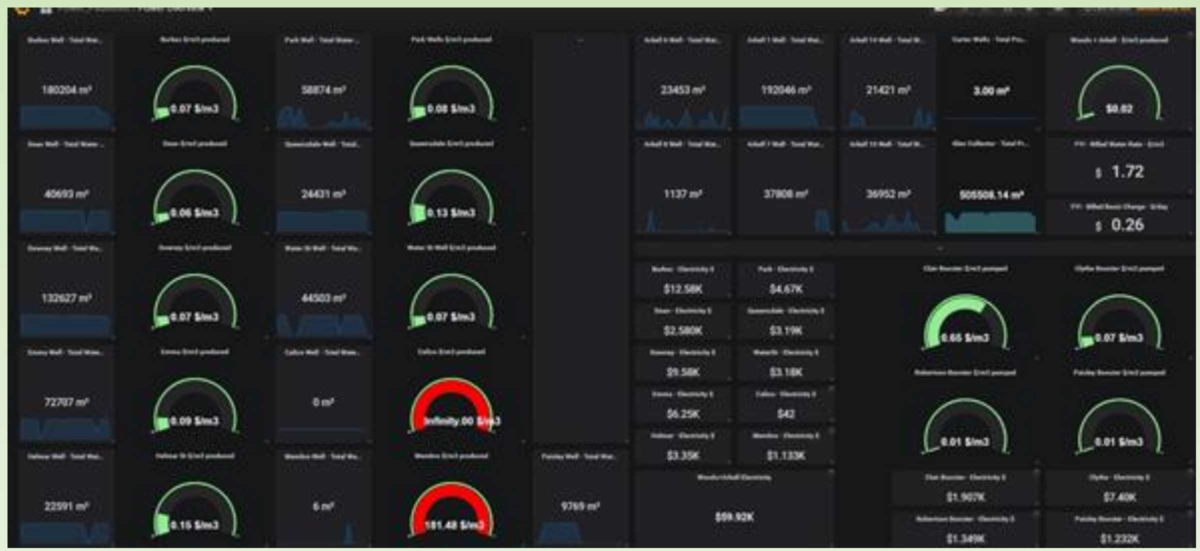
Guelph Water Services – SCADA Update

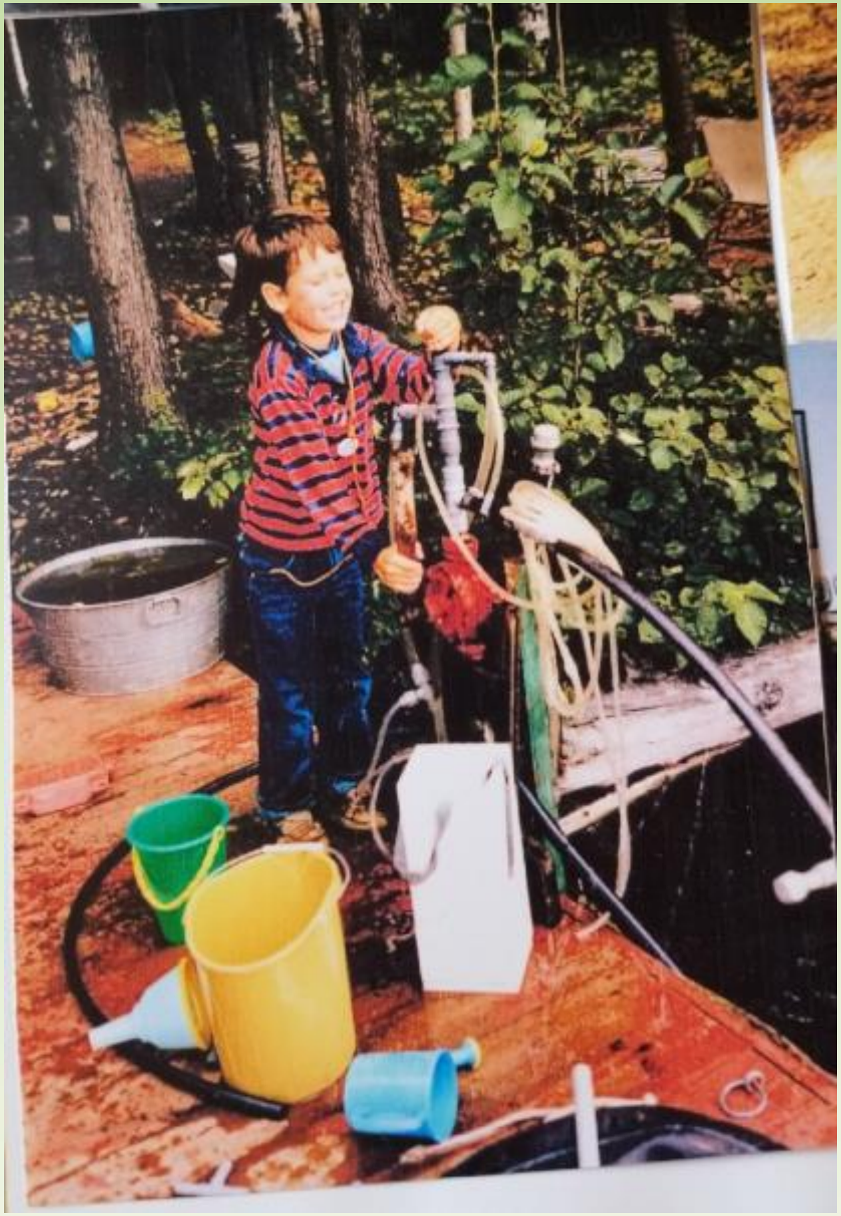
Power Usage Dashboards

DMA District Flowmeter Dashboards



Speaker: Graham Nasby, Water SCADA & Security Specialist

July 3, 2019 – Guelph, Ontario, Canada



I wanna be a Water Guy when I grow up!

The Challenge

We are a water utility = a lot of what we do involves pumping water

- **How much electricity do we use to pump water?**
- **How much is this electricity costing us?**
- **How can we get good/timely data about how we use electricity?**

- Waiting until we get power bills at the end of each month is not that helpful

- The gold standard is to create an automated reporting tool to give us:
  - kWh per m3 produced
  - $ of electricity per m3 produced
  - Ability to compare one facility to another
  - Ability to compare one operating strategy vs. another
  - Timely information for the operations team
  - Long term reporting to measure performance over time
  - Something that looks nice

Prior Work

Smart Water Initiative (2013)

- Grant money was used to install building digital power meters at all water facilities
- Custom daily power reports created by an system integrator
- Reports stopped working in mid-2015 due to programming/data-feed issues

Hydro Bill Analysis Company, online services (available since 2015)

- Service the city uses to analyze power bills
- Web-based tool for downloading and analyzing power bills
- Data is only available at the end of each month, **monthly power totals only**

Online Power Reports 2.0 (2016-2017)

- SCADA Group was asked to work with system integrator to fix online power reports
- After a year of work by the integrator, the power reports were working again
- Reports only provide daily totals (cost, kWh, m3 pumped), **data available "next day"**

But could we do better?
Better granularity, more timely data, better reports, ability to self-edit….

Skunkworks

A **Skunkworks project** is
a project developed by a small and loosely structured group of people who research and develop a project primarily for the sake of radical innovation.

The term originated with Lockheed's World War II *Skunk Works* project.

Let's see if we can use Open Source software to build something better!

Skunkworks SCADA Team

Goal: Make a better power reporting tool

Kick-off: Met at May 2017 OWWA conference

Graham Nasby

- Water SCADA & Security Specialist

Jason Little

- Open Source Software Developer
- Day job is a SCADA specialist at a nearby utility

Noah Clark

- SCADA co-op student (Jan-Apr 2018)
- Had a previous co-op at an energy management firm

Travis Murray

- SCADA Specialist (Nov`18-Jun`19)

This is what we built

How it works

Web-based Dashboard & Reporting Tool

Grafana

NEPTUNE CLUSTER

CASSANDRA

STORAGE DB

Distributed Open Source Database (no licensing fees)

Digital Power Monitors

Polls Data Every Second

Single Board Computer < $35

(Neptune Cluster software)

Logs data every 5min
Logs changes on 1 sec intervals

TITAN

BROKER

Pushes to Historizer Server

TRIDENT

HISTORIZER

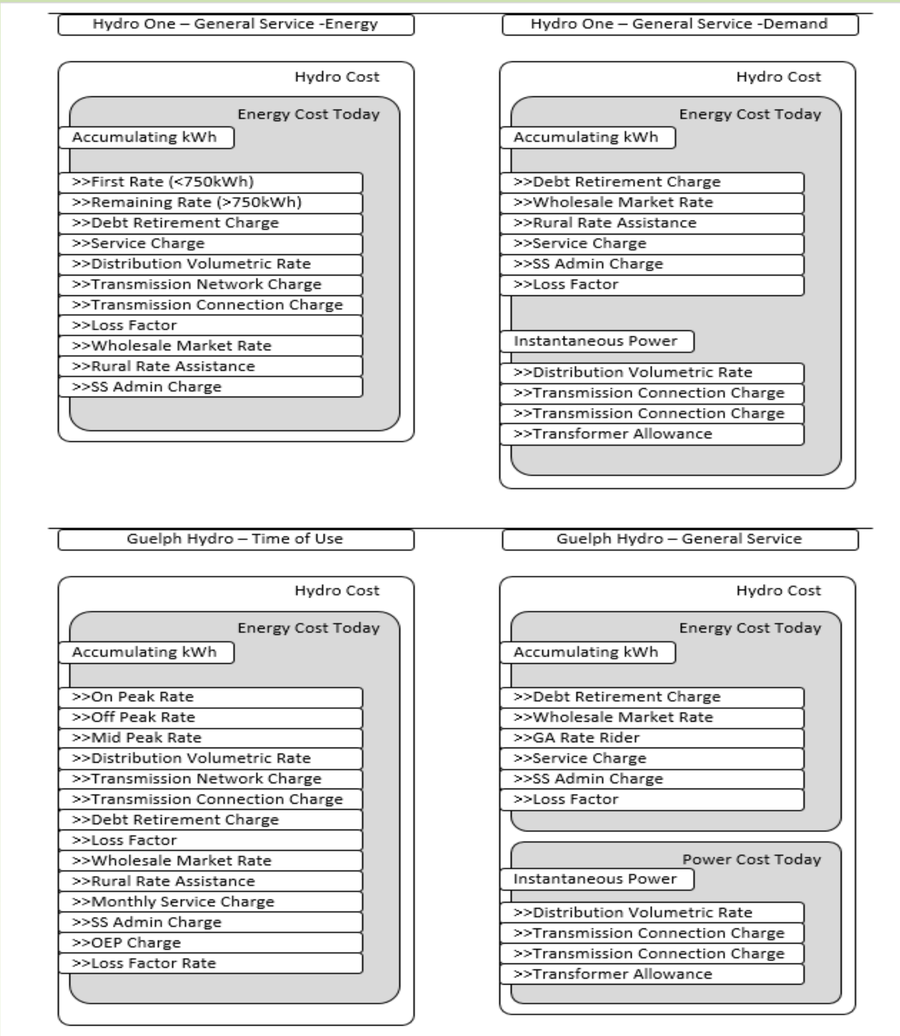
Pushes to Time Series Database

Pump Motor Starters

Power Calculations

- Measuring Electricity Usage is EASY…
- Calculating Power Costs is HARD!
- Ontario has one of the most complicated electricity pricing schemes in the world
- Connection Charges
- Transmission Charges
- Distribution Charges
- Energy Usage
- Peak Charges
- Ontario Hourly Energy Prices
- Time of Day Adjustments
- Global Adjustment
- Global Adjustment Estimates
- End of the Month Balancing
- Etc.

