State-of-the-Art Water Supply Protection

In the kNOW Webinar Series

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Presenters

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Source Water Control an Integral part of OneWater

- Growing pressure on water resources
- Impacts on source water quality
- Reductions in dissolved oxygen levels
- Source water control the first line of treatment
- Predictive technologies to enable proactive management
- Supports resilient, integrated water management

Agenda

- CCWA background and the development of a resilient raw water supply
- Reservoir Management system and results
- Proactive monitoring
- AI for Predicting Taste and Odor

Clayton County Water Authority Background

Who are We?

Clayton County

- Part of metro Atlanta
- Home to world's busiest airport
- 7 municipalities
- 295,000+ population

Clayton County Water Authority

- Created in 1955 /Governed by Board
- Serves 289,000+ people in 6 cities and unincorporated area
- ~380 employees across 12 departments


Water


Sewer


Stormwater

CCWA's mission is to provide quality water and quality services to our community.

CCWA Services for our Community

Water

5 Raw Water Reservoirs

3 Treatment Facilities

42 MGD Capacity

1500 Miles of Pipeline

Sewer

3 Water Reclamation Facilities

38.4 MGD Treatment Capacity

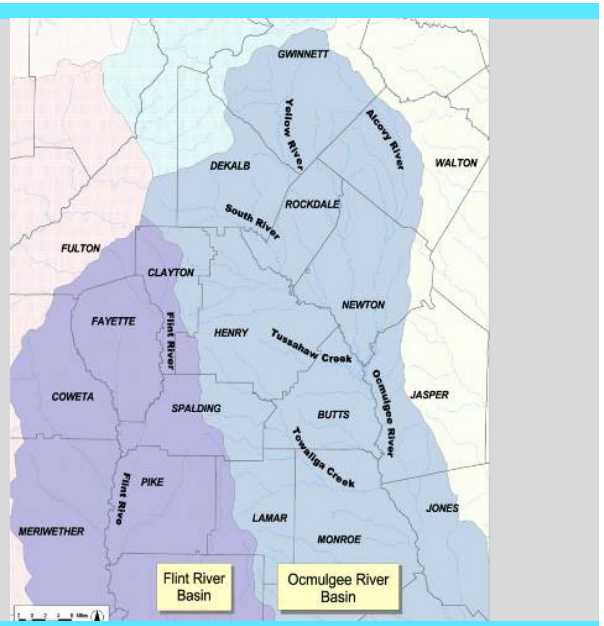
1400 Miles of Pipeline

Stormwater

Provides drainage structures to help protect property from flooding, sinkholes

500 miles of infrastructure

The History of Indirect Potable Reuse at CCWA

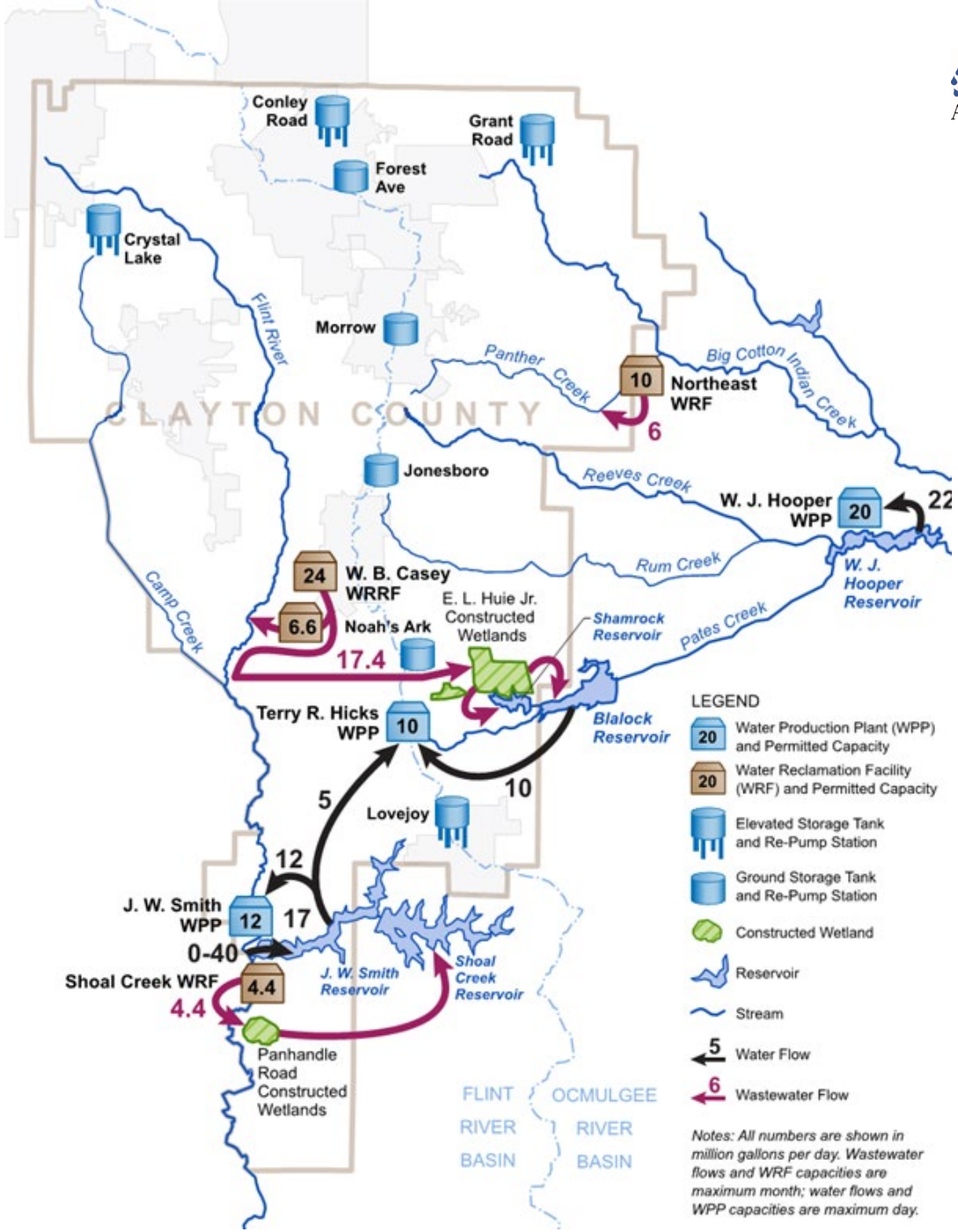


- River Basin Headwaters – limited water supply
- Flint River water quality drove innovation

- 1980 – Built Land Application System
- More than 2,400 forested acres
- 70% of reclaimed water was returned as streamflow/ downstream water supply

- 1989 - Blalock Reservoir constructed
- 2000 - Master Plan addressed aging LAS with focus on sustainable water supply
- 2004 – Huie Constructed Treatment Wetlands constructed

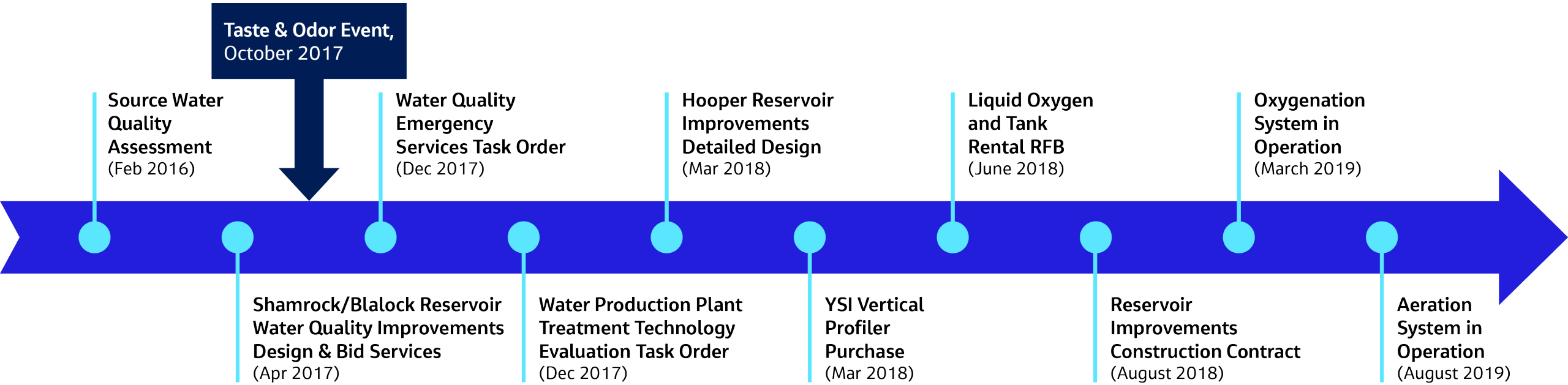
CCWA System is complex and integrated



The benefits are sometimes met with challenges

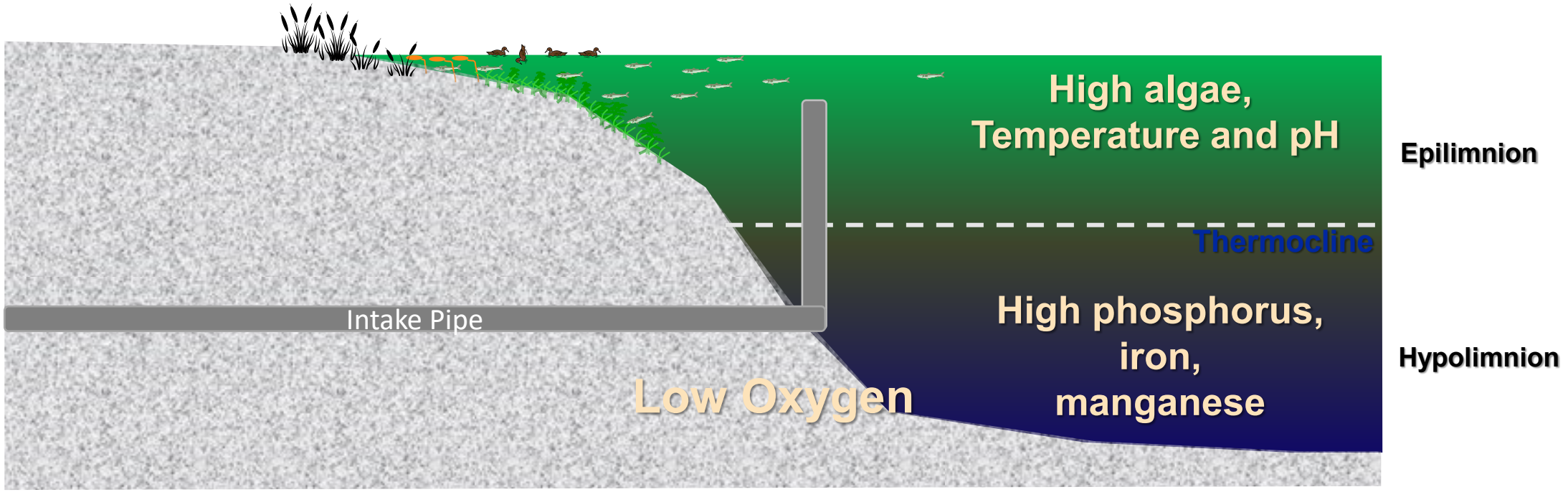
How did we get to a Reservoir Management System?

