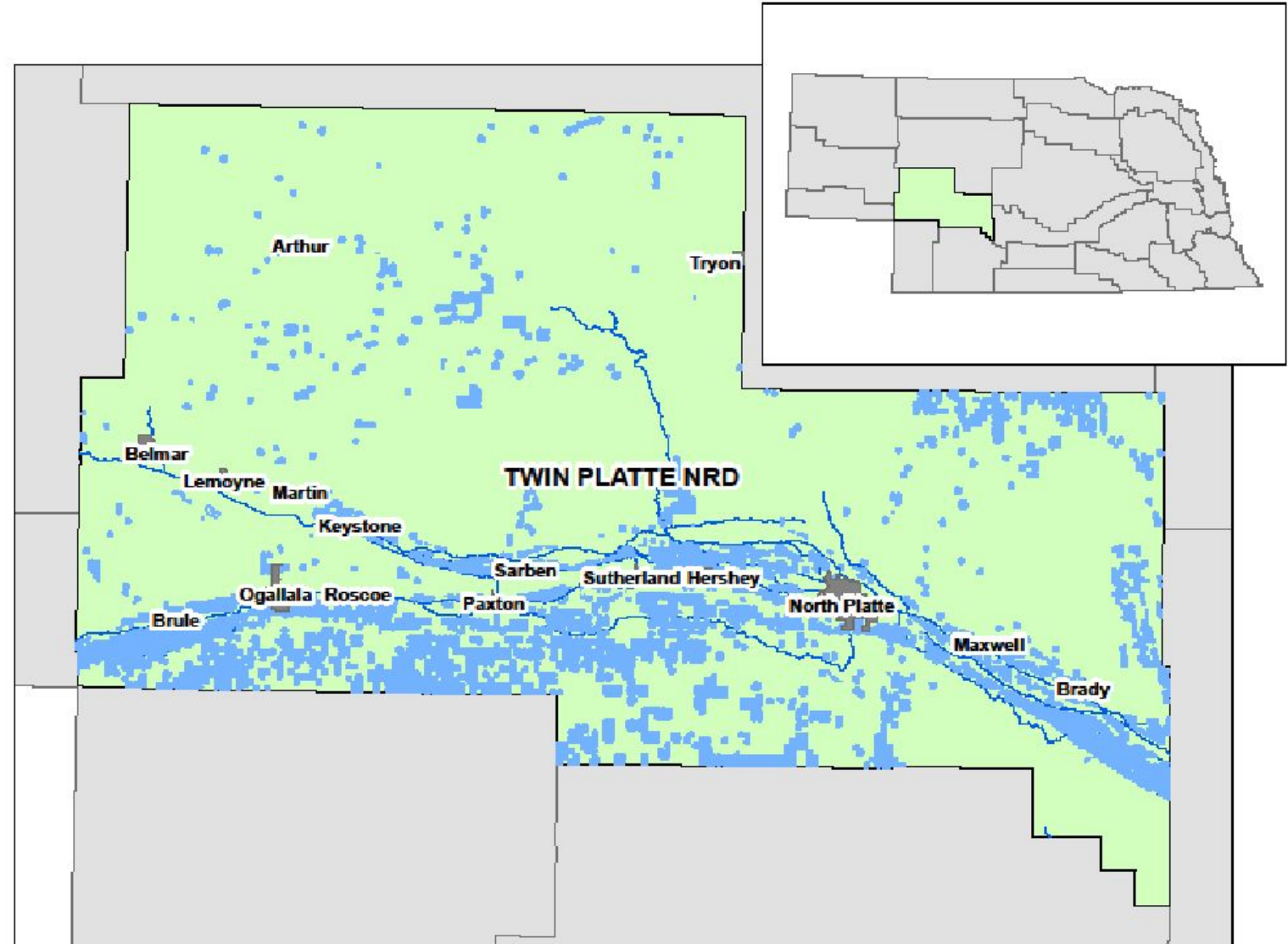




Real-time Groundwater Management with Big Data & the Internet of Things: Examples from the TPNRD Water Data Program

