TRI LAKES PROJECT: EVALUATING SEPTIC EFFECTS ON GROUNDWATER

USING MODELING AND SAMPLING TO ASSESS THE IMPACTS OF SEPTIC SYSTEMS TO WATER QUALITY IN THE LONG-PATTISON-HICKS LAKES AREA OF NORTHERN THURSTON COUNTY

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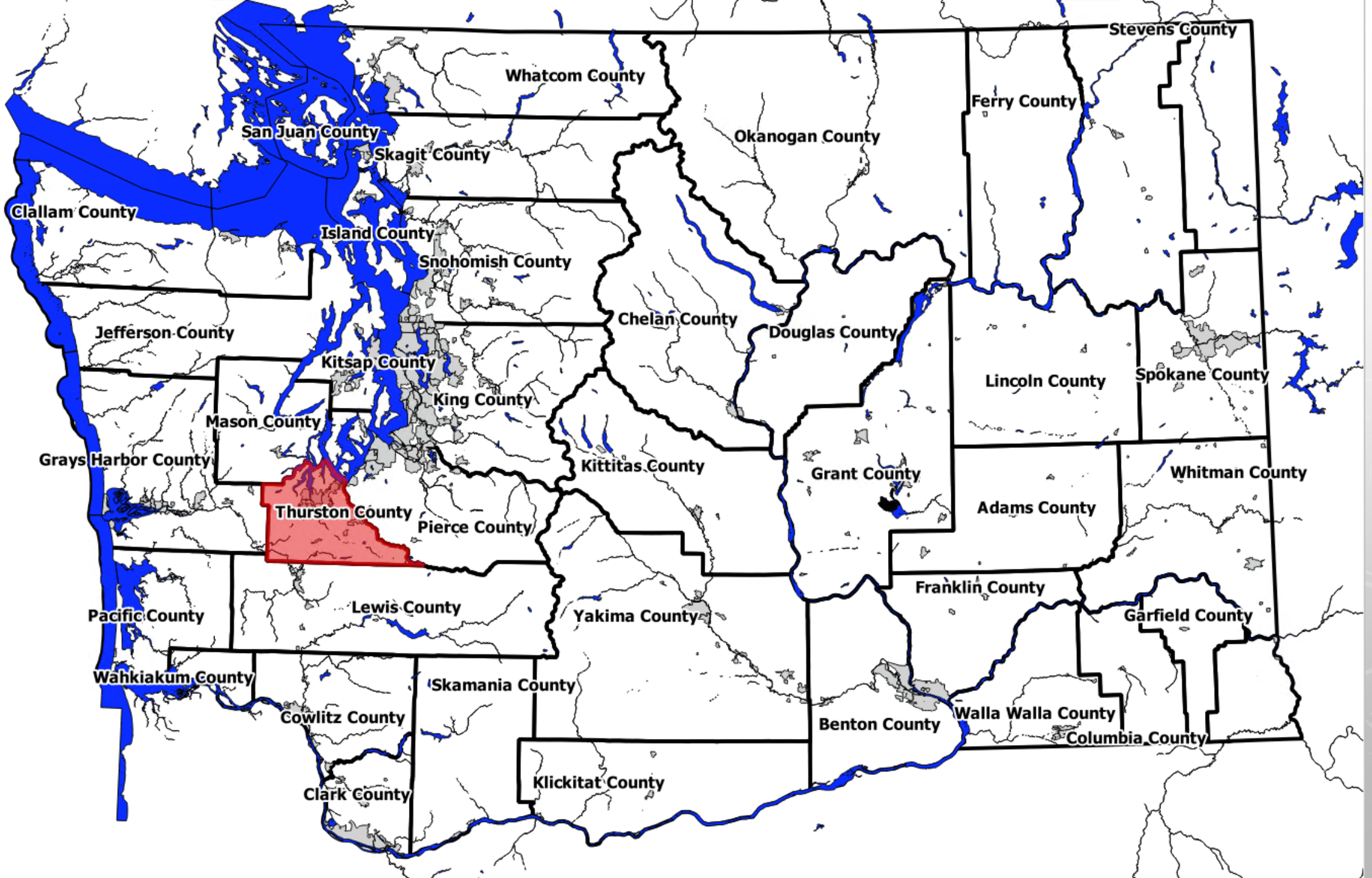
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Grant County
Whitman County
Thurston County
Adams County
Pierce County
Franklin County
Lewis County
Garfield County
Pacific County
Yakima County
Wahkiakum County
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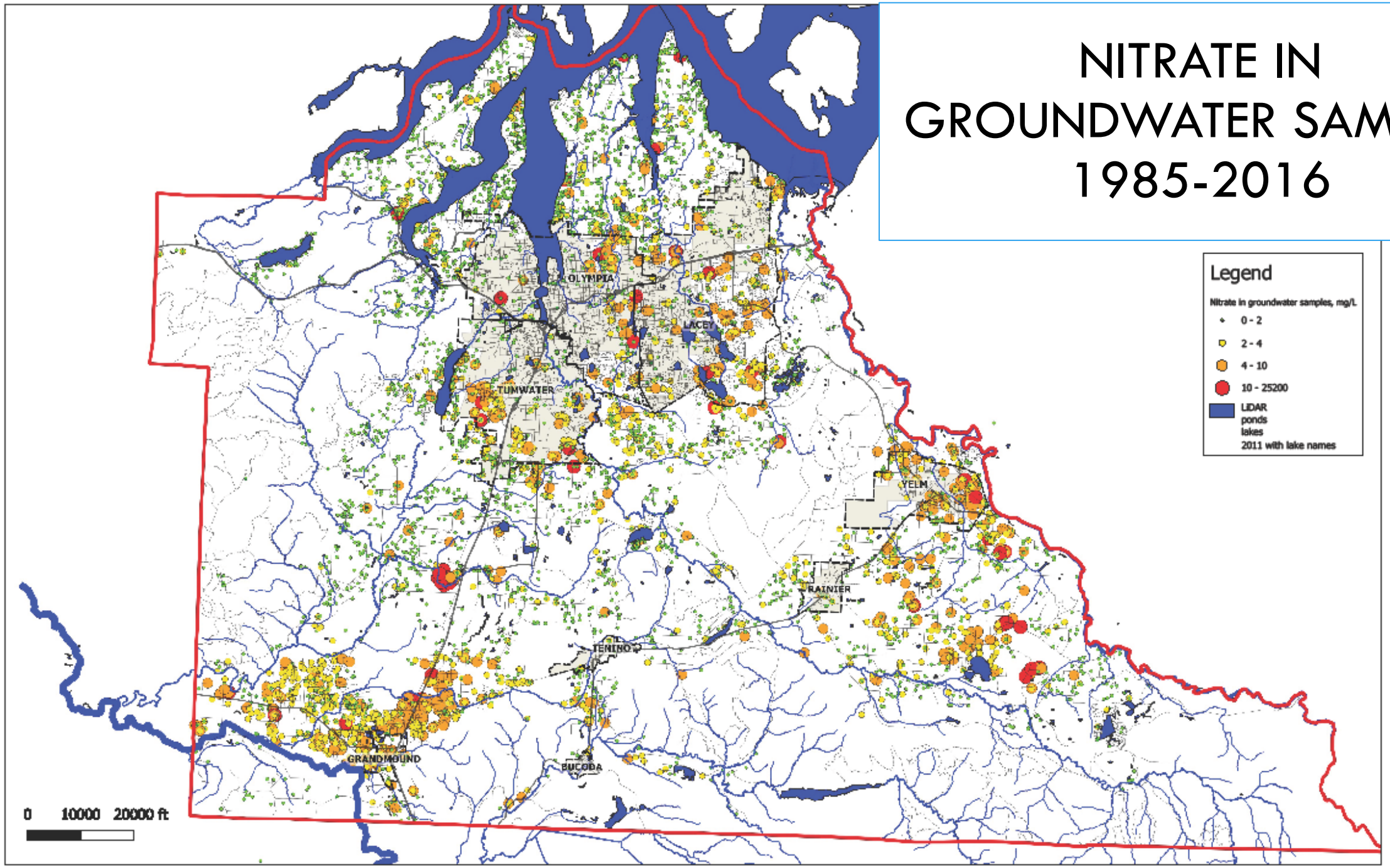
Klickitat County
Clark County