- Projects initiated in 2016
- Oxygenation system recommended for Blalock/Shamrock
- Large taste and odor event accelerated activities
- Reservoir improvements online since August 2019

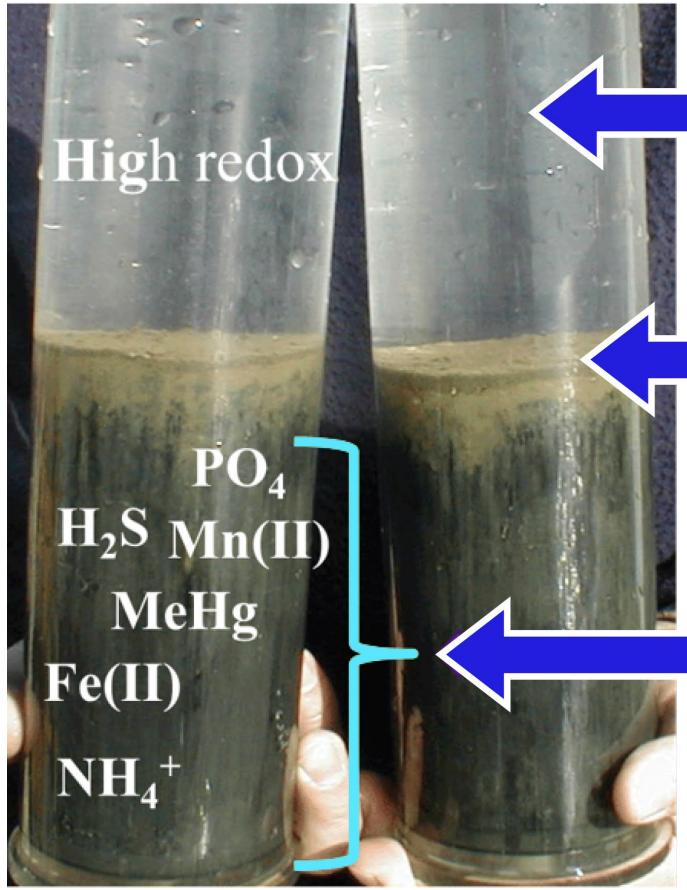


Reservoir Management Systems

High Nutrient Source Water Issues



Reservoir Restoration Philosophy



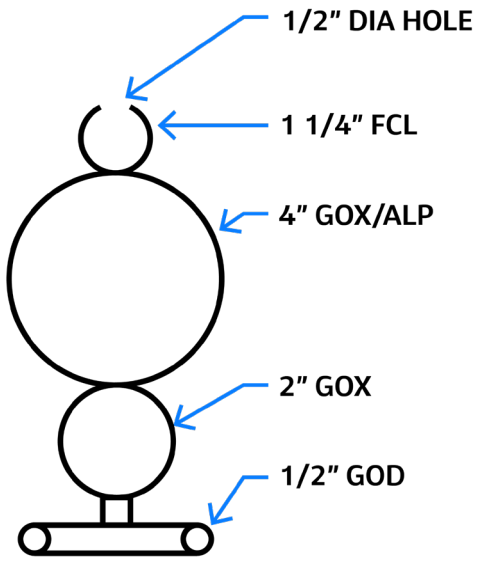
>50% O_2 saturation

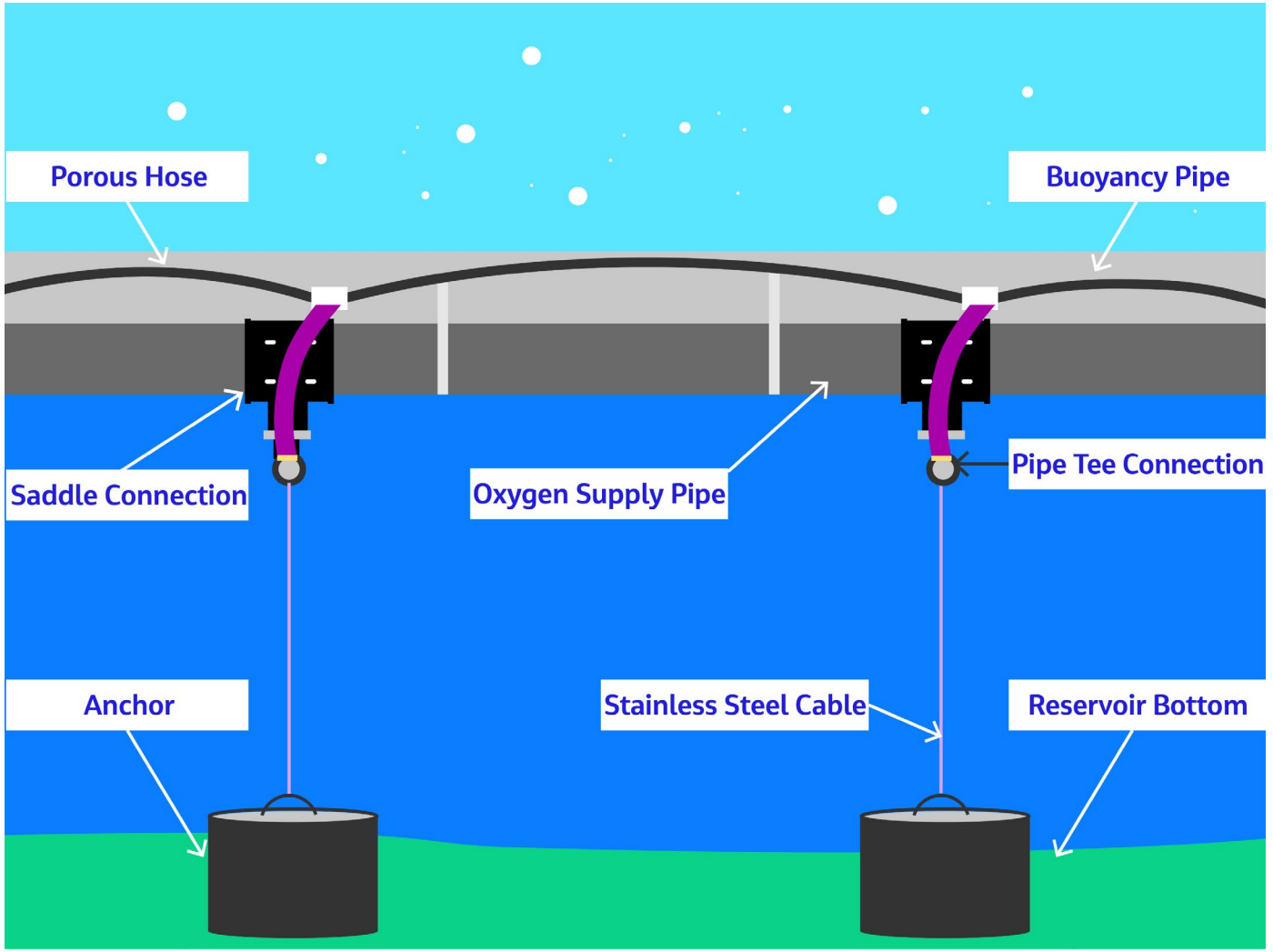
to create Fe(III) cap

... and keep these compounds in sediment.

Shamrock/Blalock: Linear Diffuser Oxygenation

- Diffuse oxygen into reservoir hypolimnion
- Meet oxygen sediment and water column oxygen demand
- Oxygen fed from liquid oxygen tank





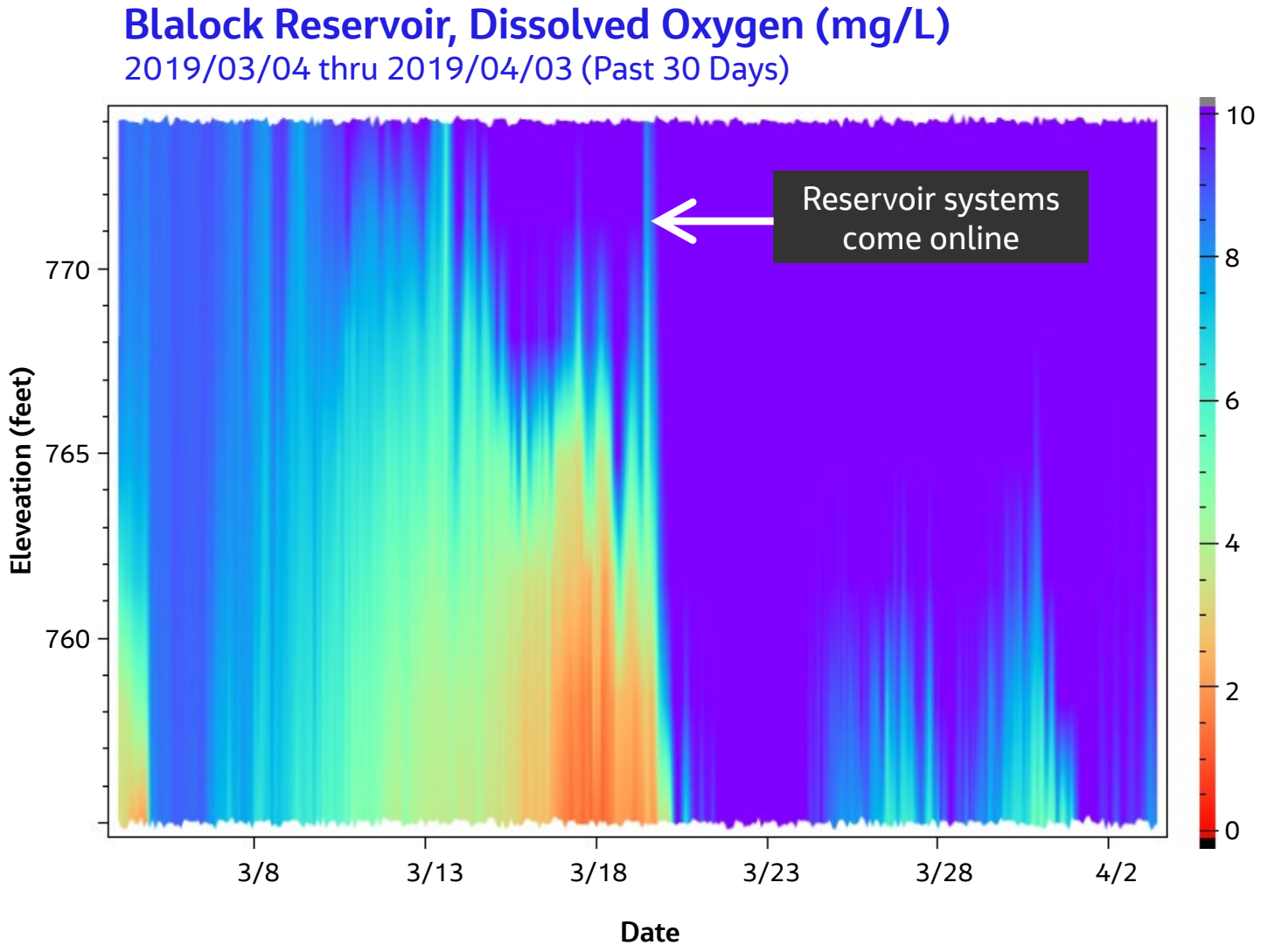
Shamrock/Blalock: LOX Storage and Feed

- Liquid oxygen (LOX) storage
- 9,000-gallon horizontal tank
- Ambient air vaporizers
  - Alternate every 12 hours for de-icing
- Gaseous oxygen mass flow control valves
  - 1 Valve for each reservoir
- LOX flow based on operator set point

Shamrock/Blalock: LOX Diffuser Layout

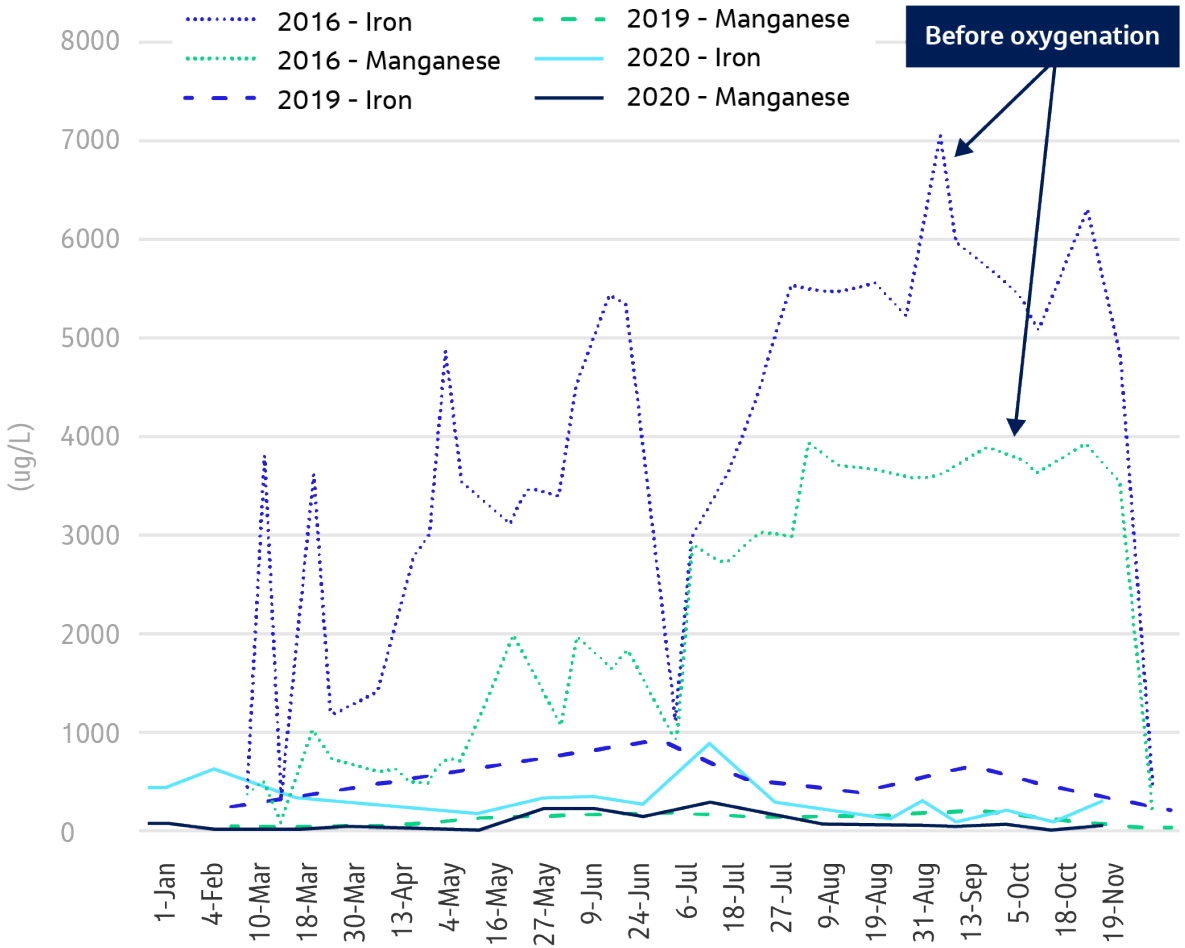
What Results Do We See?