James C. Schneider, PhD | Kathleen Elmquist

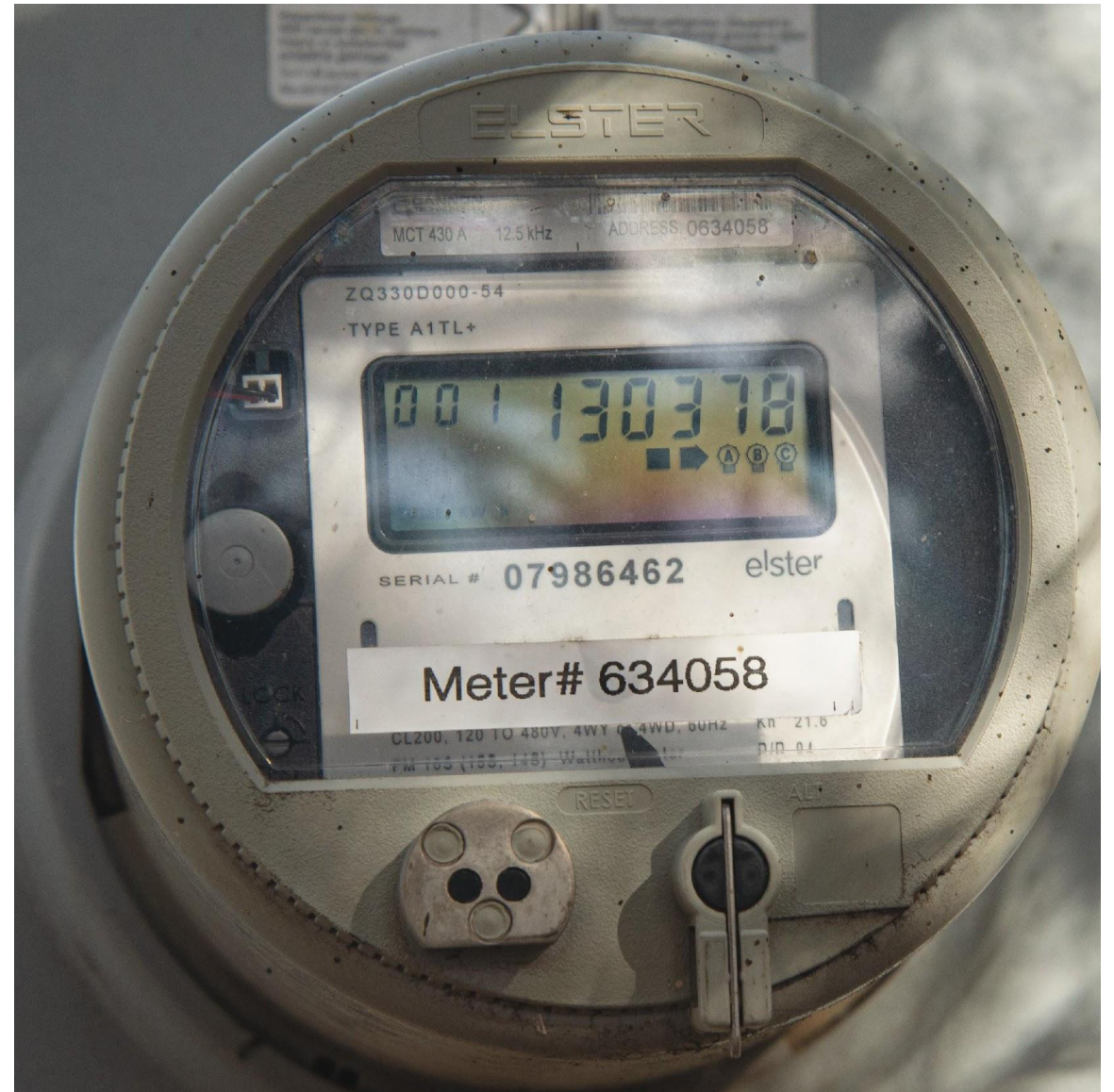
TPNRD Water Data Program



Schedule

YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEARS 5-9	YEAR 10
Sep 2019 - Aug 2020	Sep 2020 - Aug 2021	Sep 2021 - Aug 2022	Sep 2022 - Aug 2023	Sep 2023 - Aug 2028	Sep 2028 - Aug 2029
Walls & Power Poles connected spatially to irrigated acre parcels	Nebraska Public Power District starts providing data	100% signup achieved	Robust Review completed using data through 2022	Project Evaluation and Continuation	Robust Review completed using data through 2028
Dawson/Mid-west Public Power start providing data	Groundwater Manager's App MVP Completed	Groundwater Manager's App Upgraded			
AgHub (Grower Dashboard) MVP Completed	New Observation Wells Drilled for Pressure Transducer deployment	AgHub (Grower Dashboard) Upgraded			
Installation Began of Flow Meters, Pressure Transducers, Continuity Devices	Installation of Flow Meters, Pressure Transducers, Continuity Devices tripled	Continued installation of flow meters, Pressure Transducers, Continuity Devices			

TPNRD Water Data Program





Water Data Program Education Plan



- Every newsletter sent out (6) focused on the Water Data Program – mailed out 17,000+ newsletters - rural & towns
- Over-sized postcards mailed out before each open house & early spring reminding folks about flow testing & Water Data Program – mailed out to 7,000+ - rural only



