NOV 16, 2022

Water Rights Monitoring & River Modeling

Public Utility District No. 1 of Chelan County

Peter Vanney and Shaun Harrington

AVEVA

Agenda

- A Bit About US
- Chelan County Public Utility District
  - Who, What, Where
  - PI Usage
- PI Use Cases
  - Water Rights Pump Monitoring
    - Work Intake Process
    - AF structure & Display
  - River elevation modeling
    - Analytic process in and out of PI
    - Productionized PI Results

A Bit About Us

R users - data analysts/data scientists/statisticians/economists

Peter – Hydro Gen

- Started at the PUD in 2018. Formerly:
  - Statistician for Texas Highway Patrol
  - Grad student math/stats instructor
  - Peace Corps Volunteer teacher in Ghana
- MS in Statistics from University of Alaska Fairbanks
- BA in Math from Lawrence University (Appleton, WI)
- Originally from Decorah, IA

Shaun – BI & Data Analytics

- Public Utility experience starting in 2020
- BS in Economics from Utah Valley University
- Currently working on MS in Applied Economics from Boston College

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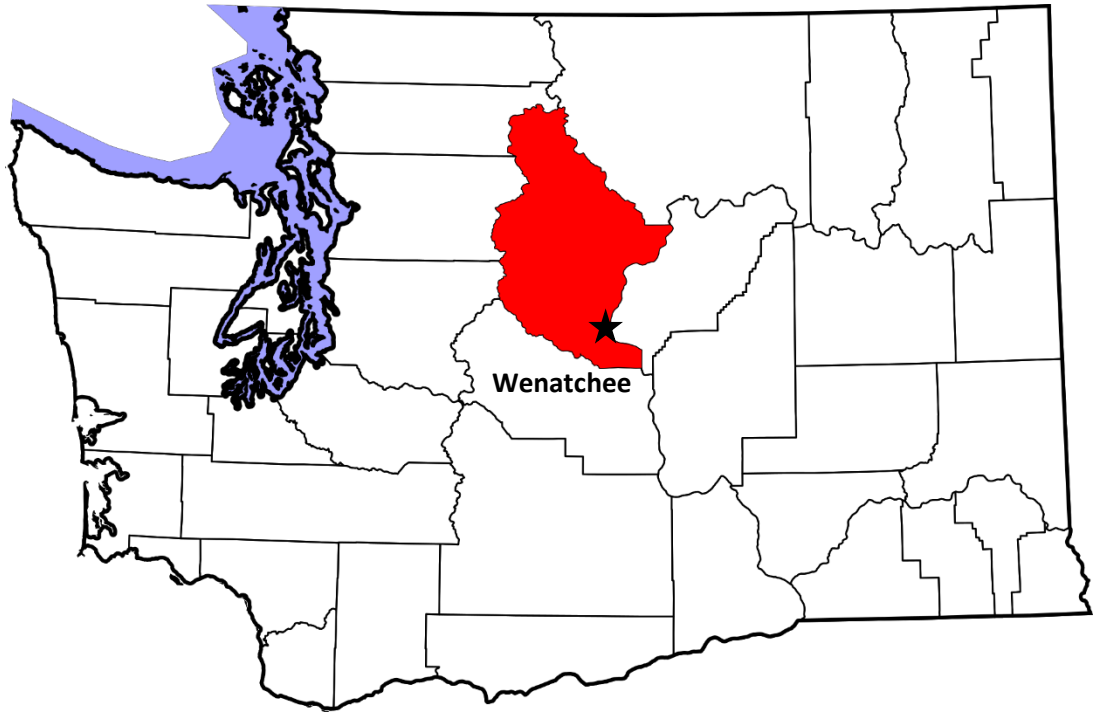
Chelan County Public Utility District (Chelan County PUD)



https://en.wikipedia.org/wiki/Chelan_County,_Washington

- Nonprofit and customer-owned
- Electric, water, wastewater, and telecommunications
- 3 hydroelectric dams ~2,000MW nameplate capacity
  - 2 on the Columbia River (mix of Kaplan and Bulb turbines)
  - 1 at the base of Lake Chelan (Francis turbines)
- Meet local load and export ~80+%
- Average residential rate just over $0.03 per KWH
- Serve about 50,000 retail electric customers

PI at Chelan County PUD

- PI System installed in 2002
- Originally:
  - PI Historian used primarily as a database for after-the-fact root cause analysis
  - Some reporting and dashboarding using DataLink and ProcessBooks
  - Use required active engagement and some knowledge silos were formed
- 2018 – now: invest in PI Visualization and Development tools
  - Initial Asset Framework based on Maximo Location Hierarchy
  - PI Vision & PI Web API development
  - Started with Generation Assets, but have enterprise-wide goals
  - AMI pilot with AVEVA PI and PowerRunner

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P.U.D.
CHELAN COUNTY

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Water Rights Monitoring

Challenge

- Visualize real-time water pump information and cumulative flows
- Improve business reporting process from monthly Excel spreadsheet
- Pumps have PI Tags already
- Incorporate field device and water rights metadata

