Roaring River Distribution System

Delta Modeling User Group

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Outline

- RRDS background
- RRDS operational patterns
- RRDS datasets
- RRDS gate rating
- RRDS treatment in DSM2
- RRDS future
Roaring River Distribution System
One of three initial facilities built in the early 1980's to mitigate for water project pumping
- Distribute lower channel salinity water to
  ~3000 Acres (DFW, GIWA, north)
  ~5000 Acres (private, south)
- ~17 miles of levee
- Intake pond on east side is about 40 acres
- Total of 40 turnout and drain structures
- Flood up first two weeks in October
- DFG land flood up in August (typically)
• 36 vertical flat fish screen panels; designed for 0.5 fps approach velocity but mandated in 1995 to 0.2 fps for Longfin smelt

• Eight 60” diameter motorized slide gates culverts to divert and control the flow rate during high tide and one-way flap gates on the pond side to prevent reverse flow into channel side

• DFD remotely operate the slide gates seasonally to meet water demands
WATER MANAGEMENT SCHEDULE

- **SHOOTING LEVEL**: +12"
- **FLOODING LEVEL**: +6"
- **POND BOTTOM**: 0"
- **DRAIN WATER LEVEL**: -6"
- **MUD FLAT**: -12"

**July** | **Aug** | **Sept** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun**

- **CIRCULATE WATER**
- **HUNTING SEASON**
- **LEACHING CYCLES**
- **SEED SET CYCLE**

**DO NOT ALLOW POND BOTTOM TO DRY**

**WATER IN DITCHES ONLY**

**DRAIN DEEP WATER AS POSSIBLE**
RRDS Operational Patterns
RRDS Datasets

- **Fishery**
  - Monthly UCD Fish Trawl Survey (MZ1 site)

- **Water quality**
  - Salinity, temperature, pH (some stations)

- **Hydrodynamics**
  - Stage us/ds, gates opening, and limited ADCP flow data behind the culverts

- **Pond and culvert specs**
  - DWR and SRCD
Roaring River Distribution System Intake Rating

Purpose

• Verify operation of RRDS Intake
• Culvert Velocity
• Operation plan for control system failure
• What gate opening will maximize flow for a given delta h?

Optimization problem

• During flood up, given \( \Delta h \), maximize flow into RRDS, subject to constraints:
  • Fish Screen Approach velocity requirements (usually 0.2 or 0.7 ft/s)
  • Maximum RRDS stage = 2.1 feet, NAVD88
  • Only open even or odd numbered gates
  • Don’t operate gates too often (no more than once every 10 minutes)

\[ V = f (\Delta h, z) \]
Roaring River Distribution System Intake Rating

RR Pond

“Screen Stage”

Montezuma Slough Stage

RRDS Fish Screens

RRDS Culverts

Roaring River Pond Stage
Δh = Screen Stage – Pond Stage

\[ \Delta h = H_e + H_{slide} + H_f + H_o + H_b + H_j + H_g + H_jc \]

\[ = H_e + H_{slide} + H_f + H_o \]

Where

- \( H_e \) = entrance loss
- \( H_{slide} \) = slide gate loss
- \( H_f \) = pipe friction
- \( H_o \) = exit loss due to expansion and flap gate resistance
- \( H_b \) = bend loss (N/A)
- \( H_j \) = junction loss (N/A)
- \( H_g \) = grate loss (N/A)
- \( H_{jc} \) = junction chamber loss (neglect)
Roaring River Distribution System Intake Rating

Entrance Head Loss

\[ H_e = K_e \left( \frac{V^2}{2g} \right) \]

Where

- \( g = 32.2 \frac{ft}{s^2} \)
- \( v = \text{pipe velocity, } \frac{ft}{s} \)
- \( K_e = 0.9 \)

Flow direction

Junction chamber

Entrance

Slide gate

Flap gate

Screen Stage

Montezuma Slough Stage

Roaring River Pond Stage

5 ft CMP

Entrance Head Loss

Calculation:

\[ H_e = K_e \left( \frac{V^2}{2g} \right) \]

Flow direction
Pipe Friction Head Loss

\[ H_f = \left(\frac{K_u n^2 L}{R^{1.33}}\right) \frac{V^2}{2g} \]

Where

\[ g = 32.2 \frac{ft}{s^2} \]
\[ v = \text{pipe velocity, ft/s} \]
\[ K_u = 29 \]
\[ n = 0.010 \]
\[ L = 98.5 \text{ ft} \]
\[ R = \frac{A}{P} = \frac{D}{4} = 1.25 \text{ ft} \]
Roaring River Distribution System Intake Rating

Slide Gate Head Loss

\[ H_{slide} = K_{slide} \left( \frac{v^2}{2g} \right) \]

Where

\[ g = 32.2 \frac{ft}{s^2} \]
\[ v = \text{pipe velocity,} \frac{ft}{s} \]

\[ k_{slide} = az^{-0.5} + bz^{-1} + c(\ln(z)) + de^{-z} + \text{offset} \]

- \( a = -1.5054793354300118E+03 \)
- \( b = 2.7190730109379151E+03 \)
- \( c = -5.3801061023326348E+01 \)
- \( d = 4.7556873740337003E+04 \)
- Offset = 3.6927943575932562E+02