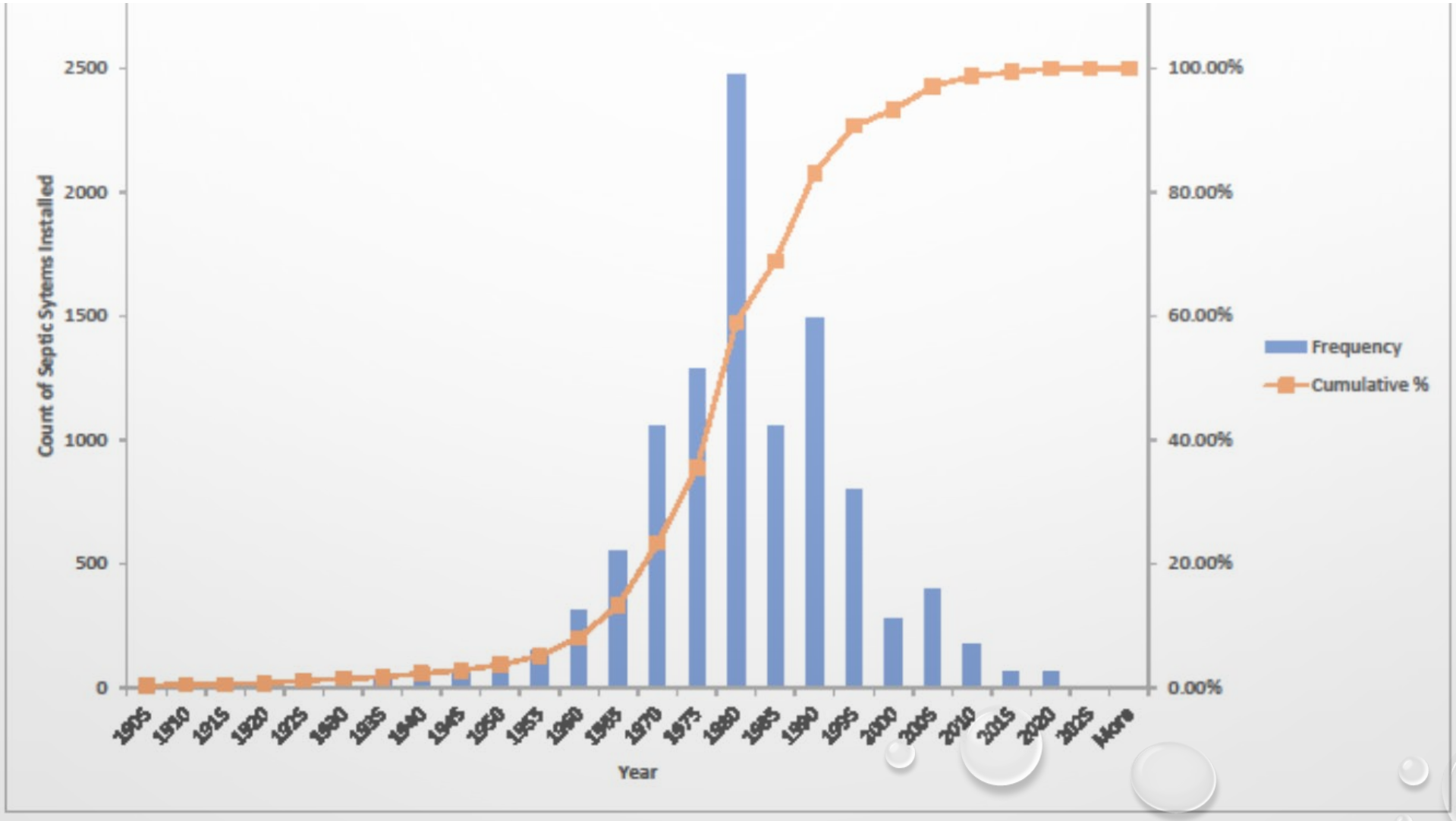
NITRATE IN GROUNDWATER SAMPLES 1985-2016