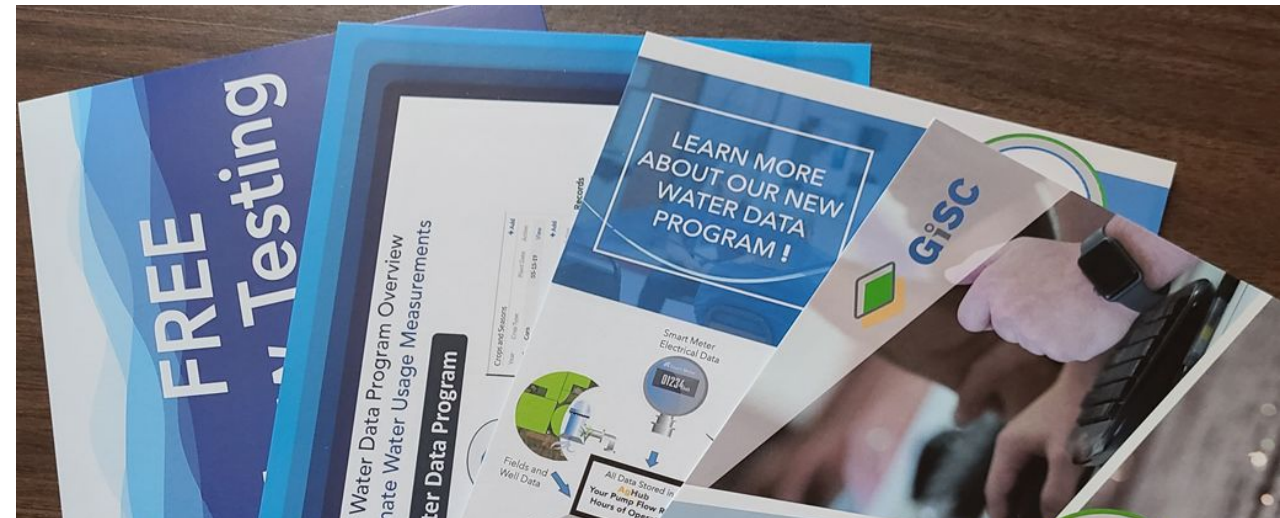
Water Data Program Open Houses

Sept 2019 – 4 Open Houses

Jan 2020 – 5 Open Houses

Jun/Aug/Dec 2021 – 7 Open Houses

Great 1-on-1 time with growers, ask lots of questions, show how the dashboard looks for an existing user, can see the value of program



TPRND Water Data Program



Growers



- When we sit down and talk with them – explain why we are doing this, what is currently being used, how this can benefit them
- Standoffish at first – as they become educated, they understand and become receptive to the program
- On their own will in the office when something is missing or doesn't look right
- Use this to check their other tools, Field Net or Ag Sense
- Like sitting down 1-on-1

Water Data Program | Stats

as of September 24th

100% 
of acres registered

~300,000
acres in Water Data Program

~500 
users signed up
(operators & landowners)

**over
1,000**
well connections to Electric
Smart Meter & Paige Wireless Devices

*Electric Users - Midwest & Dawson allow data to go back to 2019 when they sign up