Minimize Hypolimnetic Anoxia to Quench Algae Growth

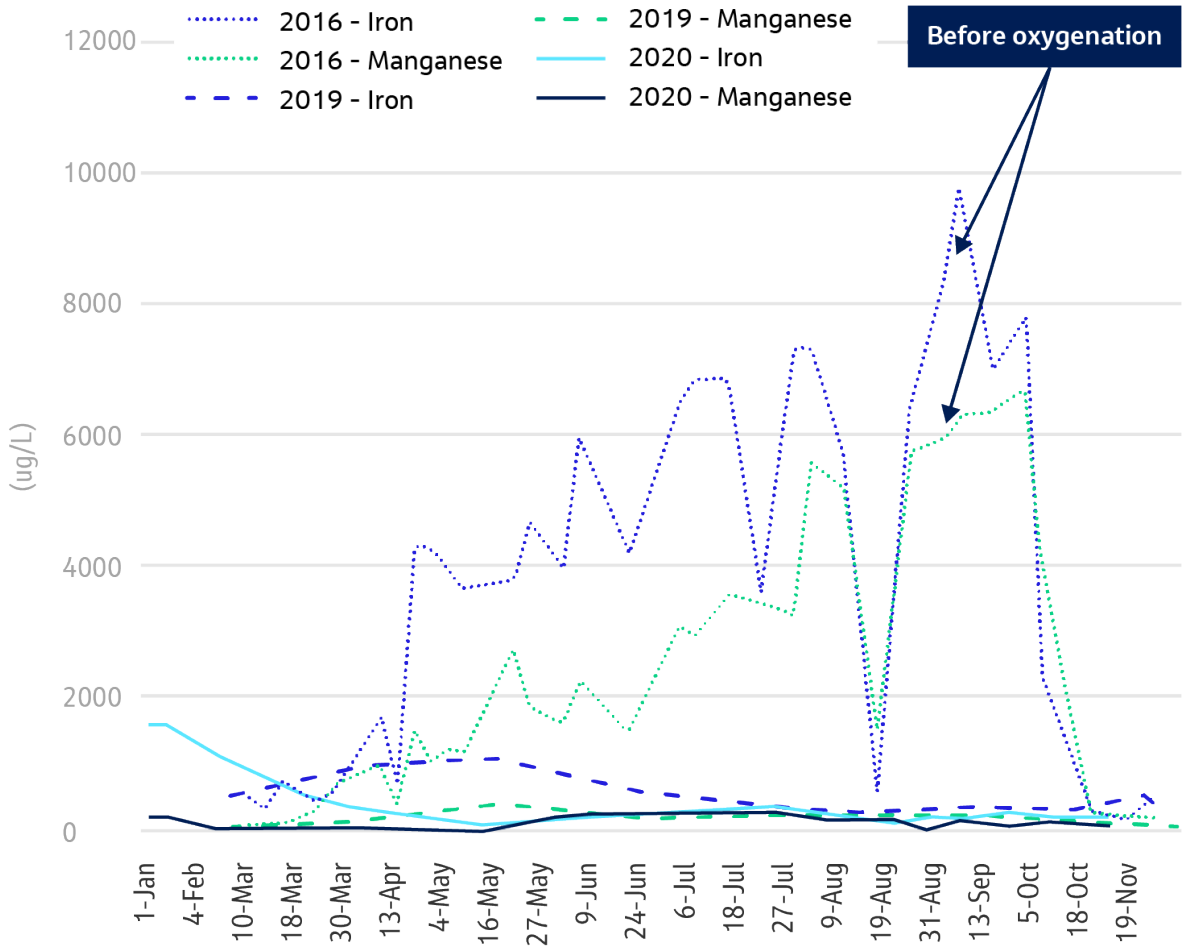


Metals Release from the Bottom of the Reservoirs

Shamrock Hypolimnion - Metals

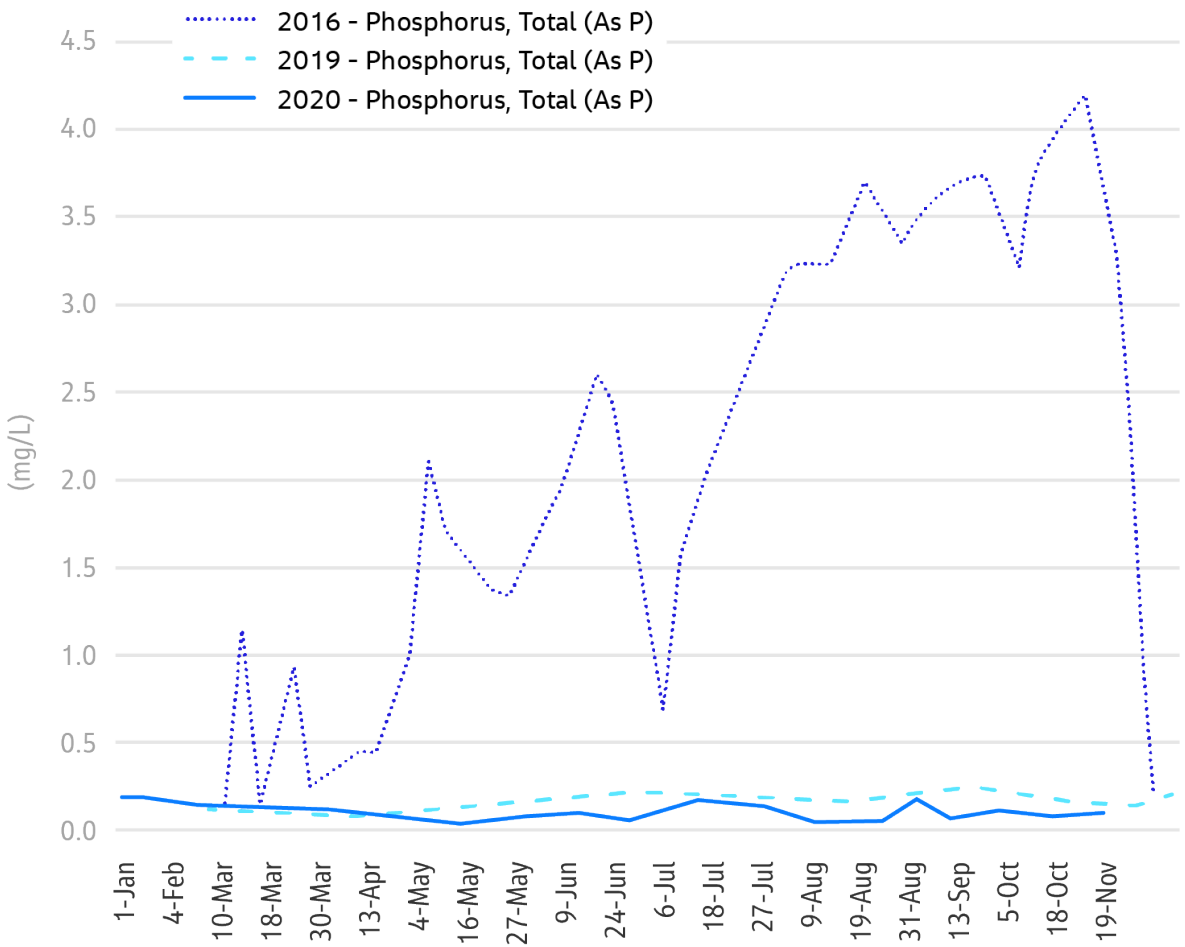


Blalock Hypolimnion - Metals

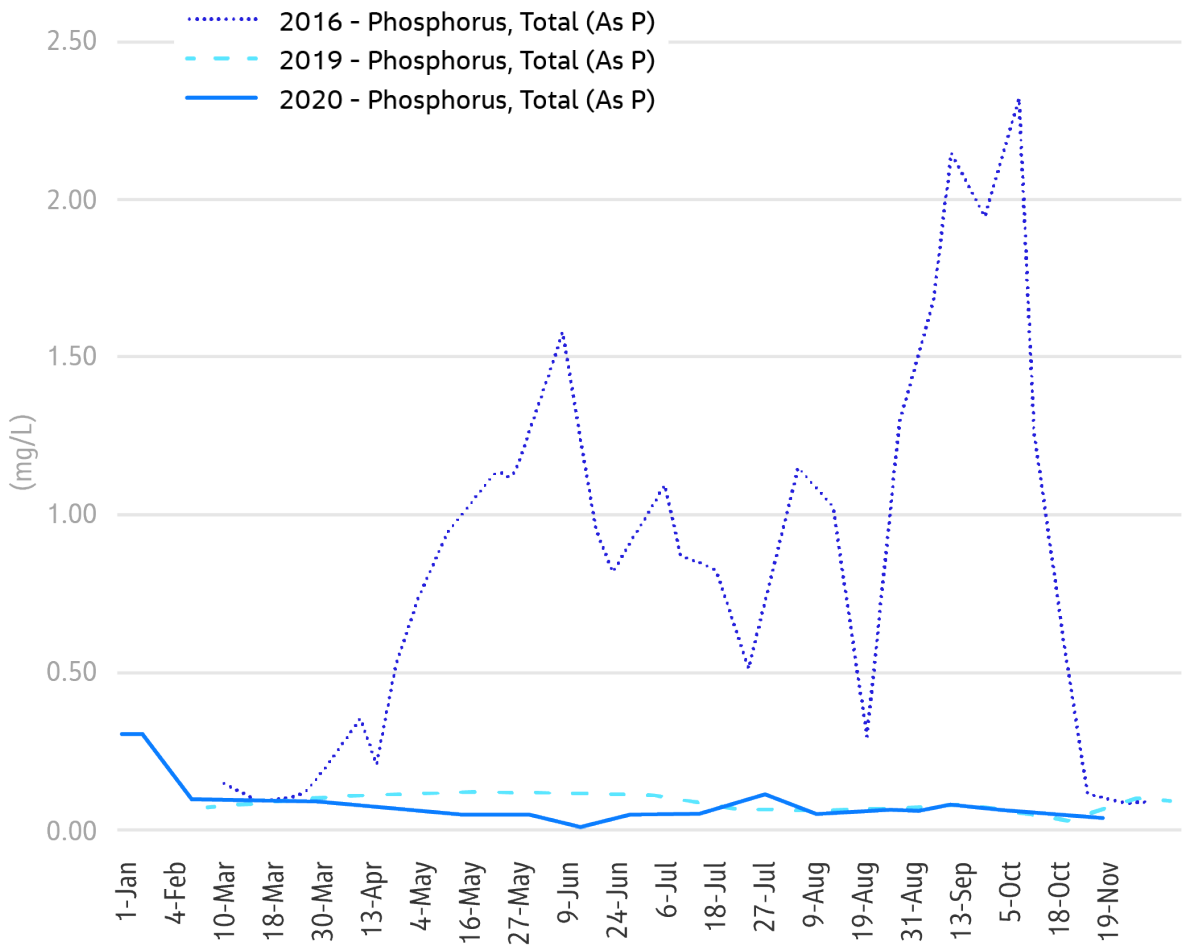


Phosphorus Release from the Bottom of the Reservoirs