CAN WE DETERMINE IF SEPTIC SYSTEMS ARE THE PRIMARY SOURCE?

- KEY PROJECT QUESTION
- LOTS OF SEPTIC SYSTEMS….
- …BUT OTHER SOURCES ARE KNOWN TO CONTRIBUTE:
  - LAWN/YARD CARE PRODUCTS
  - ANIMAL WASTE
  - AGRICULTURE
  - STORMWATER

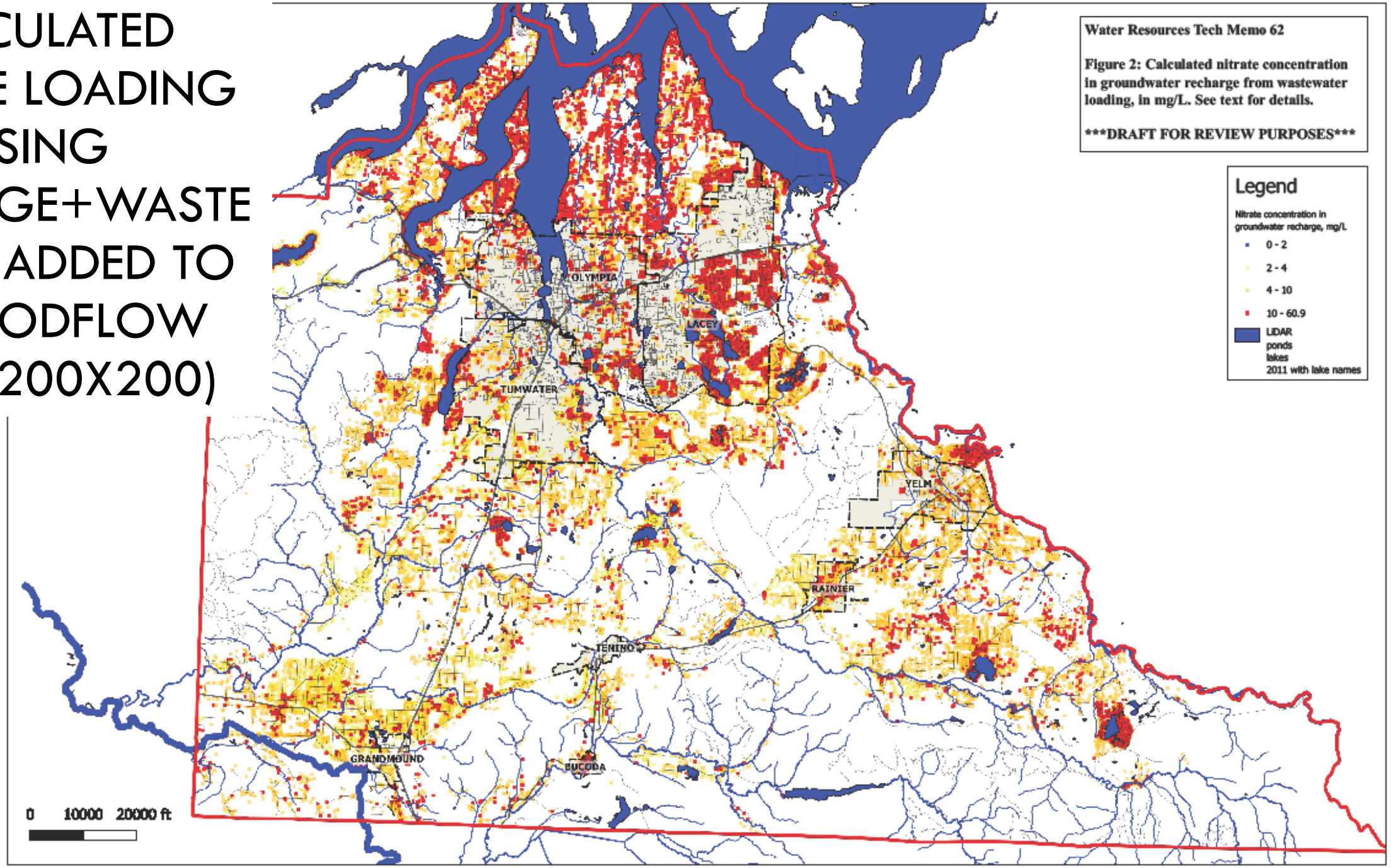
DISTRIBUTION OF HOME CONSTRUCTION AGE 10,541 HOMES WITH SEPTIC SYSTEMS



COVID PROJECT #1
UPDATE SEPTIC LOADINGS

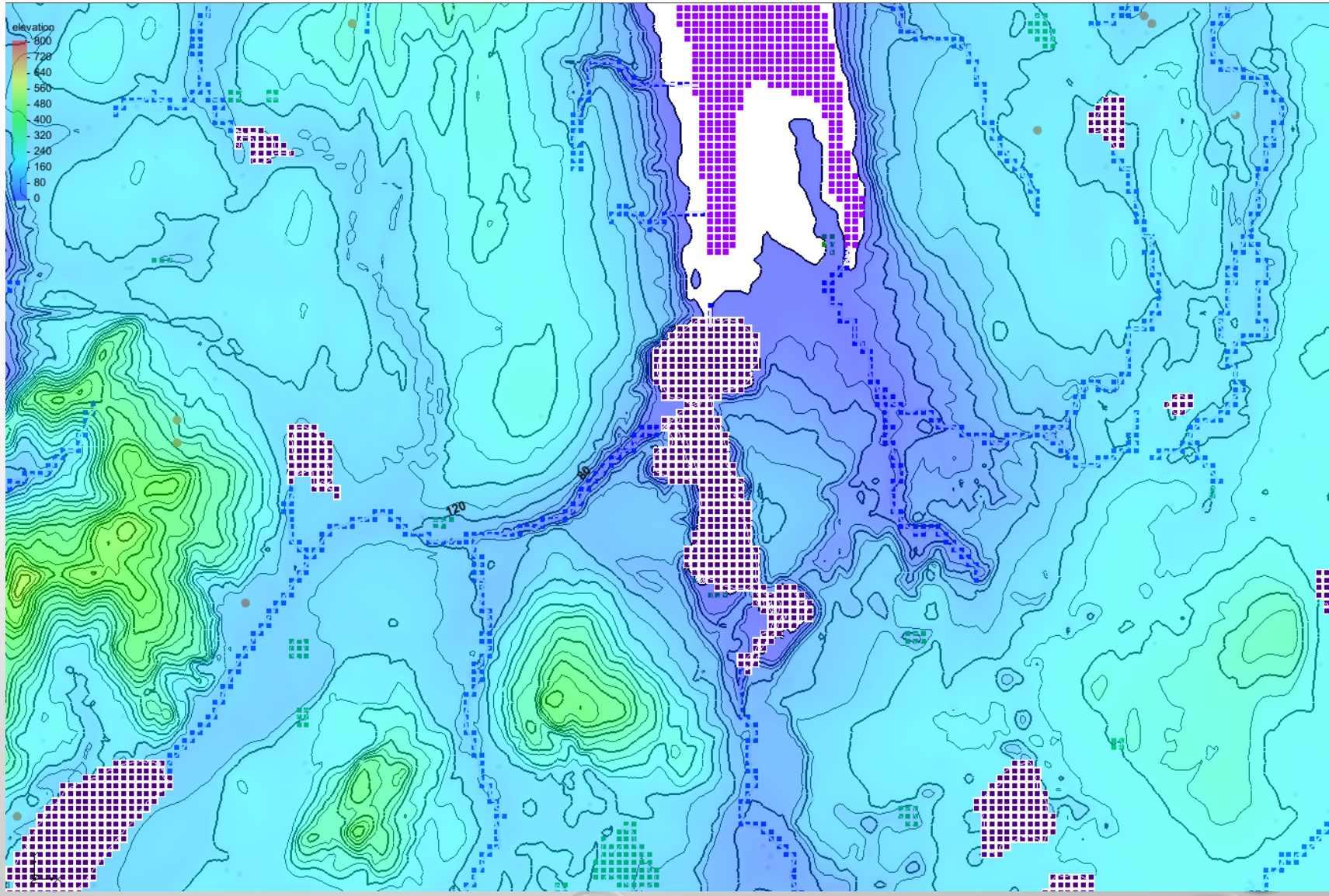
- OCCUPANCY DATA ADDED ~9,000 PRESUMED SEPTIC SYSTEMS
- AGGREGATE SEPTIC LOADING TO MODFLOW MODEL CELLS
- WATER FLUX: SWB RECHARGE + SEPTIC DISCHARGE BASED ON ASSESSOR'S BEDROOM COUNT

CALCULATED NITRATE LOADING USING RECHARGE+WASTE WATER ADDED TO THE MODFLOW GRID (200X200)



GROUNDWATER FLOW MODEL

- BOUNDARY CONDITIONS ALLOW WATER TO <u>ENTER</u> THE MODEL
  - RECHARGE, RAINFALL, INJECTION WELLS
  - STREAMS, LAKES
  - MODEL EDGES
- BOUNDARY CONDITIONS ALLOW WATER TO <u>LEAVE</u> THE MODEL
  - WELLS
  - OCEAN
  - RIVERS, LAKES
  - EVAPORATION
  - PLANT TRANSPIRATION
  - MODEL EDGES