Devices Installed in the TPNRD



paigewirelessSM



Devices Employed | Device Inventory

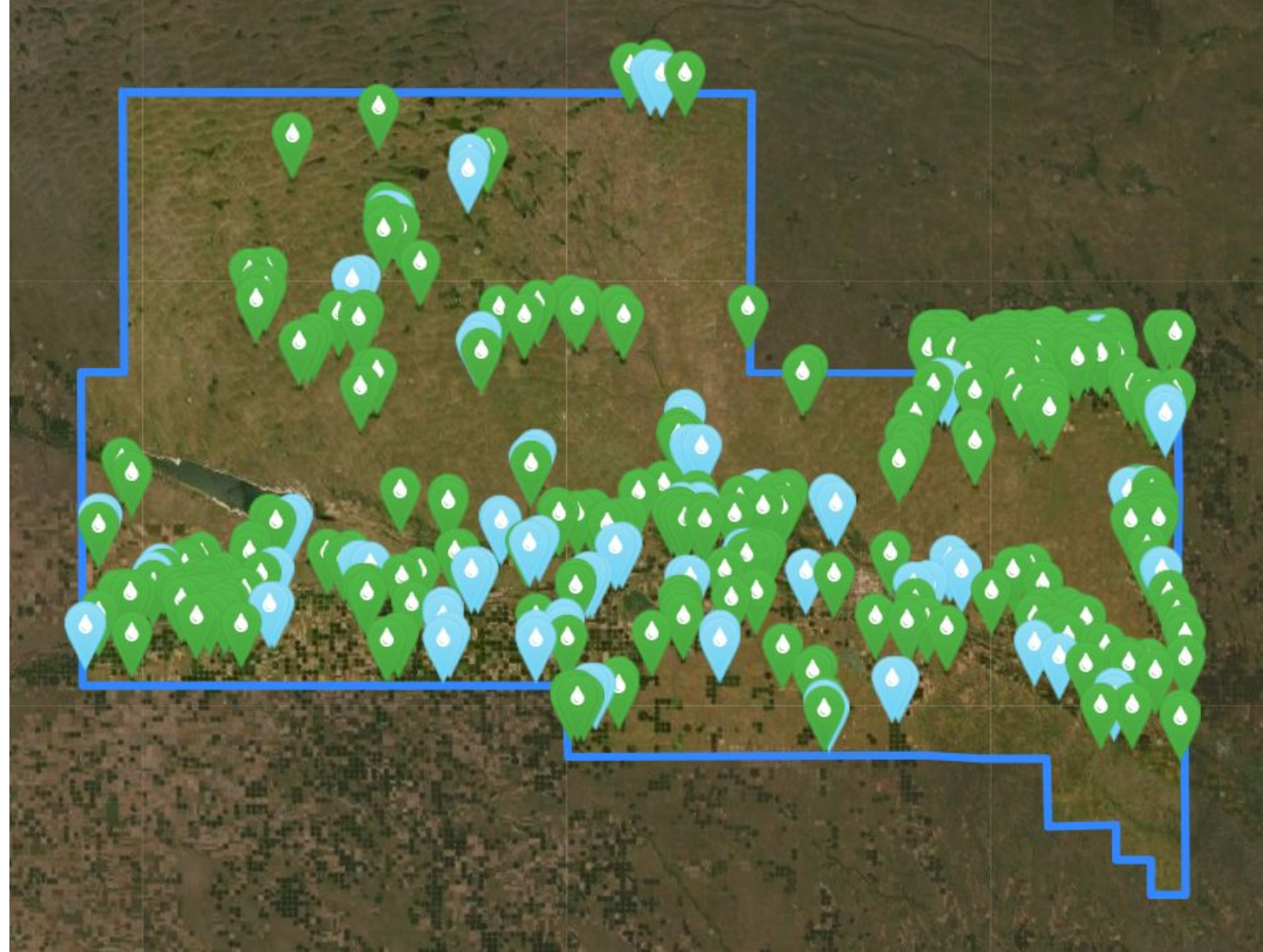
Devices deployed:

- 84 flowmeters
- 90 water level sensors
- 349 pump monitors

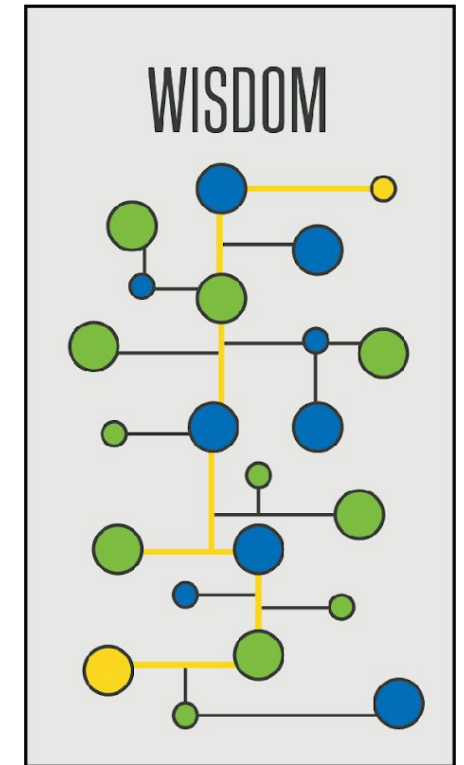
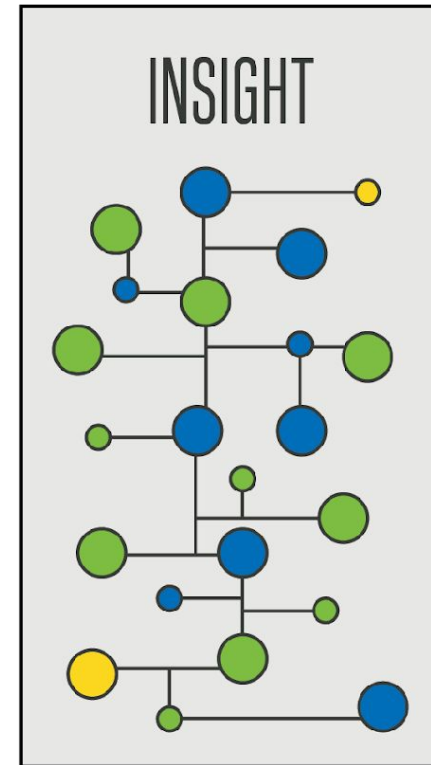
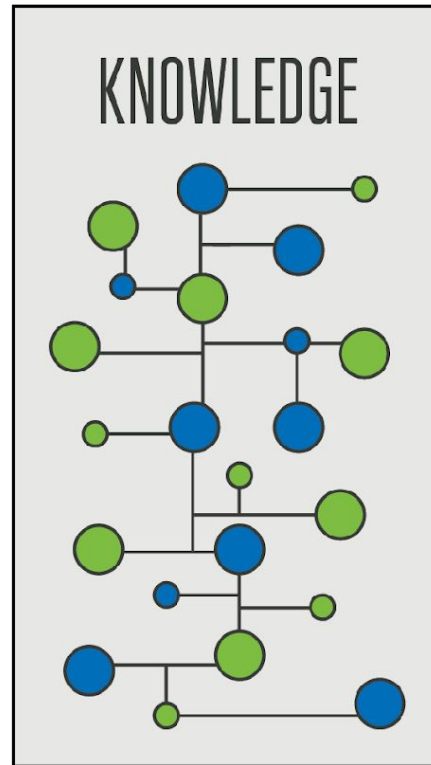
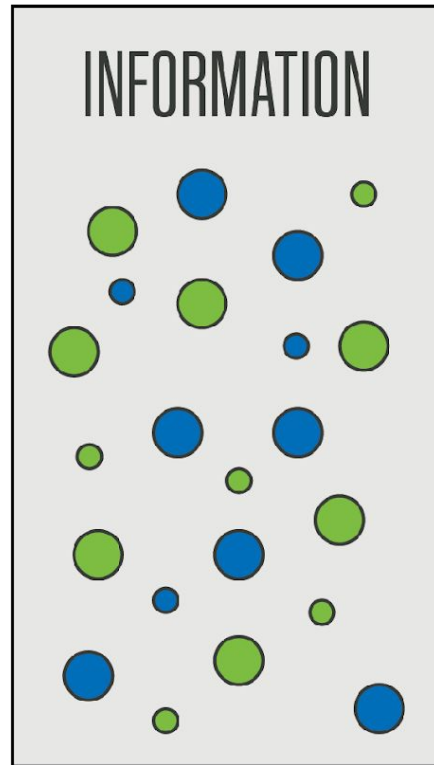
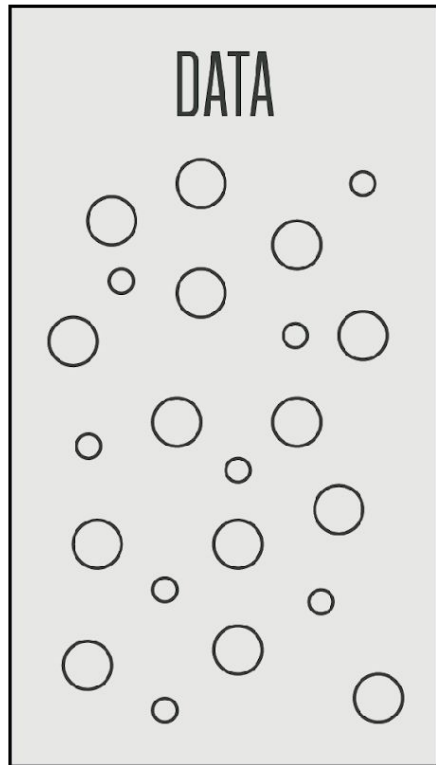
Devices planned for deployment:

- 300 pump monitors

Over 800 IoT devices!



Modern Systems must be more than just Data Management Tools....



System Design Approach | Start with the People, not the Technology

1

Identify
personas



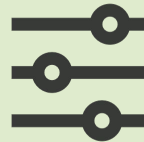
2

Inventory
user tasks



3

Estimate
level of effort



4

Determine
priorities



5

Start
building!





System Design Approach

Step 1 | Identify Personas

Example Persona – Groundwater Manager

- A Groundwater Manager is a TPNRD staff member, who is responsible for overseeing the groundwater management program across the district and reporting to agency partners.

