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Let's Solve Water

Applying CVSG – SonTek QC4

Isaac Jones – Sr. Application Engineer

Xylem Environmental
Global Dealer Workshop

October 7, 2025

Outline

LSPIV Approach
Large-Scale Particle Image Veloci
Cross correlation of sequenti
vector fields

STIV Approach
Space time image velc
Quantifies chang
variation through
dimensional sea

1. **QC4 development background**
2. CVSG method overview
3. QC4 hardware review
4. Application example – Prado Dam, Southern California
5. Application example – Page River, Australia
6. Hydrosphere preview

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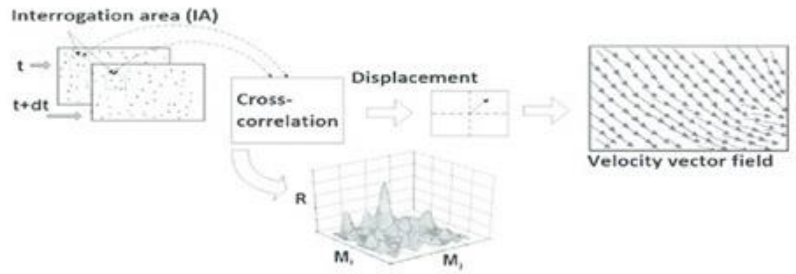
Development

University of Queensland research by **Nick Hutley** and **Simon Albert**

LSPIV Approach

Large-Scale Particle Image Velocimetry

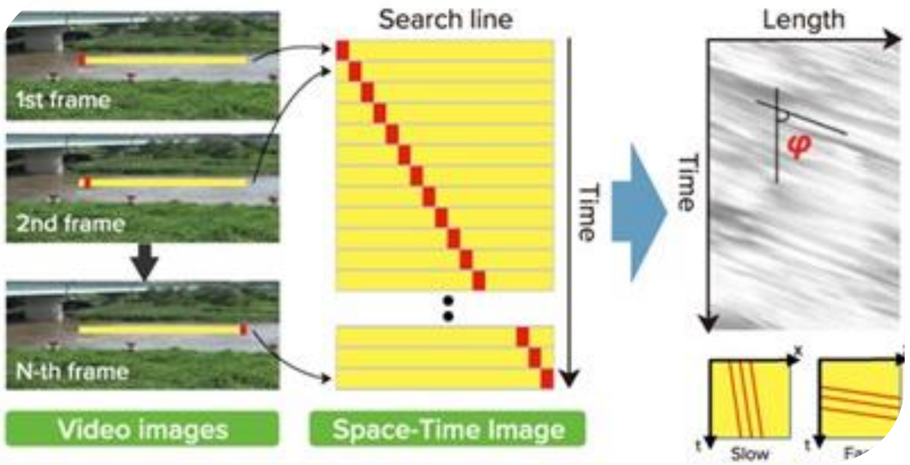
Cross correlation of sequential image vector fields



STIV Approach

Space time image velocimetry

Quantifies change in luminance variation through time across one-dimensional search lines



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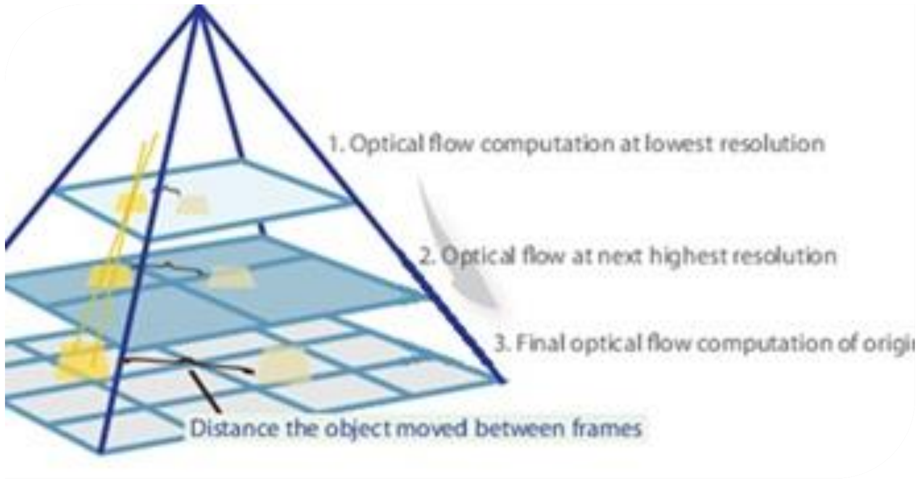
Development

New Optical Flow Approach

The motion of variation in luminance at different scales



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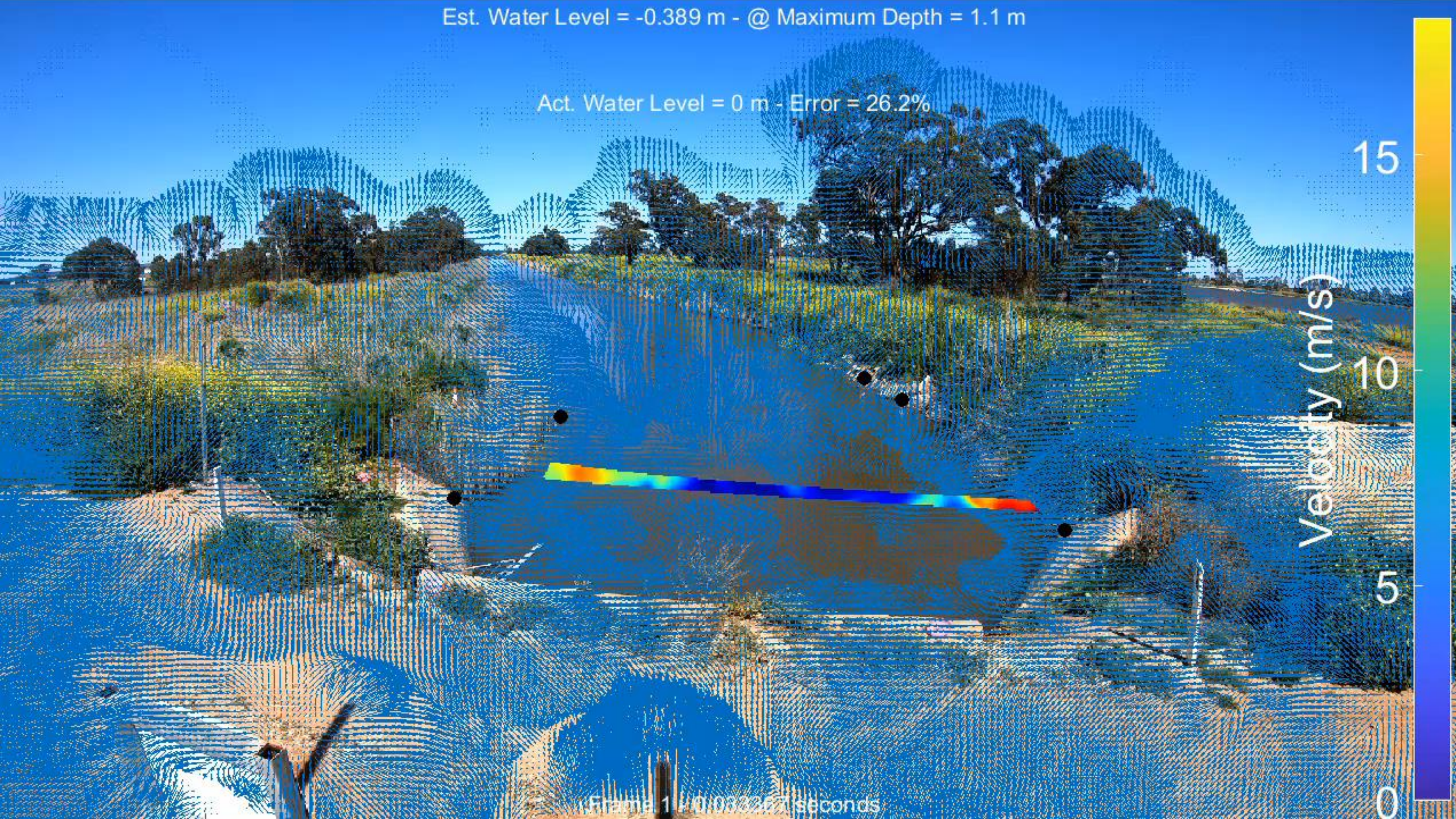

Est. Water Level = -0.389 m - @ Maximum Depth = 1.1 m
Act. Water Level = 0 m - Error = 26.2%
Velocity (m/s)
0
5
10
15

European Geosciences Union

Hydrology and Earth Syste

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31 May 2023

Adaptively monitoring streamflow using a stereo computer vision system

Nicholas Reece Hutley, Ryan Beecroft, Daniel Wagenaar, Josh Soutar, Blake Edwards, Nathaniel Deering, Alistair Grinham, and Simon Albert

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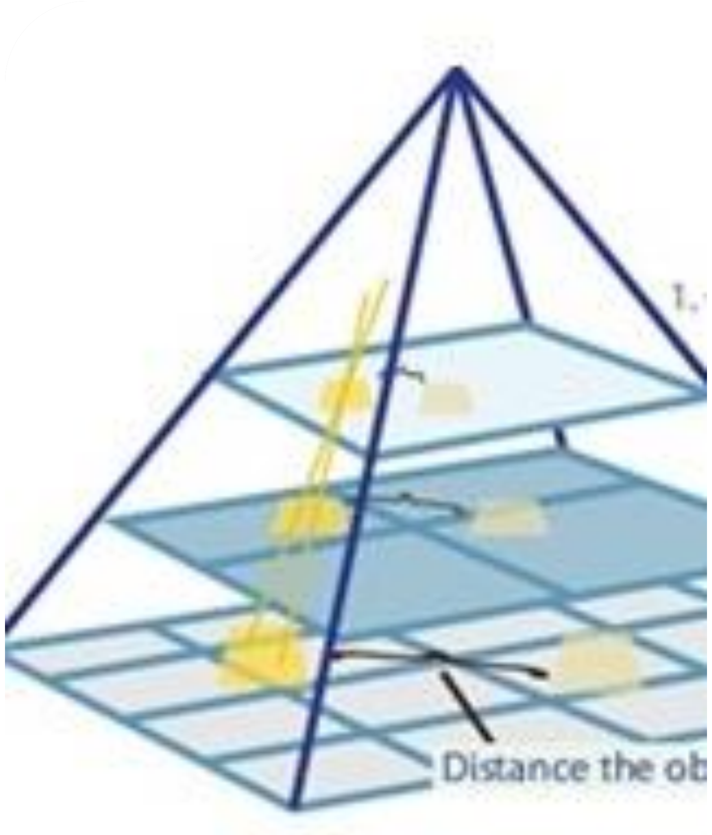
Method