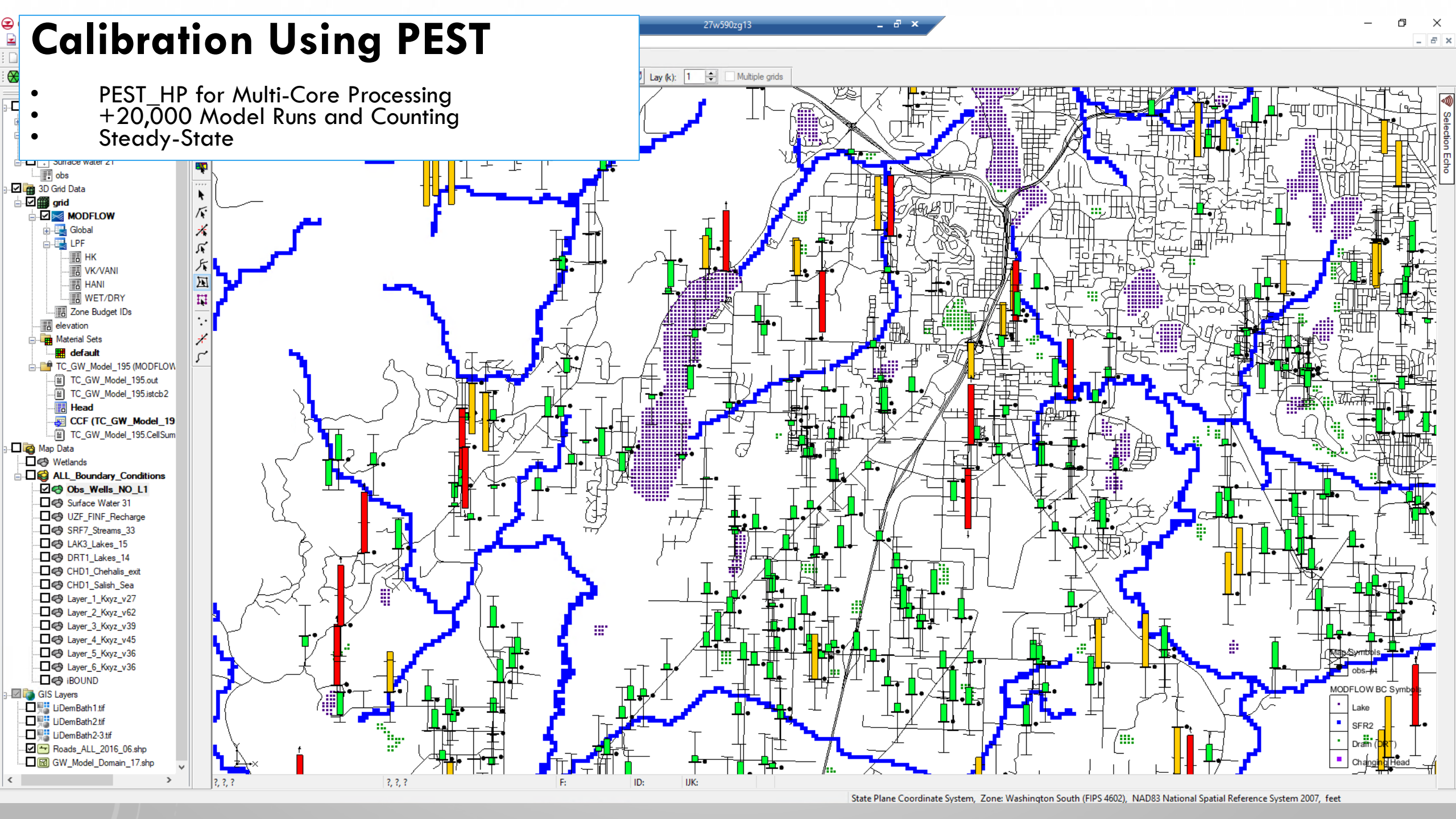


MODFLOW MODEL INTEGRATES

- ~4.08MILLION ACTIVE CELLS, 200X200 FEET, 6 LAYERS
- 2011 LIDAR-REFERENCED TO NAVD88 DATUM THROUGHOUT
- +23,000 WELLS AND +50,000 SEPTICS
- +900 MILES OF SFR STREAMS
- LAK AT 125 LARGER LAKES, DRN AT +300 LAKES
- CURRENT WETLANDS, HYDRIC SOILS AND HIGH GROUNDWATER
- AQUIFER PROPERTIES FROM MANY PRIOR STUDIES
- SOLVER: NEWTON-RAPHSON METHOD (NWT) SOLVER
- PEST_HP: CALIBRATED USING +20,000 MODEL RUNS USING AUTOMATION OF PEST_HP

Calibration Using PEST

- PEST_HP for Multi-Core Processing
- +20,000 Model Runs and Counting
- Steady-State



WITH A RUNNING MODEL, WE APPROACHED WA DOH

- SEPTIC DENSITIES ARE VERY HIGH IN THE “TRI LAKES” AREA OF NORTHERN THURSTON COUNTY
- UP TO 6 SYSTEMS PER ACRE WERE ALLOWED UNTIL THE SANITARY CODE CHANGED IN THE 1990S
- MODELING SERVED AS GUIDANCE FOR SAMPLING
- CALIBRATION OF MODEL DATA WAS BENEFICIAL
- EARLY WARNING FOR SMALLER GROUP B WELLS NOT FREQUENTLY SAMPLED (LESS THAN FIFTEEN CONNECTIONS)

