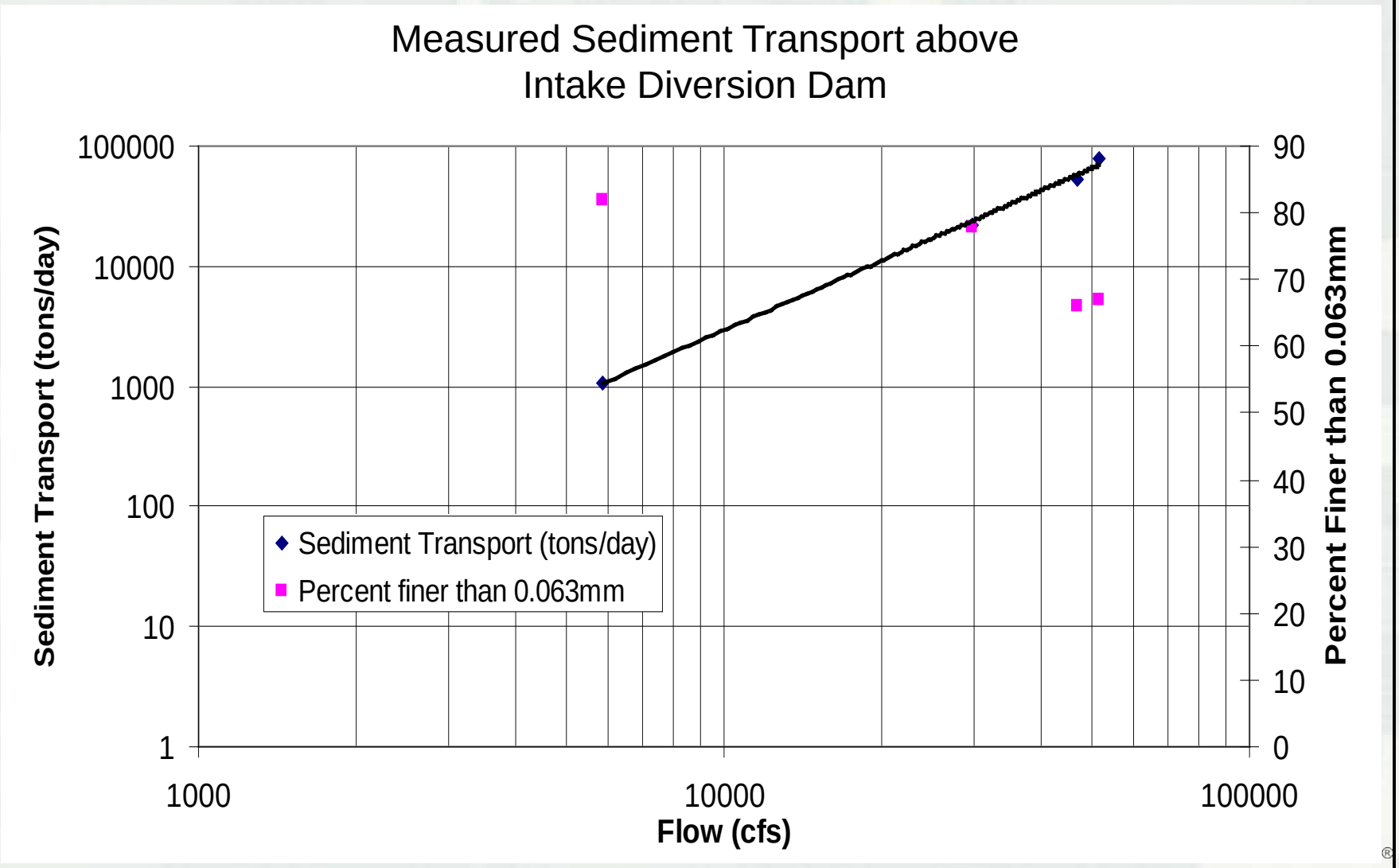
Sediment Data Input

- Twelve grain size classes from very fine sand to boulders (Wentworth classification)
- Four bed layers
  - Very thin top layer for sorting
  - Middle layers based on bar grab samples (upstream and downstream)
  - Ramp modeled as boulders
- Inflow concentrations computed from measured transport and particle size distributions