Shamrock Hypolimnion - Phosphorus

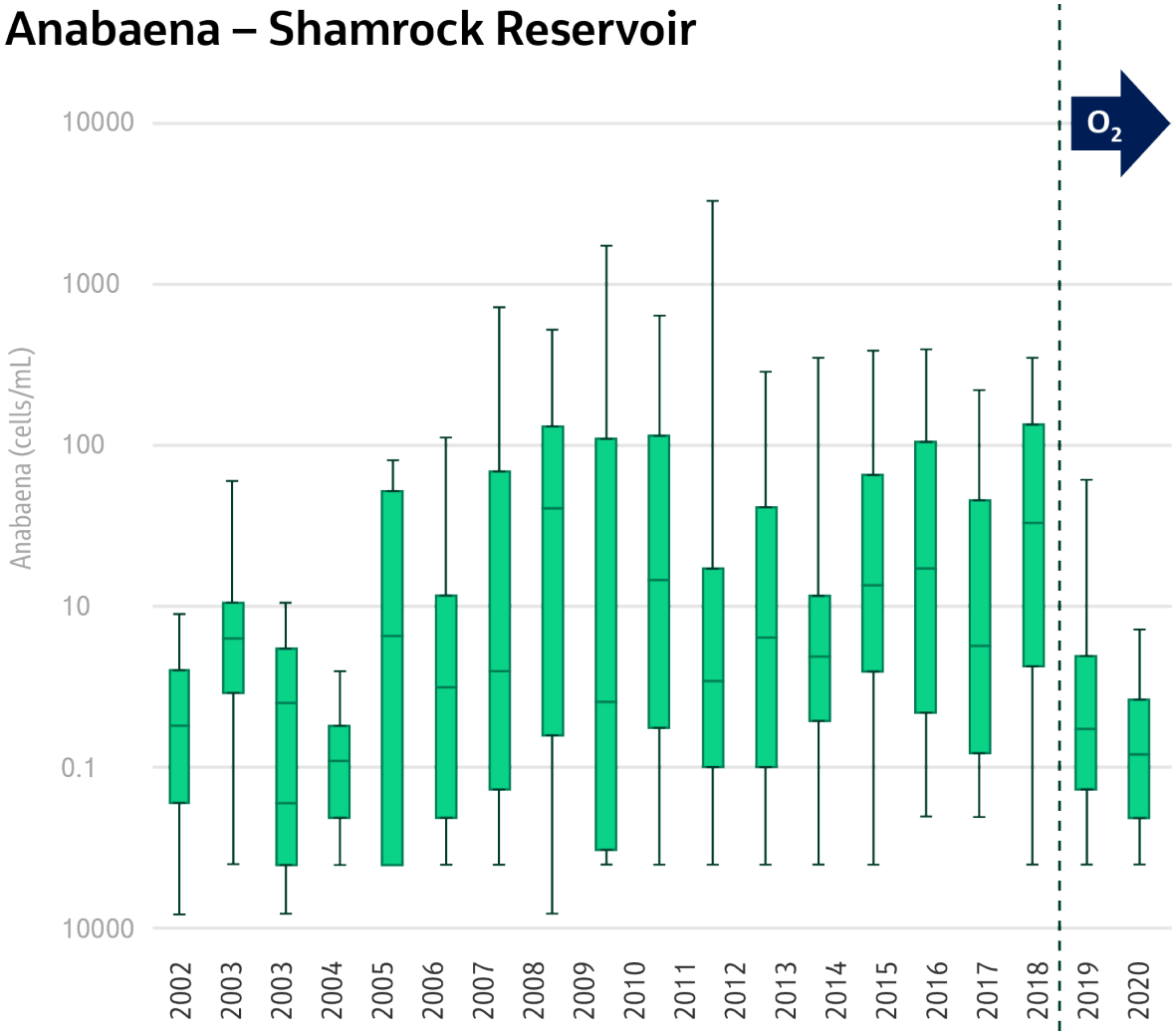


Shamrock Hypolimnion - Phosphorus

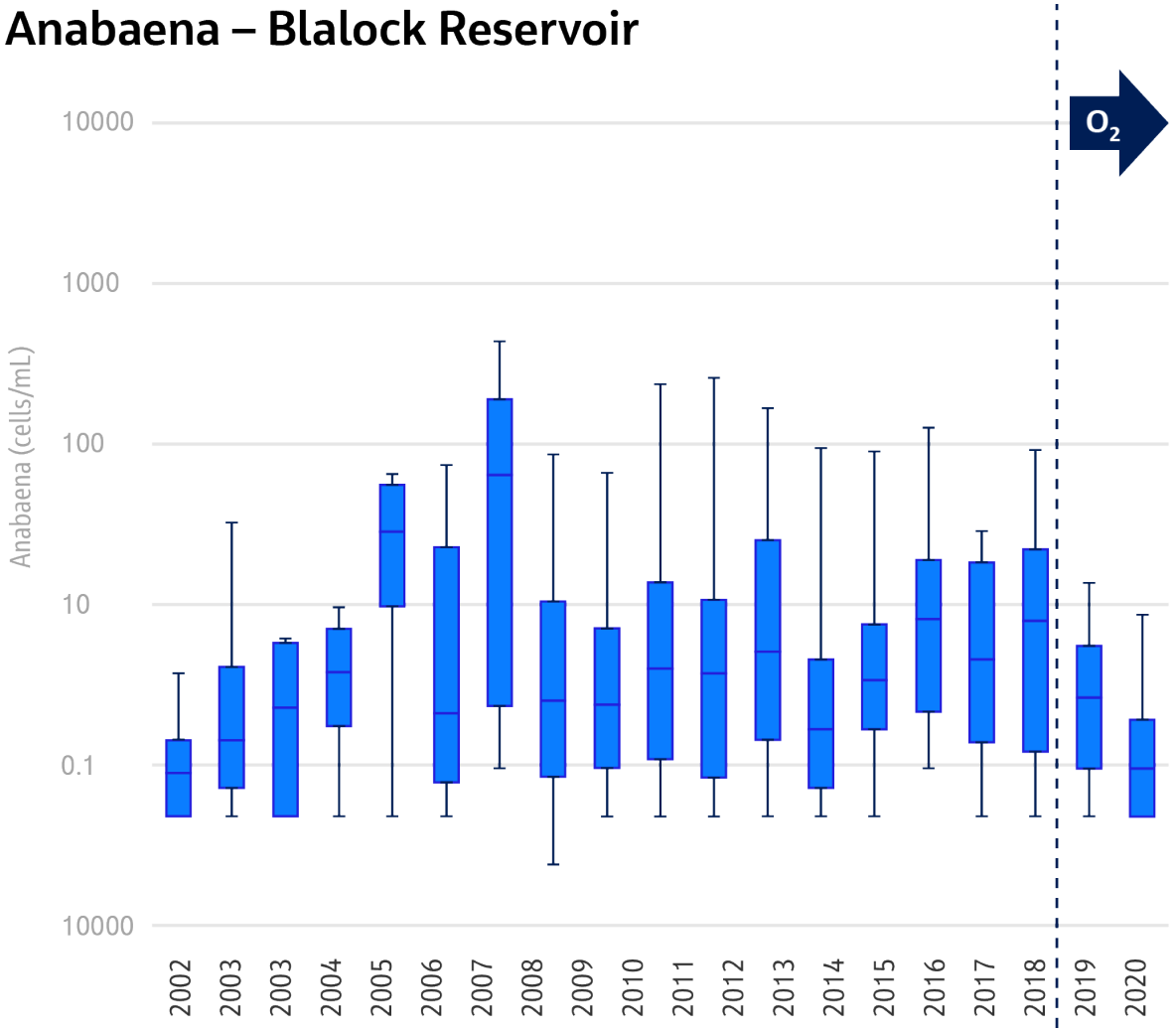


Levels of Anabaena Are now Closer to Pre-Huie Levels

Anabaena – Shamrock Reservoir



Anabaena – Blalock Reservoir

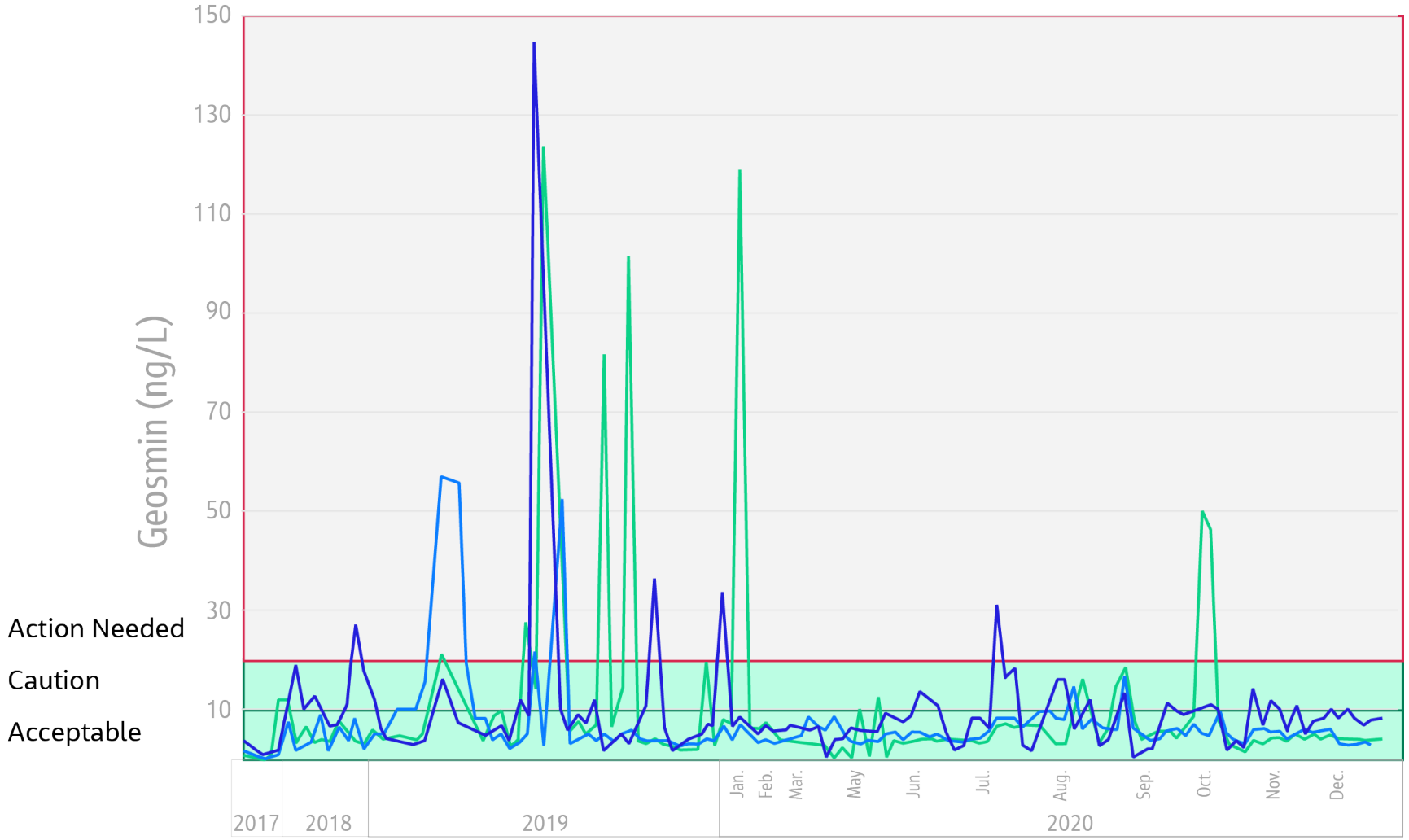


Levels of Geosmin Have Decreased Over Time