Power Calculations



Hydro One	
<50kW	>50kW
General Service – Energy (aka Two Tiered)	General Service – Demand
Arkell 08	Arkell 06
Arkell 14	Arkell 07
Arkell 15	
Guelph Hydro	
<50kW	>50kW
Time of Use	General Service
Calico	Burke Well
Carter	Clythe Creek
Clair Booster	Downey
Dean	Emma
Helmar	Membro
Queensdale	Paisley
Robertson	Park
	Univeristy
	Water Street
	Woods

Power Calcs

IESO Website

Live Feed of Hourly Global Adjustment Hourly Energy Prices

Web-based Dashboard & Reporting Tool

Grafana

Digital Power Monitors

Plant PLC's (Flow Data)

NEPTUNE CLUSTER

Distributed Open Source Database

CASSANDRA STORAGE DB

Calculates Live Energy Costs every 5 mins

Polls Data Every Second

Single Board Computer < $35

(Neptune Cluster software)

Logs data every 5min

Logs changes on 1 sec intervals

TITAN BROKER

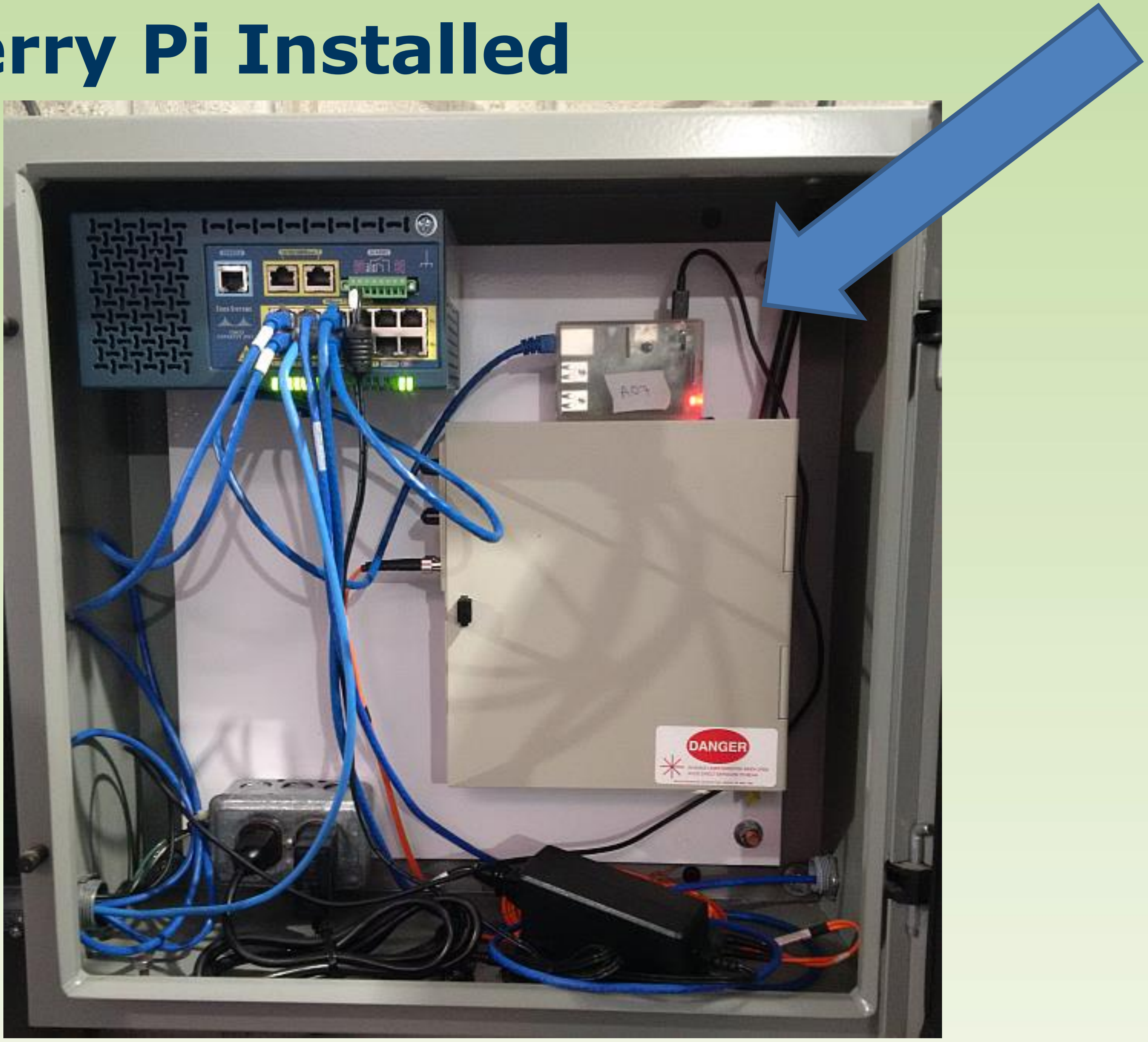
Pushes to Historizer Server

TRIDENT HISTORIZER

Pushes to Time Series Database

Pump Motor Starters

Raspberry Pi Installed



Collecting the Data

Grafana - DMA Overview | Grafana - Report - Monthly Pow | 172.16.1.122:8080 | Node-RED Dashboard | Trident Historizer : 172.16.1.120

Not secure | 172.16.1.122:1880/ui/#/0

Neptune Cluster Dashboard

Triton Edge Messengers

Site	State	Buffer	Poll	RBE	CPU	IP	Uptime
A06	ONLINE	0	52	3	0.63	172.16.65.29	507.89
A07	ONLINE	0	56	8	0.79	172.16.65.39	503.22
A08	ONLINE	0	55	13	0.89	172.16.65.49	385.23
A14	ONLINE	0	53	10	0.66	172.16.65.19	41.38
A15	ONLINE	0	55	2	0.62	172.16.65.9	507.87
ADV	ONLINE	0	7	1	0.20	172.16.65.59	507.88
BKS	ONLINE	0	40	3	0.88	172.16.72.49	148.31
CAB	ONLINE	0	49	12	0.63	172.16.28.49	510.82
CBS	ONLINE	0	58	7	0.74	172.16.73.49	349.00
CCB	ONLINE		51	6	0.72	172.16.51.49	116.16
CLT	ONLINE	0	5	0	0.22	172.16.73.46	30.63
CWS	ONLINE	0	52	6	0.57	172.16.53.49	99.34
DEB	ONLINE	0	50	2	0.61	172.16.22.49	70.16
DOB	ONLINE	0	56	13	0.72	172.16.71.49	210.07
EWS	ONLINE	0	52	1	0.64	172.16.43.49	56.23
HEB	ONLINE		60	5	0.87	172.16.45.49	350.18
MEB	ONLINE	0	53	13	0.69	172.16.23.49	507.74
PAB	ONLINE		54	7	0.61	172.16.44.49	127.15
PRB	ONLINE	0	51	2	0.53	172.16.26.49	15.17
QUB	ONLINE	0	49	4	0.53	172.16.25.49	510.79
ROB	ONLINE	0	52	11	0.65	172.16.41.49	36.30
SCS	ONLINE		2	0	0.09	172.16.52.49	507.91
SPT	ONLINE	0	5	0	0.24	172.16.27.49	41.27
UNB	ONLINE	0	57	3	0.72	172.16.24.49	13.18
VET	ONLINE	0	4	0	0.14	172.16.42.49	52.86
WDB	ONLINE		13	1	0.33	172.16.1.79	166.96
WWS	ONLINE		52	2	0.63	172.16.21.49	237.14