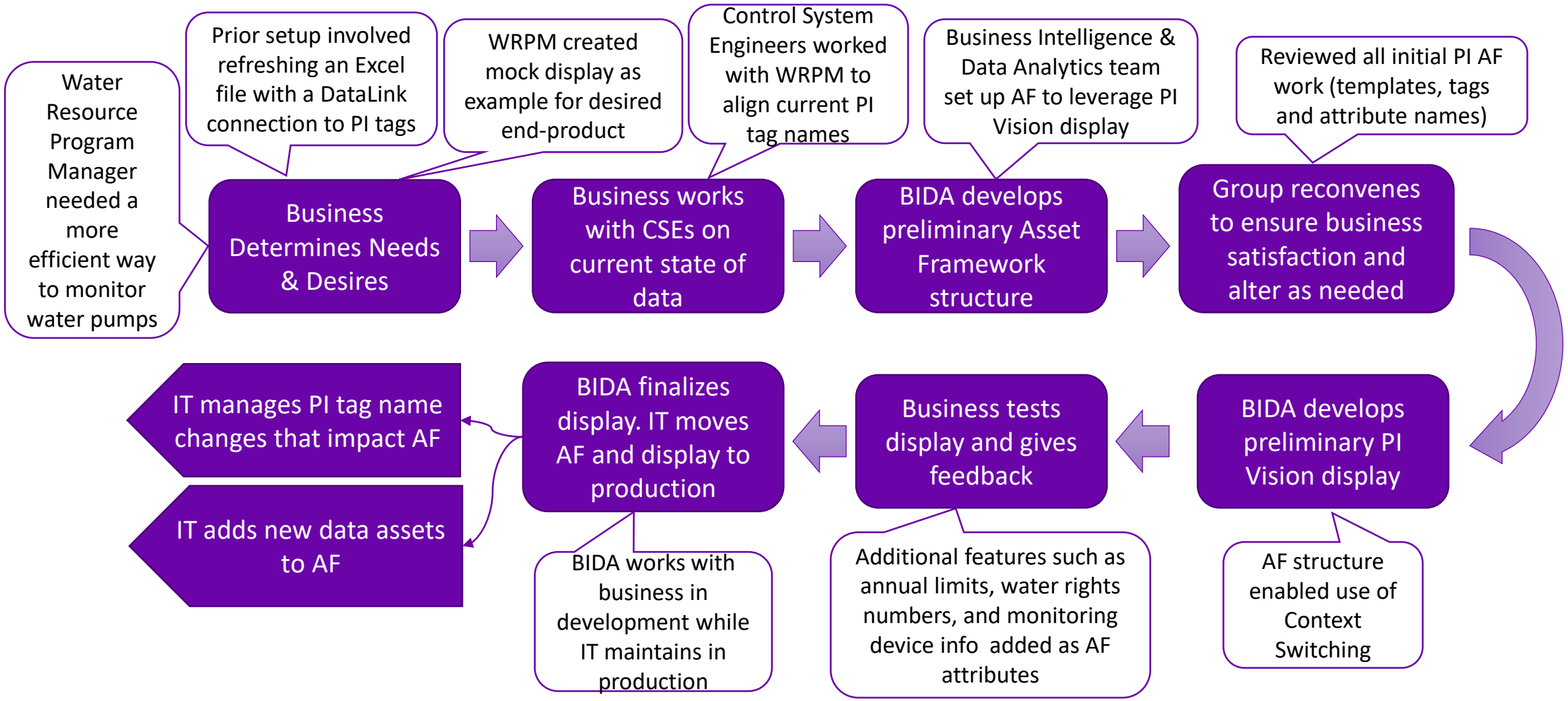
Solution

- PI development intake process
- Use PI AF to standardize data
- Leverage PI AF templates to speed up development
- Create PI Vision display for enterprise-wide monitoring
- Asset/context switching simplifies display development and interface
- PI AF attributes for PI Tags and metadata

Benefits

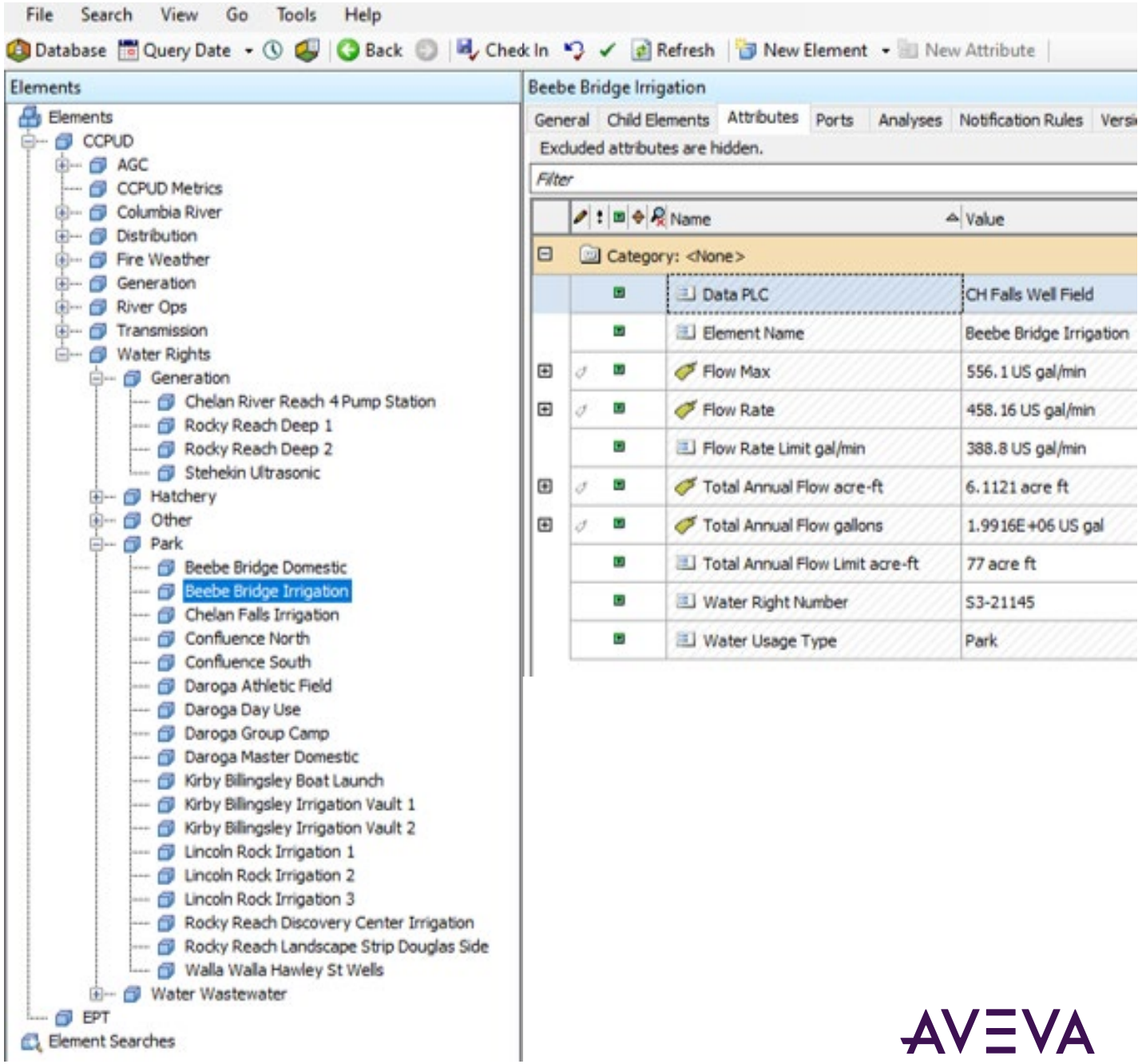
- Site managers can monitor asset performance and identify problems real-time with PI Vision display
- Tech shop can quickly detect data quality issues
- Streamlines data reporting process to WA Dept of Ecology
- PI solutions are flexible for future enhancements