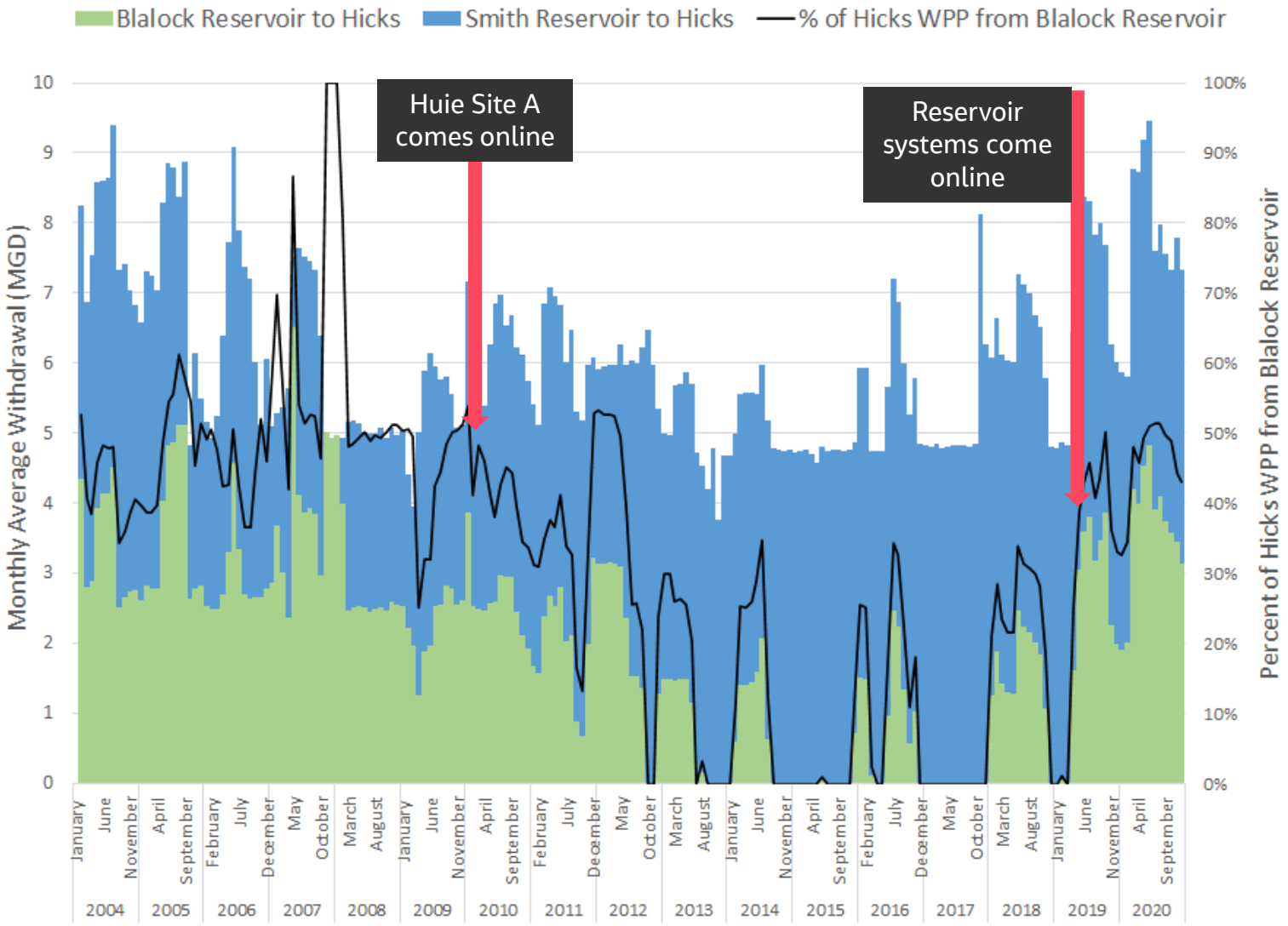
Blalock Reservoir

Hooper Reservoir

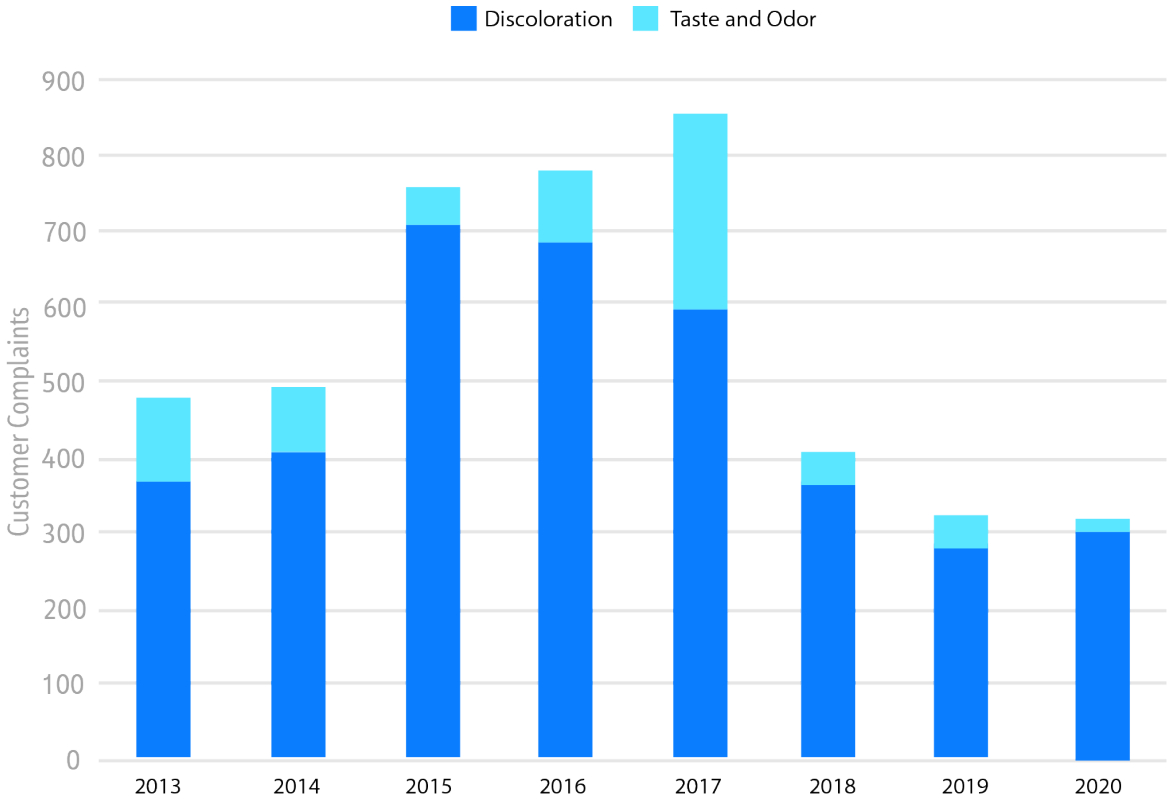
Shamrock Reservoir

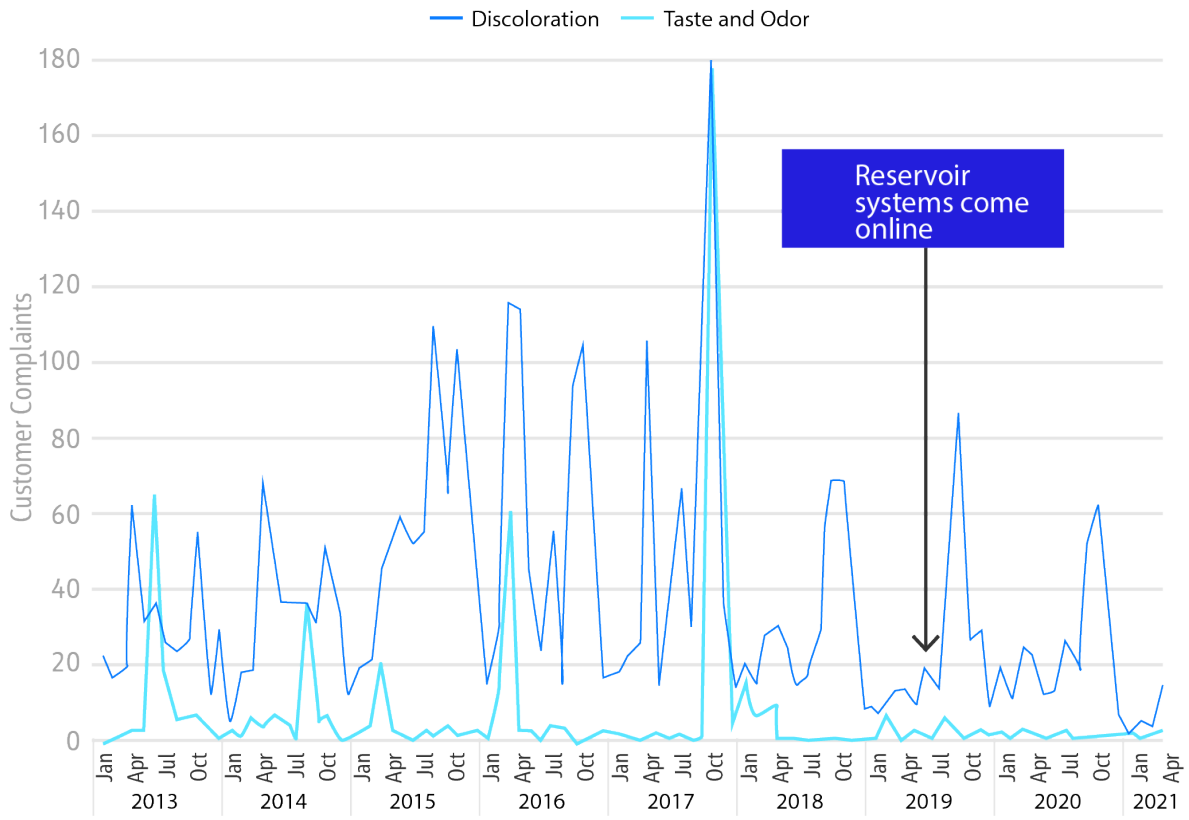


Treatability of Blalock Reservoir Raw Water



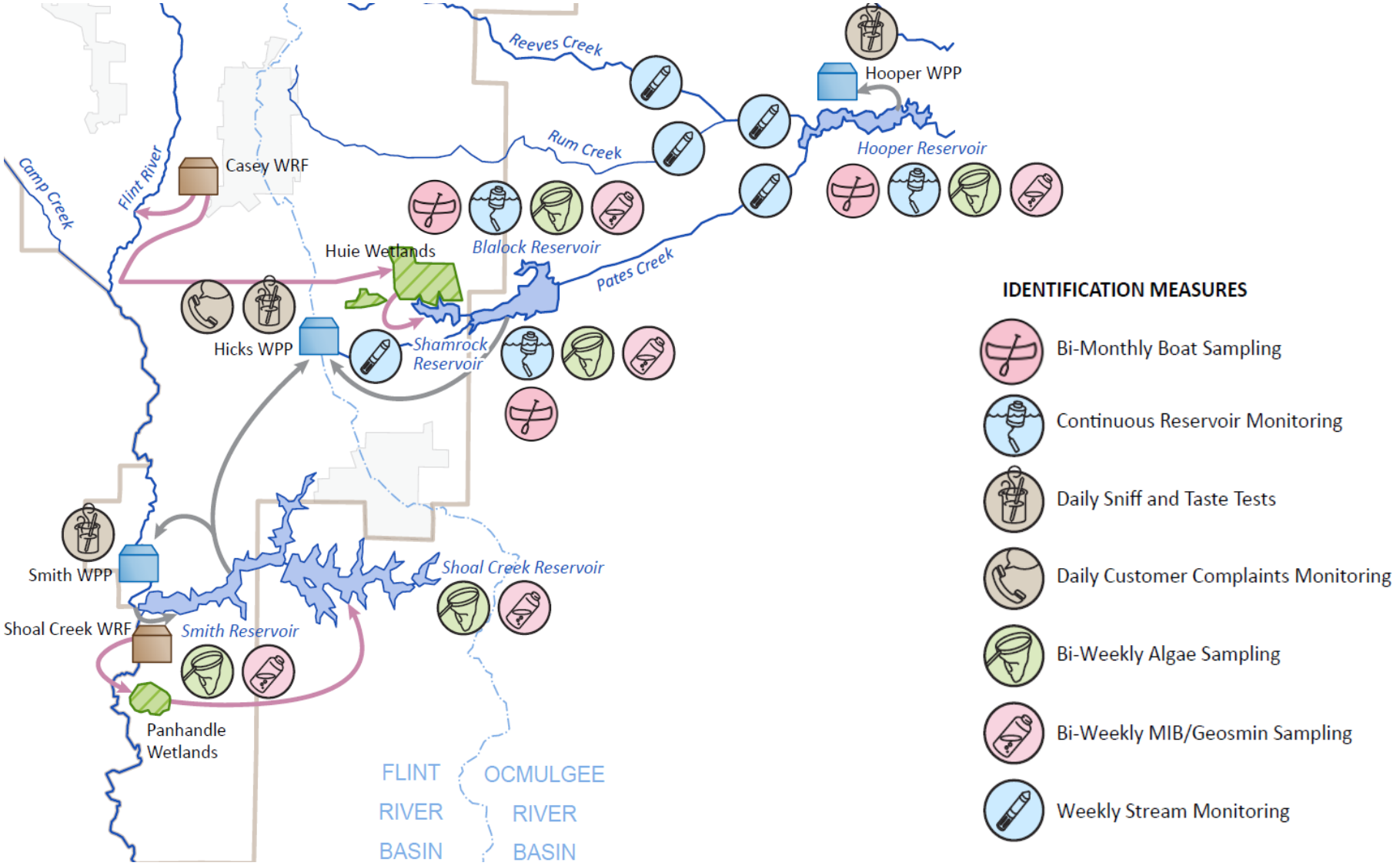
Decrease Customer Complaints of Taste, Odor, and Discoloration in Drinking Water