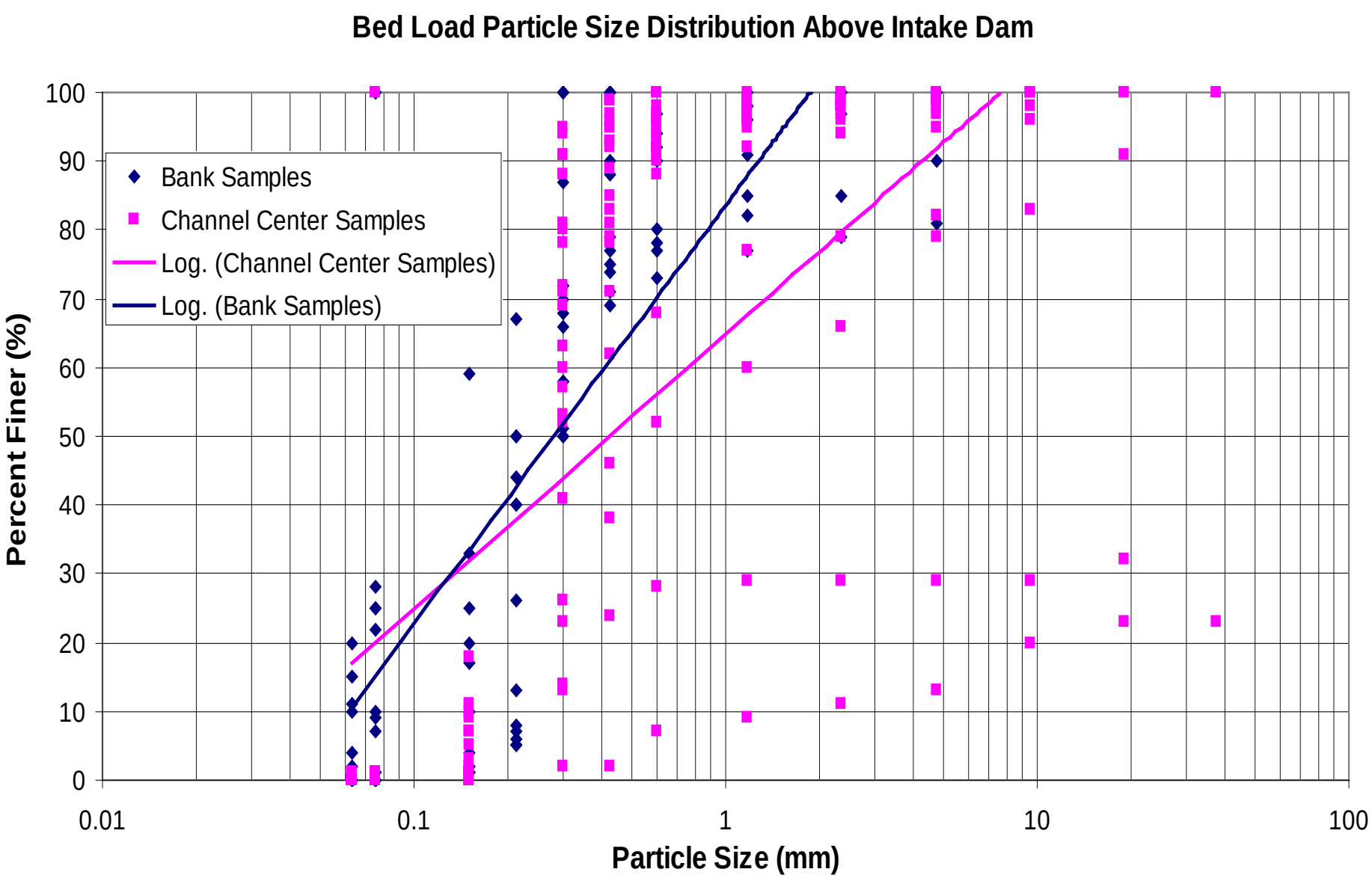
Sediment Data Input (cont'd)



Sediment Data Input (cont'd)



Sediment Data Input (cont'd)