In user-centered design, a “persona” is a representative type of user. System designers use personas as a way to incorporate user’s goals, desires, and limitations in a product or platform

We considered the following personas during platform development:

Groundwater Manager	Producers Data Manager
Groundwater Modeling	Wireless Device Maintainer
Producer/Landowner	Field Technician



System Design Approach

Step 2 | Inventory User Tasks

**As a
Groundwater
Manager,
I want to:**

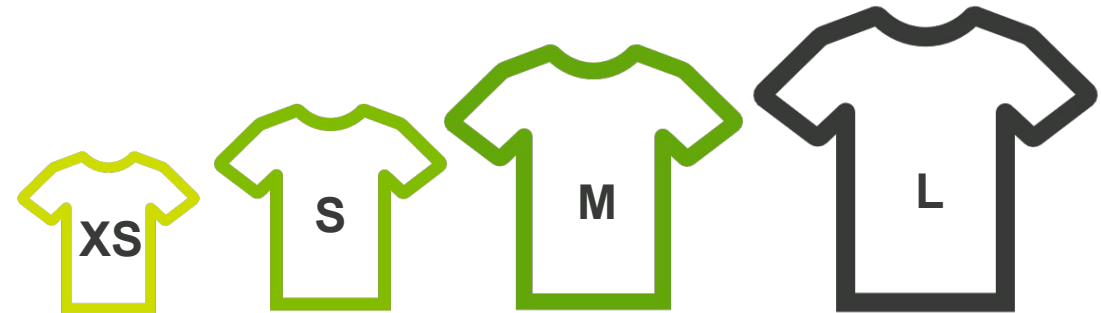
- View aggregated water usage throughout the district, including usage data reported by Producers
- View all wells to see available data including water level and water quality over varying periods of time
- View model results
- See data in units of my choosing: volume (acre-inches) and depth (acre-inches / acre)
- Have a near real-time understanding of current water usage via a color-coded map



System Design Approach

Step 3 | Estimate Level of Effort

- Features are reviewed by the development team and assigned a “point” estimate
- 1 point corresponds to a team day of development time
 - i.e., two developers working on the feature for a day, plus time to develop detailed requirements, testing, and iteration



Estimating accurately is hard! The goal is to get the right magnitude and calibrate over time to provide budget confidence



System Design Approach

Step 4 | Determine Priorities

- Users rate the Frequency and Criticality of each user task on a scale of 1 to 5 where 5 is the most critical or frequent.
- Once the tasks have been rated, they can be reviewed to confirm priority.

Persona	User Task	Frequency	Criticality	Prioritization Notes
Groundwater Manager	1. View aggregated water usage throughout the district; including usage data reported by producers			
Groundwater Manager	a. View a map of streamflow Zone (SFZ) polygons and see total volume pumped per interesting polygon in a color-coded map for these polygons	3	5	Probably needs to be average pumping (per acre) to allow for comparison between zone
Groundwater Manager	b. Click a streamflow Zone polygon and see time series charts aggregated for the selected polygon	3	3	
Groundwater Manager	c. View a water balance graph for the whole district	2	3	No urgency, many things need to fall into place before this would be meaningful
Groundwater Manager	d. Aggregate data and allow map selection and aggregated data charts for other interesting polygons beyond SFZ, including:	2	3	



System Design Approach

Step 5 | Start Building!

Compare Usage, ET, and Precipitation

Compare
Usage,
ET,
and
Precipitation
Sources

groundv

Welcome Kathleen Elmquist Home Manage Learn More Report

TWIN PLATTE NATURAL RESOURCES DISTRICT

Water Level Explorer Water Data Program Well Map Permits and Inspections Search...

Irrigation Unit Summary

Editable text for irrigation unit index page: TPIDs are links to irrigation unit detail pages, Well IDs are links to well detail pages