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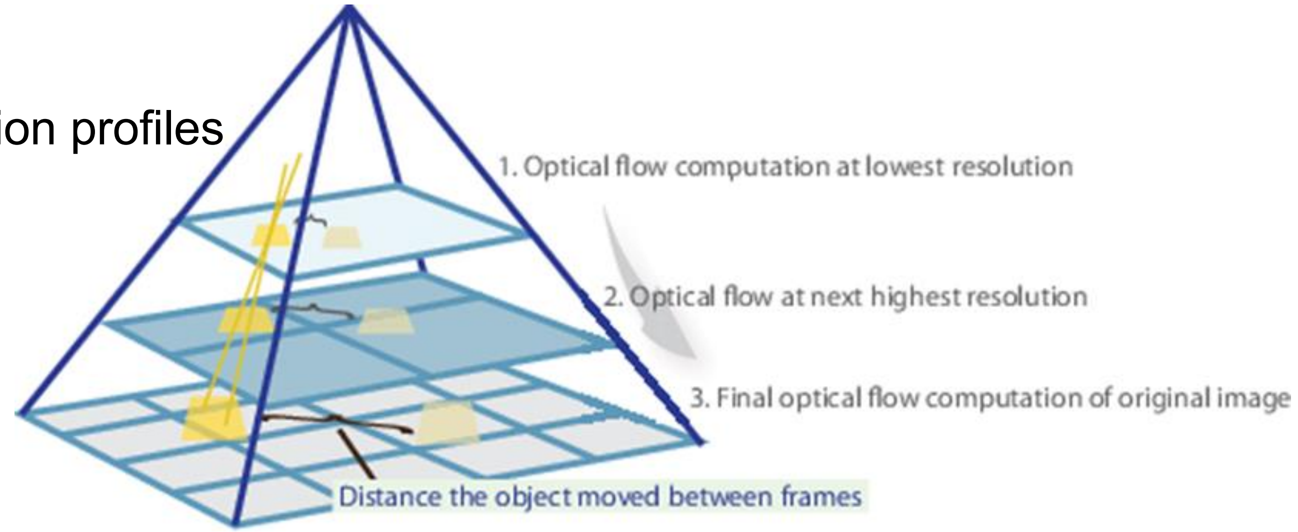
Computer Vision

Methodology

Cross-section and water level estimation

- Stereophotogrammetry
- Rectification
- Point Cloud
- Adaptive learning of cross section profiles
- Water level estimation



Surface velocimetry estimation

- Motions computed with Farneback algorithm
  - High accuracy
  - Dense flow fields
  - Lower sensitivity to noise
- Four level pyramid processing

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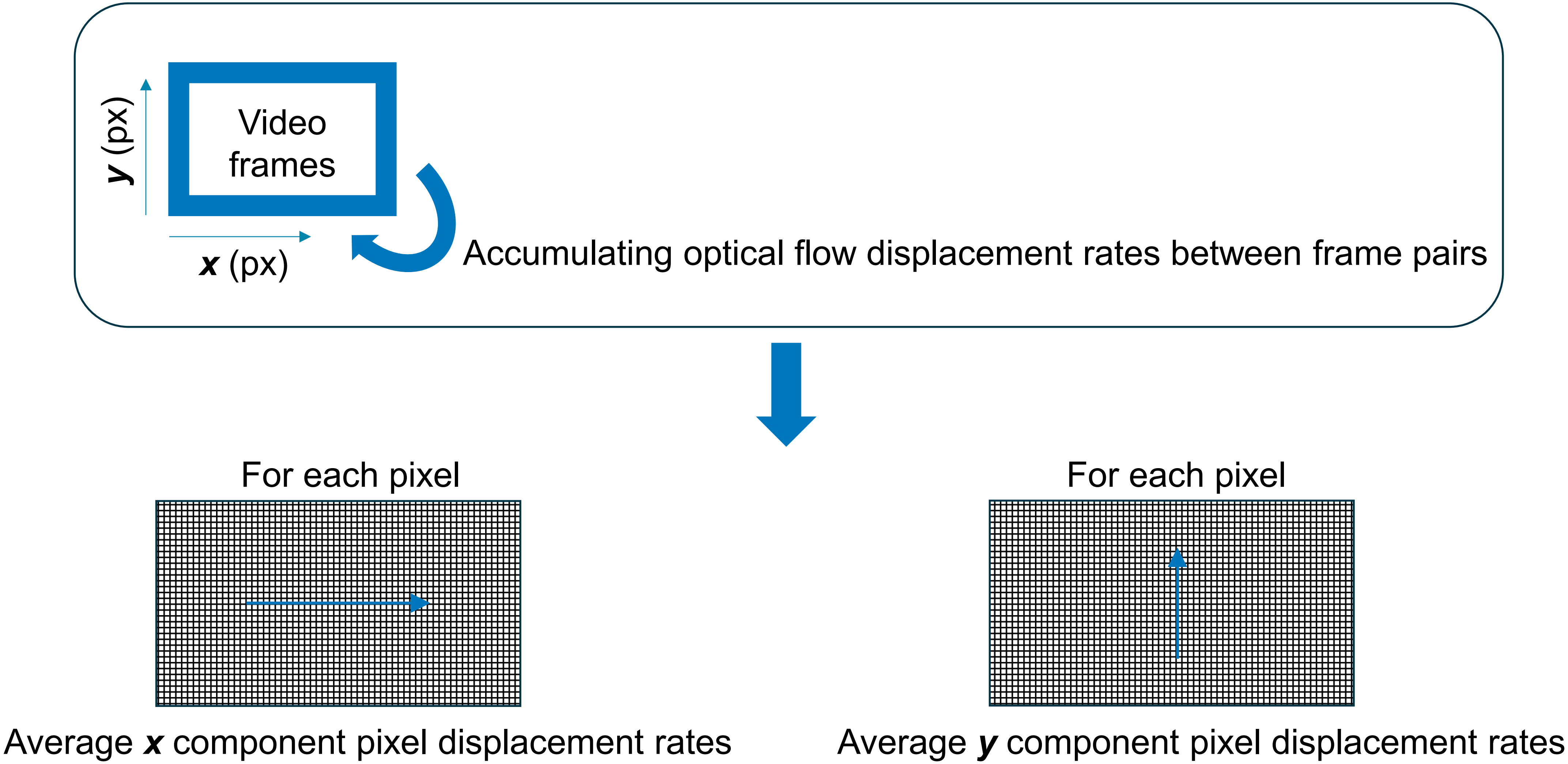
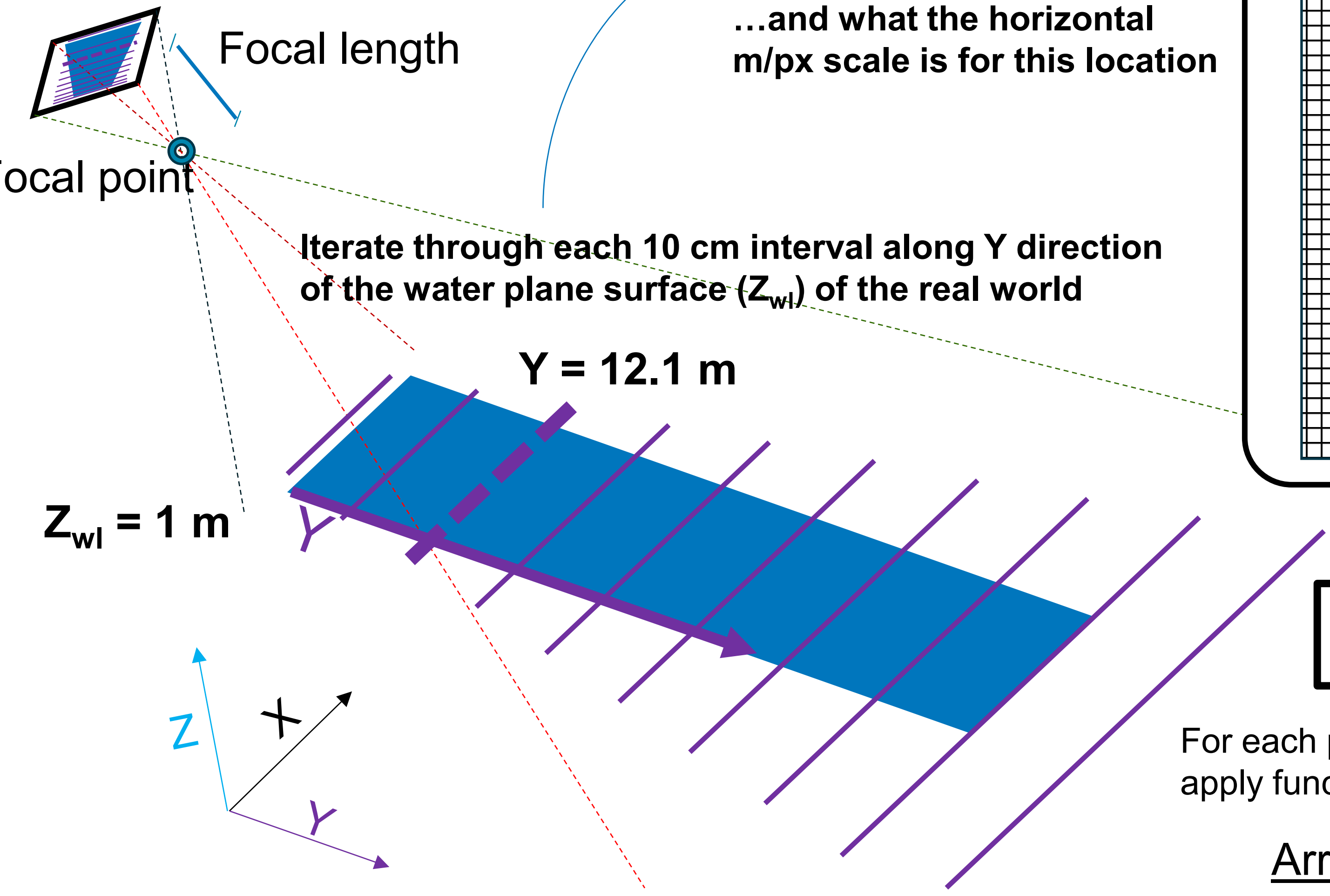
Net Optical Flow Displacements