Titan Brokers

Broker 1: **ONLINE**

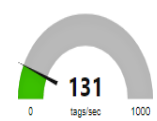
response **0.382 ms**

Trident Historizers

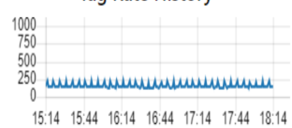
Historizer 1: **ONLINE**

Tag Count: **6617**

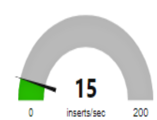
Tag Rate



Tag Rate History



Insert Rate



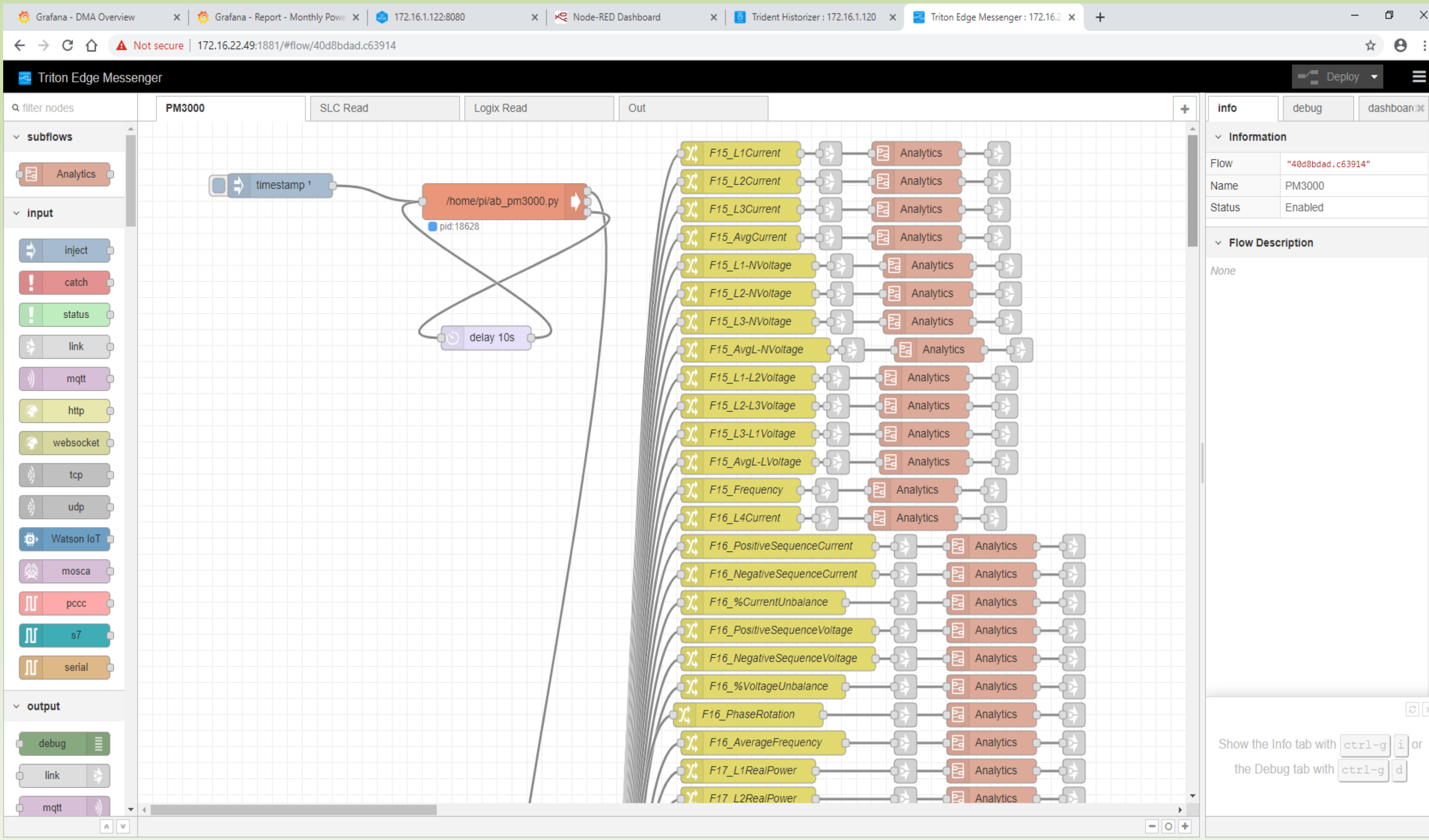
Insert Rate History

Clustered Storage Nodes

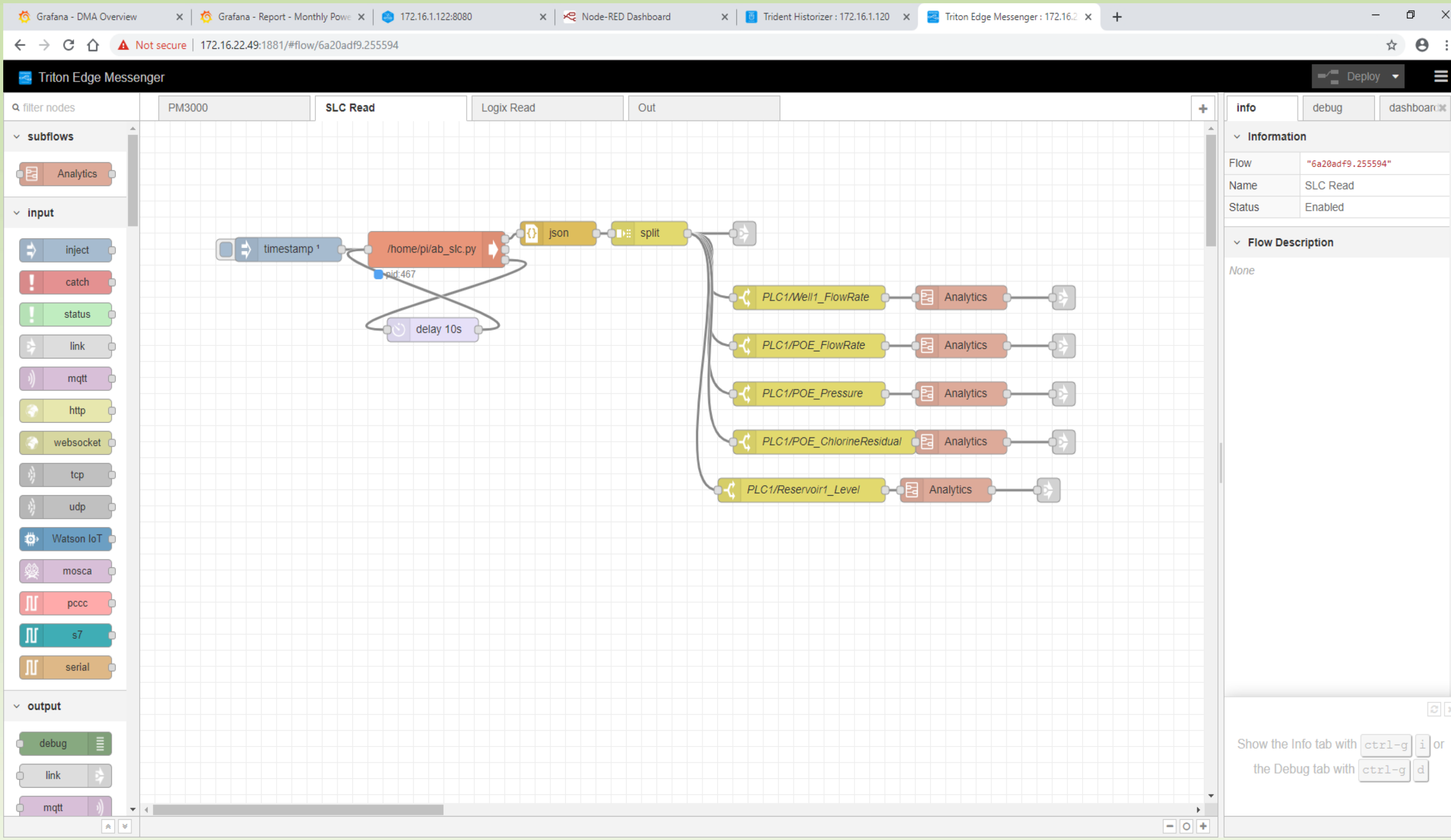
Node 1: **ONLINE**

response **1.03 ms**

Pulling Data from Digital Power Monitors

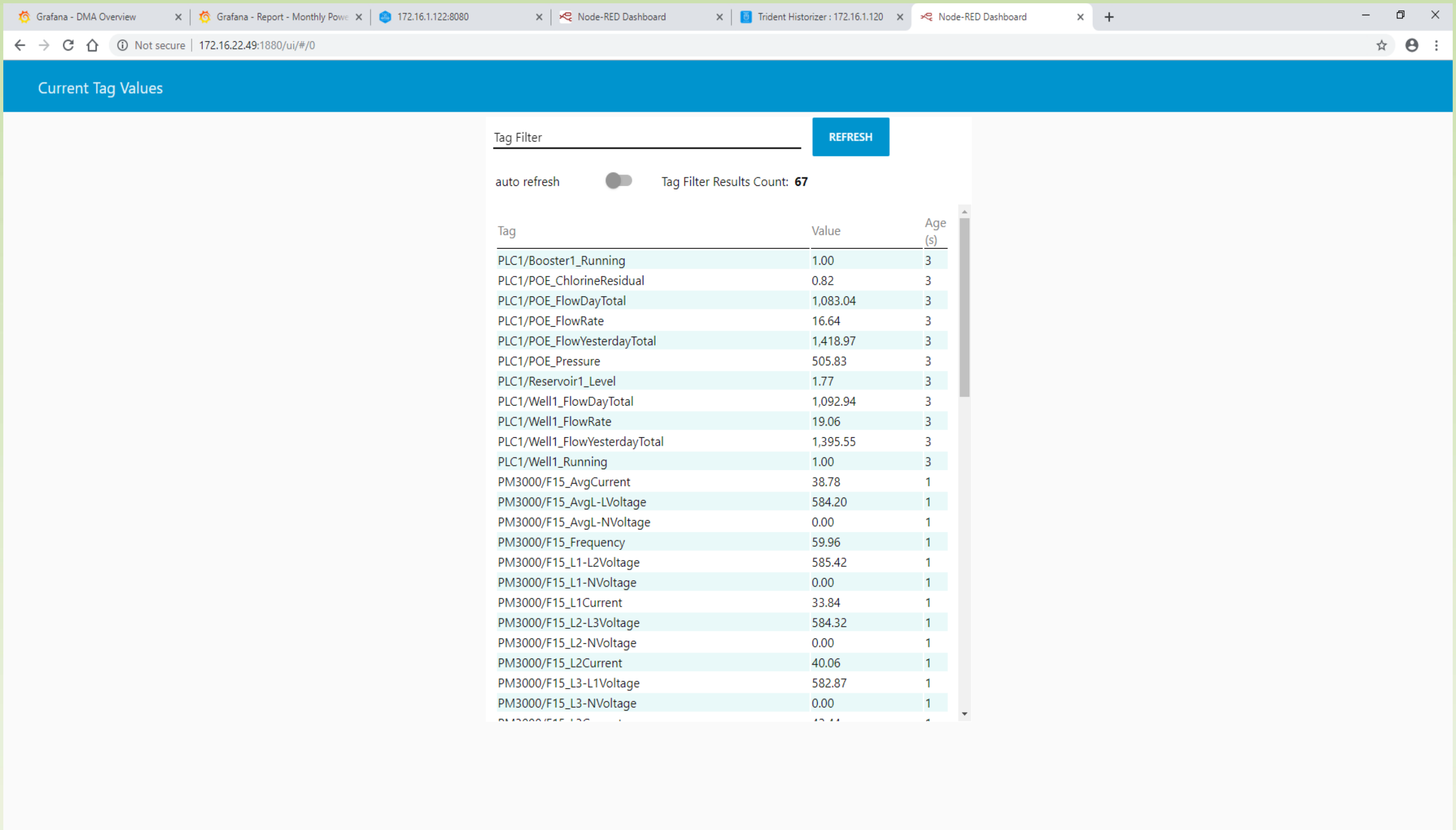


Pulling Data from Water Supply Site PLCs



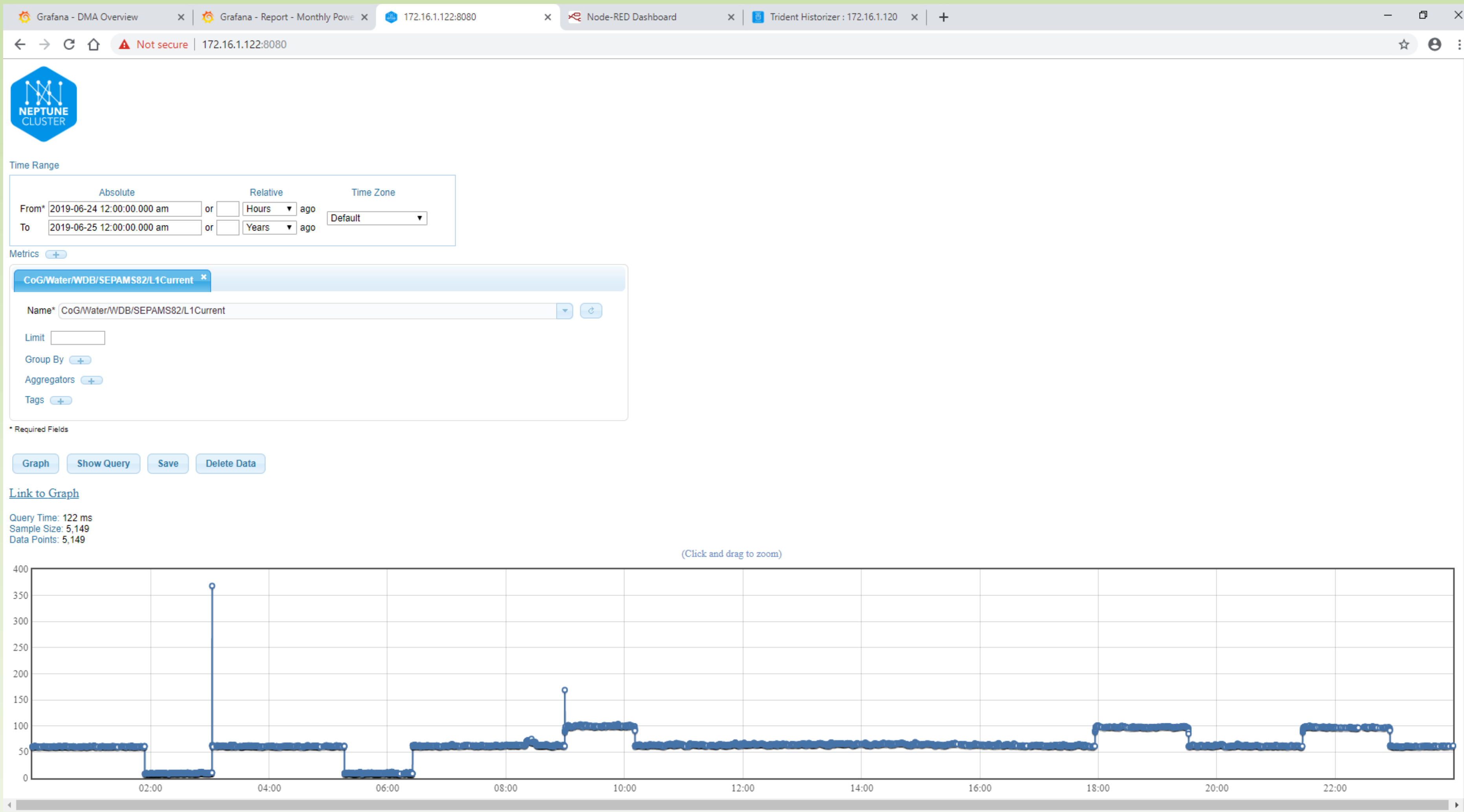
City of Guelph — Making a Difference

Buffering Data in the Raspberry Pi’s



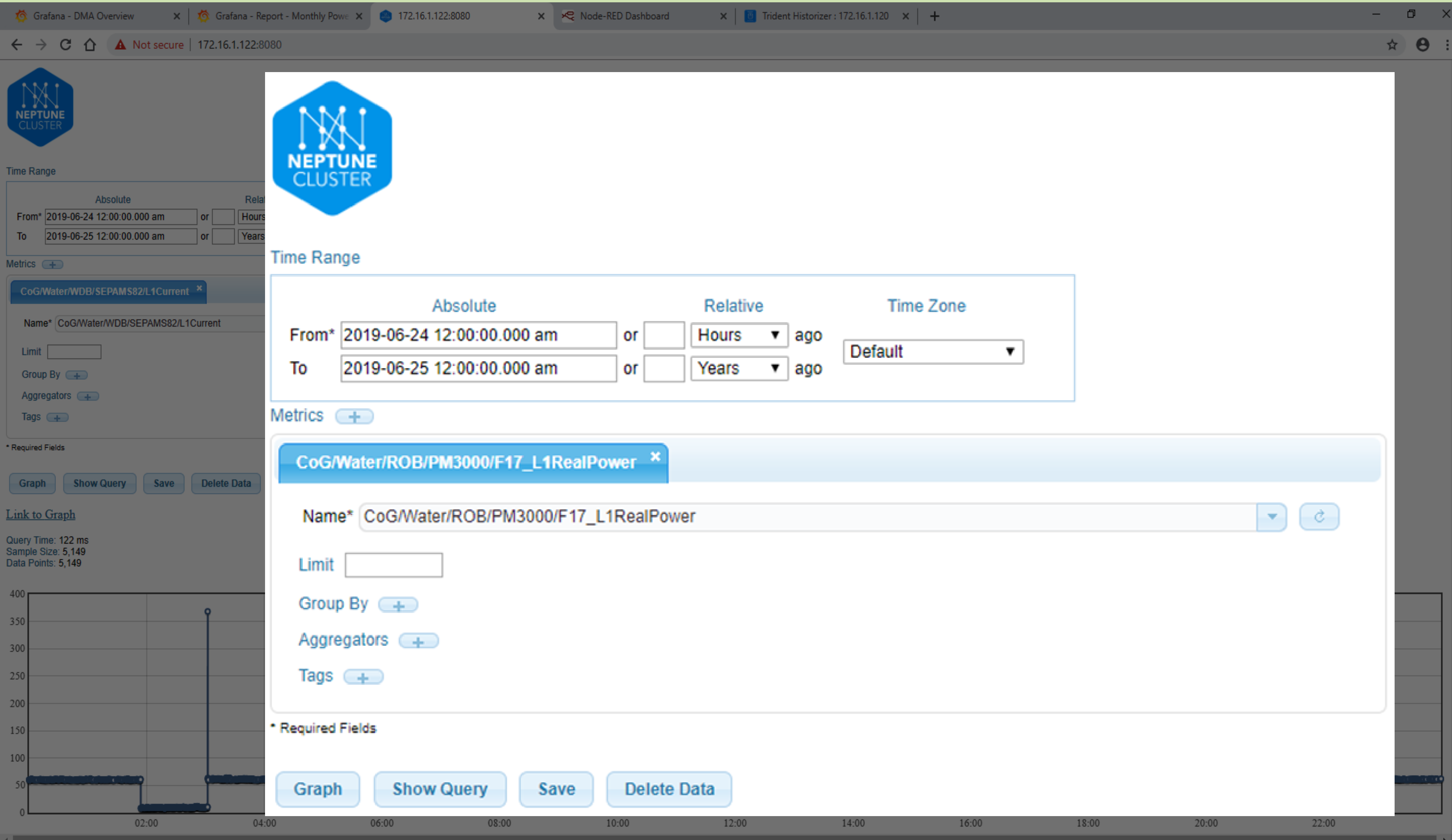
Tag	Value	Age (s)
PLC1/Booster1_Running	1.00	3
PLC1/POE_ChlorineResidual	0.82	3
PLC1/POE_FlowDayTotal	1,083.04	3
PLC1/POE_FlowRate	16.64	3
PLC1/POE_FlowYesterdayTotal	1,418.97	3
PLC1/POE_Pressure	505.83	3
PLC1/Reservoir1_Level	1.77	3
PLC1/Well1_FlowDayTotal	1,092.94	3
PLC1/Well1_FlowRate	19.06	3
PLC1/Well1_FlowYesterdayTotal	1,395.55	3
PLC1/Well1_Running	1.00	3
PM3000/F15_AvgCurrent	38.78	1
PM3000/F15_AvgL-LVoltage	584.20	1
PM3000/F15_AvgL-NVoltage	0.00	1
PM3000/F15_Frequency	59.96	1
PM3000/F15_L1-L2Voltage	585.42	1
PM3000/F15_L1-NVoltage	0.00	1
PM3000/F15_L1Current	33.84	1
PM3000/F15_L2-L3Voltage	584.32	1
PM3000/F15_L2-NVoltage	0.00	1
PM3000/F15_L2Current	40.06	1
PM3000/F15_L3-L1Voltage	582.87	1
PM3000/F15_L3-NVoltage	0.00	1