PI (Water Rights Monitoring) Intake Process



Water Rights AF Structure and Display

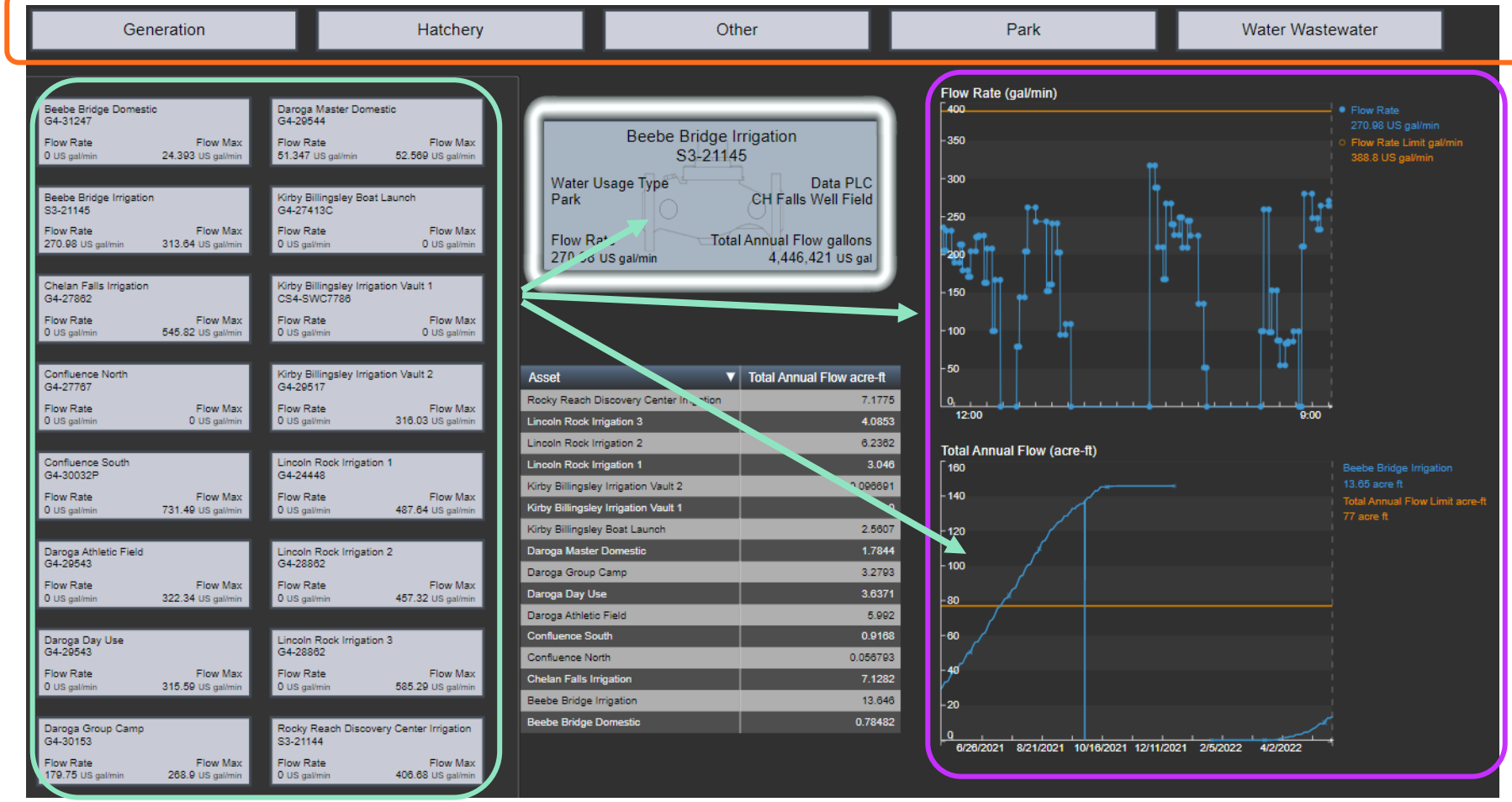
- Create AF Templates for ‘Water Usage Type’ and ‘Water Pump’
- Collaborative field naming
- Attributes are flexible. Add text metadata, tags, and numeric values
- Change unit of measure without using another Tag



PI Vision - Water Rights Monitoring

Parent attribute context switching using ‘Water Usage Type’ template buttons

Both button sets are ‘collections’ which display all matching template types in the defined search criteria.



Context switching of centered detail and graphs leverage attribute switching buttons at the ‘Water Pump’ level

Graphs show both tags and manually entered numeric attributes

SERVER\CCPUD\CCPUD\Water Rights\Park\Beebe Bridge Irrigation | Flow Rate

River Elevation Modeling

Challenge

- Make an app that informs Columbia River and Lake Chelan users of changing conditions at boat launches and beaches
- Centralize public data distribution
- Leverage realtime PI data
- Apply data science and analytics for accuracy

Solution

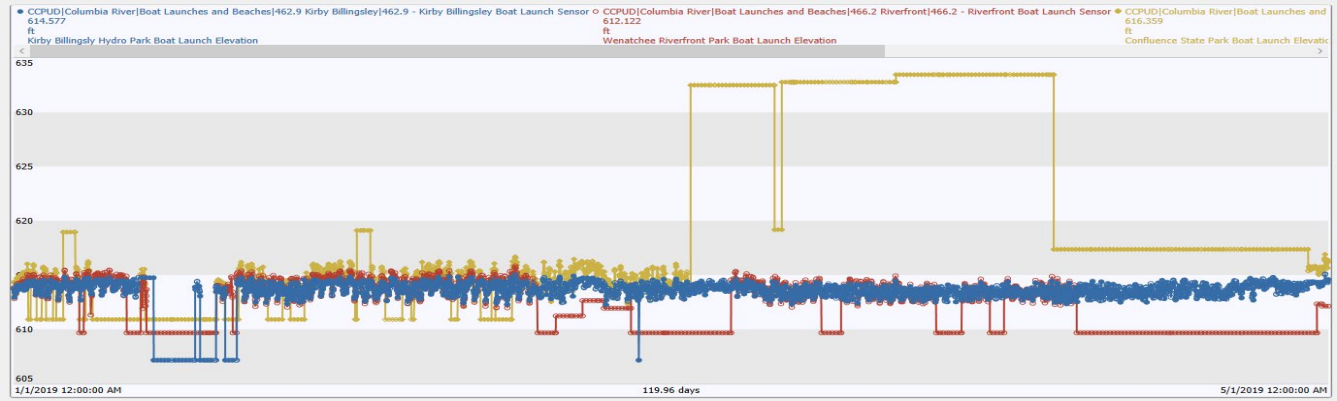
- Evaluate current reporting and analytic solutions
- Use PI AF to standardize data
- Leverage PI AF templates to speed up development
- Create PI Vision display for enterprise-wide monitoring
- Develop PI Web API portal for public data