Water surface coordinate projection

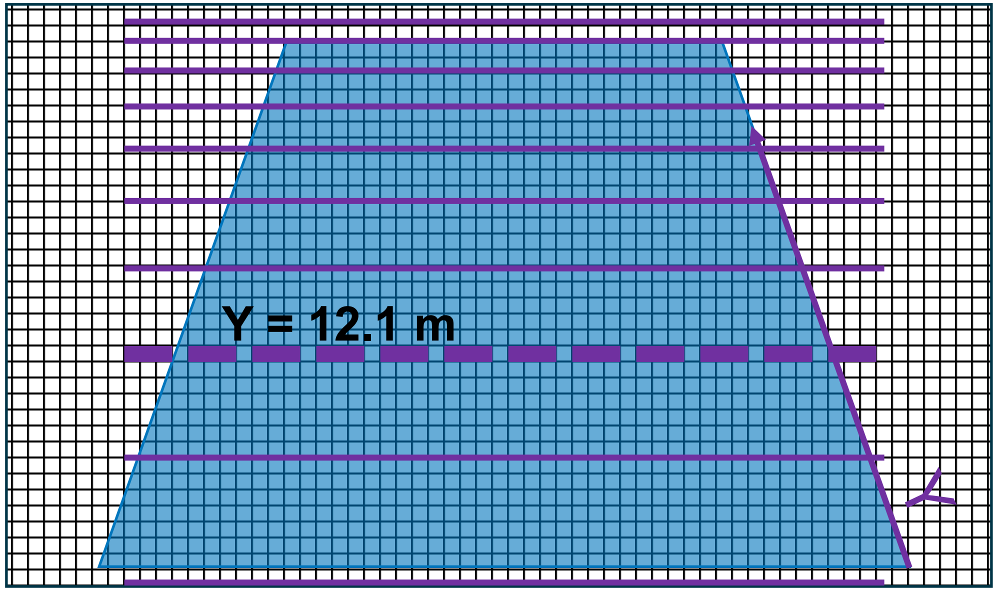
Y_{cam} = 2.4 m
Z_{cam} = 10 m



Iterate through each 10 cm interval along Y direction of the water plane surface (Z_{wl}) of the real world

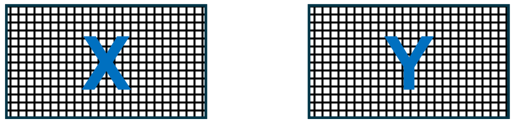
Apply trigonometry to find which pixel row the light from this Y coordinate of the surface lands on…
…and what the horizontal m/px scale is for this location

Camera POV (un-flipped horizontally & vertically)



Create interpolation functions mapping the planar coordinates and pixels to surface distance scaling

For each pixel in the image apply functions to calculate:



Arrays of water surface X coordinates & Y coordinates

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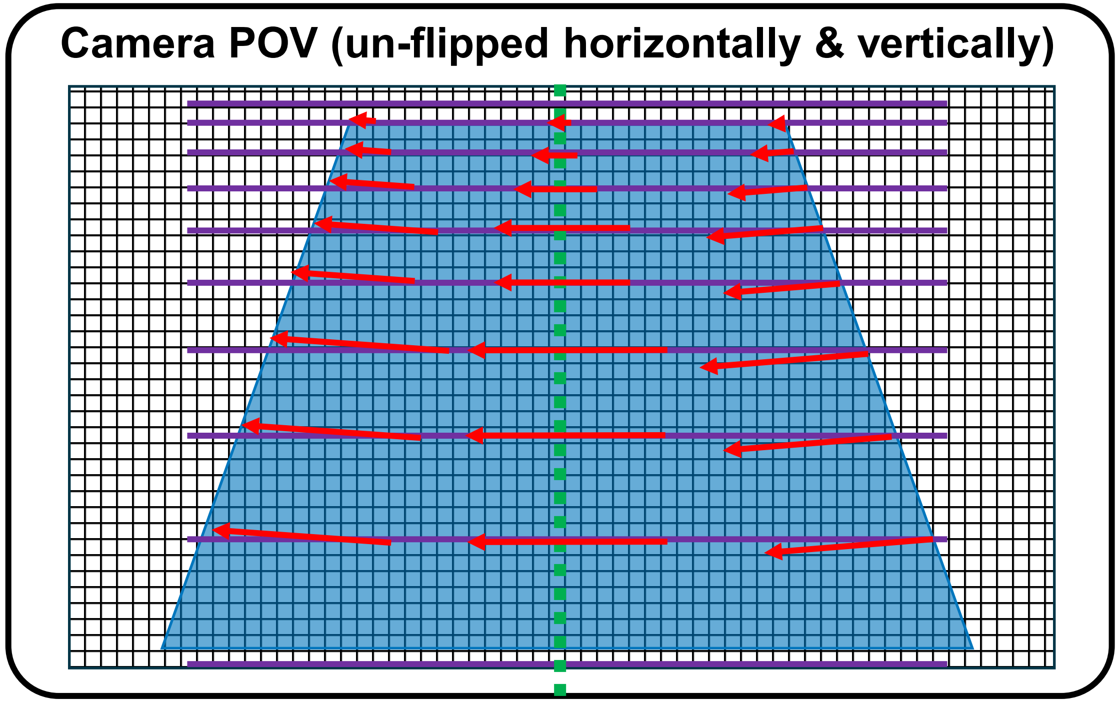
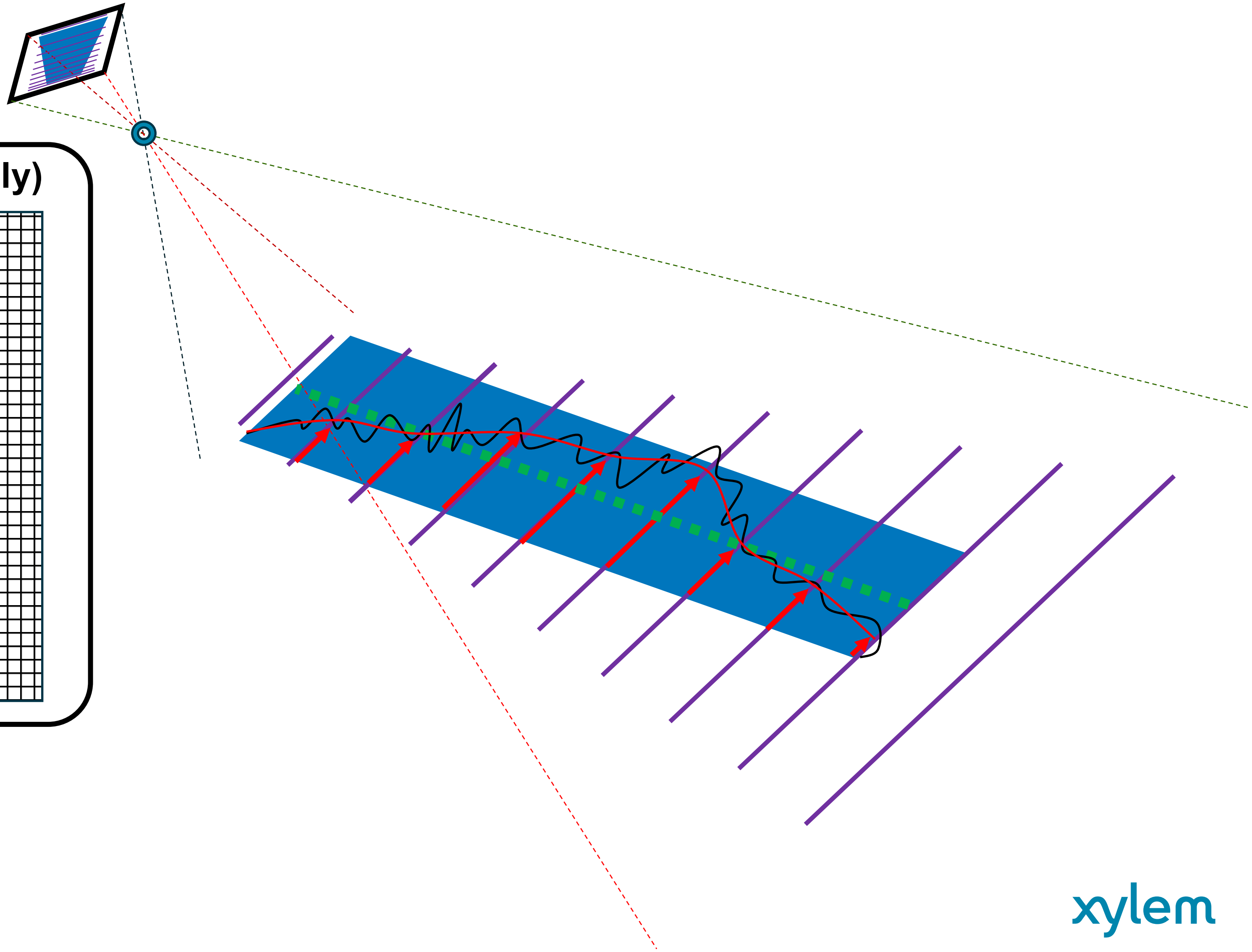
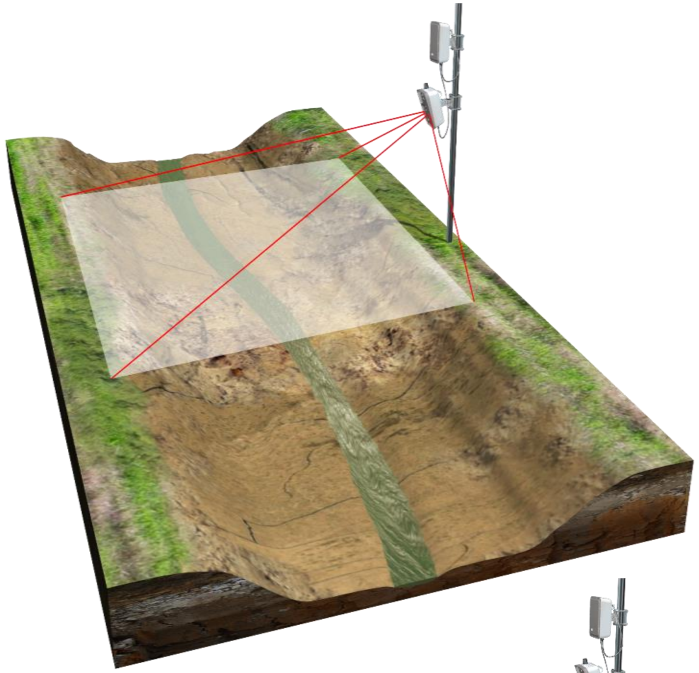
Raw planar surface velocity rectification