Sed Input

(handy table courtesy of Aaron Buesing)

```
! Sediment Constituent Properties
! from EM 1110-2-1100 (Part III), page III-1-8
! Size Class        range                 geometric mean (m)
!                   (mm)                          sqrt(D1D2)
! COLLOIDS                0.000061-0.00049        0.0000001729
! FINE CLAY               0.00049-0.00098         0.0000006930
! MEDIUM CLAY             0.00098-0.00195         0.0000013824
! COARSE CLAY             0.00195-0.0039          0.0000027577
! VERY FINE SILT          0.0039-0.0078           0.0000055154
! FINE SILT               0.0078-0.0156           0.0000110309
! MEDIUM SILT             0.0156-0.0312           0.0000220617
! COARSE SILT             0.0312-0.0625           0.0000441588
! VERY FINE SAND          0.0625-0.125            0.0000883883
! FINE SAND               0.125-0.250             0.0001767767
! MEDIUM SAND             0.250-0.50              0.0003535534
! COARSE SAND             0.50-1.00               0.0007071068
! VERY COARSE SAND        1.00-2.00               0.0014142136
! GRANULE                 2.00-4.00               0.0028284271
! SMALL PEBBLE            4.00-8.00               0.0056568542
! MEDIUM PEBBLE           8.00-16.00              0.0113137085
! LARGE PEBBLE            16.00-32.00             0.0226274170
! VERY LARGE PEBBLE       32.00-64.00             0.0452548340
! SMALL COBBLE            64.00-128.00            0.0905096680
! LARGE COBBLE            128.00-256.00           0.1810193360
! BOULDER                 256-4096                1.0240000000
```

```
! Sand Sediment
!   CN SND {The constituent ID number} {Cha
CN SND 2 1.0 0.0000883883 2.65 0.3
CN SND 3 1.0 0.0001767767 2.65 0.3
CN SND 4 1.0 0.0003535534 2.65 0.3
CN SND 5 1.0 0.0007071068 2.65 0.3
CN SND 6 1.0 0.0014142136 2.65 0.3
CN SND 7 1.0 0.0028284271 2.65 0.3
CN SND 8 1.0 0.0056568542 2.65 0.3
CN SND 9 1.0 0.0113137085 2.65 0.3
CN SND 10 1.0 0.0226274170 2.65 0.3
CN SND 11 1.0 0.0452548340 2.65 0.3
CN SND 12 1.0 0.0905096680 2.65 0.3
CN SND 13 1.0 1.0240000000 2.65 0.3
```

```
! Sediment Applied by Material
!   MP SBM {Bed layer ID number} {Material type ID number} {The bed layer thick
MP NBL 4
MP SBM 1 1 1.0    0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.25 0.25 0.50
MP SBM 2 1 7.0    0.00 0.08 0.07 0.08 0.08 0.06 0.10 0.07 0.08 0.18 0.20 0.00
MP SBM 3 1 2.0    0.00 0.08 0.07 0.08 0.08 0.06 0.10 0.07 0.08 0.18 0.20 0.00
MP SBM 4 1 0.0001 0.20 0.20 0.20 0.20 0.20 0.00 0.00 0.00 0.00 0.00 0.00 0.00
MP SBM 1 2 1.0    0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.25 0.25 0.50
MP SBM 2 2 7.0    0.26 0.22 0.22 0.23 0.07 0.00 0.00 0.00 0.00 0.00 0.00 0.00
MP SBM 3 2 2.0    0.26 0.22 0.22 0.23 0.07 0.00 0.00 0.00 0.00 0.00 0.00 0.00
MP SBM 4 2 0.0001 0.20 0.20 0.20 0.20 0.20 0.00 0.00 0.00 0.00 0.00 0.00 0.00
MP SBM 1 3 1.0    0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.25 0.25 0.50
MP SBM 2 3 5.0    0.53 0.08 0.06 0.07 0.09 0.07 0.06 0.04 0.00 0.00 0.00 0.00
MP SBM 3 3 2.0    0.53 0.08 0.06 0.07 0.09 0.07 0.06 0.04 0.00 0.00 0.00 0.00
MP SBM 4 3 0.0001 0.20 0.20 0.20 0.20 0.20 0.00 0.00 0.00 0.00 0.00 0.00 0.00
MP SBM 1 4 1.5    0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 1.00
MP SBM 2 4 1.5    0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 1.00
MP SBM 3 4 1.5    0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 1.00
```

Upstream

Canal

Overbanks

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Sediment Data Input (cont'd)