Direct Query Tool for Cassandra Database



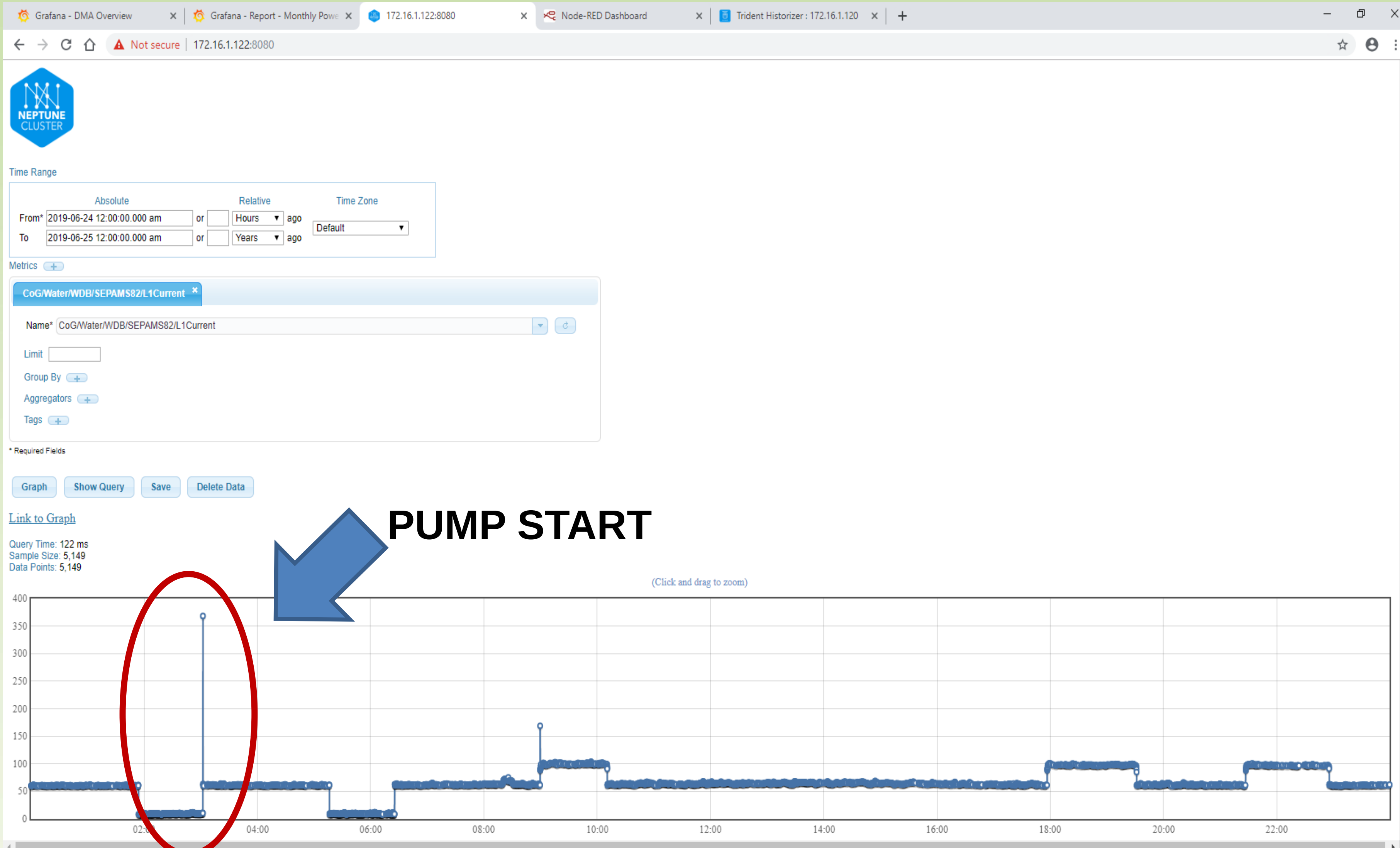
City of Guelph — Making a Difference

Direct Query Tool for Cassandra Database



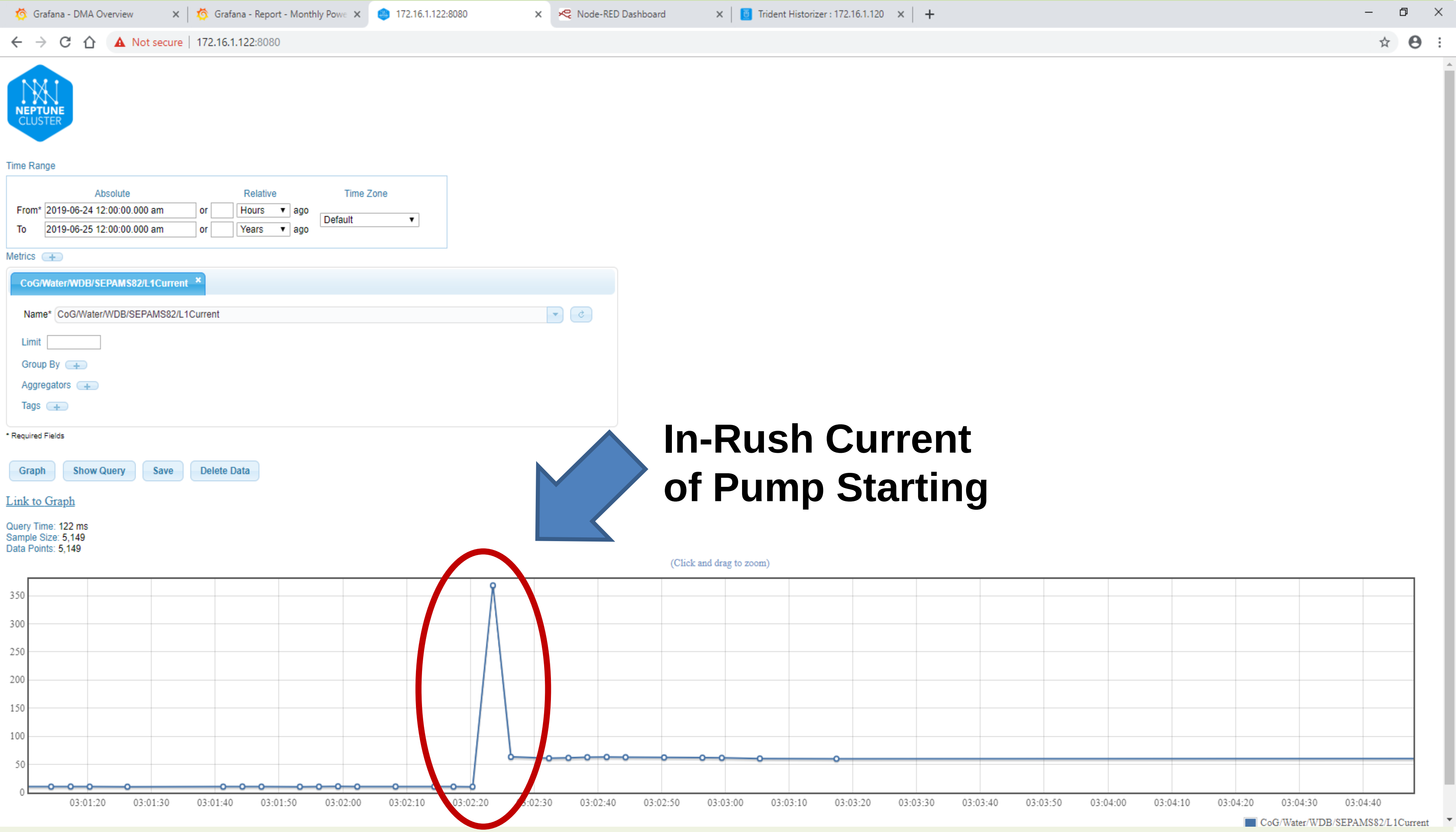
Guelph
Making a Difference

Direct Query Tool: Woods Pump Starts

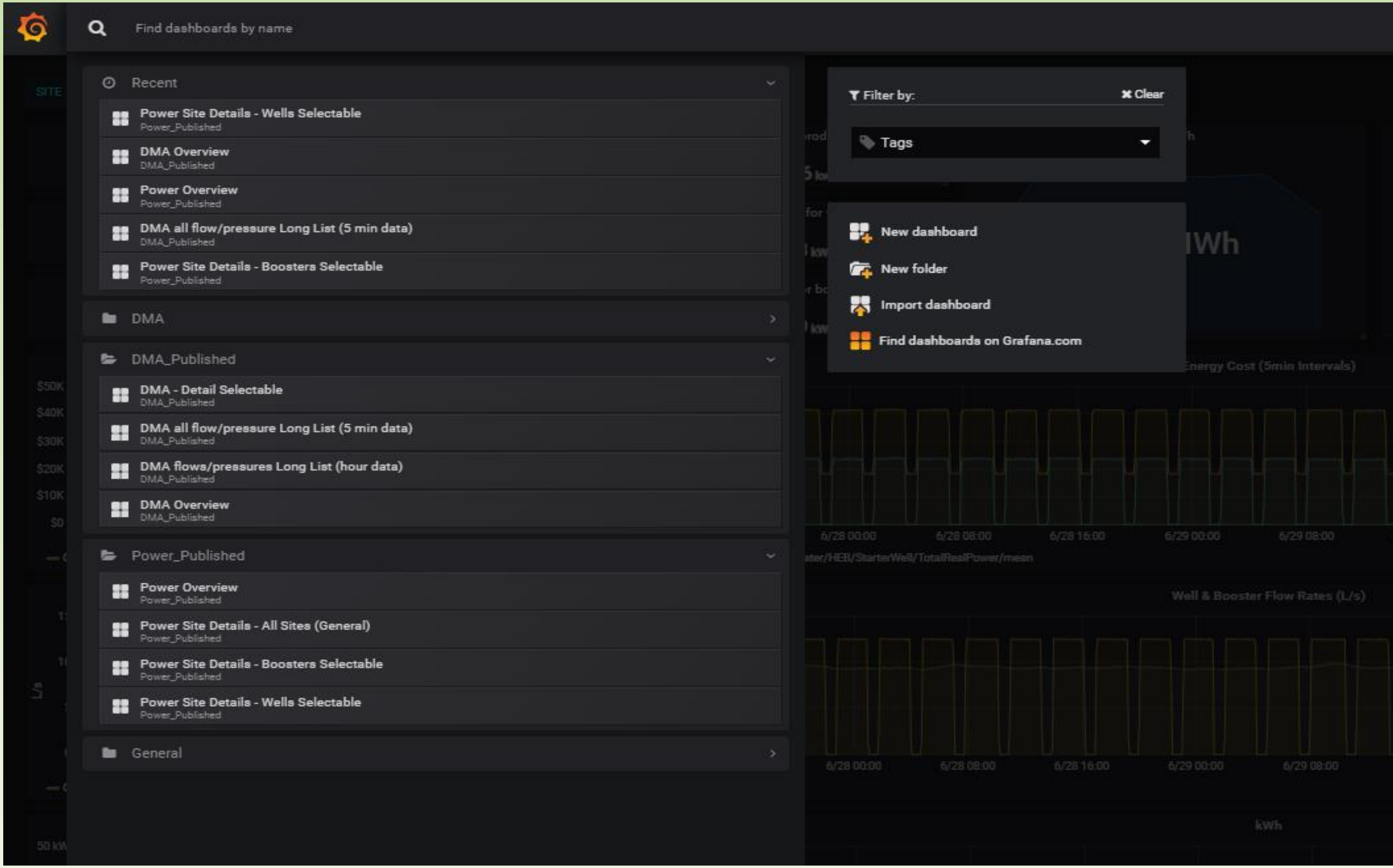


City of Guelph
Making a Difference

Direct Query Tool: Woods Pump Starts

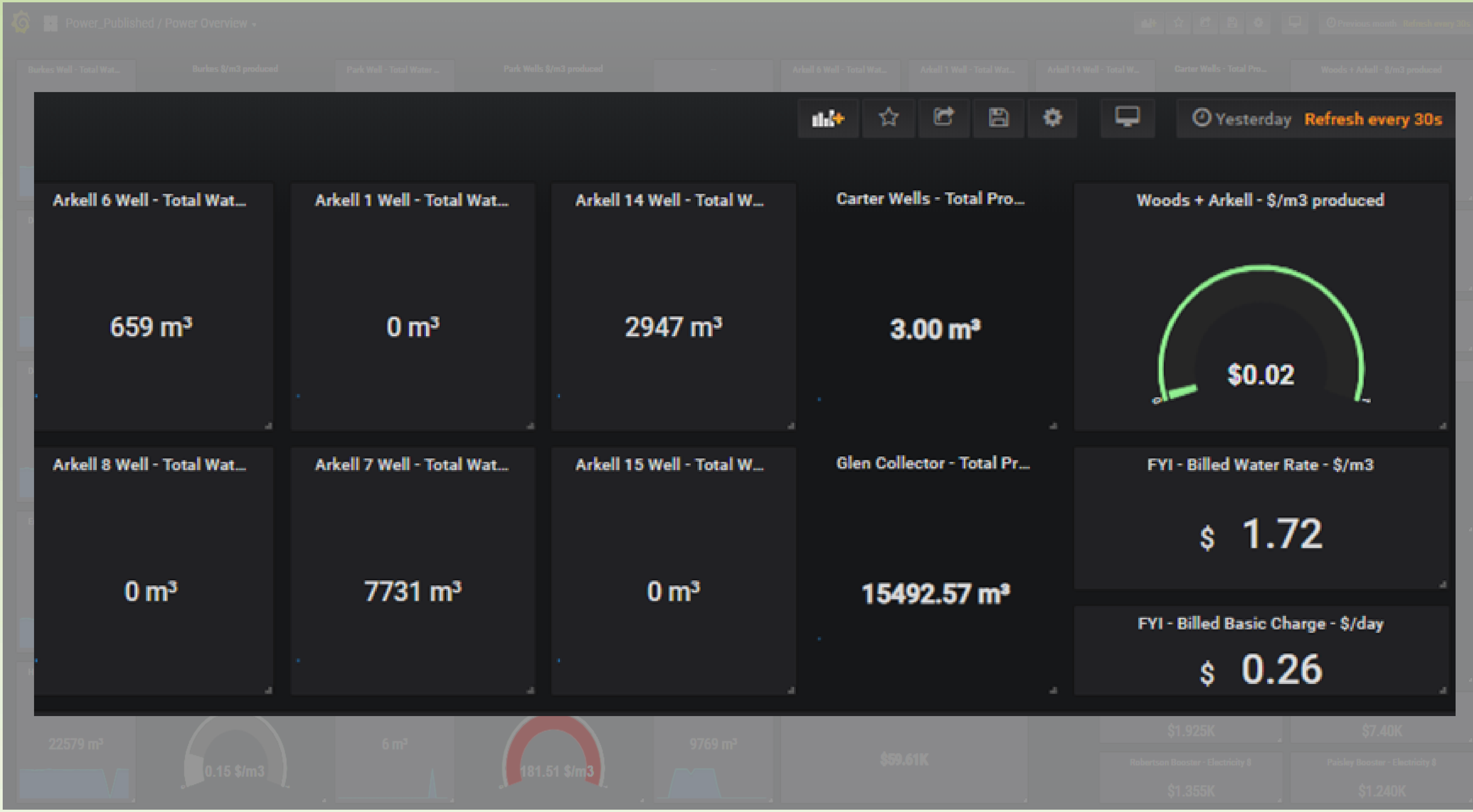