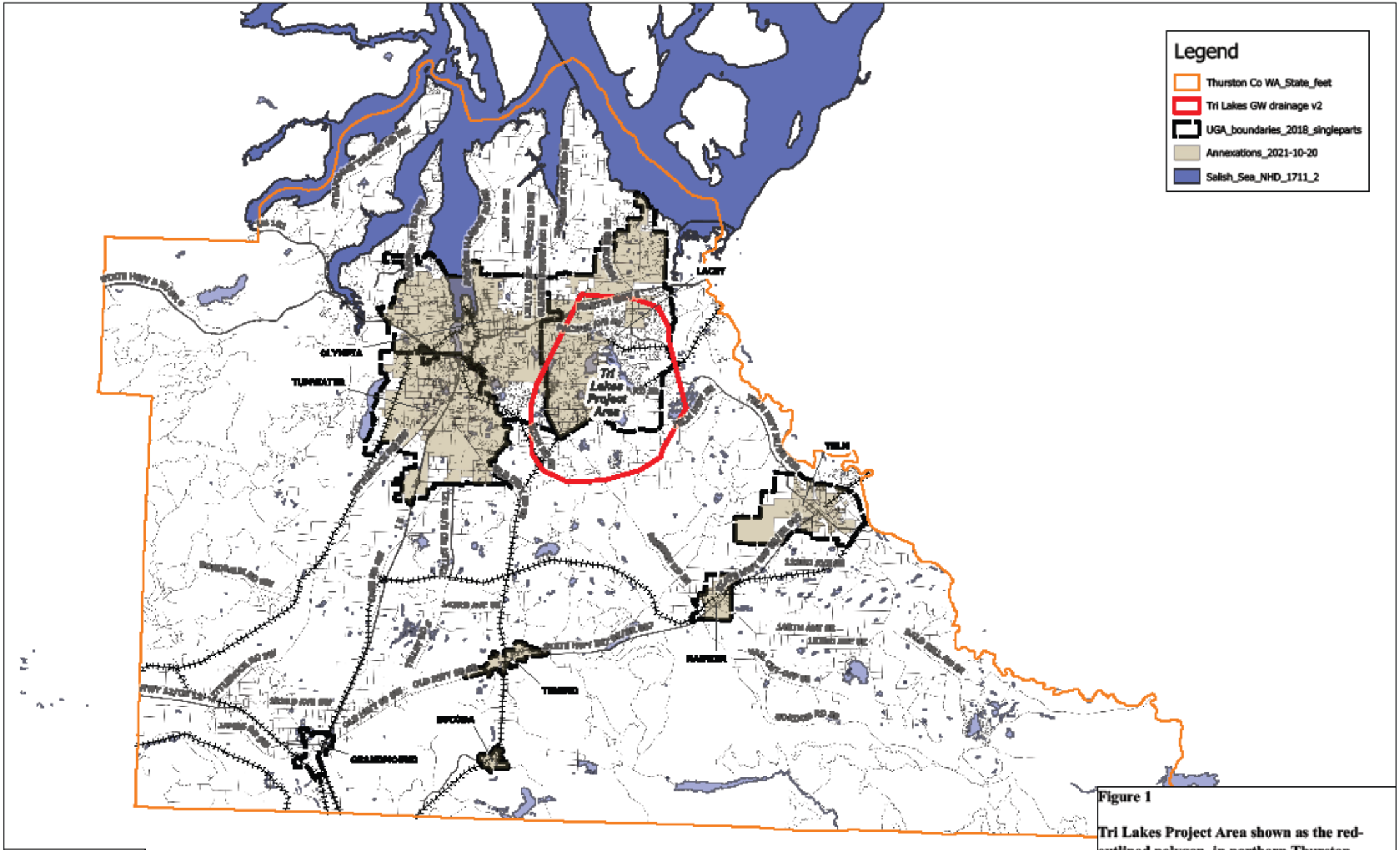
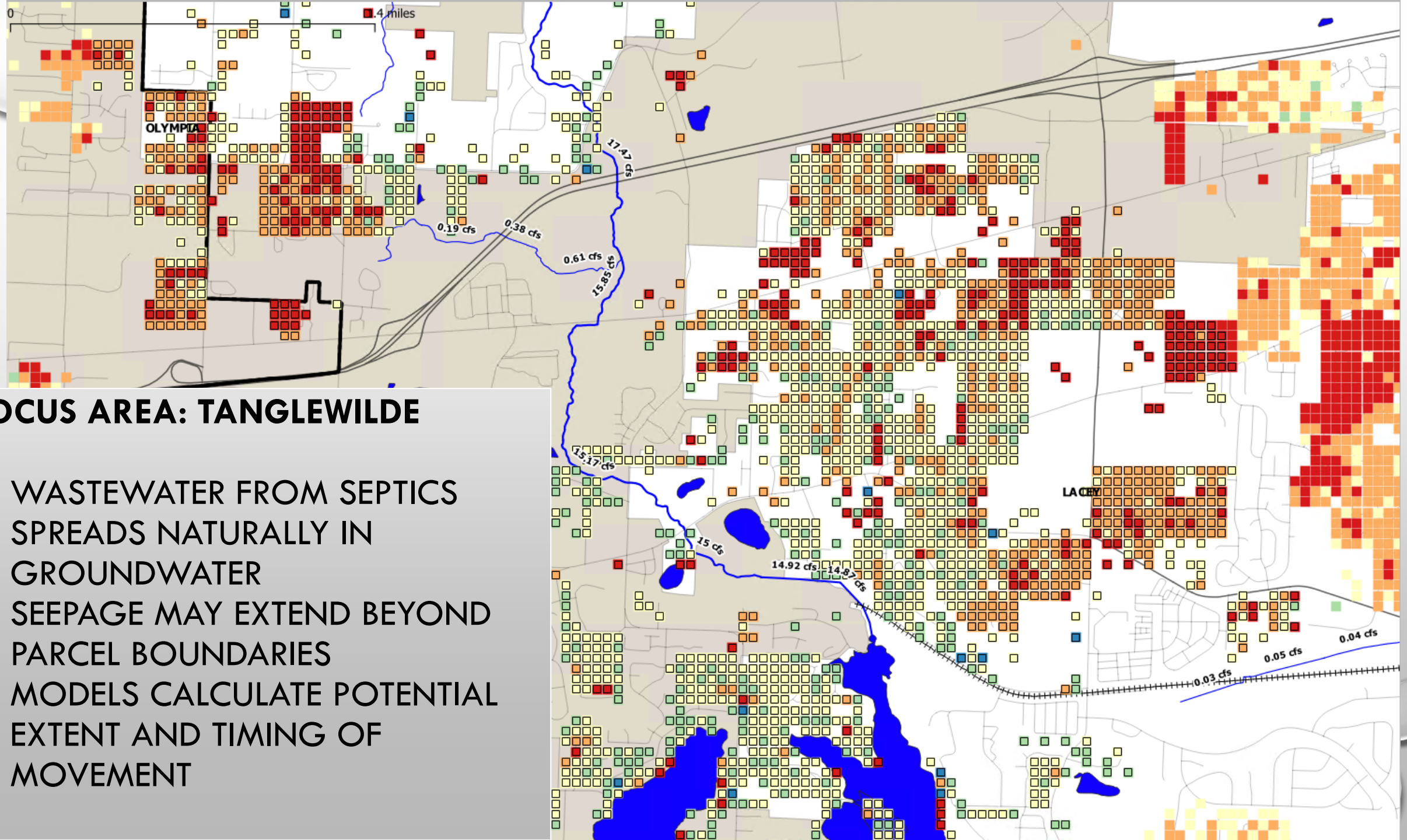