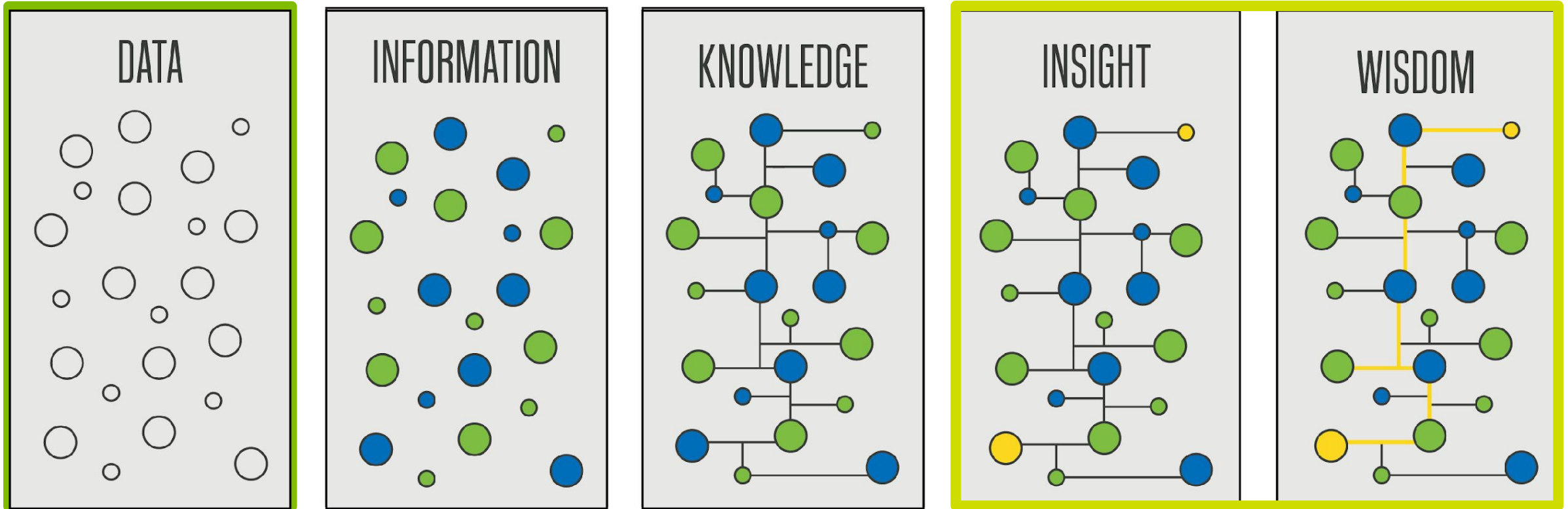
Start Date: 1 2022 End Date: 8 2022 Update

Volume (gal) Depth (in) Clear All Filters

Irrigation Unit ID	Irrigation Unit Area (a)	Associated Well Count	Associated Well(s)	Precipitation (in)	Evapotranspiration (in)	Flow Meter PumpedDe...	Continuity Meter Pump...	Electrical Usage PumpedDe...
TP1906	133.42	1	G-052163	8.6	13.4	0.0	27.9	-
TP1822	111.96	1	G-040910	7.6	17.8	17.5	20.4	-
TP0093	131.80	1	G-062865	5.9	14.0	16.4	15.6	-
TP2264	172.26	1	G-105795	7.5	9.8	4.2	13.7	-
TP1691	132.77	1	G-039926	9.3	10.9	8.6	12.5	-
TP1770	127.00	1	G-163921	8.0	13.9	9.7	11.8	-
TP2259	89.55	1	G-108521	7.5	15.3	0.0	11.5	-
TP0091	126.86	1	G-053579	5.9	12.5	13.5	11.2	-
TP1893	154.52	1	G-065708	8.4	11.5	10.7	9.9	-
TP2450	121.28	1	G-059105	8.7	9.8	4.8	9.7	-
TP0870	133.22	1	G-036540	6.2	9.5	8.4	9.5	-
TP2334	125.42	1	G-162367	8.0	15.8	12.9	9.3	-
TP1689	123.37	1	G-117777	9.4	9.6	6.4	8.5	-
TP1821	129.64	1	G-065706	7.6	16.0	9.7	6.5	-
TP1324	136.71	1	G-040388	8.3	9.0	7.0	1.5	-

1 to 68 of 68 Page 1 of 1

What's Next?



We start here – many new and existing connected data sources provide information and Knowledge, and have just begun daylighting previously unavailable Insights

How do we continue progressing towards Insight and Wisdom?

What's next?