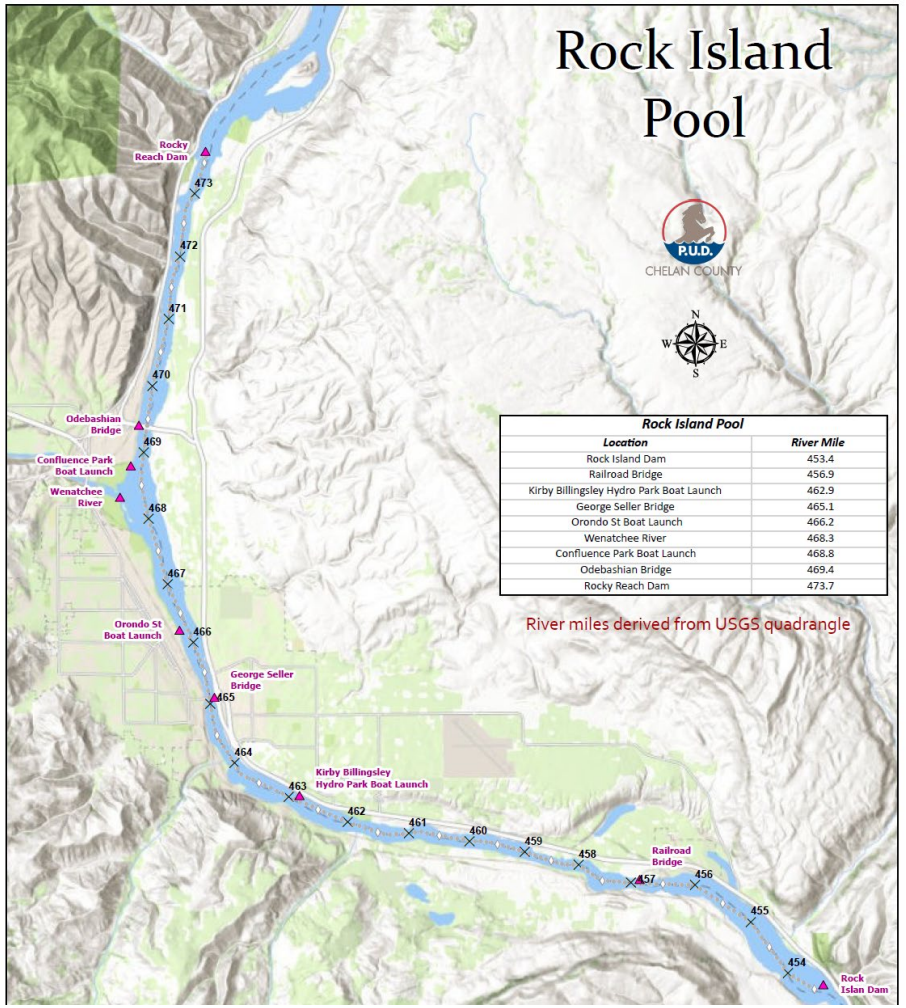
Benefits

- Current app provides more information for our customer owners
- Enable realtime monitoring of river and lake conditions (boat launch water levels, flows, temperatures, fish counts)
- PI solutions are flexible for future enhancements

River Elevations by Mile Background

- **Data Goal:** leverage flow and elevation sensor (5) data to develop a model for river elevation → depth of water at boat launches and beaches
- Already have backwater curve profiles: engineering studies of expected elevation for multiple steady flows
- Sensor data was dirty (the sensors were originally meant to be temporary)
- How to interpolate elevation of 20 miles of river?

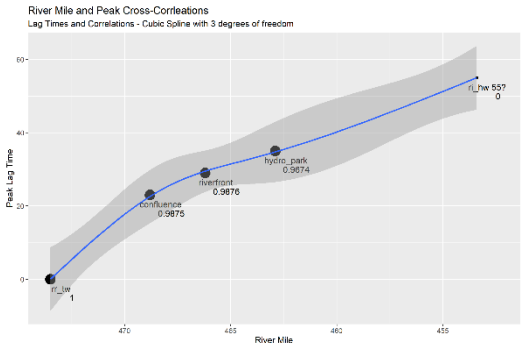


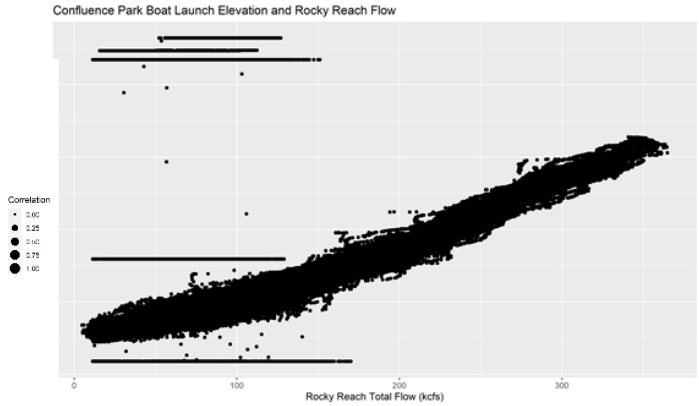


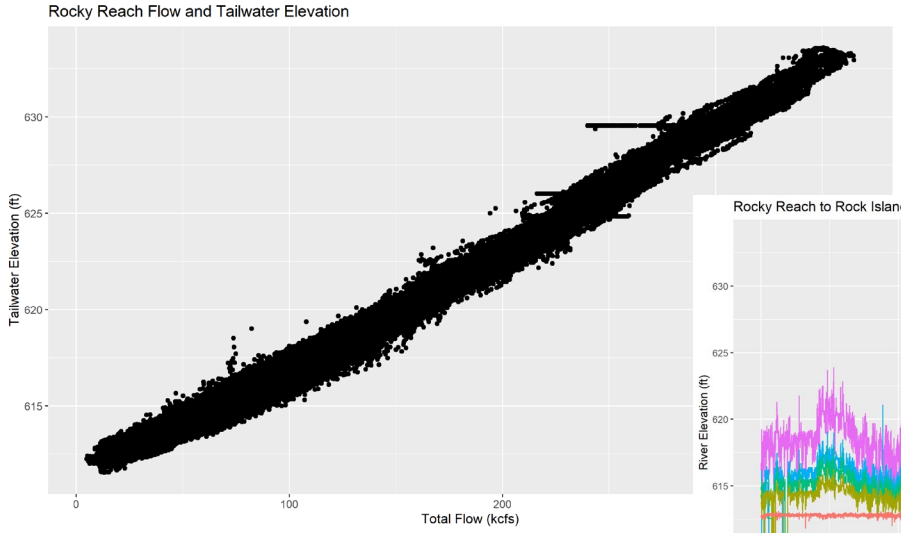
(There shouldn't be any flat lines…)