Current Monitoring Practices

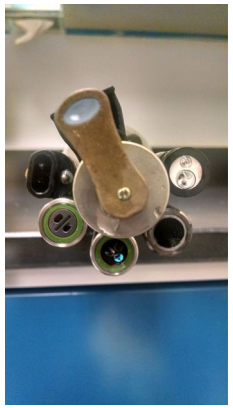
CCWA's Response to Challenges includes a Diversity of Measures



Monitoring

Continuous Reservoir Monitoring

- Vertical profiler (Xylem/YSI System)
- Buoys (Sea Bird System)

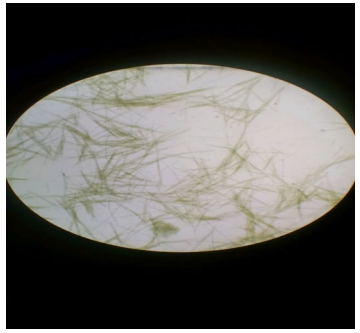
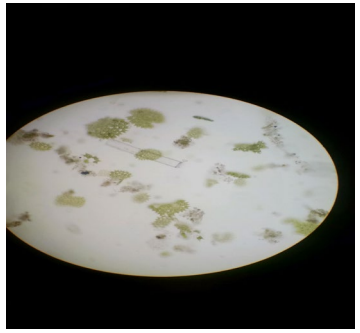

Weekly EXO1 Sonde Stream Monitoring

- Total algae/BGA
- fDOM sonde

Monitoring

Bi-Weekly Algae Sampling

- 5 Reservoirs
- Water quality grab samples from epilimnion

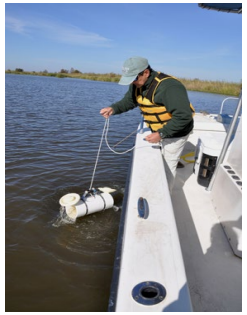




Bi-Weekly MIB/Geosmin Sampling

- 5 Reservoirs
- 3 Water Production Plants
- 2 Ground Storage Tanks

Bi-Monthly Boat Sampling

- Shamrock, Blalock, and Hooper Reservoirs
- Samples from hypolimnion and epilimnion



AI for Predicting Taste and Odor

The Challenge

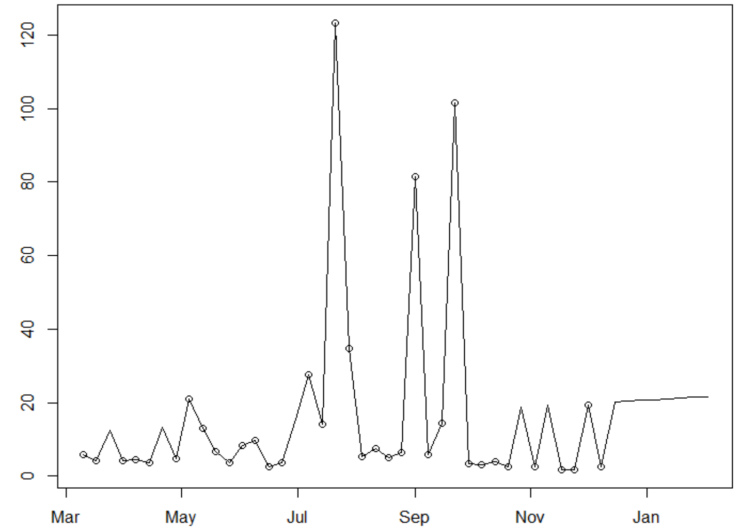
- Quantitative prediction of taste & odor (T&O) and harmful algae blooms (HAB) in raw water has been elusive
- Both T&O can be a BIG surprise that causes BIG problems at the water treatment plant (WTP)
- Model prediction needs:
  - Fair warning: prepare at WTP
  - Prevention: Inform reservoir operations

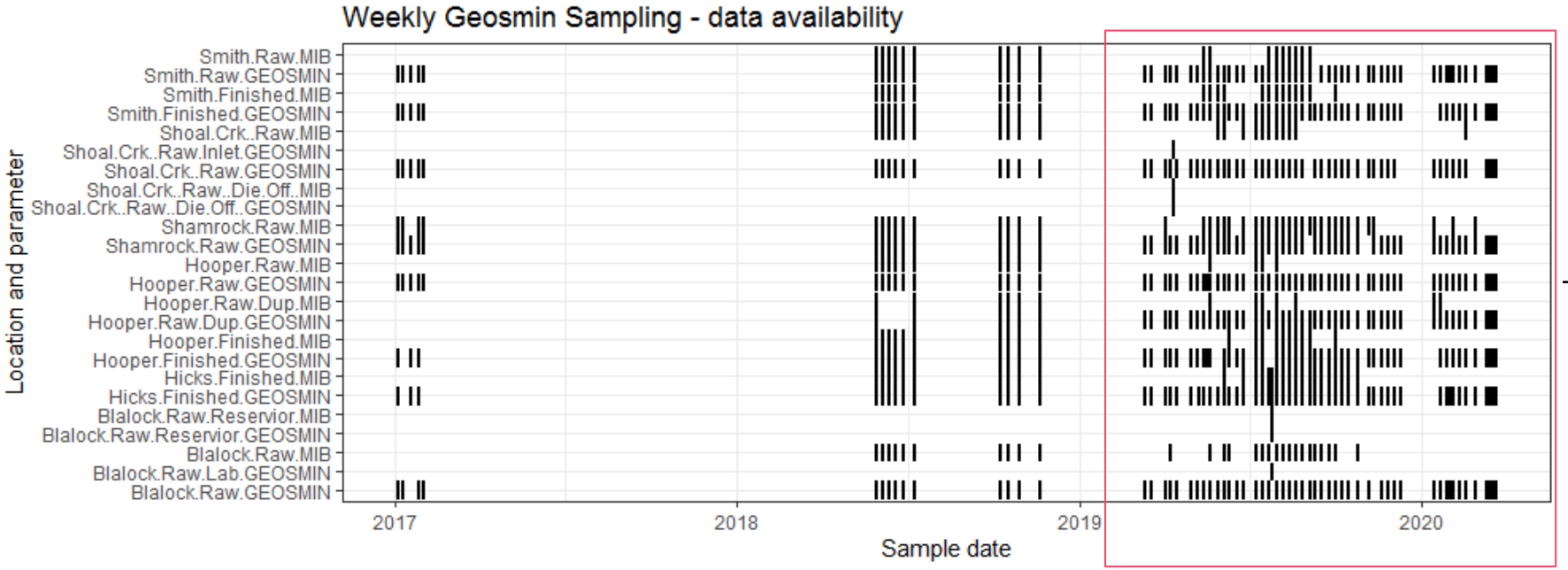
Model Inputs

- Continuous Data Sources
  - Vertical Profiler
  - Buoys
  - Local Weather Station
- Discrete Data Sources
  - Taste Odor Samples
  - Lake Grab Samples
  - Stream Grab Samples
  - Wetland Outfall Samples

Data – Taste and Odor

- T&O data spans May 2017 – November 2020
- 542 geosmin samples
- 221 2-MIB samples
- CCWA upgraded T&O testing capacity in 2019 – **Key to training models**





Feature extraction

- Large number of features available
- Model parsimony – reduce the number of inputs to the minimum
- Use recursive feature elimination
- Select the smallest subset of inputs (features) that maximizes the accuracy

Feature extraction results

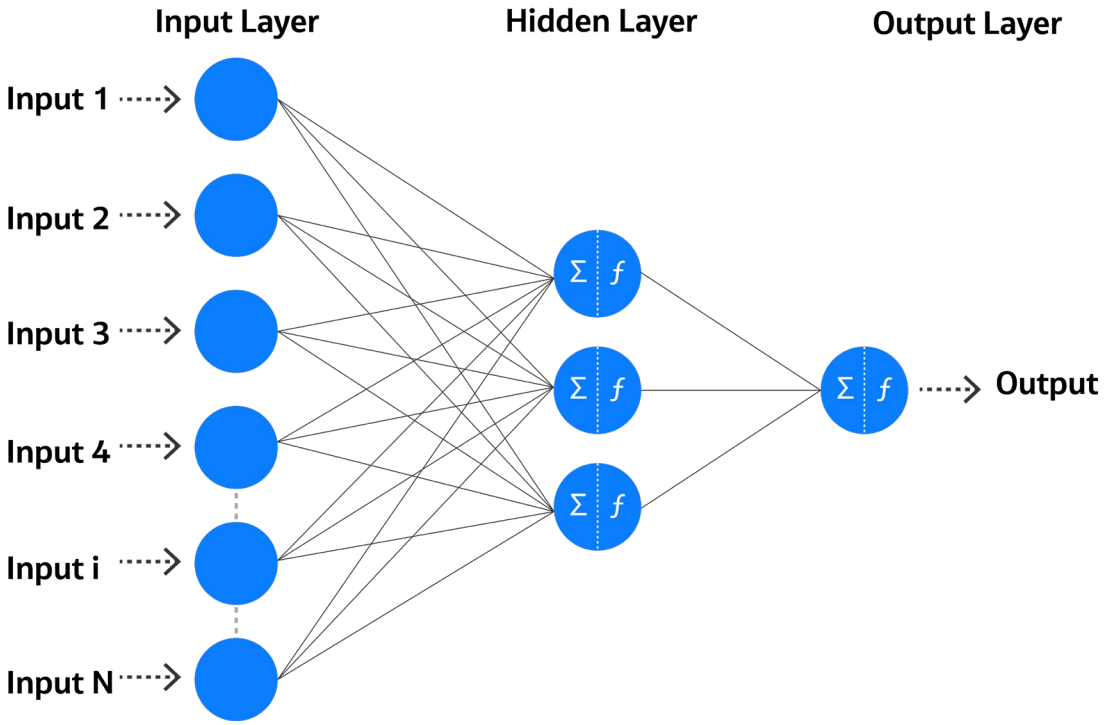
Top 5 Features for Blalock geosmin	Top 5 Features for Shamrock geosmin	Top 5 Features for Hooper geosmin
▪ [Rate of change of Dissolved Oxygen with time in Blalock at 8 ft] $_{t= - 2weeks,}$ ▪ Blalock.Inlet.Anabaena ▪ WET.EFF.00310K.BOD.KG2" \ ▪ [Rate of change of Dissolved Oxygen with time in Blalock at 12 ft] $_{t= - 2weeks,}$ ▪ Blalock.Anabaena	▪ [OUTFALL.003.TOTAL.FLOW] $_{t= - 3weeks}$ ▪ Dissolved.Oxygen.Shamrock.Bottom ▪ WET.INF.74055.FECAL.COLIFORM.100ML“ ▪ [CDOM.Shamrock.Surface] $_{t= -2 weeks}$ ▪ OUTFALL.001.00400.PH.S.U.	▪ Rate of change of DO with Depth at 12 ft in Blalock ▪ [Turbidity in Blalock at 5 ft] $_{t= - 4}$ ▪ Hooper.Anabaena ▪ Hooper.am.Anabaena ▪ Rate of change of pH with Depth at 12 ft] $_{t= - 4 weeks}$

Guide Only – free to add or exclude variables
Sensitivity analysis – effect on model accuracy