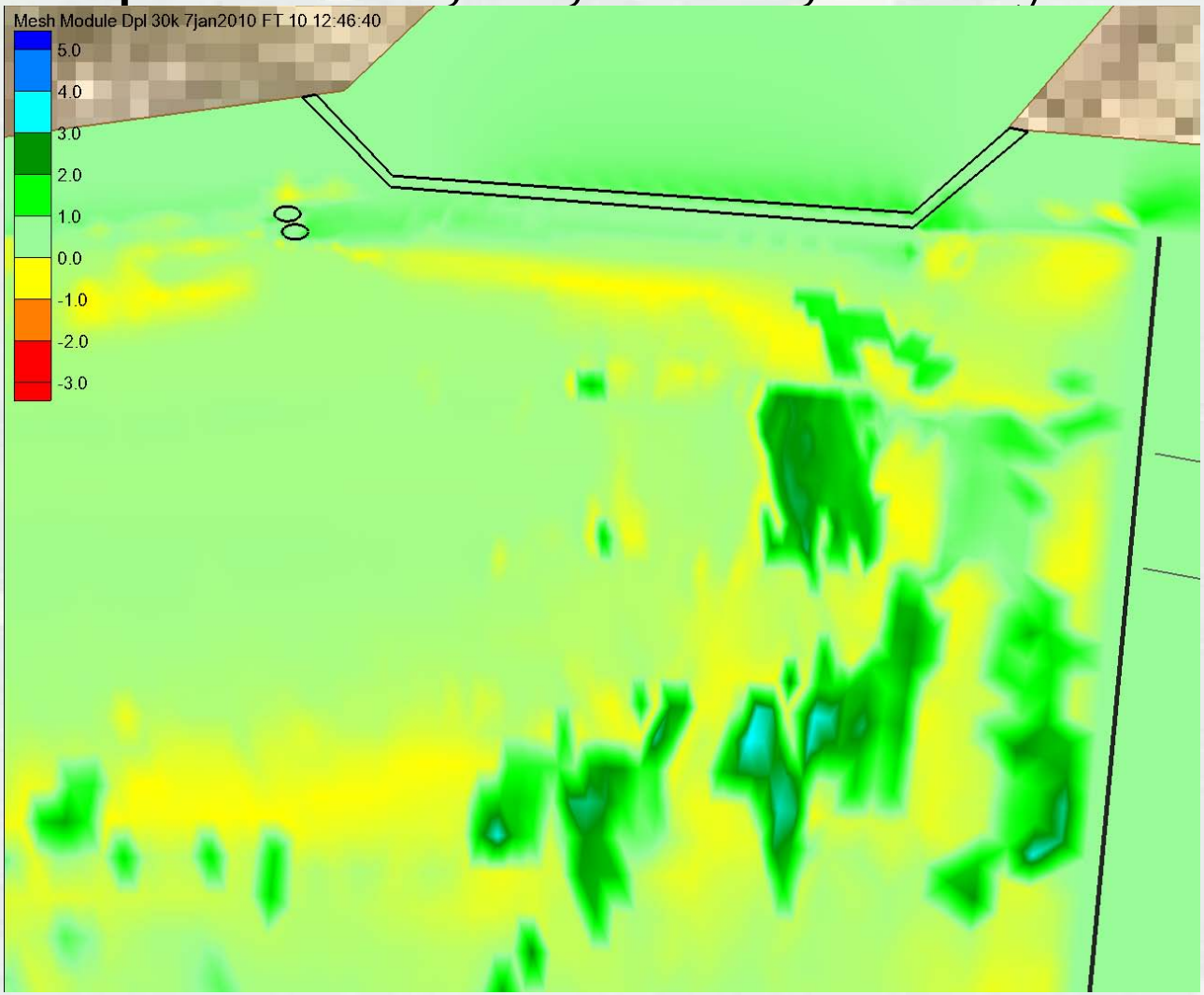
- Molecular diffusion rate = 0.002
- Using Dirichlet-Transport at upstream end (DB TRN)