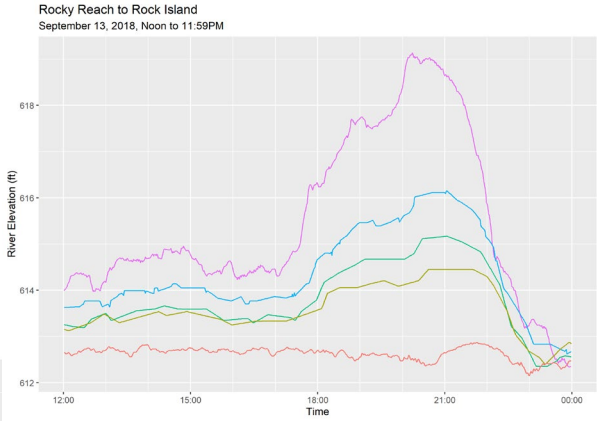
River Elevations by Mile Exploratory Analysis

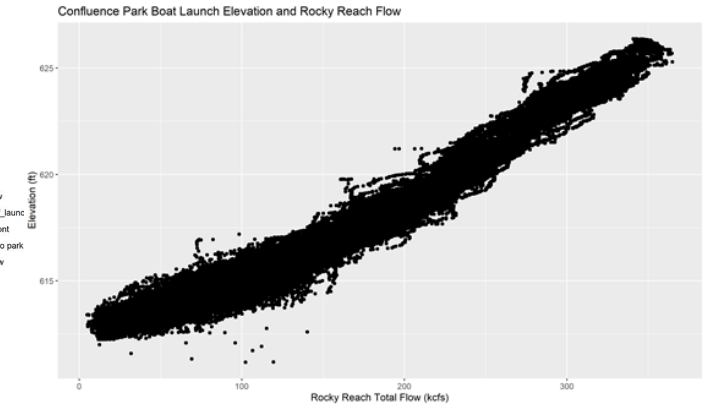
- Read what others have done
- Summarize and plot data and look for patterns and correlations