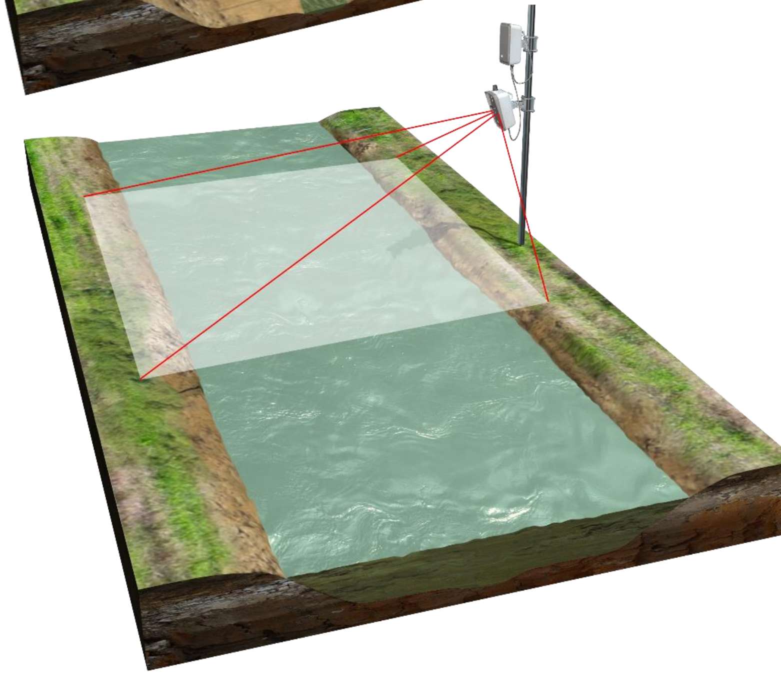




Site Selection Requirements

- **Higher stream wise velocity [0.1-8 m/s (0.32-26 ft/s)]** within the measurement section is required to accurately resolve surface velocity. This is contrary to site selection requirements for traditional flow monitoring sites,
- **Increased water surface roughness** within the measurement is required to accurately resolve surface velocity. This is contrary to site selection requirements for traditional flow monitoring sites.
- **Avoid measurement sections with smooth water surface**,
- **Excessive reflections** on the water surface can impact the ability to resolve surface velocities accurately, especially if smooth water surface is present,
- **Clear view of the measurement section** over expected stage range, with no vegetation impeding the measurement section or analysis area,
- **Avoid measurement sections located close to artificial light sources** such as streetlights, flood lights, etc. If artificial light is too close or in line with FOV of camera the images can be too bright or overexposed during low light conditions.





Cross-section survey

- Survey Cross Section
- Water Elevation
- Water Edge
- Camera location elevation

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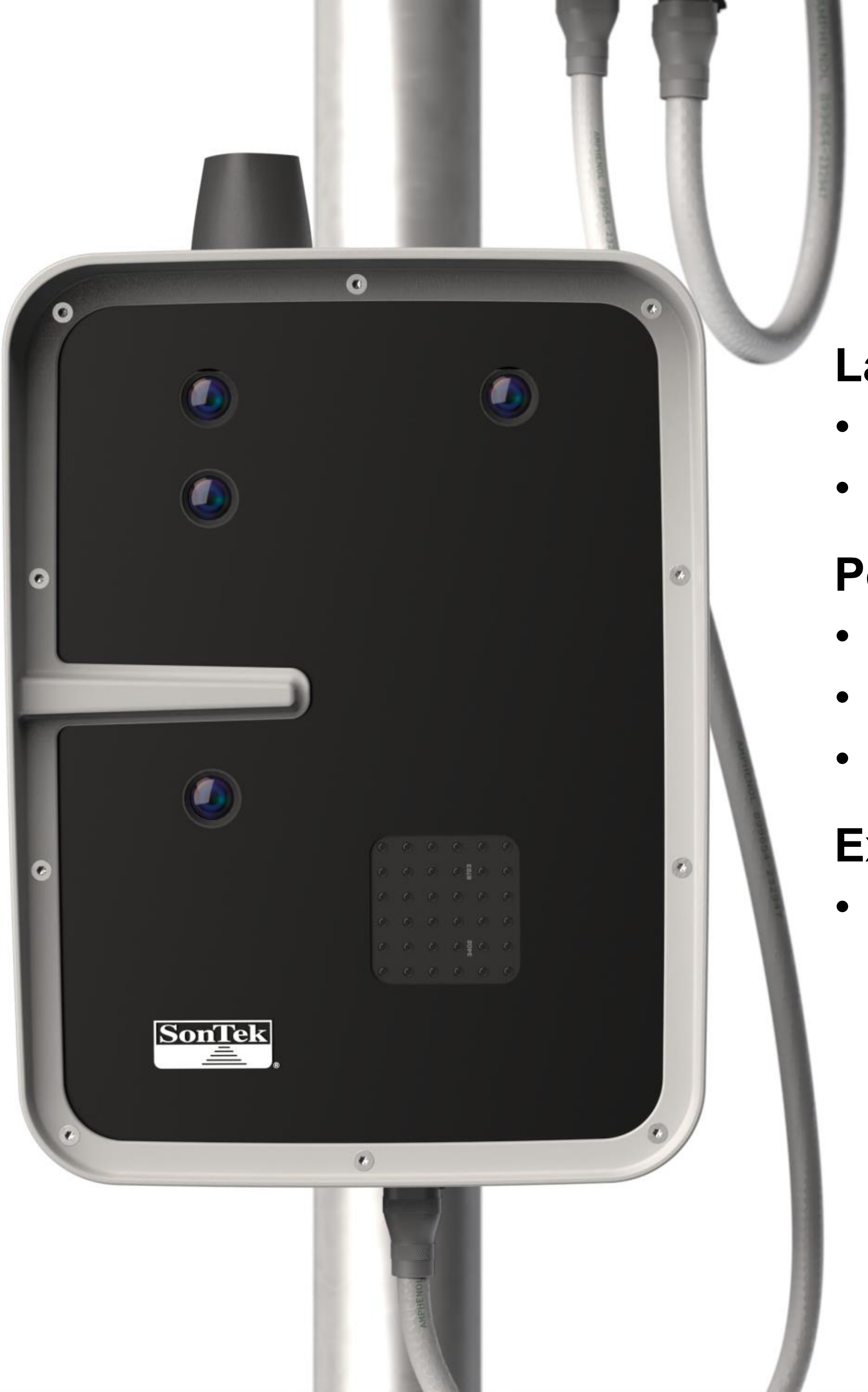
Hardware

Footnotes, references, citations here if needed

SonTek-QC4
Hardware Components



Landscape
- 2mm Lens
- Wider FOV

Portrait
- 4mm Lens
- Longer Range
- Measure closer to camera

External Light Trigger
- Night measurement

SonTek-QC4

Hardware Components

Camera

- Two Stereo camera
- Onboard computer
- 1TB Memory
- Infrared Light/external light trigger

Power

- Solar 30-50W
- 4 x 85 Wh batteries
- Average power consumption 1.5 W
- Selectable power modes

Connectivity

- Wi-Fi, 4G, & Satellite
- Local connection via App
- GPS

External Sensors

- 4-20mA, RS485 Water Level Sensor
- API Functionality
- External light power/trigger