Sediment Output

- Model run time ≈ 1 day / hour *

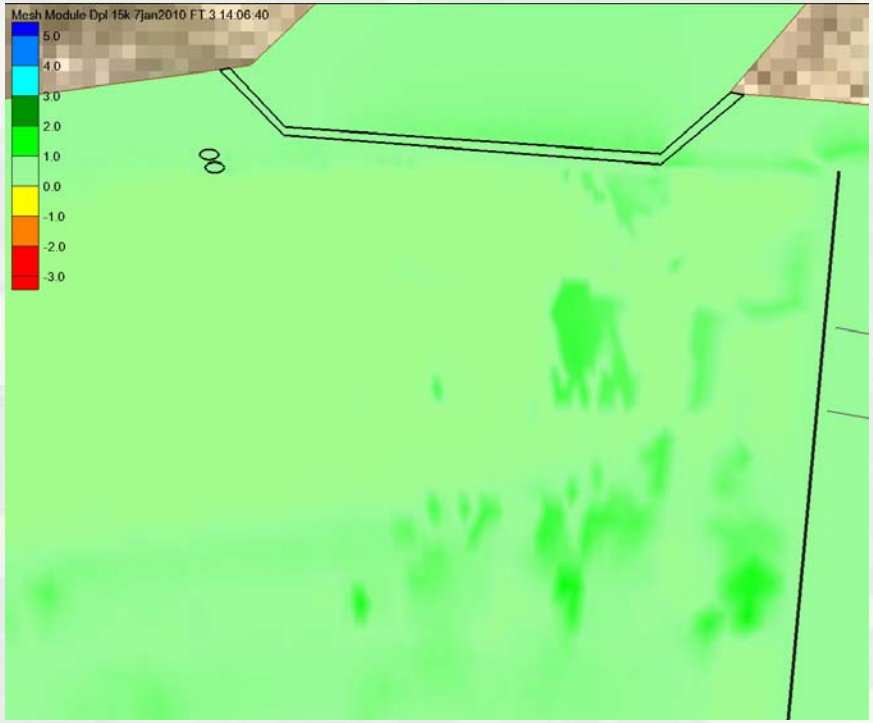
Sediment Output

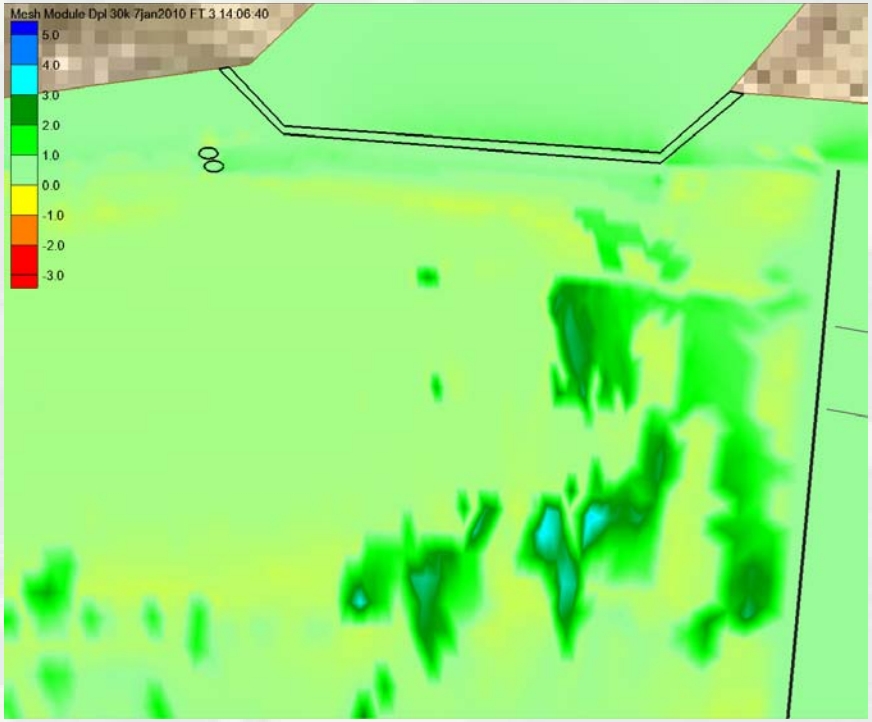
- Displacement; 30,000cfs; 10 days



Sediment Output

- Displacement; 15kcfs vs 30kcfs; 3 days





Known issues

- Minimal sediment data available at the site
- Calibration to existing conditions
  - Existing conditions is a moving target
  - No data available on existing rock field
- Comparison with physical model-still evaluating

Sediment Modeling Concerns

- Natural bed material is cobbles
- Proposed ramp will be boulders

- Issues foreseen with modeling this sediment size? Suggestions?

Discussion?