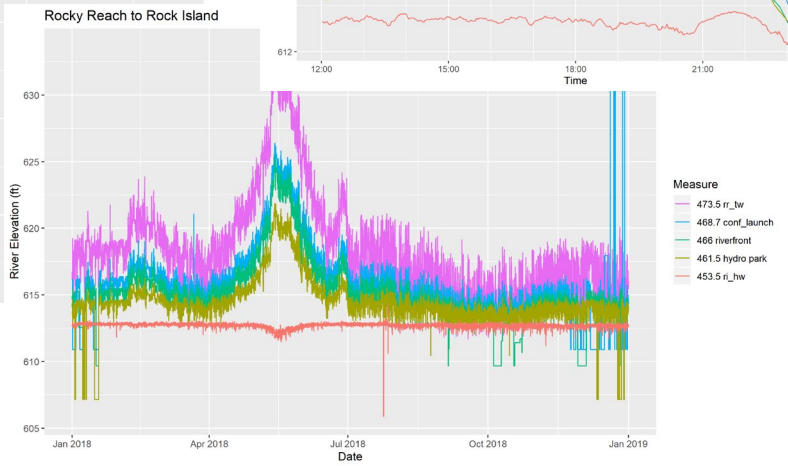


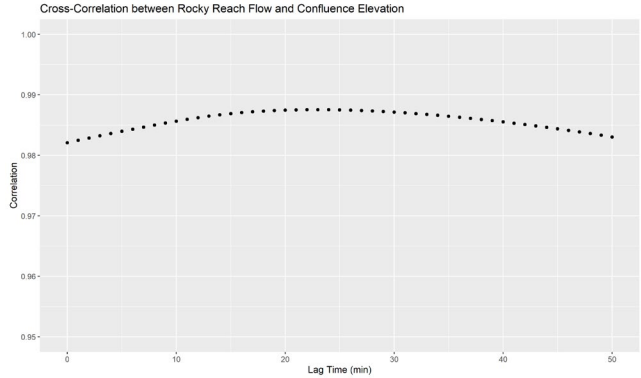










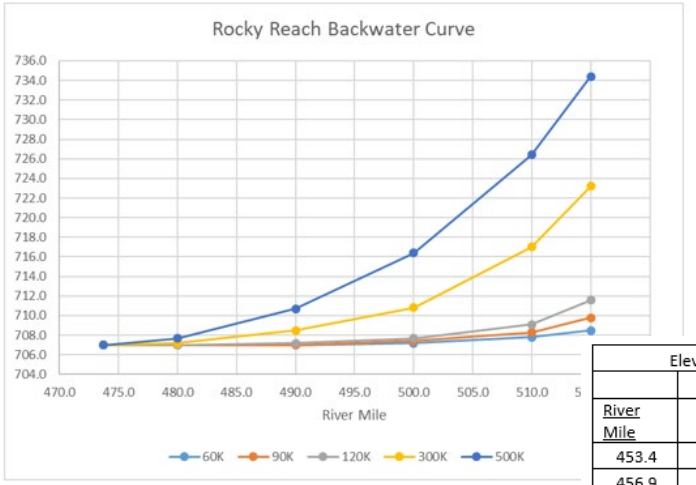


River Elevations Modeling

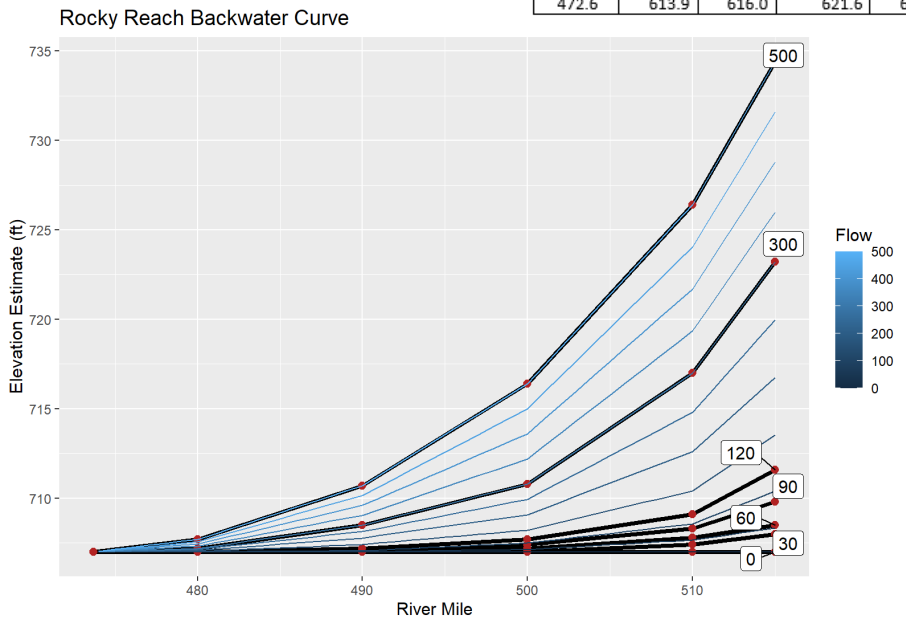
- Exploratory analysis and statistical modeling are helpful, but you can only fit a model where you have data
- Back to the backwater curve profiles

To go from a static analysis in Excel to production model in PI you need to:

- Create reference/lookup tables
- Setup necessary inputs
- Calculate the output
- Templatize your work to speed up the process



Elevations Between Rock Island & Rocky Reach					
	Flow in KCFS				
River Mile	50	100	200	390	464
453.4	613.0	613.0	613.0	613.0	613.0
456.9	613.1	613.1	613.5	614.3	614.8
460.1	613.1	613.5	614.6	618.6	620.5
463.6	613.1	613.7	615.7	621.5	624.2
467.0	613.4	614.8	618.8	626.5	631.0
470.9	613.7	615.5	620.5	630.9	634.6
472.6	613.9	616.0	621.6	632.2	636.0



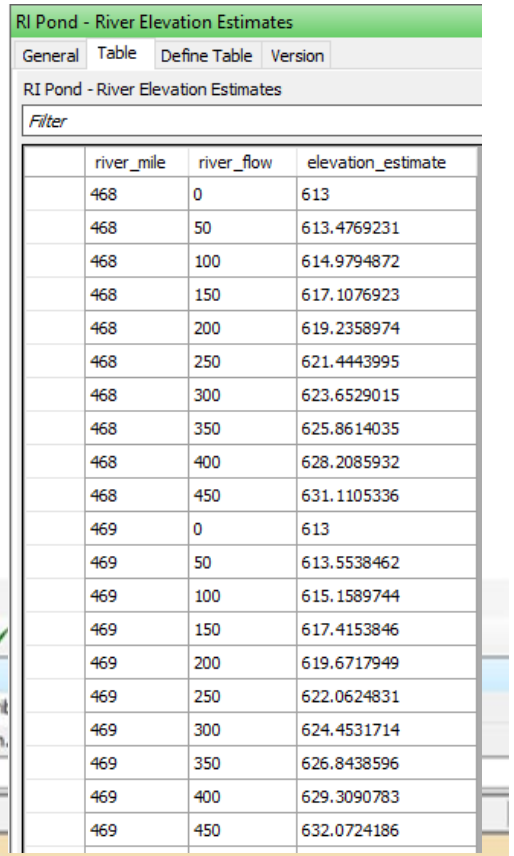
River Elevations in PI

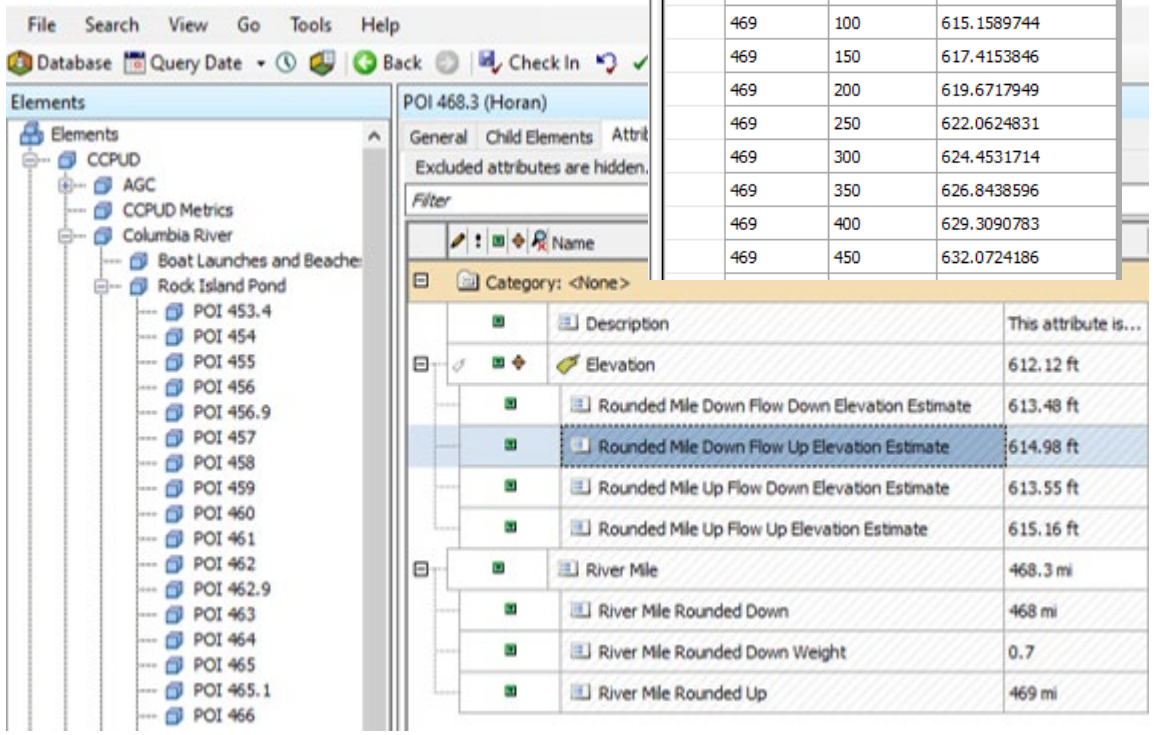
Rounded Elevation Analysis (lookup nearest 4 points to current location and condition):

```
SELECT [elevation_estimate]
FROM [RI Pond - River Elevation Estimates]
WHERE [river_mile] =
@[|River Mile|River Mile Rounded Down;UOM=mi]
 AND [river_flow] =
  @[..\|Rocky Reach Total Flow Rounded Up to
Nearest 50;UOM=k ft3/s]
```