Grafana web-based Dashboarding Tool

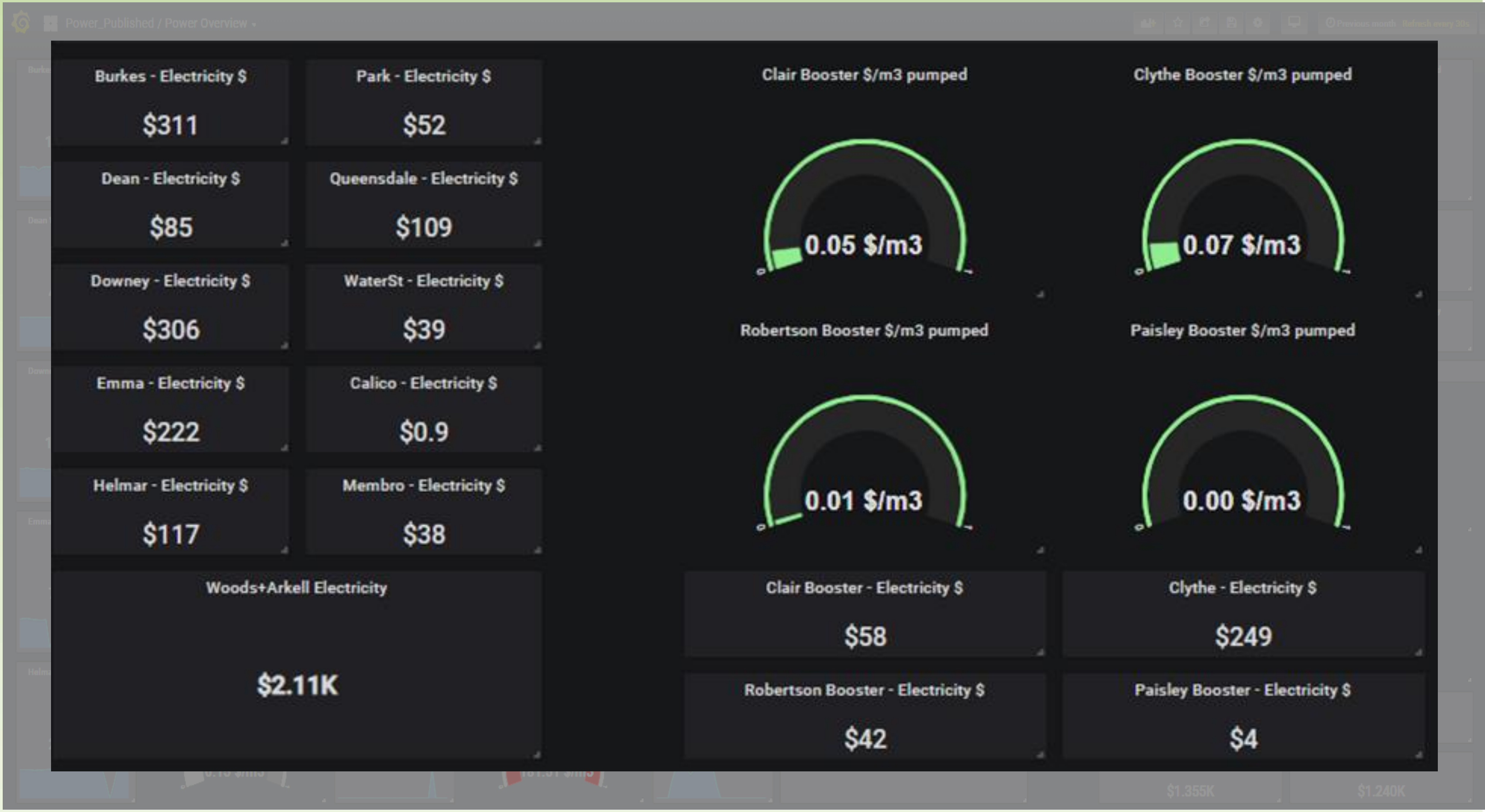


Power Overview Dashboard

Power Overview Dashboard



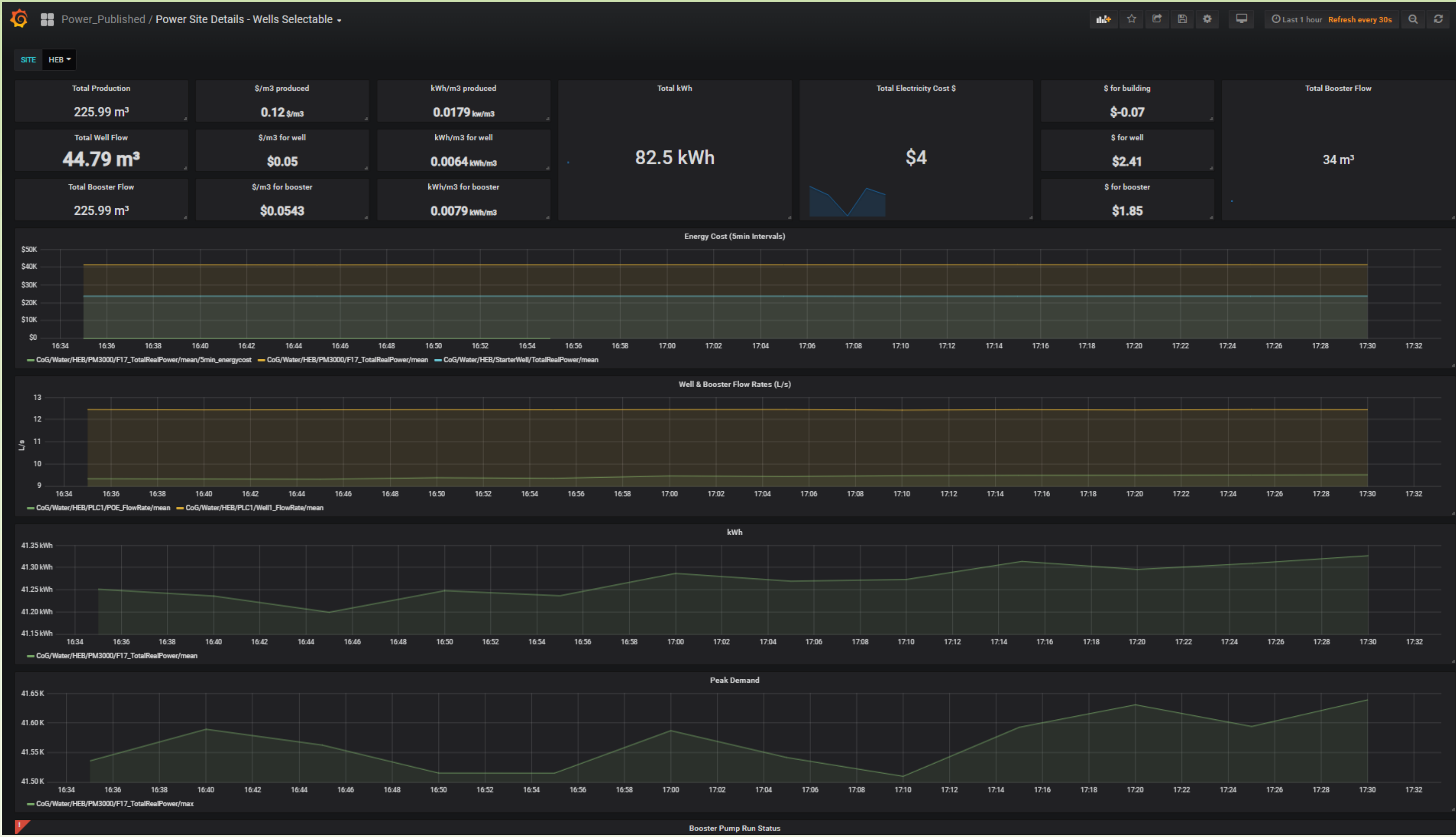
Power Overview Dashboard



Power Overview Dashboard

Power Overview Dashboard

Site Detail - Helmar Well (1hour)



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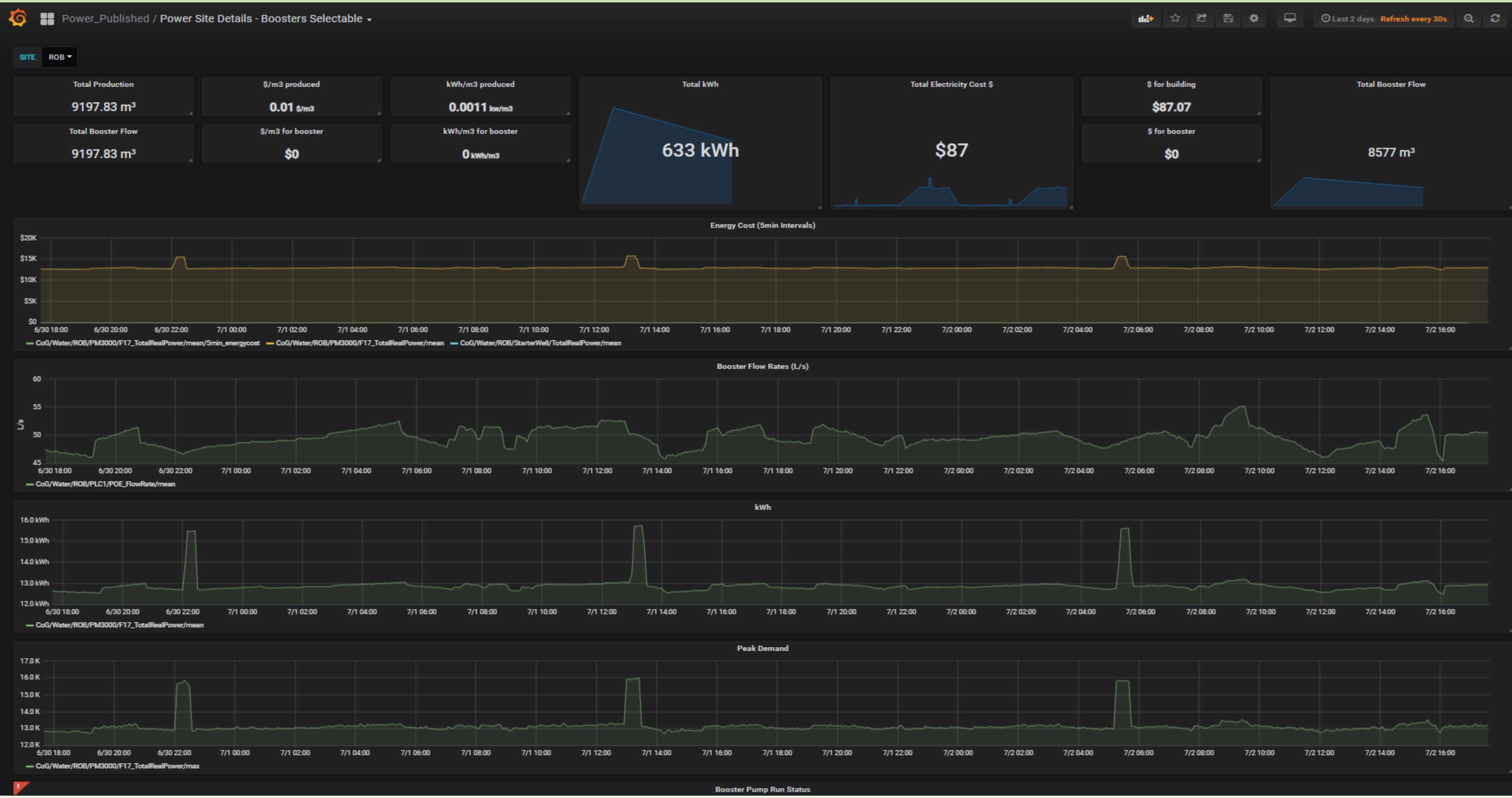
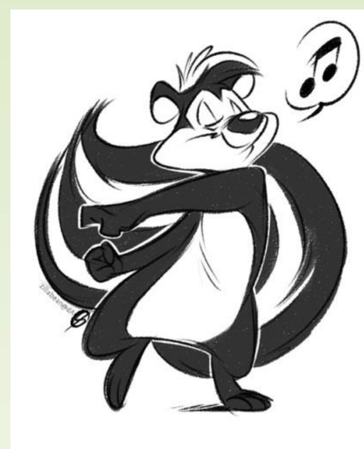
Site Detail– Robertson Booster (2 days)