Day settings

- FPS: 30
- Resolution: 1080
- Duration: 10 seconds
- Frequency: 15 mins

Night Setting

- FPS: 15
- Resolution: 1080
- Duration: 5 seconds

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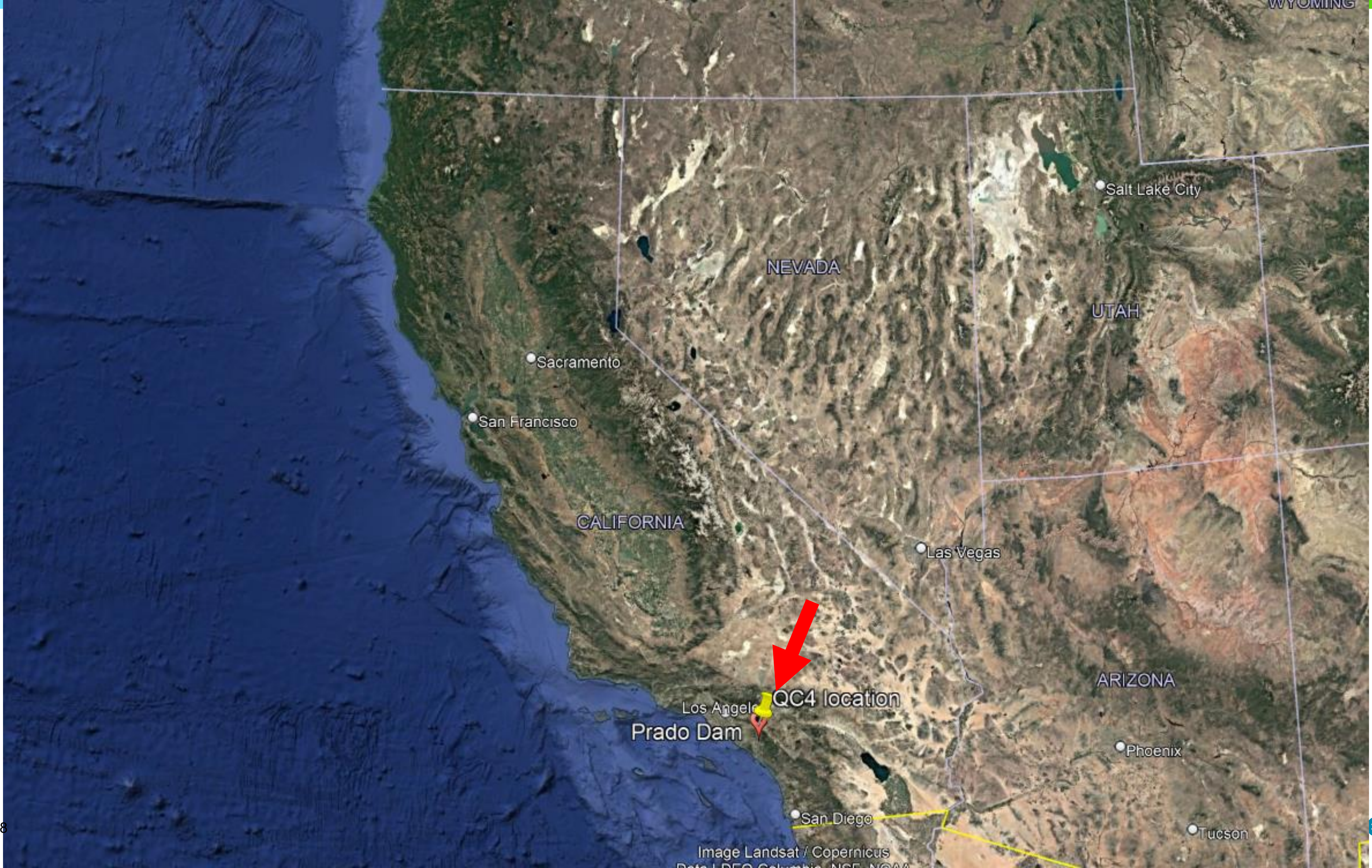
Application

Prado Dam, Southern California

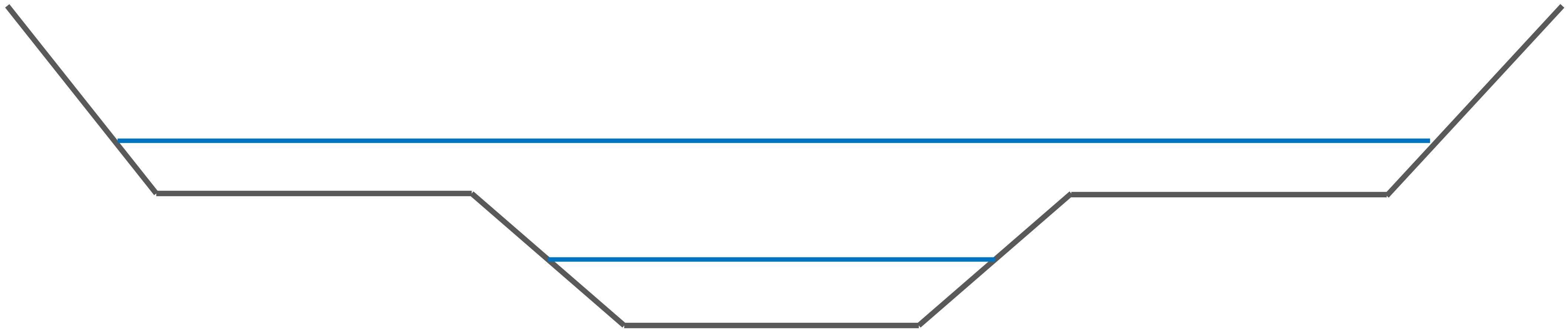
Footnotes, references, citations here if needed


WYOMING
Salt Lake City
NEVADA
UTAH
Sacramento
San Francisco
CALIFORNIA
Las Vegas
ARIZONA
QC4 location
Los Angeles
Prado Dam
Phoenix
San Diego
Tucson
Image Landsat / Copernicus


Prado Dam
200 YEARS OF FREEDOM
Santa Ana River
QC4 location
Santa Ana River
Wardlow Wash

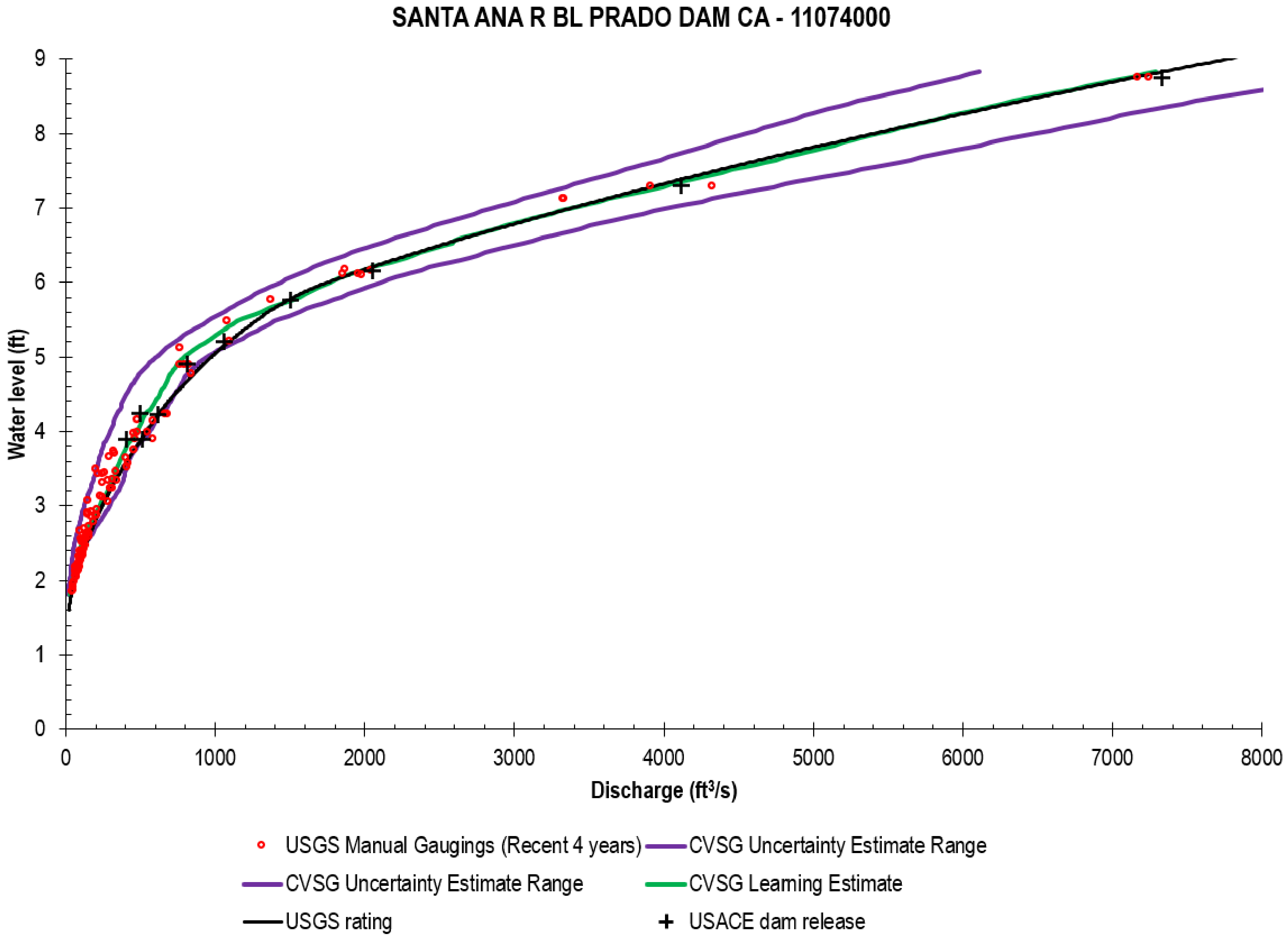
Legend
Monitoring Location
Active Monitoring Locations
Upstream Flowline
Downstream Flowline
Upstream Basin
5 km
3 mi
Leaflet | USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Names Information System, National Hydrography Dataset,...