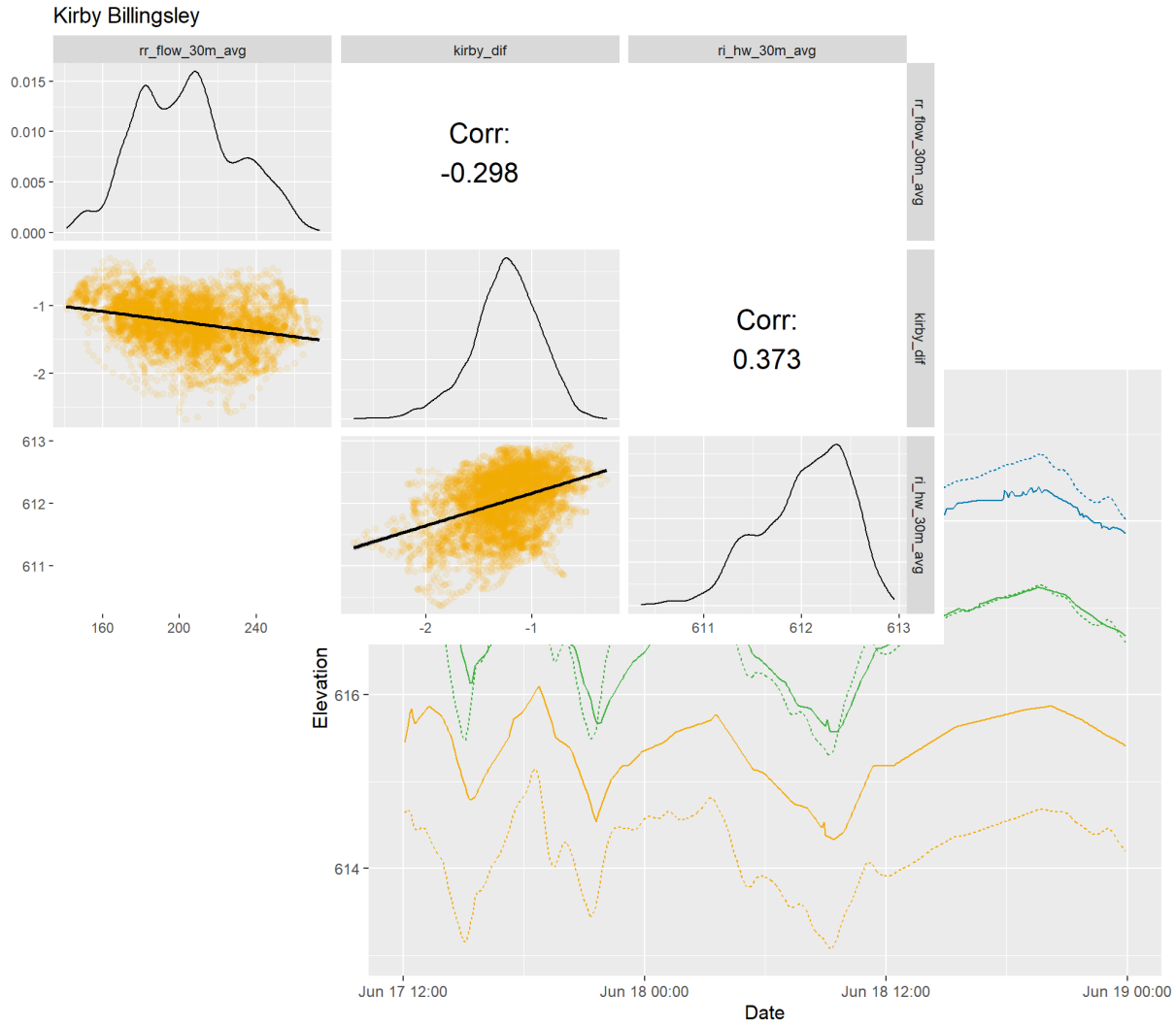
Elevation Analysis (weighted average of 4 nearest points):

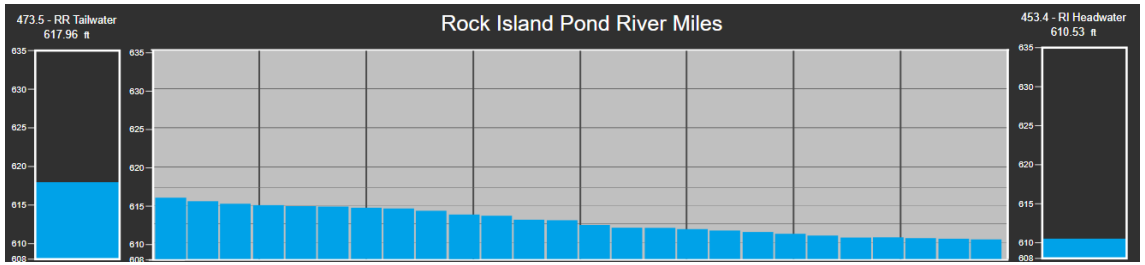
```
'..|Rock Island Headwater Difference From Max'
 +
( 'Elevation|Rounded Mile Down Flow Down Elevation Estimate'*
  'River Mile|River Mile Rounded Down Weight'*
  '..|Rocky Reach Total Flow Rounded Down Weight')
 +
( 'Elevation|Rounded Mile Down Flow Up Elevation Estimate'*
  'River Mile|River Mile Rounded Down Weight'*
  (1 - '..|Rocky Reach Total Flow Rounded Down Weight') )
 +
( 'Elevation|Rounded Mile Up Flow Down Elevation Estimate'*
  (1 - 'River Mile|River Mile Rounded Down Weight')*
  '..|Rocky Reach Total Flow Rounded Down Weight' )
 +
( 'Elevation|Rounded Mile Up Flow Up Elevation Estimate'*
  (1 - 'River Mile|River Mile Rounded Down Weight')*
  (1 - '..|Rocky Reach Total Flow Rounded Down Weight')  )
```





River Elevations
Deploy, Monitor, Adjust





The model was not aligned with one boat launch sensor, so after a chat with a subject matter expert I reanalyzed the data and adjusted the model.