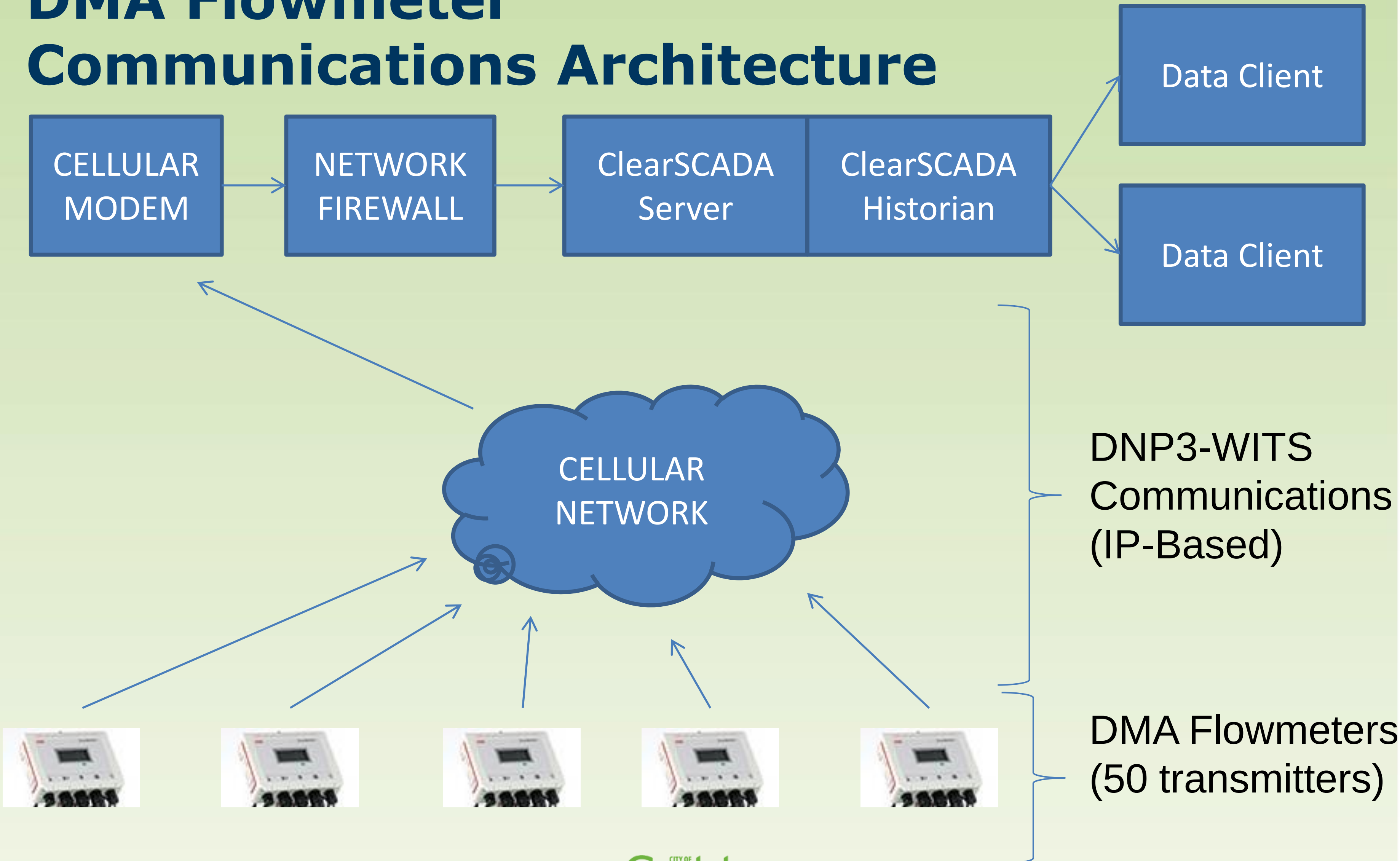
Site Detail– Robertson Booster (30 days)

Let’s use Neptune to manage our DMA Flowmeter Data…

NEPTUNE
CLUSTER

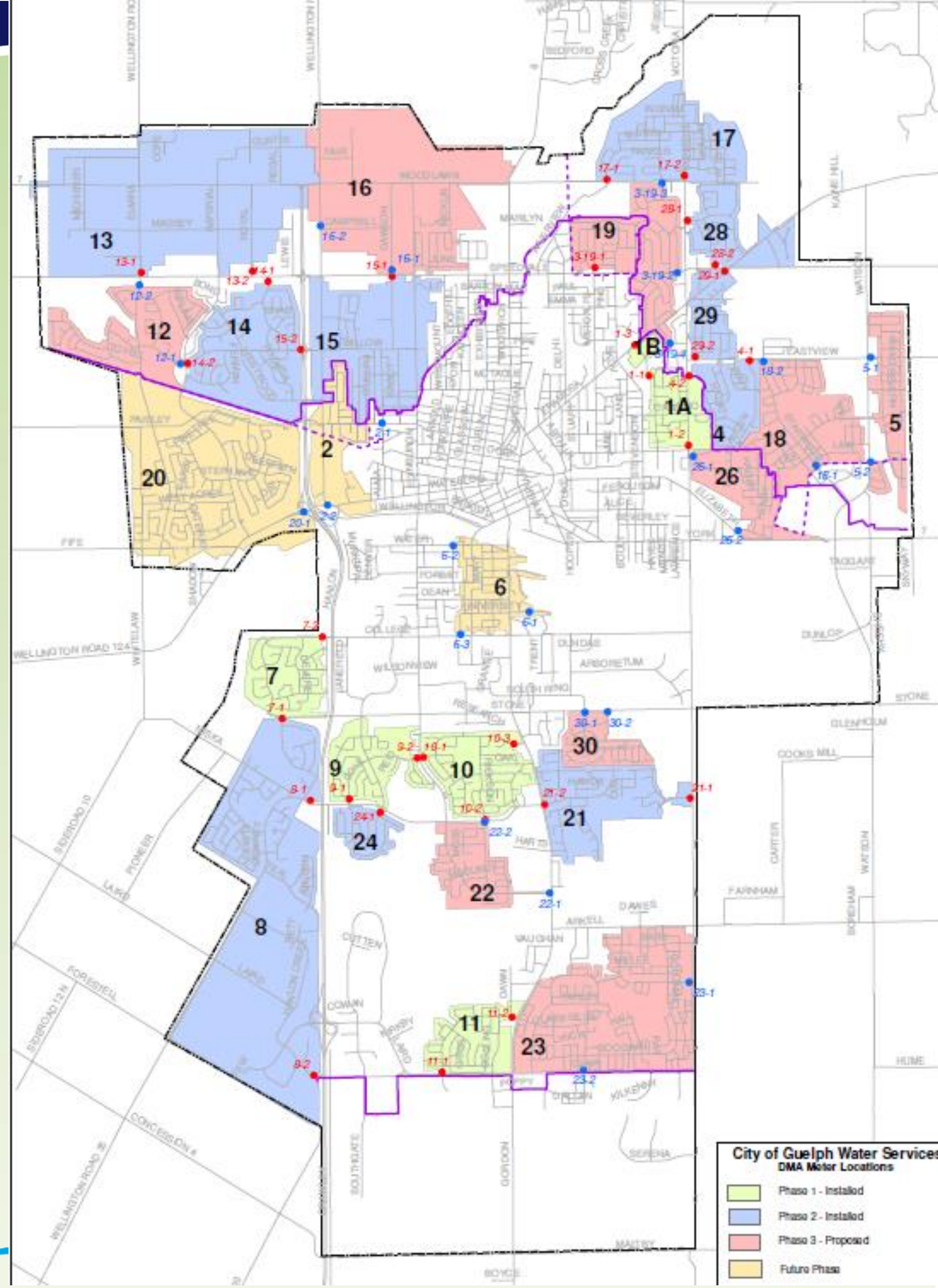


DMA Flowmeter Communications Architecture



District Metered Areas

- Segments Water Distribution into DMA Areas with 1-3 connections on borders
- Put flowmeters on the DMA's border connections
- What this give us:
  - Water in/out of DMAs
  - Compare to Customer Meters
  - Compare to Wells & Pumping Station meters
  - Calibrate Water Models

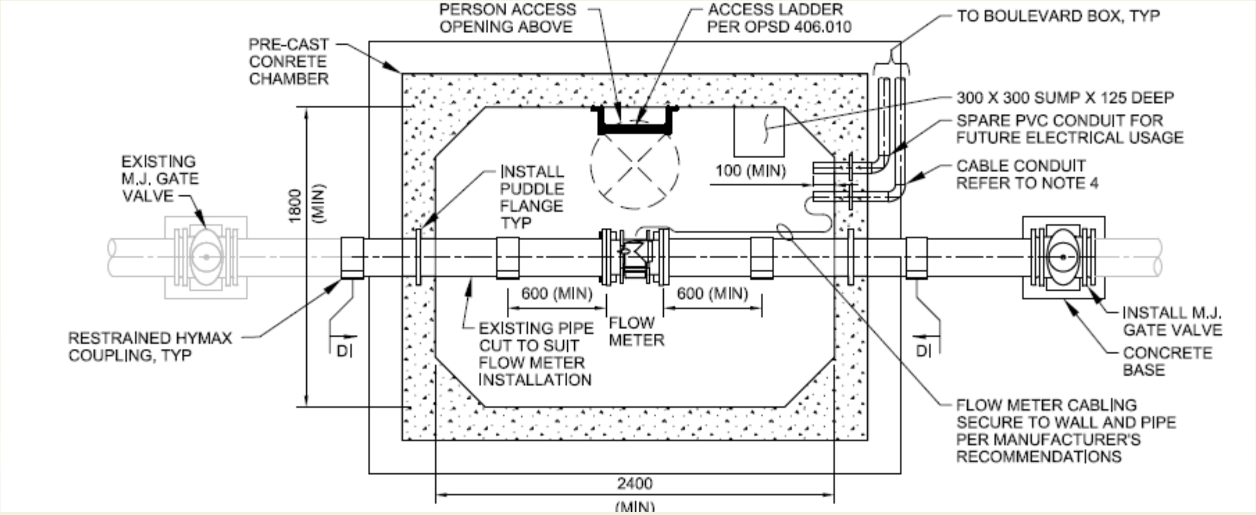


District Flow Meters

- Magnetic Flowmeter
- Integrated Remote Transmitter
  - Transmitter
  - Data Logger
  - Cellular Modem & Antenna
  - Built-in DNP3-WITS Protocol
  - IP 68 Submersion Rated
  - Long Life Battery
- Flow Tube
  - IP68 Submersion Rated

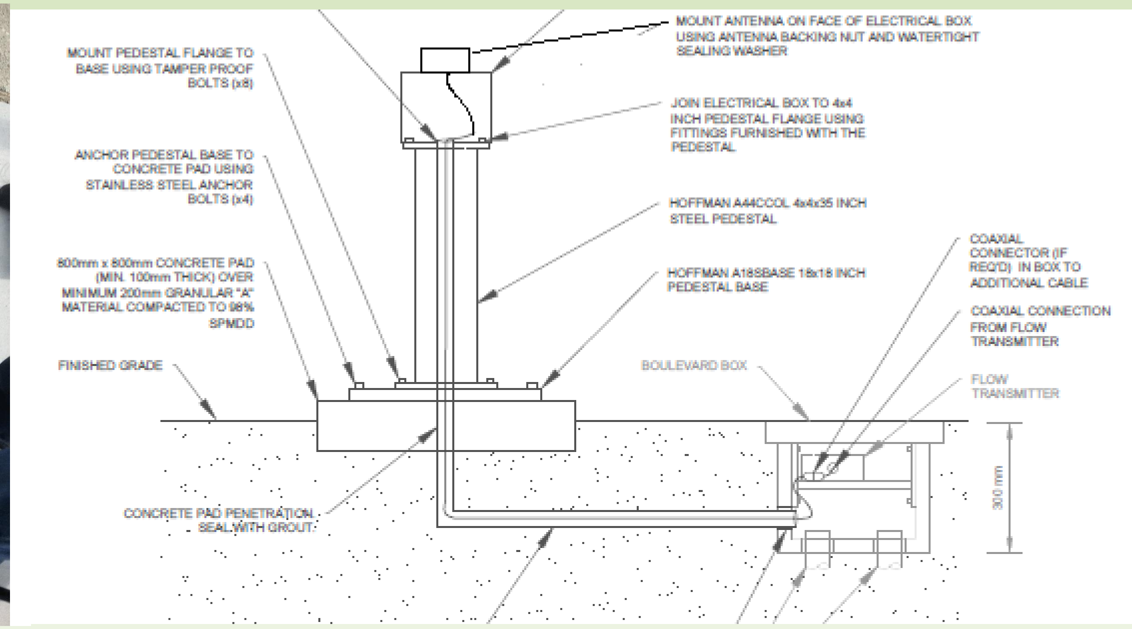
Flowmeter Chambers

- Each DMA is enabled by closing valves, so only 2-3 entry points
- Put Flowmeter chamber on each of DMA's entry points
  - Chamber contains the Flowmeter "flow tube"
  - Pressure sensor (also monitored by flowmeter electronics)
  - Upstream and downstream isolation valves