Channel Cross-section



CVSG Installation

Results


SANTA ANA R BL PRADO DAM CA - 11074000
Water level (ft)
0
1
2
3
4
5
6
7
8
9
0
1000
2000
3000
4000
5000
6000
7000
8000
Discharge (ft³/s)
USGS Manual Gaugings (Recent 4 years)
CVSG Uncertainty Estimate Range
CVSG Uncertainty Estimate Range
CVSG Learning Estimate
USGS rating
USACE dam release

Application

Pages River, Australia

1 QC4 development background

2 CVSG method overview

3 QC4 hardware review

4 Application example – Prado Dam, Southern California

5 Application Example – Pages River, Australia

6 Hydrosphere preview

Footnotes, references, citations here if needed

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Pages River at Blandford

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Installation

- Surefoot Base Plate
- 1.8m anchor poles

- Hilti Jackhammer

- 4m Swivel Pole
- Secured with padlock

Hardware

- QC4 Camera
- IR Light

- 50W Solar Panel
- Lead-Acid Battery Box

- 12V 50 Ah Battery
- SmartSolar MPPT 75/10

Cross Section Survey

- RTK Survey
- Setup Rover and Base Station

- Survey Camera Elevation

- Survey Cross Section
- Water Elevation
- Water Edge

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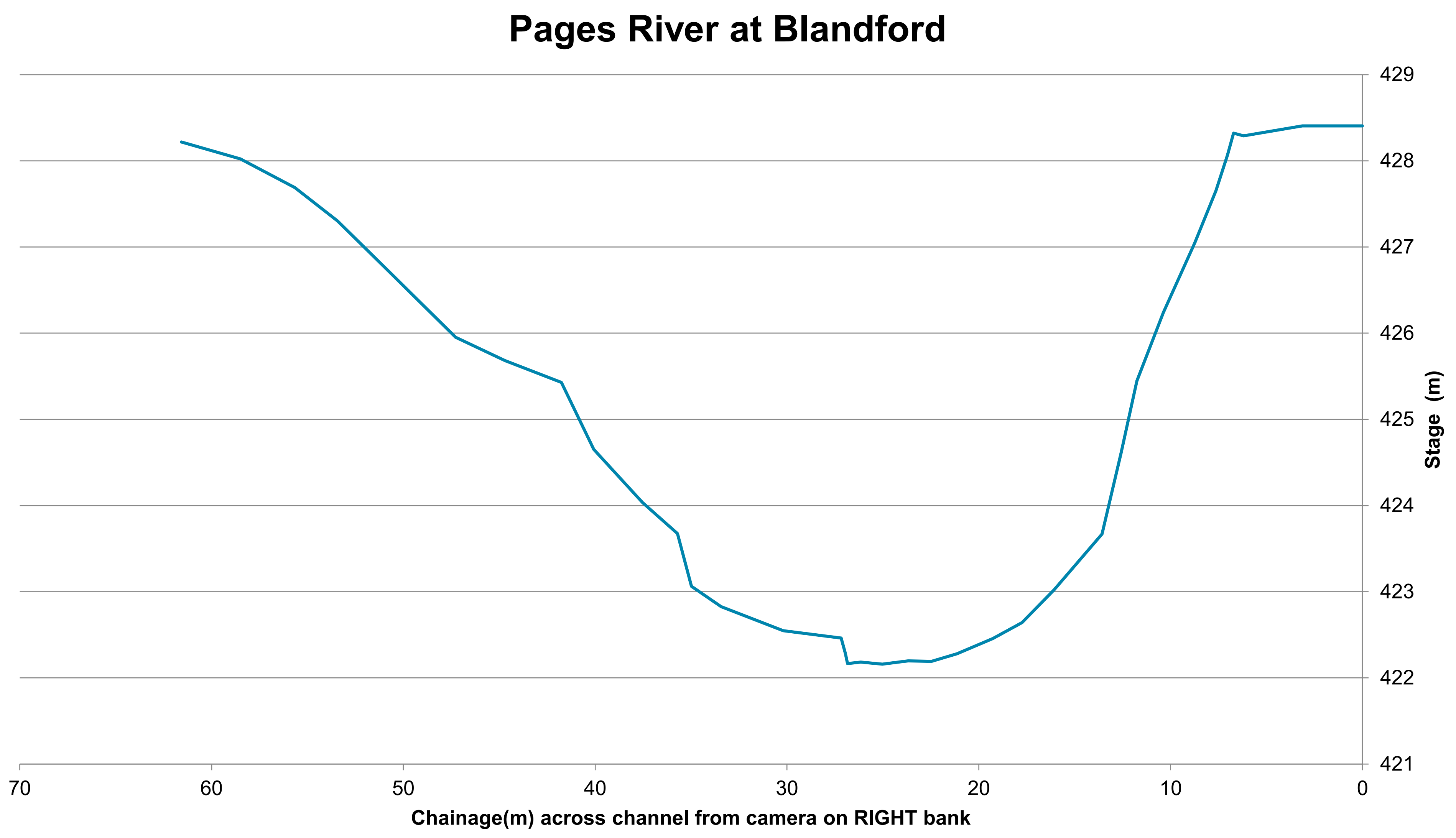
Cross Section Plot



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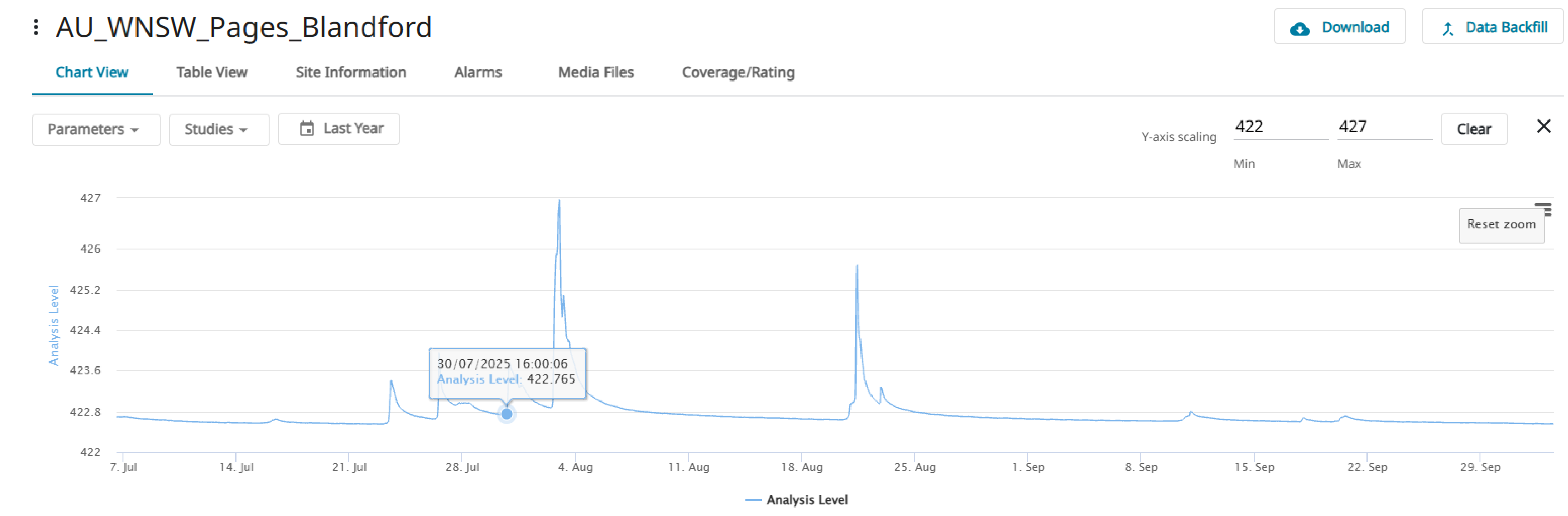
HydroSphere – Water Level



HydroSphere – Daytime Analysis

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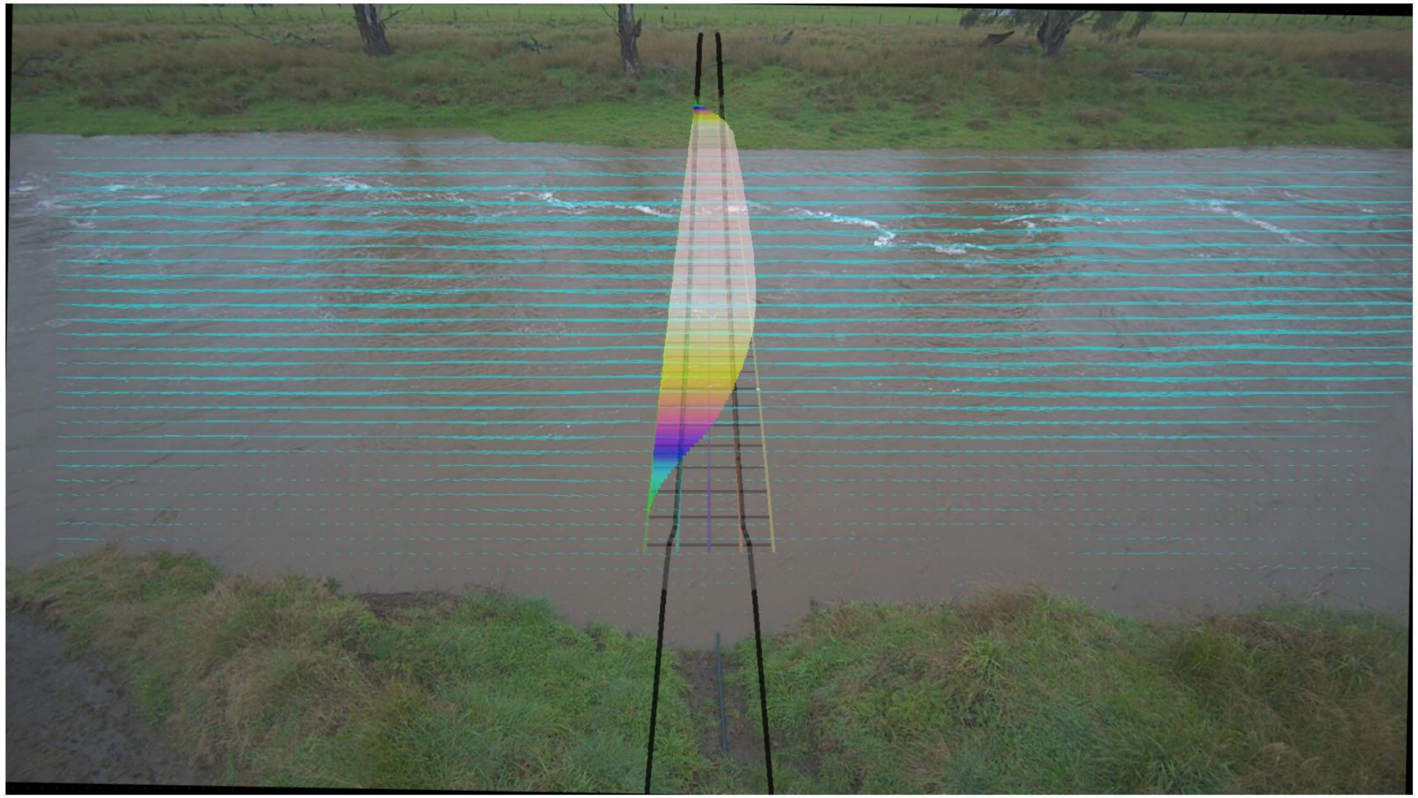
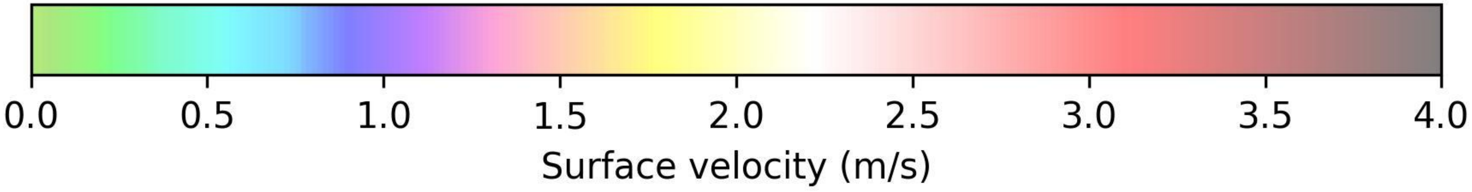
HydroSphere – Daytime Analysis