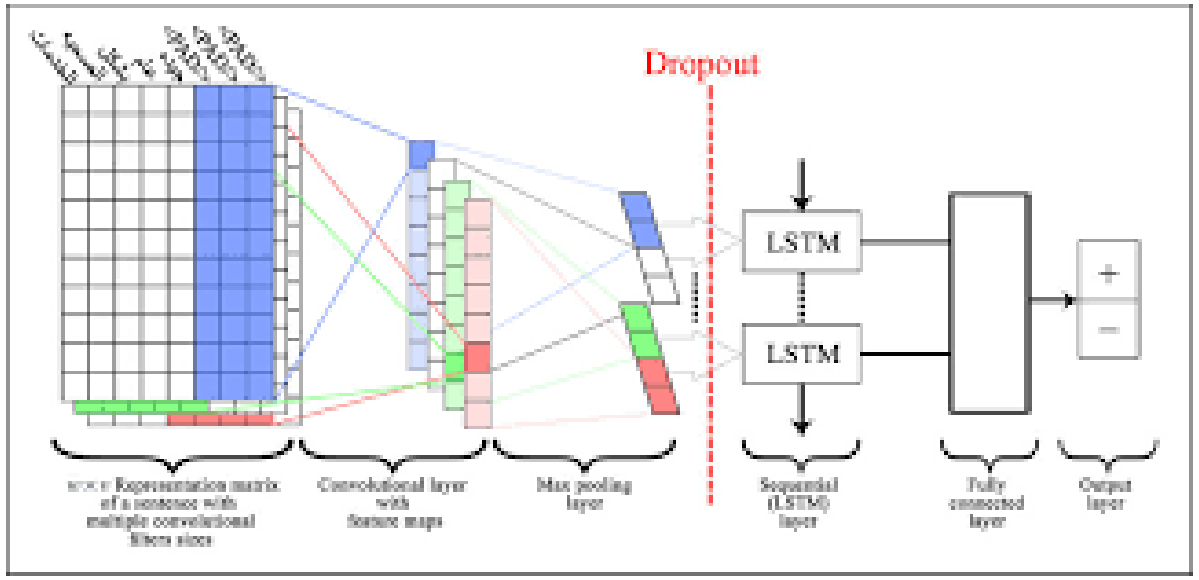
***Anabaena* cell count is important**

Models used in this work

Artificial Neural Network

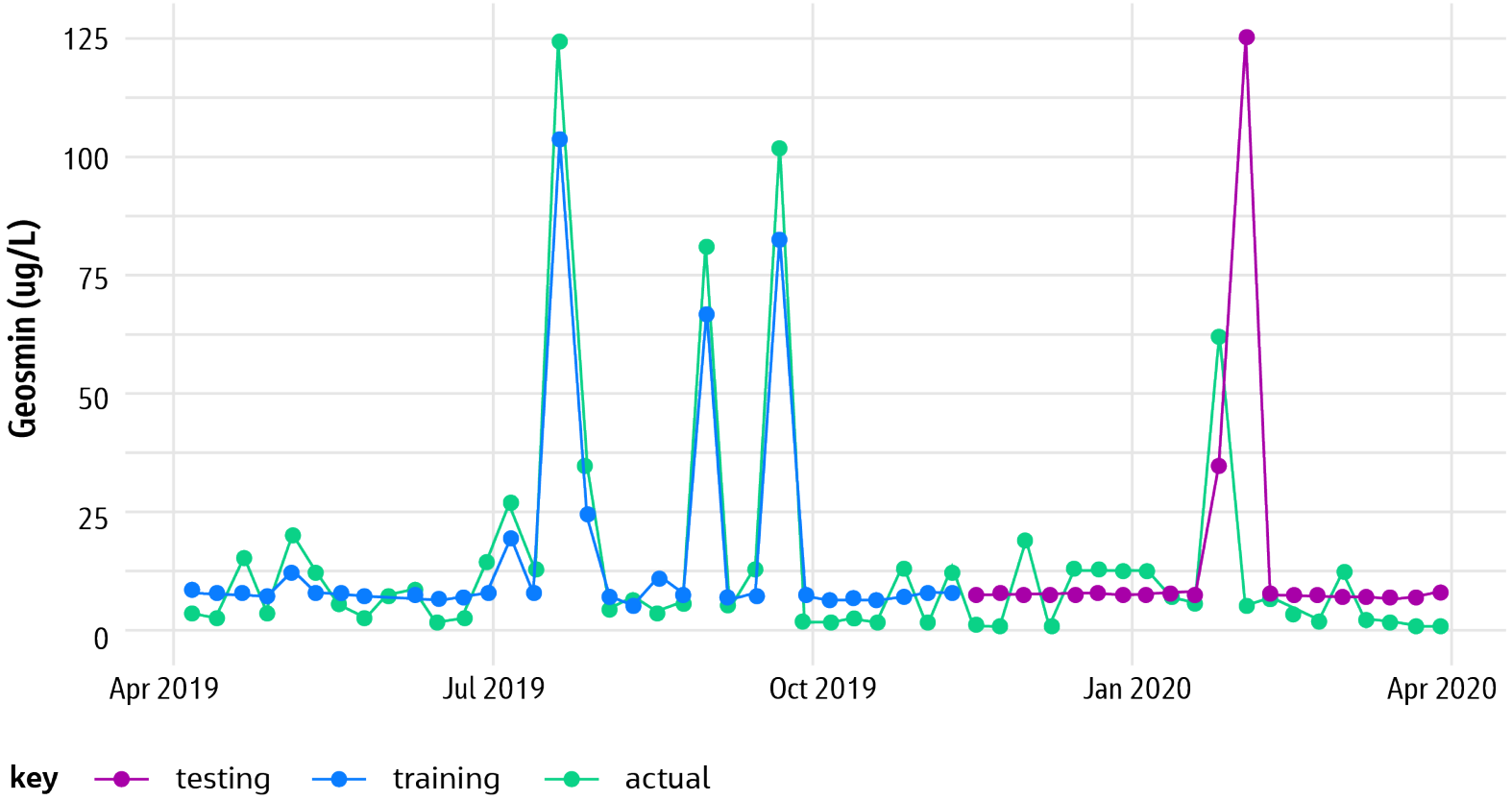


Convolutional Neural Network and Recurrent Neural Networks



Modelling results - geosmin

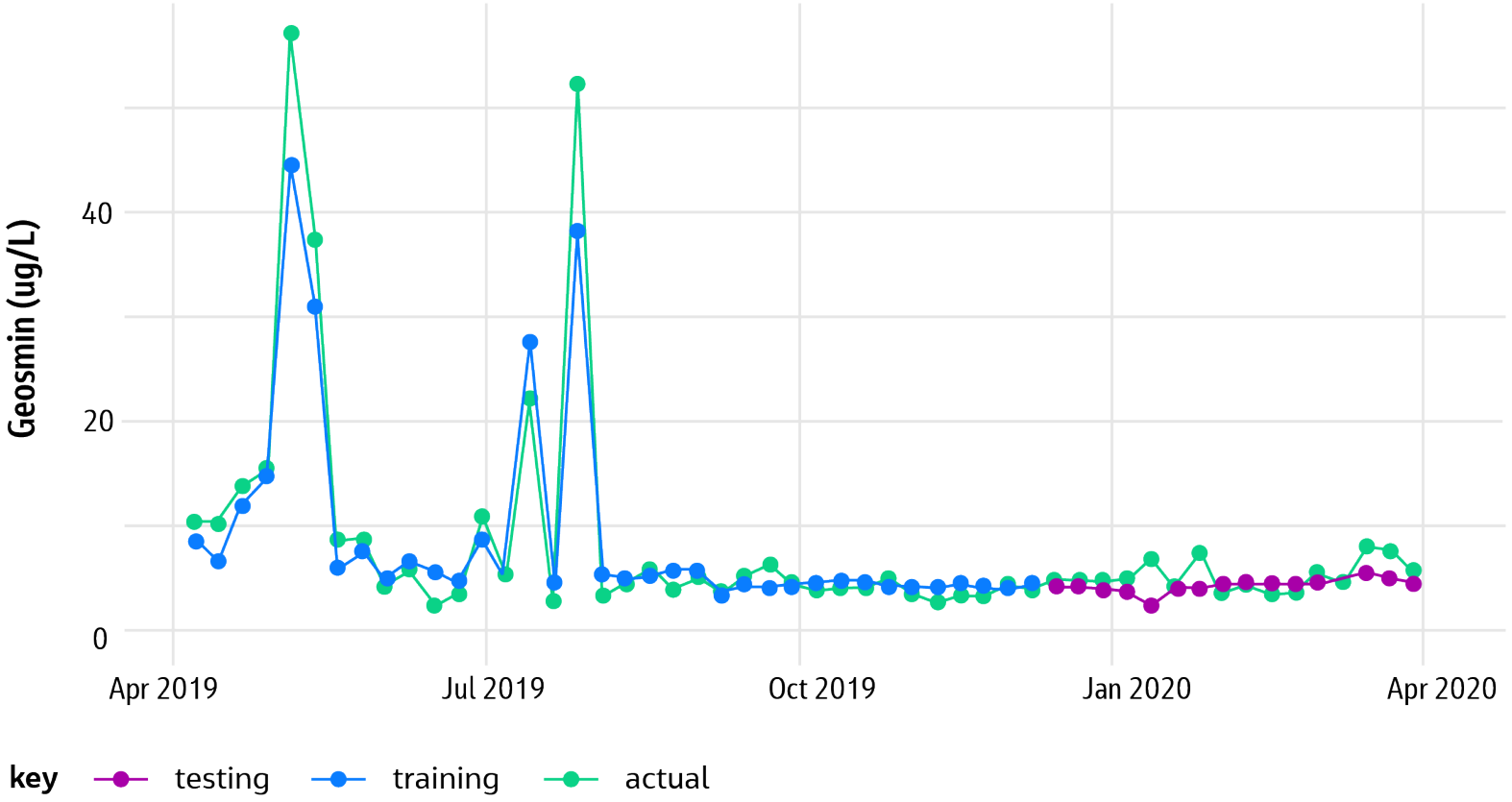
Contemporaneous (e.g t=0) Blalock



- Data split into training and testing sets
- 80:20 split
- Evaluate on accuracy or error of testing set
- Limited T&O events during testing set but single event that occurred was successfully predicted

Geosmin Modelling results

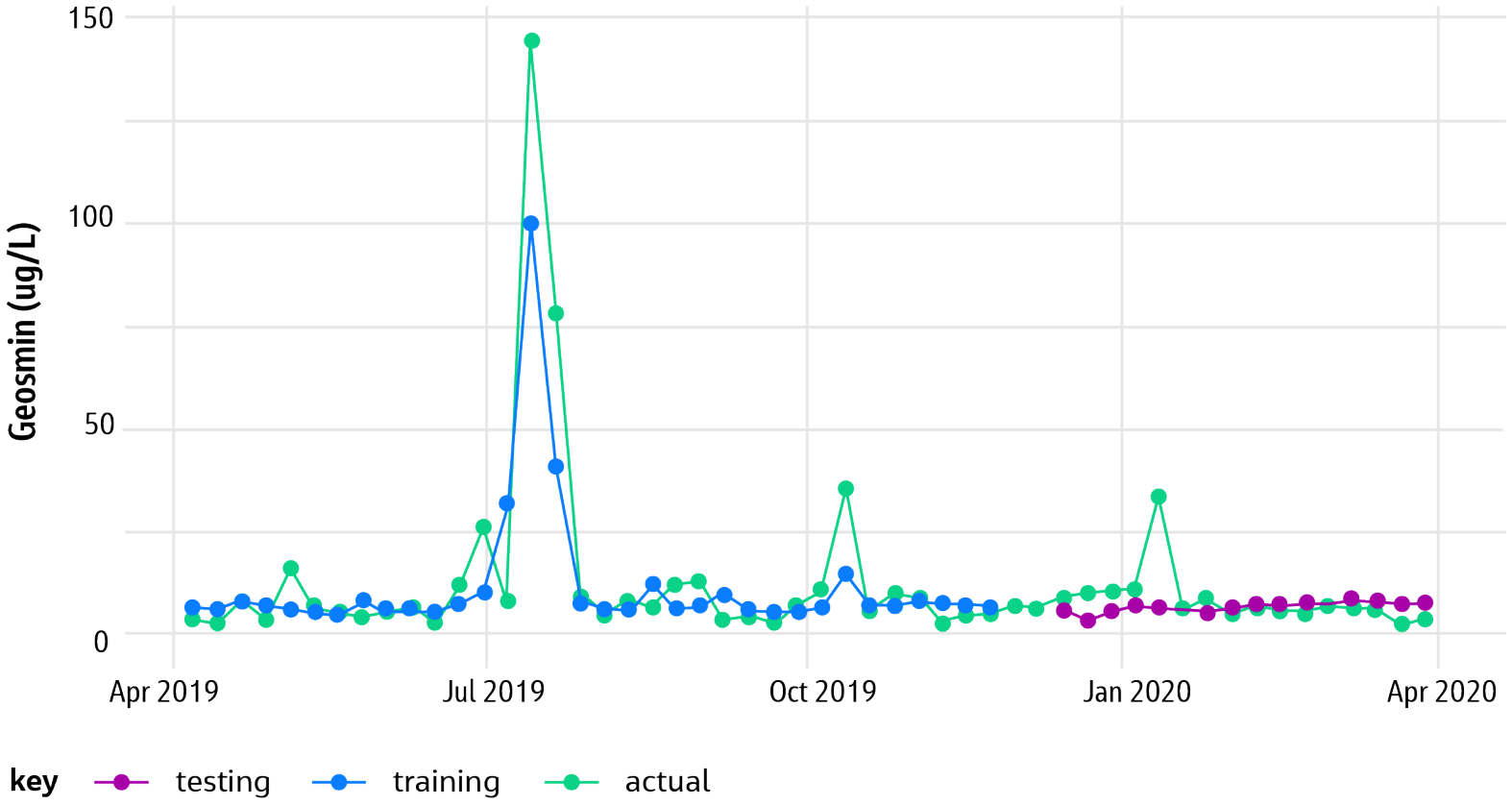
Contemporaneous Hooper



Limited T&O events during testing set but no false positives were generated by the model