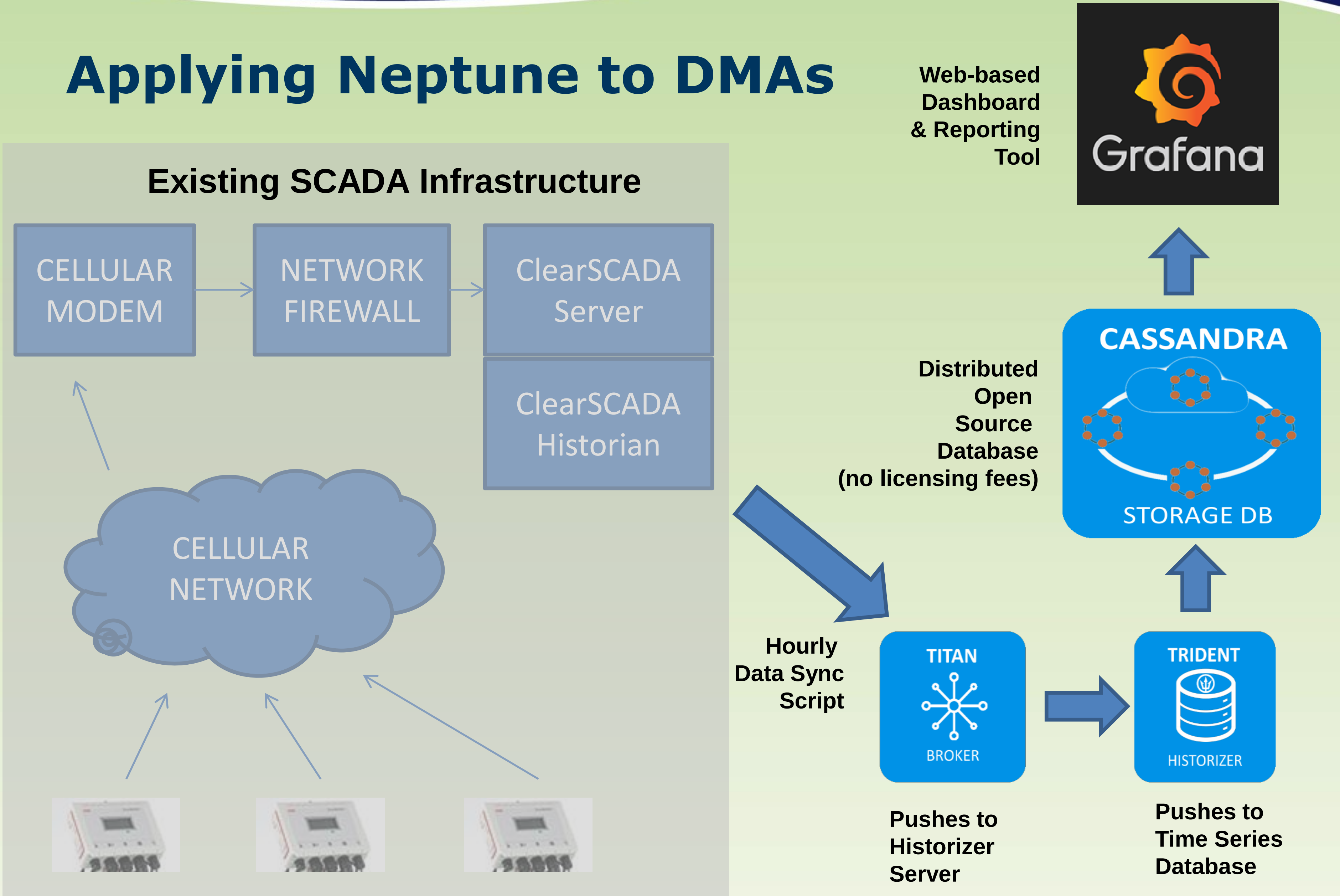


Flowmeter Transmitters

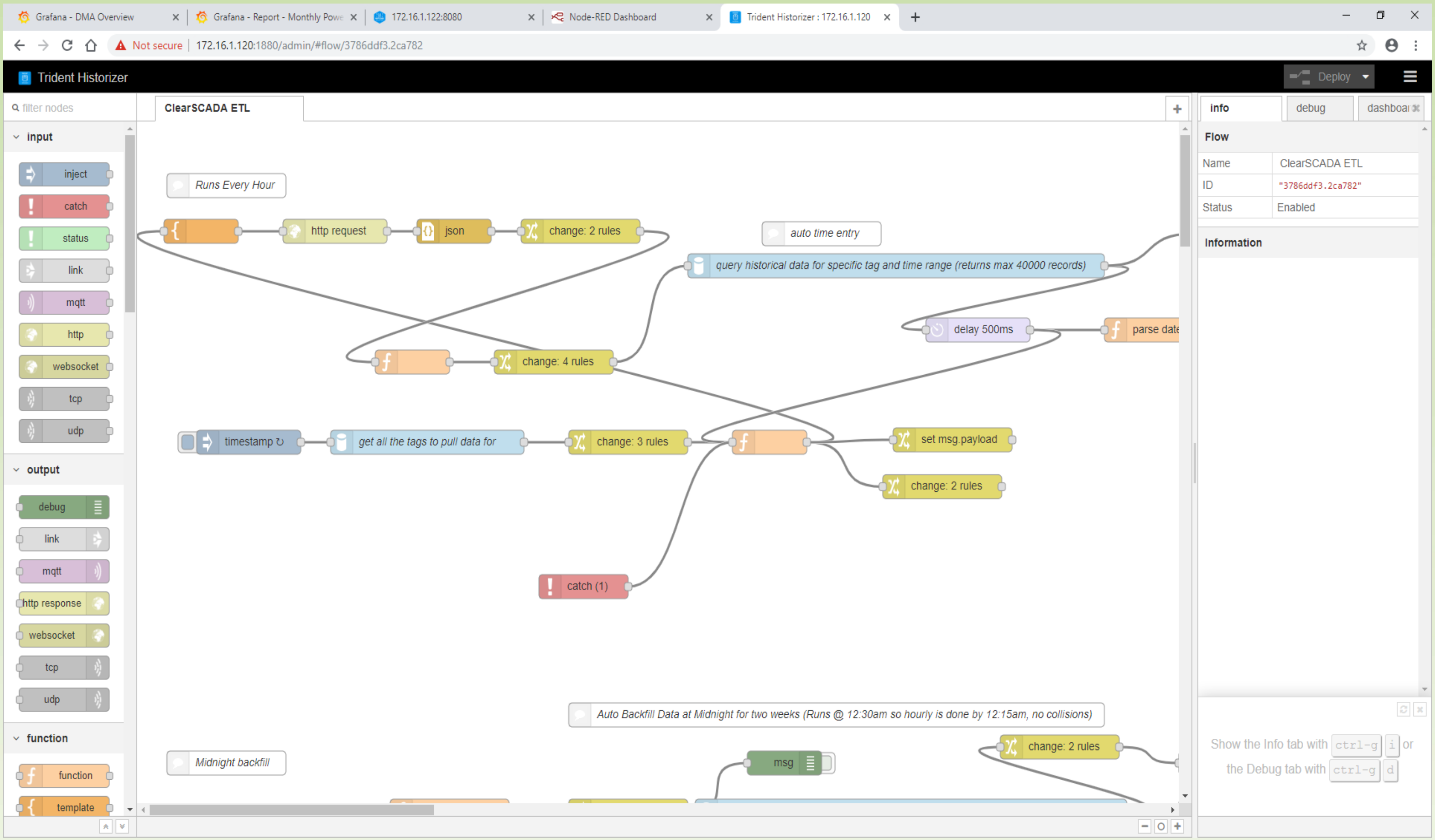
- Flowmeters installed into boulevard boxes
- Antenna pedestals to mount cellular antennas on