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HydroSphere – Night-time Analysis

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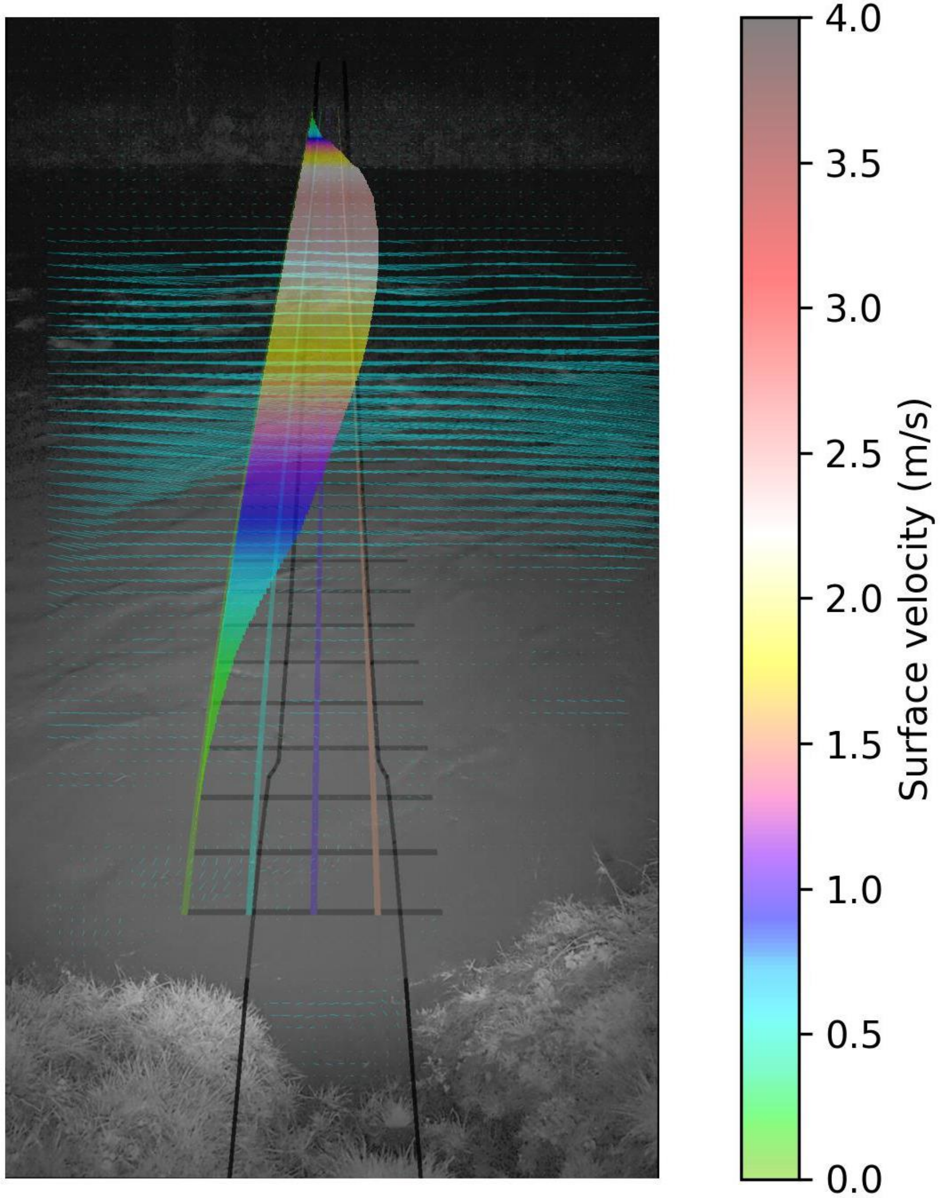
HydroSphere – Night-time Analysis



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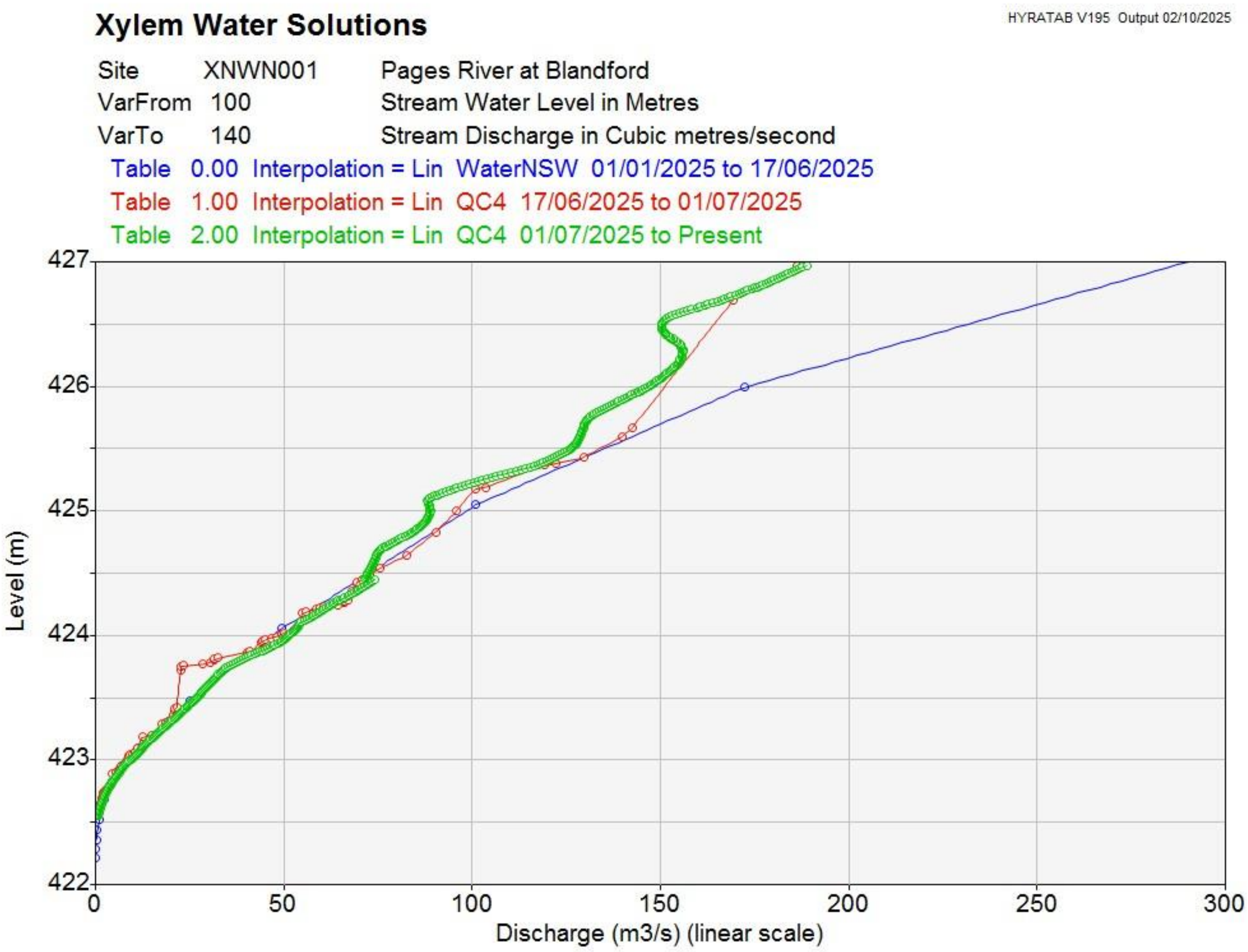
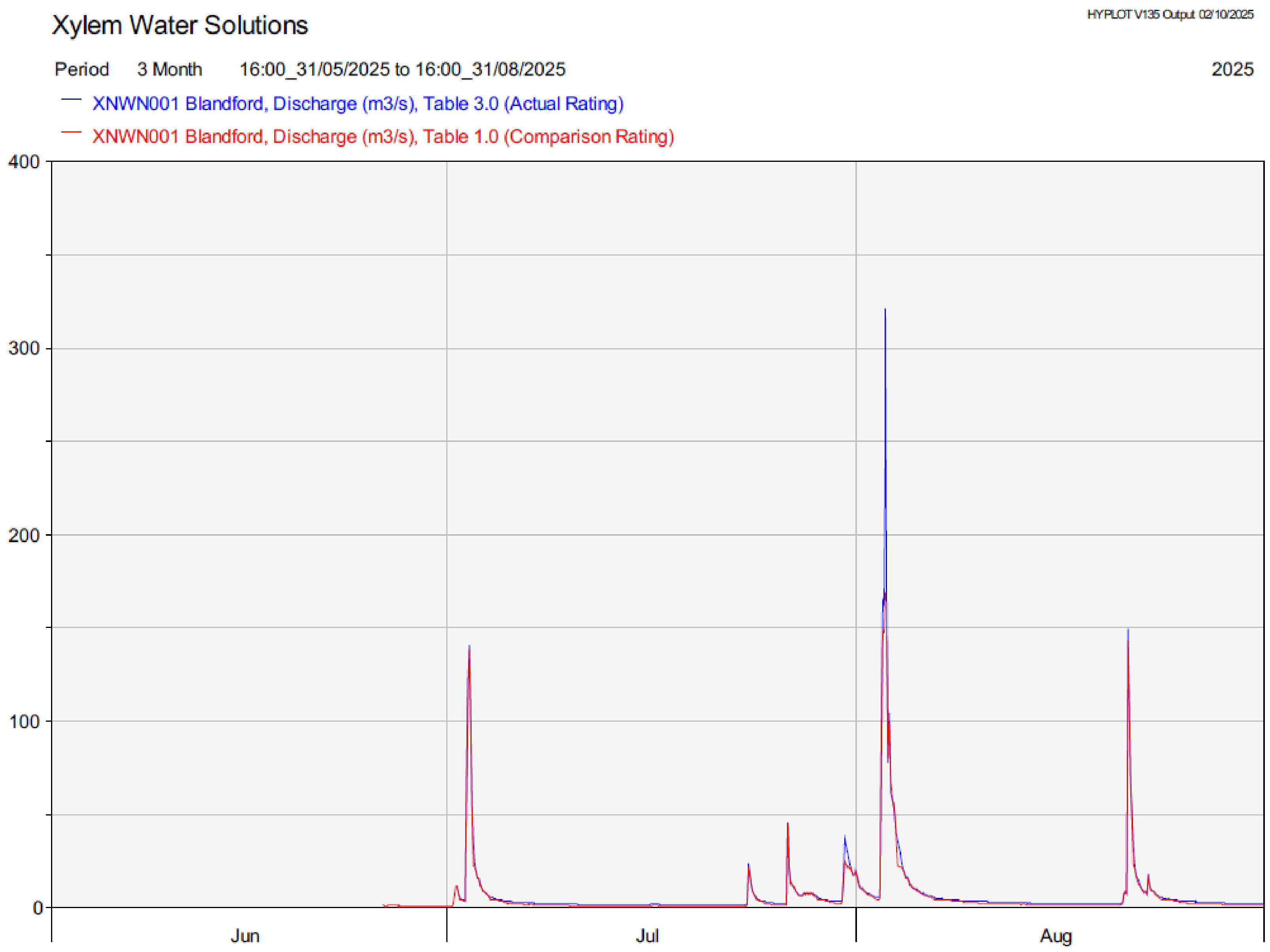
Stage-Discharge Rating