Curve fit using zunzun.com
Roaring River Distribution System Intake Rating

Outlet (flap gate) Head Loss

\[ H_o = H_{exp} + H_{flap} \]

\[ H_o = \frac{V^2}{2g} \left( 1 + 8k_{flap} e^{-\frac{1.15v}{\sqrt{d}}} \right) \]

Where

\[ g = \frac{32.2 \text{ ft}}{\text{s}^2} \]

\[ v = \text{pipe velocity, \text{ft/s}} \]

\[ d = \text{pipe diameter, \text{ft}} \]

\[ k_{flap} = \text{calibration coefficient} \]
Δℎ = \sum_{i=1}^{\text{npipes}} \left( \frac{v_i^2}{2g} \right) \left[ K_{ei} + K_{slidei} + \left( \frac{K_u n^2 L}{R^{1.33}} \right) + 1 + 8k_{flap} \right] e^{\left( \frac{-1.15v_i}{\sqrt{d}} \right)}

Where

\text{npipes} = 8
\quad g = 32.2 \frac{ft}{s^2}
\quad v = \text{pipe velocity}, \frac{ft}{s}
\quad K_e = 0.9
\quad k_{slide} = a z^{-0.5} + b z^{-1} + c (ln(z)) + d e^{-z} + \text{offset}
\quad a = -1.5054793354300118E+03
\quad b = 2.7190730109379151E+03
\quad c = -5.3801061023326348E+01
\quad d = 4.7556873740337003E+04
\quad \text{Offset} = 3.6927943575932562E+02
\quad v = \text{pipe velocity}, \frac{ft}{s}
\quad d = \text{pipe diameter}, \text{ft} = 5 \text{ ft}
\quad k_{flap} = \text{calibration coefficient}
\quad K_u = 29
\quad n = 0.010
\quad L = 98.5 \text{ ft}
\quad R = \frac{A}{P} = \frac{d}{4} = 1.25 \text{ ft}
Roaring River Intake Structure

\[ \Delta h = \sum_{i=1}^{n_{pipes}} \left( \frac{v_i^2}{2g} \right) \left[ K_{e_i} + K_{slide_i} \left( \frac{K_wn^2L}{R^{1.33}} \right) + 1 + 8k_{flap_i} e^\left(\frac{-1.15v_i}{\sqrt{d}}\right) \right] \]

\[ V = f(\Delta h, z) \]
\[ Q = VA \]

Solving the equation

- Iterative solver
- Java application
- spreadsheet
- Solve for a range of \( \Delta h \) and gate openings to create
  - 3D lookup table
  - graph
Roaring River Intake Structure

October 2010

RRDS Intake Flow
Calculated vs Observed, 2010 Flow Study
equation calibrated using kflap=3

- Observed Flow
- Flow, Calculated

December 2011

RRDS Intake Flow Calculated vs Observed, 2011 Flow Study
equation calibrated using kflap=3

- Observed Flow, cfs
- Flow, Calculated
Roaring River Intake Structure
Flow Measurement and Calculation Issues

**Flow Measurement Challenges**
- Turbulence
- Fish Screen Debris
- Pond Vegetation

**Flow Calculation Assumptions & Unknowns**
- Neglecting Junction Chamber and Trash rack headlosses
- Approach velocity estimate assumes $Q_{culverts} = Q_{Fish\ Screen}$
- Fish screen headloss coefficient is variable due to debris
When $Z_{wb} < Z_{node}$

\[ Q = nC_{op\_from} C_{from} A(z_{node}, p) \sqrt{2g(z_{node} - z_{wb})} \]

Where:

- $C_{from} = 0.5$
- $C_{op\_from} = 1.0$
- $n$ = number of duplicate devices = 8, $g$=gravity,
- $C_{op\_to}$ and $C_{op\_from}$ = operating coefficient for controls, e.g. flap valves
- $C_{to}$ and $C_{from}$ = coefficients representing gate’s hydraulic efficiency
- $A$ = area of flow depending on higher water surface and position $p$
- $z_{res}$ and $z_{node}$ = water surface elevations at the reservoir and node
RRDS Future?
Delta Smelt Resiliency Strategy

Two of ten actions are in the Suisun Marsh:

- SMSCG: August Reoperation
- RRDS: Install west end drain pipe & repair existing east end drain pipe
Roaring River East and West Drains

- East Drain repaired (June 2017)
- West drain install (July 2018)
- Duration and how it will be operated is unknown
- Biological and water quality monitoring
RRDS Future: Dual Purpose

- Continue to be a water supply system for SRCD and DFW managed wetlands to mitigate for water projects (SWP/CVP) pumpings

- Potential food production for Delta smelt as identify one of ten action items in the 2016 Delta Smelt Resiliency Strategy
RRDS Final Thoughts

- The need to improve RRDS in DSM2
- Increased collaboration of data sharing
Questions?

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References


EXTRA SLIDES
Available Stage Data near Roaring River Intake Structure

- RRDS Fish Screens
- “Screen Stage”
- RRDS Culverts
- Montezuma Slough Stage
- Roaring River Pond Stage
Roaring River Fish Screen Approach & Sweeping Velocities

\[ V_{App} \approx \frac{\sum_{i=1}^{npipes} Q_i}{\text{Fish Screen wetted area}} \]

assuming

\[ Q_{screen} = Q_{culverts} \]

And no debris on the screens