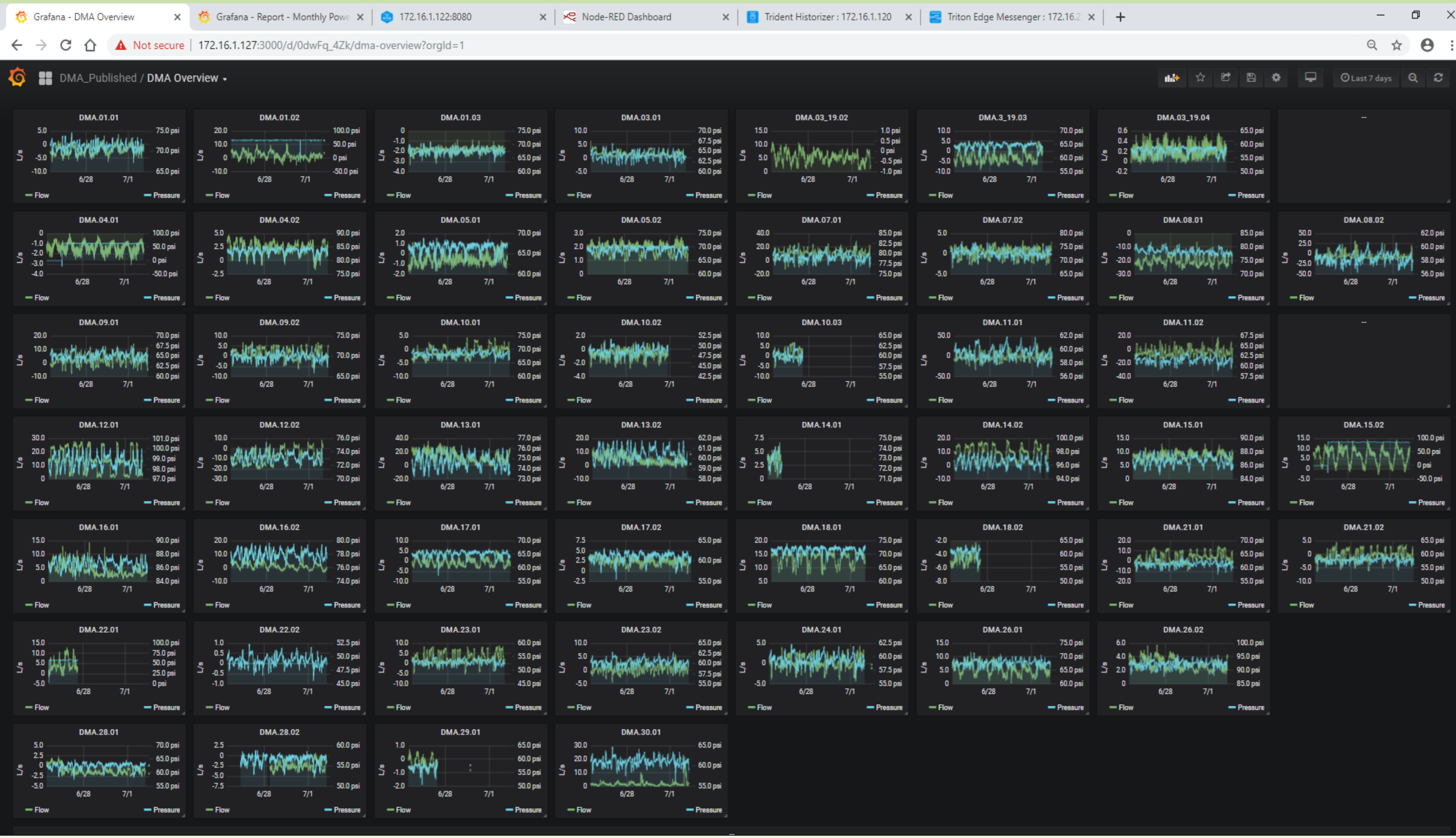
Applying Neptune to DMAs



Neptune Hourly Data Sync Scripting

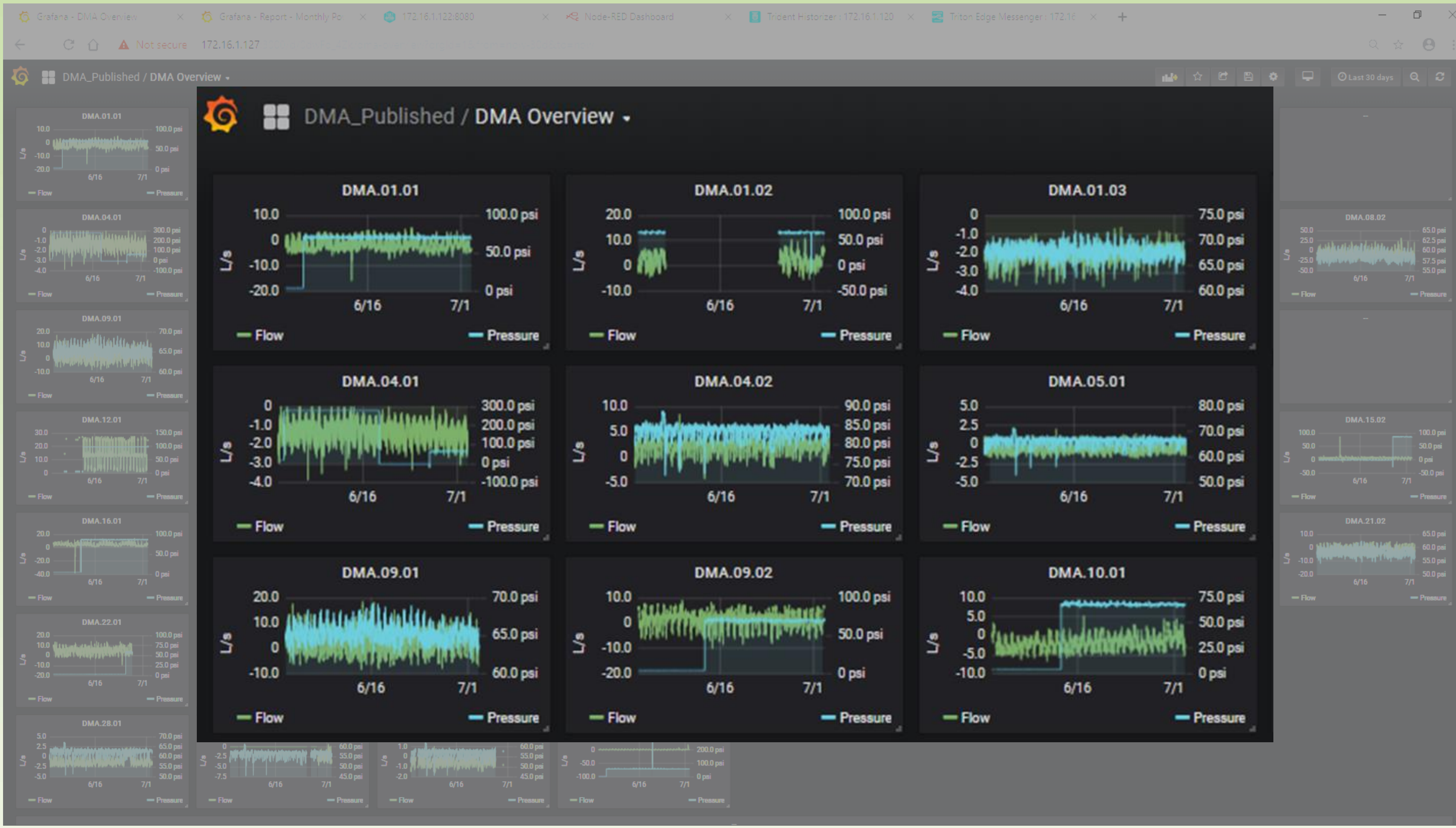


DMA Dashboard

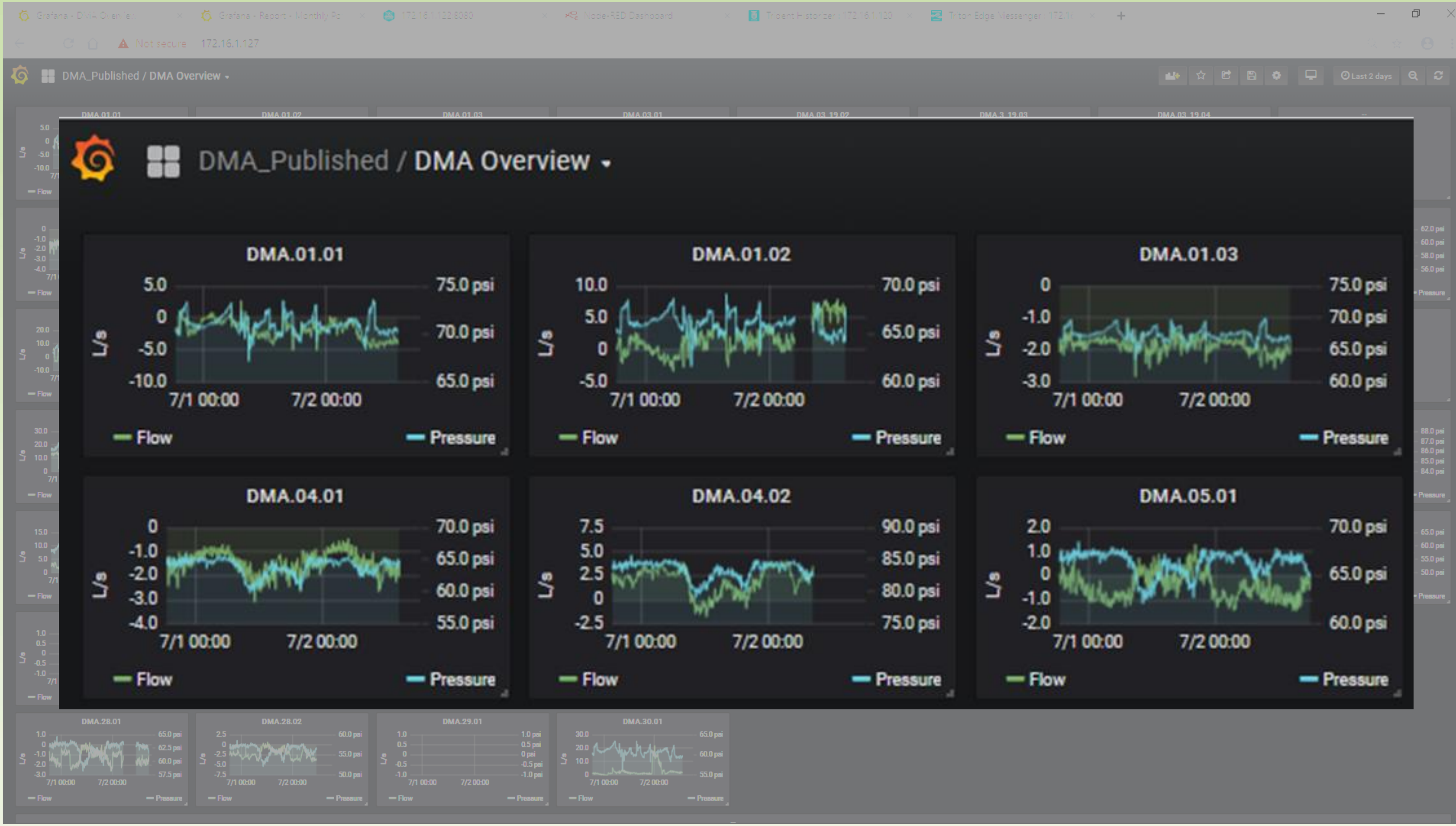


DMA Dashboard – showing last 7 days

DMA Dashboard – showing last 30 days



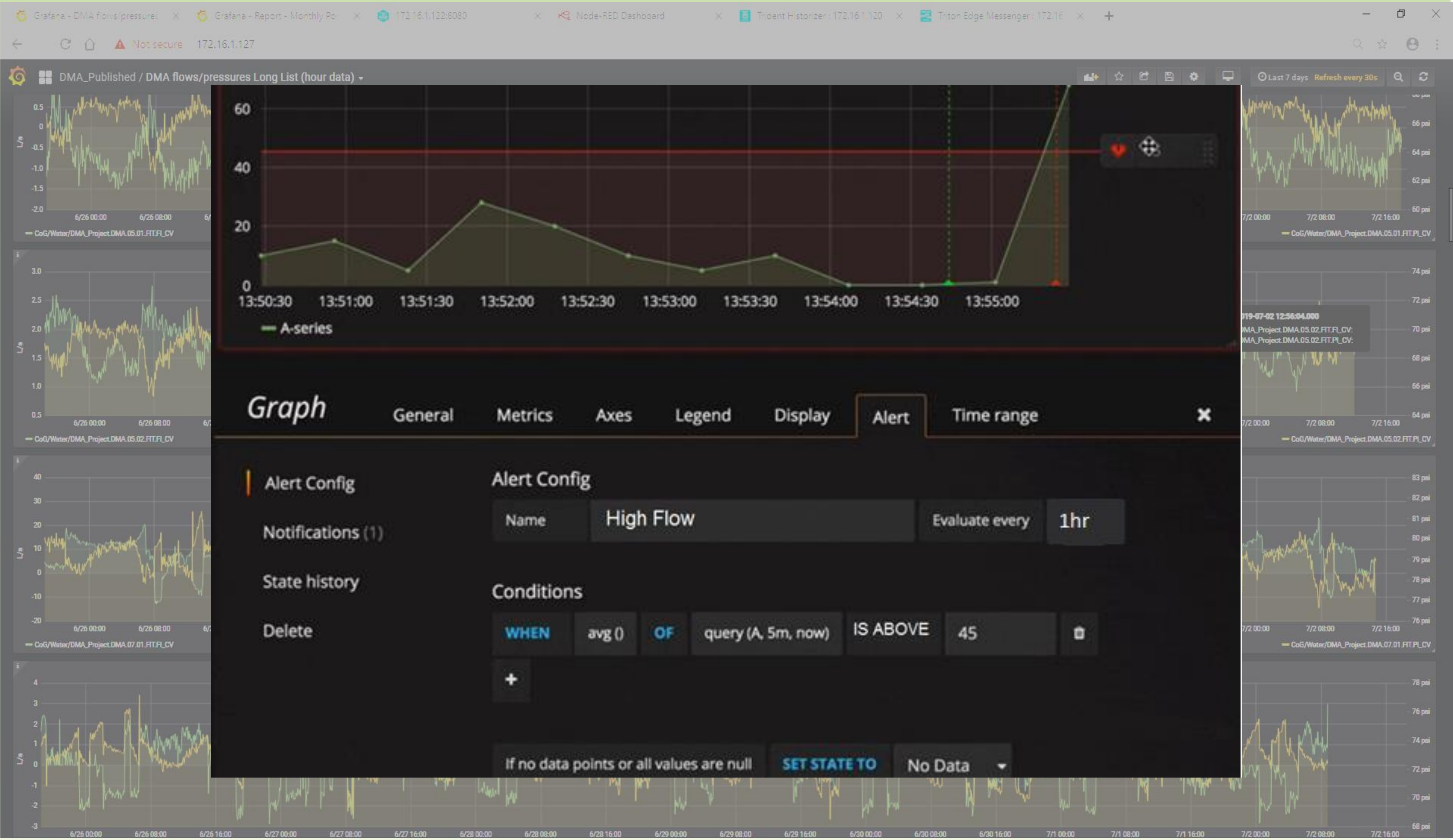
DMA Dashboard – or last 2 days



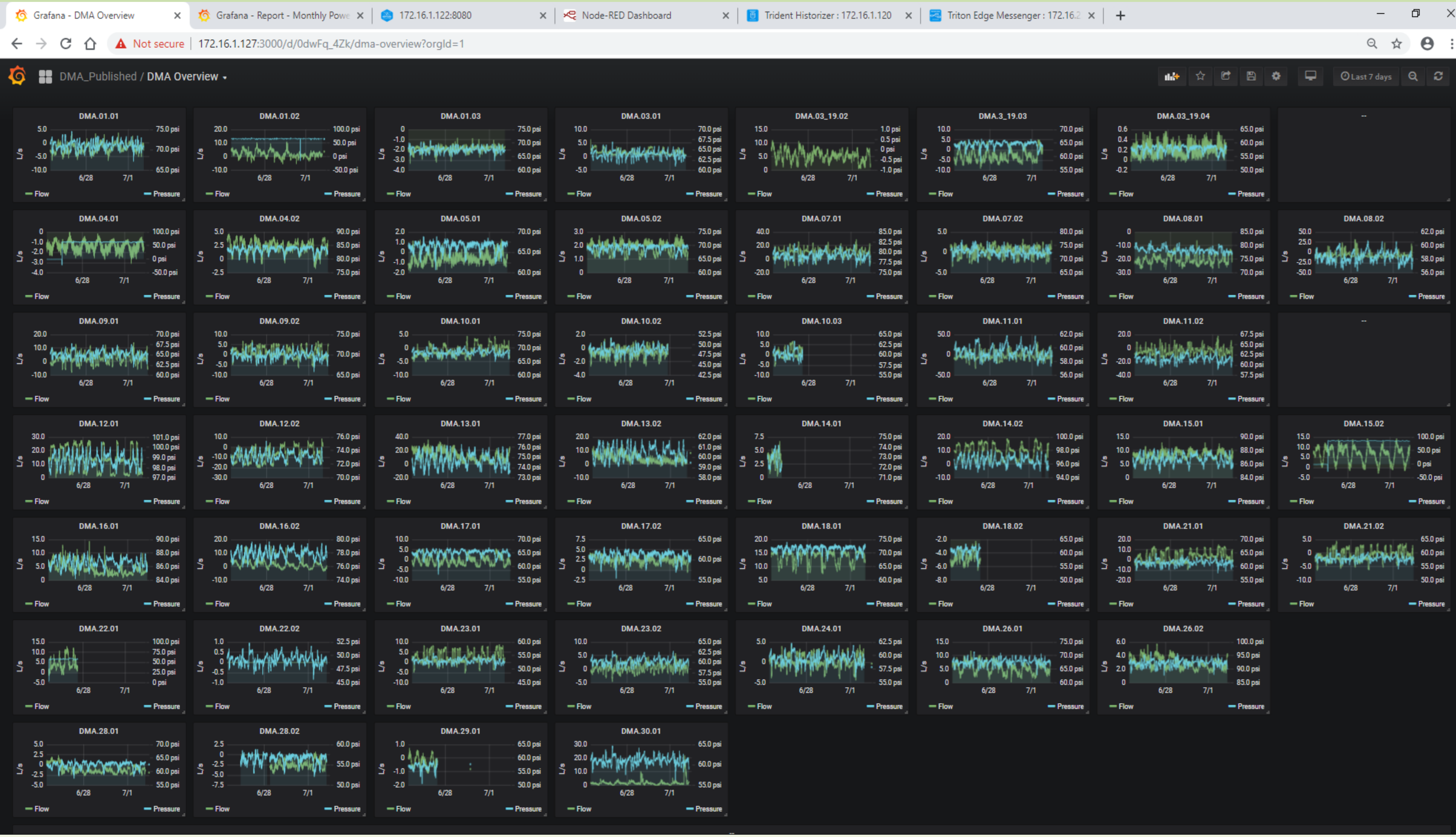
DMA Dashboard – Detail View

DMA Dashboard – Individual Flowmeter

DMA Dashboard – Setting up Email Alerts



DMA Dashboard



Power Overview Dashboard

Next Steps

Power Usage Dashboards

- Has been gathering data for past 12 months
- Final testing and adjustments in progress
  - Some tweaking still left to do
  - Automatic PDF email reports feature still under development (initial testing done)
  - Install work for network connections to existing Pump Motor Starters is in progress
- Next Steps
  - Mount display in Woods hallway as a realtime energy dashboard
  - Making Data-query web-interface accessible to Water Services staff (via desktop)
  - Making Grafana web-interface available to make dashboards for Water Serv. staff

DMA Flow & Pressure Dashboards

- All DMA flowmeter flow/pressure hardware issues resolved as of Jun 28, 2019
- Each flowmeter pushes data to server very approx. 6 hrs, longer if poor weather/signal
- Five meters need site visits every 2 weeks to push data (upgrades in 2020 should fix)
- Final testing and adjustments in progress
  - Some tweaking of dashboards & reporting tool still left to do
  - Selecting criteria to test out email alert feature (e.g. high flow rates) and testing
- Next Steps
  - Mount display in Woods hallway near Distribution Ops as a realtime dashboard
  - Making Data-query and Grafana web-interface available to Water Services staff