Flow Hydrograph - Adaptive Rating Curve



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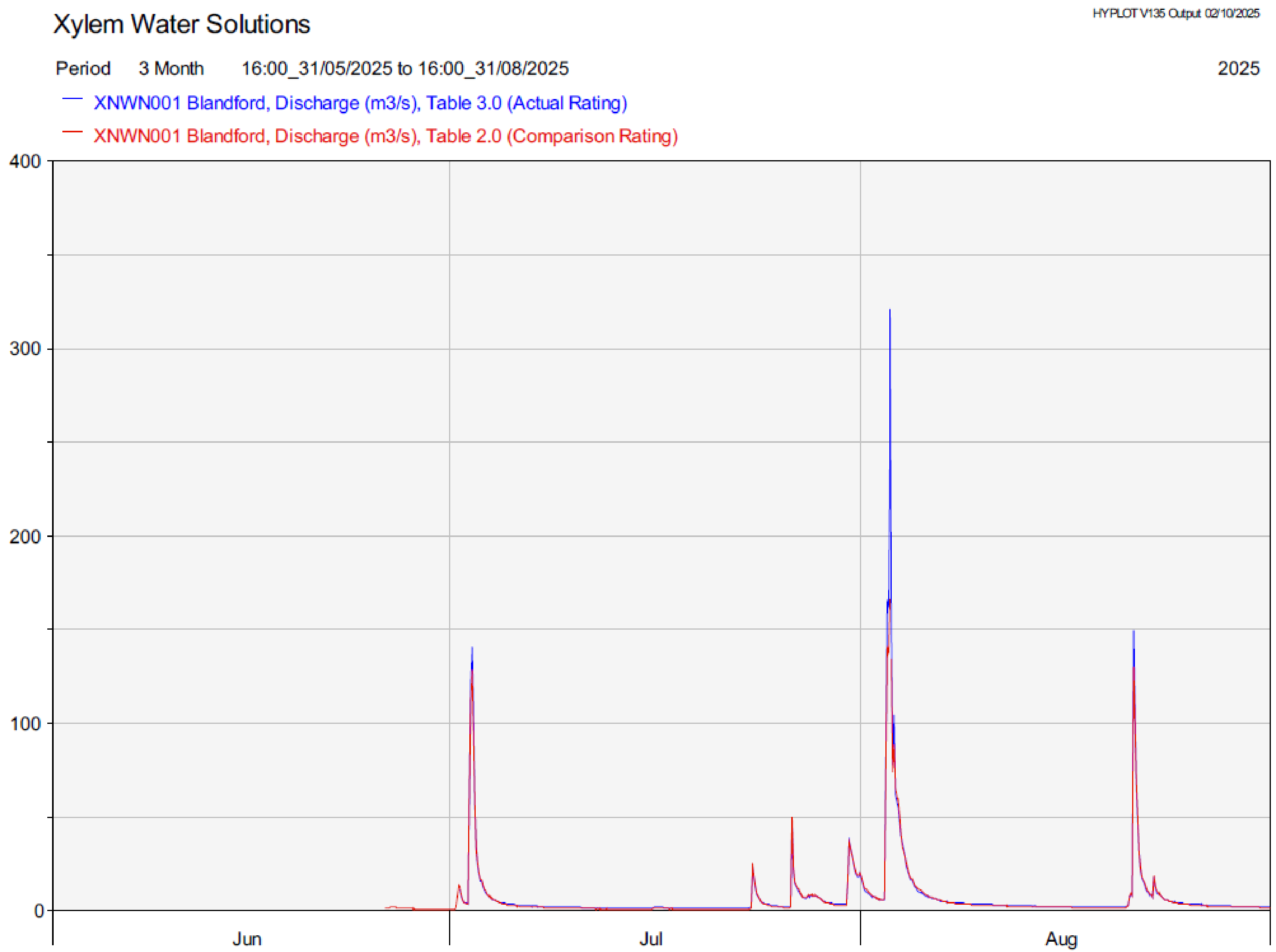
Flow Hydrograph – Learning Rating Curve



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Hydrosphere

Footnotes, references, citations here if needed

Resources

Optical Flow Proves Crucial in High Water Flow at Prado Dam

Isaac Jones, SonTek Sr. Application Engineer, Daniel Wagenaar, Xylem Sr. Hydrologist | Oct 10, 2024

Optical Flow Proves Crucial in High Water Flow at Prado Dam

The monitoring of accurate and reliable flow data can be particularly challenging in certain site and hydraulic conditions when using traditional measurement methods. Many natural and man-made waterways, such as rivers, streams, and canals, often exhibit complex flow patterns and hydraulic characteristics that can make it difficult to obtain precise, representative flow data using standard techniques. Take, for example, the U.S. Geological Survey (USGS) gage located just below Prado Dam in Southern California, as shown in Figure 1.

Mission Water #11: SonTek-QC4 Article

The SonTek-QC4

Evolved from trail cameras that Fluvio's Simon Albert and Nick Hutley pointed at Australia's rivers to provide visual context for their instrument readings, the SonTek-QC4 combines two pairs of cameras with powerful processing capability.

Each pair of lenses acts like a pair of human eyes—because they see from slightly different angles, every pair of images delivers depth perception, allowing the analytical engine to use these videos to measure stage and velocities. The cameras can gather 5 to 30 seconds of data every 15 minutes.

Technical overview:

- Non-contact flow measurement
- Stage-discharge rating development
- Real-time video
- Alerts during events
- App-based data visualization
- Automated cloud processing
- API database integration

The QC4's processor computes velocity using the Farneback Method: identifying unique patterns of bright pixels in two video frames, then calculating the distance the pixels traveled between the moments the frames were shot. If bumped or reoriented, the QC4's built-in inertial measurement unit (IMU) registers the change and automatically adjusts calculations.

The system includes twin cameras, IMU, an 85 watt-hour LiFePO4 battery, GPS, infrared light for night monitoring, and 1TB of expandable onboard storage. Through 4G, Ethernet, or wifi, it connects to cloud-based management, automated learning workflows, and operational monitoring dashboards.

The existing monitoring program was recording concentrations of nitrate, but discharge data from the QC4s enabled the calculation of nitrate load—a much more inclusive estimate of the number of kilograms of nitrate carried downstream.

The Lower Burdekin and Lower Herbert regions were a perfect test case for the new QC4.

Developed by a small group of University of Queensland scientists and SonTek, **the QC4 combines two stereoscopic cameras with processors and telemetry equipment.** The system processes data from the images to calculate surface velocity and discharge. The QC4 can also develop stage-rating curves, which hydrologists use to accurately estimate the volume of flow in a water body from water level data.

The unique ability of the SonTek-QC4 CVSG system to account for distortion from camera height and angle eliminates the need for complicated surveys and ground control points, which kept the field teams efficient...and out of the water. Previous technology required users to install and survey fixed points in view of the camera to establish the geometry of the site. **Not the QC4.**

Without requiring any ground control points in the camera shot, the QC4 offers a clear advantage in convenience. Accessing the opposite bank of a waterway is not always straightforward, or even possible—especially in North Queensland, with the presence of saltwater crocodiles.

Staying out of the water is safer for equipment, too, adds Simon Albert, a founder of Fluvio with Nick Hutley and Allstair Grinham. While at the University of Queensland, Hutley and Albert developed and prototyped both the software and hardware behind the CVSG system at the heart of the QC4.

"When you've got thousands of dollars' worth of gear underwater, they can get wiped out in floods," Albert says. "Right when you need them, there's a big tree trunk coming at them at four meters [13 feet] per second. **So the non-contact element was the Holy Grail. One of the big pushes to move to the camera approach is that you can put them high and dry."**

The 2023 cyclones provided valuable lessons about how high to mount the technology above extreme flood levels.

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Thank You

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