Geosmin Modelling results (cont)

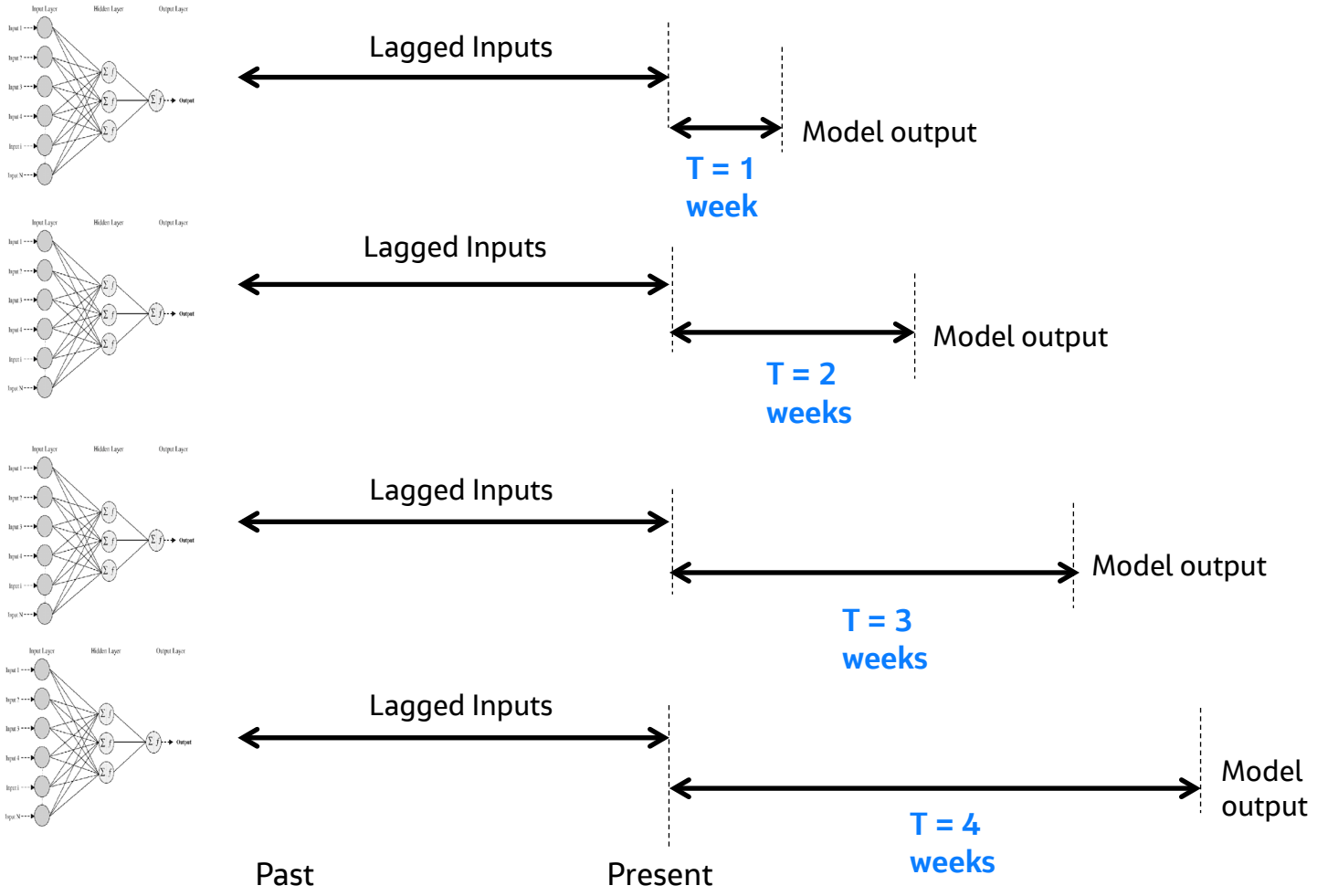
Contemporaneous Shamrock



Limited T&O events during testing set but no false positives were generated by the model

4 Week Forecast Model

- 4 individual models
- Each model can take different inputs up to time t=0
- Forecast by predicting geosmin at time t=1…4



4 Week Forecast

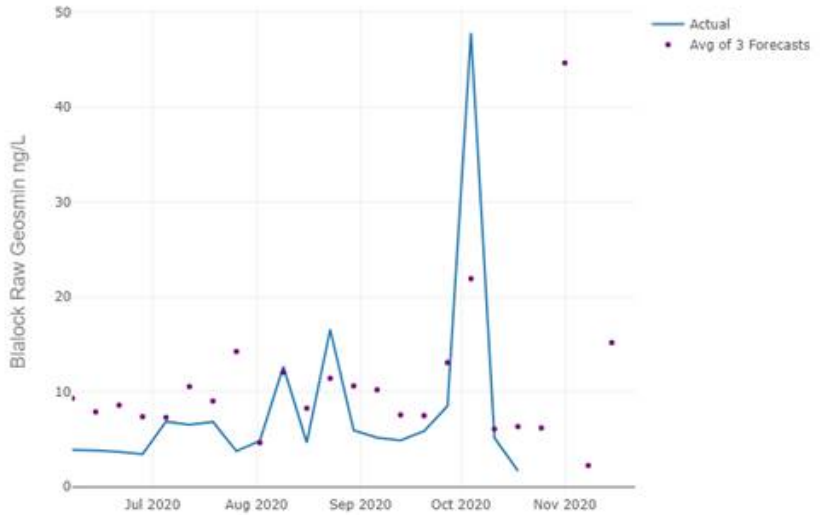
Comparison forecast with lab results

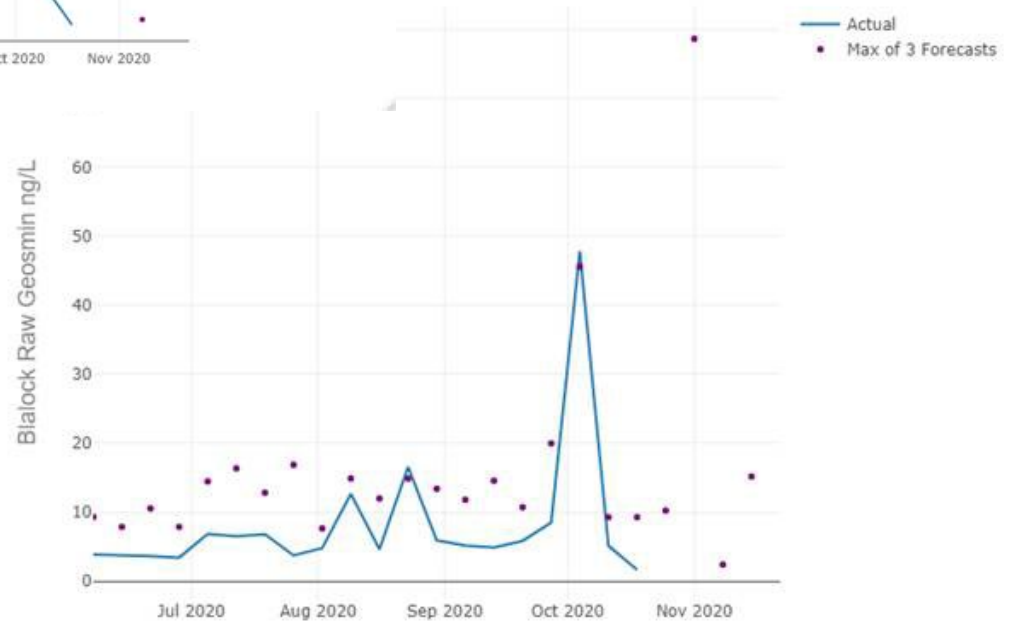
Date	Forecast	Lab	Forecast	Lab	Forecast	Lab
2019-12-15	20	14	7	13	2	8
2020-01-12	7	7	90	62	7	7
2020-02-02	7	7	8	5	11	13

Each of the models produced useful results for the forecast window

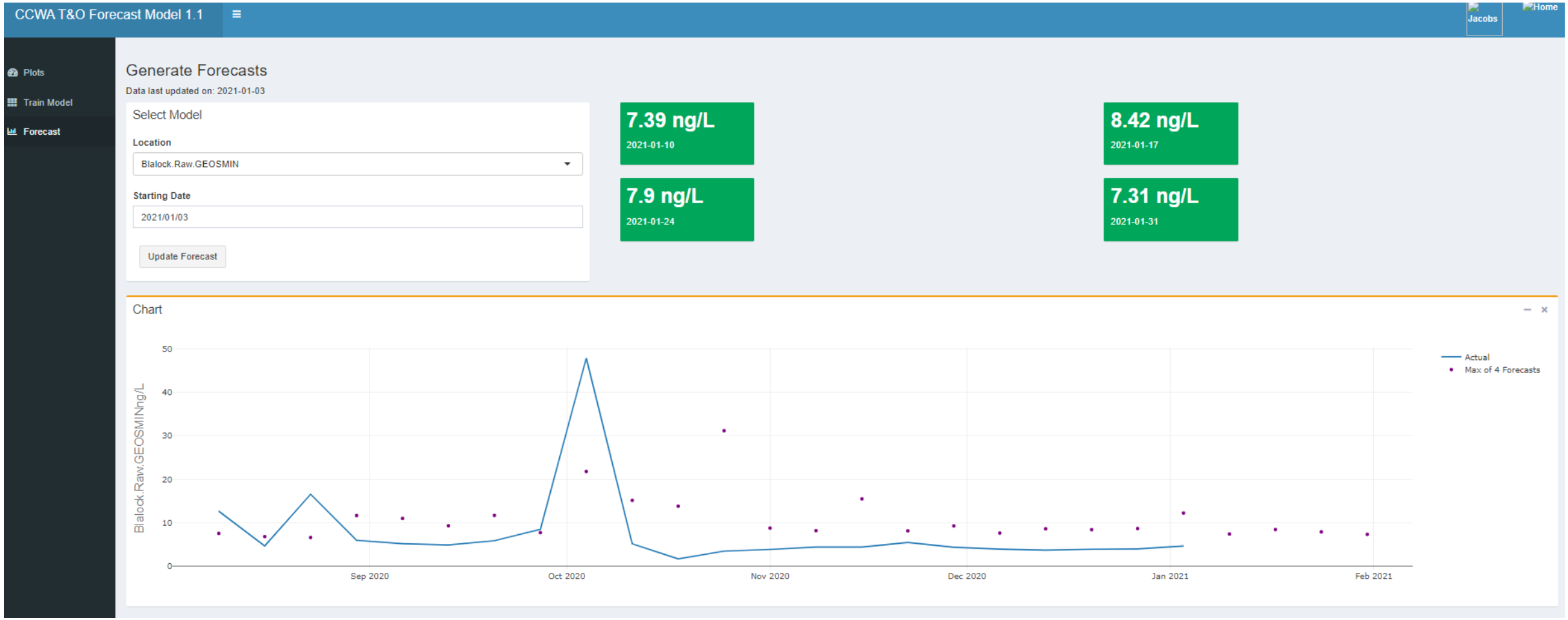
Fall 2020 Retraining

- Model retrained in Fall of 2020
- Data split into training and testing 80:20 as before
- Model picked up the November T&O spike





Web-Based Platform



Summary and Next Steps

- Relatively accurate geosmin forecasts obtained with a small set of parameters
- Forecast potentially very useful tool for drinking water utilities
- Future extension to cyanotoxin and harmful algae bloom prediction could be evaluated

Our State-of-the-Art System Promotes OneWater

- We are constantly working to anticipate, adapt, and evolve to protect our water resources
- Challenges have presented themselves over time
- Monitoring and data analysis → We have improved interdepartmental coordination and understanding
- Monitoring and predictive model → We are proactive, instead of reactive
- Oxygenation system → We are treating the cause of the problem, not the problem itself
- We have many accomplishments since 2016, but there is more to be done

Polling Question #1

- What level of treatment are you able perform on your raw water source?
  1. No treatment
  2. Occasional chemical application
  3. Continuous treatment

Polling Question #2

- How much forewarning of taste and odor spikes or harmful algae bloom onset would your utility need to take appropriate management actions?
  1. 24 to 72 hours
  2. 1 week
  3. 2 weeks
  4. Not applicable

Questions

Thank You

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