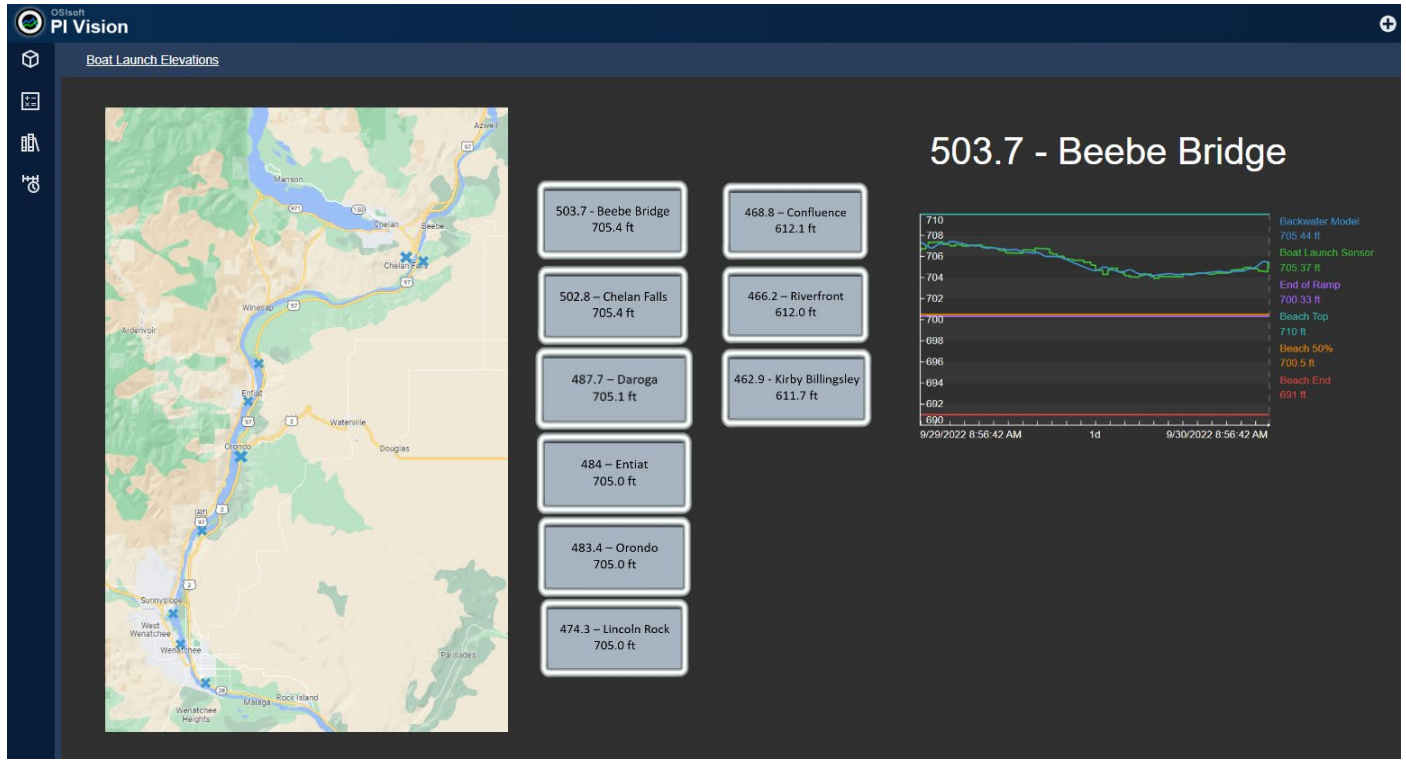
```
lm(formula = residual ~ hw_diff + rr_flow_30m_avg + I(rr_flow_30m_avg^2),
    data = df)

Residuals:
     Min       1Q   Median       3Q      Max
-0.94224 -0.13197 -0.00917  0.12364  1.29227

Coefficients:
                      Estimate Std. Error t value Pr(>|t|)
(Intercept)         -6.753e-01  3.747e-02  -18.02   <2e-16 ***
hw_diff             -2.484e-01  4.040e-03  -61.50   <2e-16 ***
rr_flow_30m_avg      1.111e-02  4.266e-04   26.05   <2e-16 ***
I(rr_flow_30m_avg^2) -1.438e-05  1.183e-06  -12.16   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

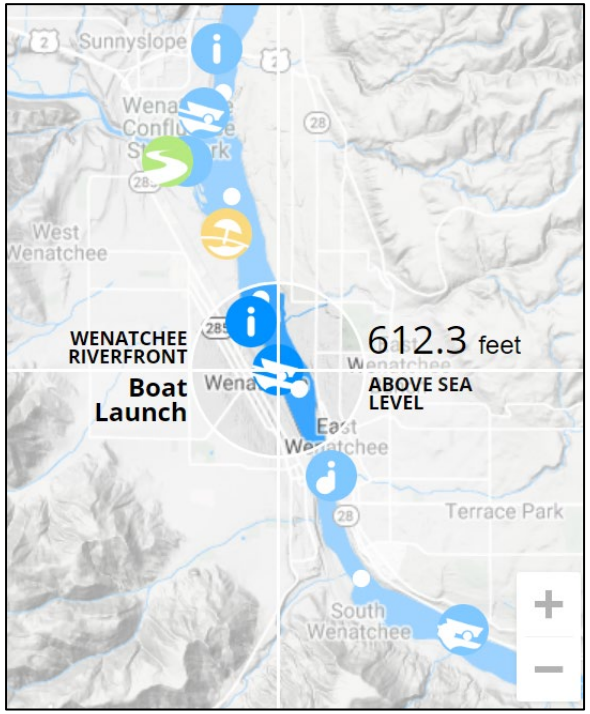
Name	Expression	Value at Evaluation	Value at Last Trigger	Output Attribute	
Standard	'..|Rock Island Headwater Difference Fr	612.6 ft	612.6 ft	Map	⊗
Adjustment	-0.6753 - 0.2484*'..|Rock Island Headwa	0.30836	0.30836	Map	⊗
Final	Standard+Adjustment	612.91 ft	612.91 ft	Elevation	⊗

River Elevations

In production: Internally (PI Vision) and Externally (via PI Web API)

[Current app](#) provides more information for our customer owners





PI Value Analytics at Chelan PUD

Challenge

- Broaden operational data access and visibility
- Leverage existing investments in systems
- Stay flexible with solutions
- Emphasize safety and security

Solution

- Leverage investment in the PI System
  - PI Archive, PI AF, PI Web API, PI Analysis Service, PI Event Frames, PI Notifications, PI Vision
- Modernize technology and reporting solutions

PI Benefits

- Defined time-series data strategy
- Speedy analysis and results
- Templatized data modeling
- Centralized displays
- Data-driven decision making

Peter Vanney

Data Analyst, Hydro Generation

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Questions?

Please wait for the microphone.

State your name and company.

Please remember to…

Navigate to this session in the mobile app to complete the survey.

Thank you!

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