*Q: How do we continue progressing towards
Insight and Wisdom?*



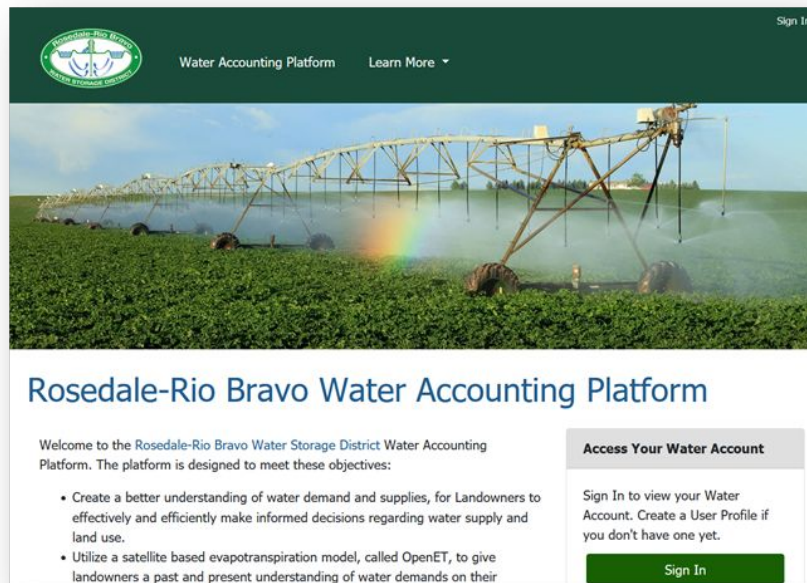
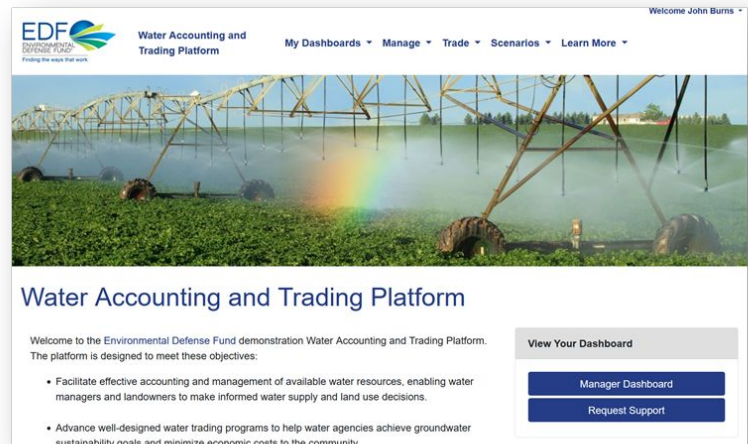
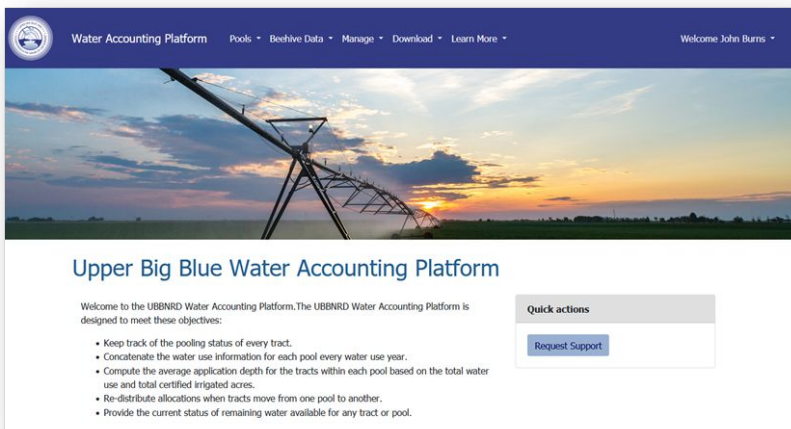
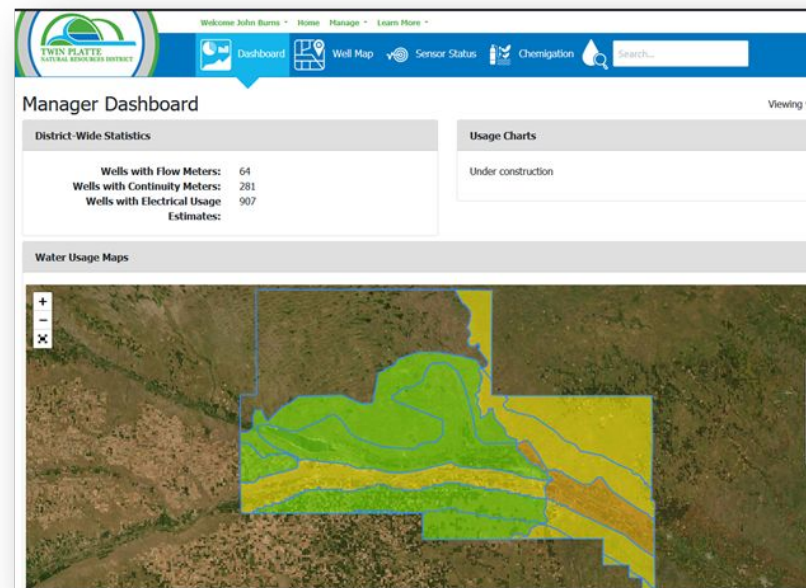
A: Three parallel strategies:

1) Integrate more sophisticated, automated analysis tools such as the Groundwater Evaluation Toolbox

2) Work with subject matter experts to define and build data visualizations such as dashboards, maps, charts

3) Continue to perform analysis using new data sources such as remote sensed water usage and precipitation

Building a family of open, shared technologies



A photograph of a lush green cornfield stretching towards a horizon under a dramatic, sunset-colored sky. The word "Questions?" is written in large, white, bold, sans-serif font across the center of the image.

Questions?

olsson®

ESA