Figure 1

Tri Lakes Project Area shown as the red-outlined polygon, in northern Thurston County, Washington.



FOCUS AREA: TANGLEWILDE

- WASTEWATER FROM SEPTICS SPREADS NATURALLY IN GROUNDWATER
- SEEPAGE MAY EXTEND BEYOND PARCEL BOUNDARIES
- MODELS CALCULATE POTENTIAL EXTENT AND TIMING OF MOVEMENT

ABOUT 10% OF WELLS COULD BE SAMPLED

Class of Well	Count of Pumping Wells in Study Area by Well Class	Wells Sampled for this Project
Public Supply Group A Systems	57	12
Public Supply Group B Systems	39	18
Domestic	421	20
Monitoring	-	8
Totals	554	58

…AFTER MONTHS OF WORK

- MAILED LETTERS
- MAILED POSTCARDS
- CALLS
- DOOR KNOCKING – THE BEST WAY TO GET “YES”

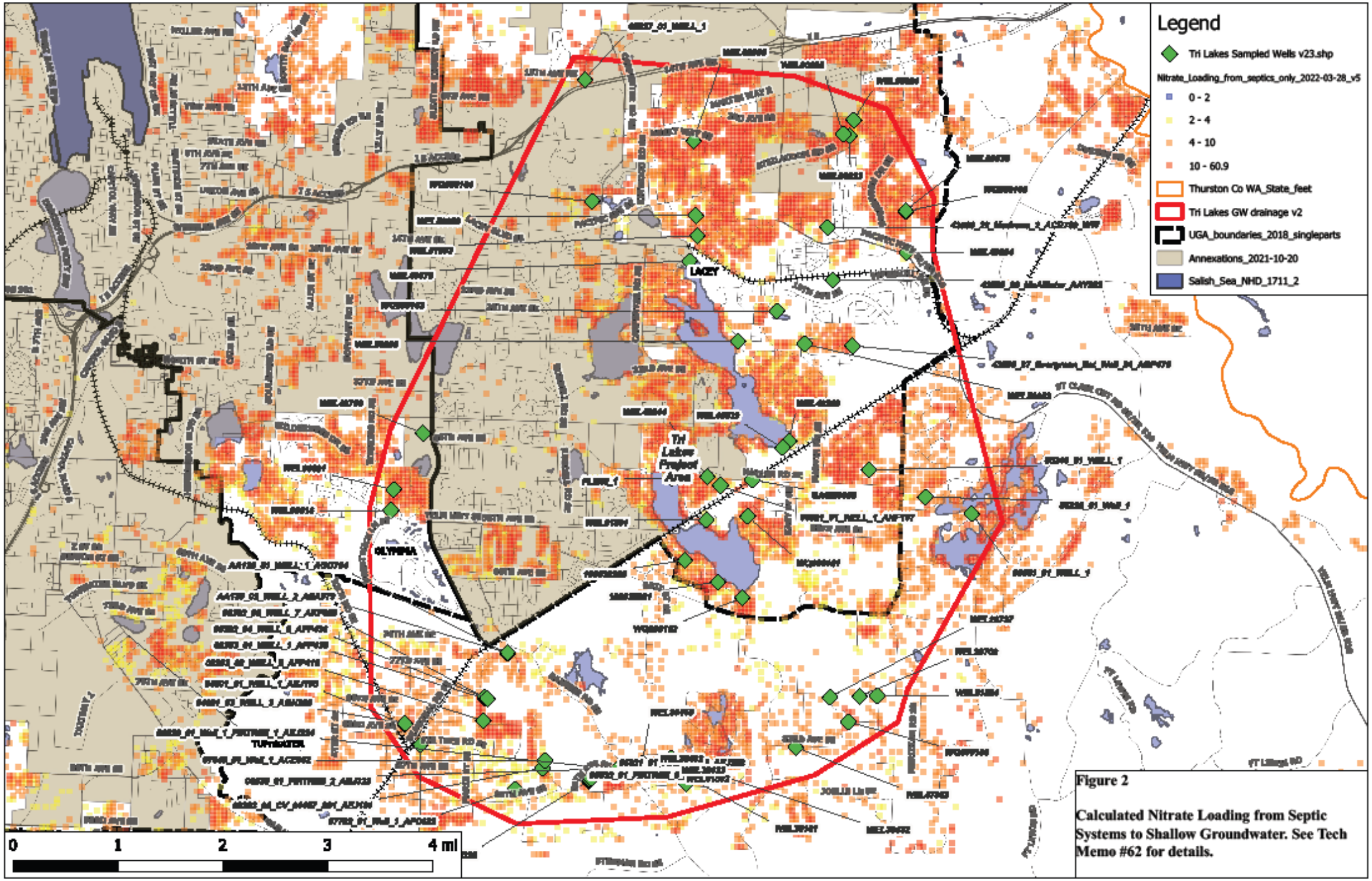


Figure 2

Calculated Nitrate Loading from Septic Systems to Shallow Groundwater. See Tech Memo #62 for details.

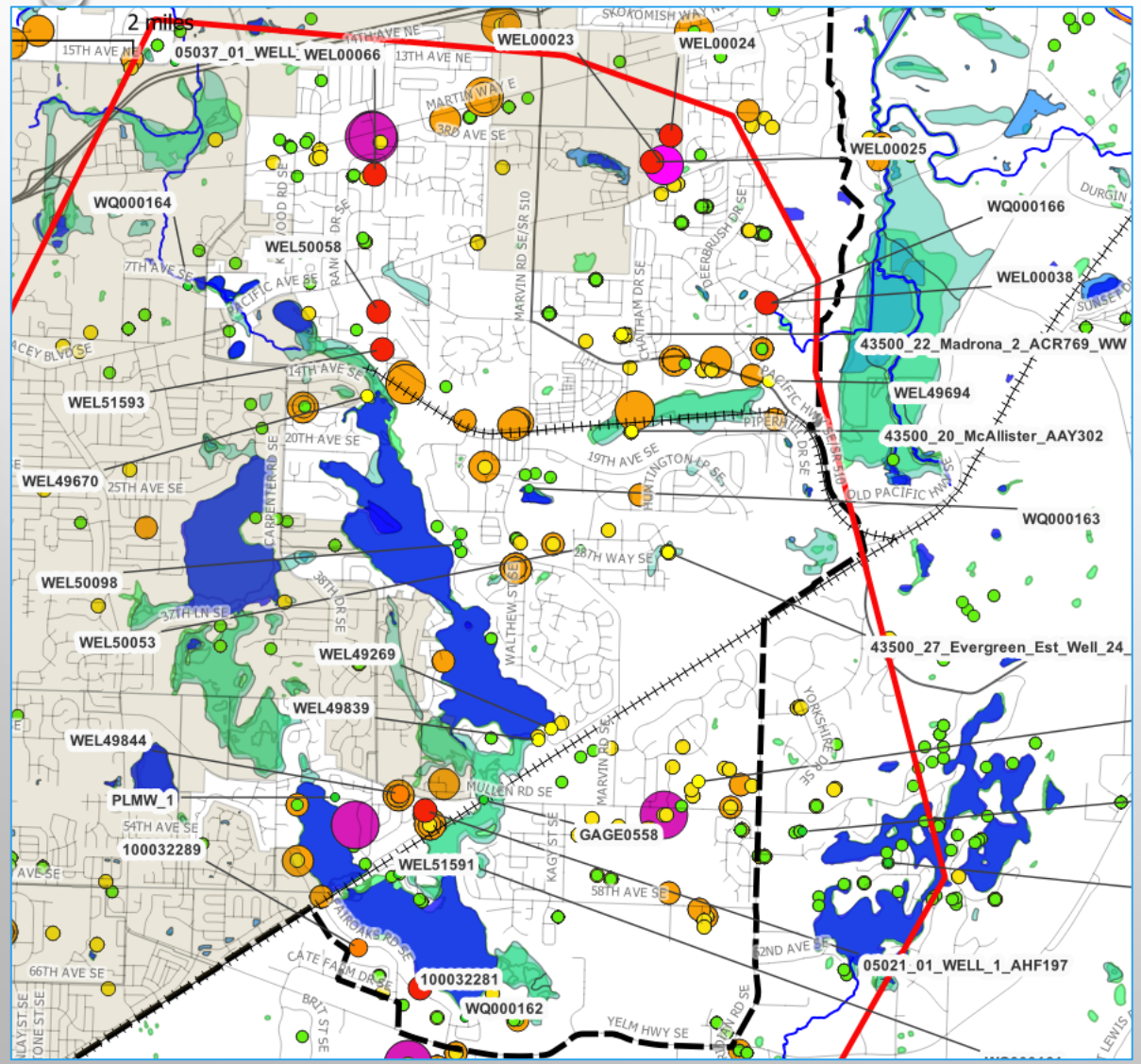
WHAT DID WE FIND? - PART 1 NITRATE…

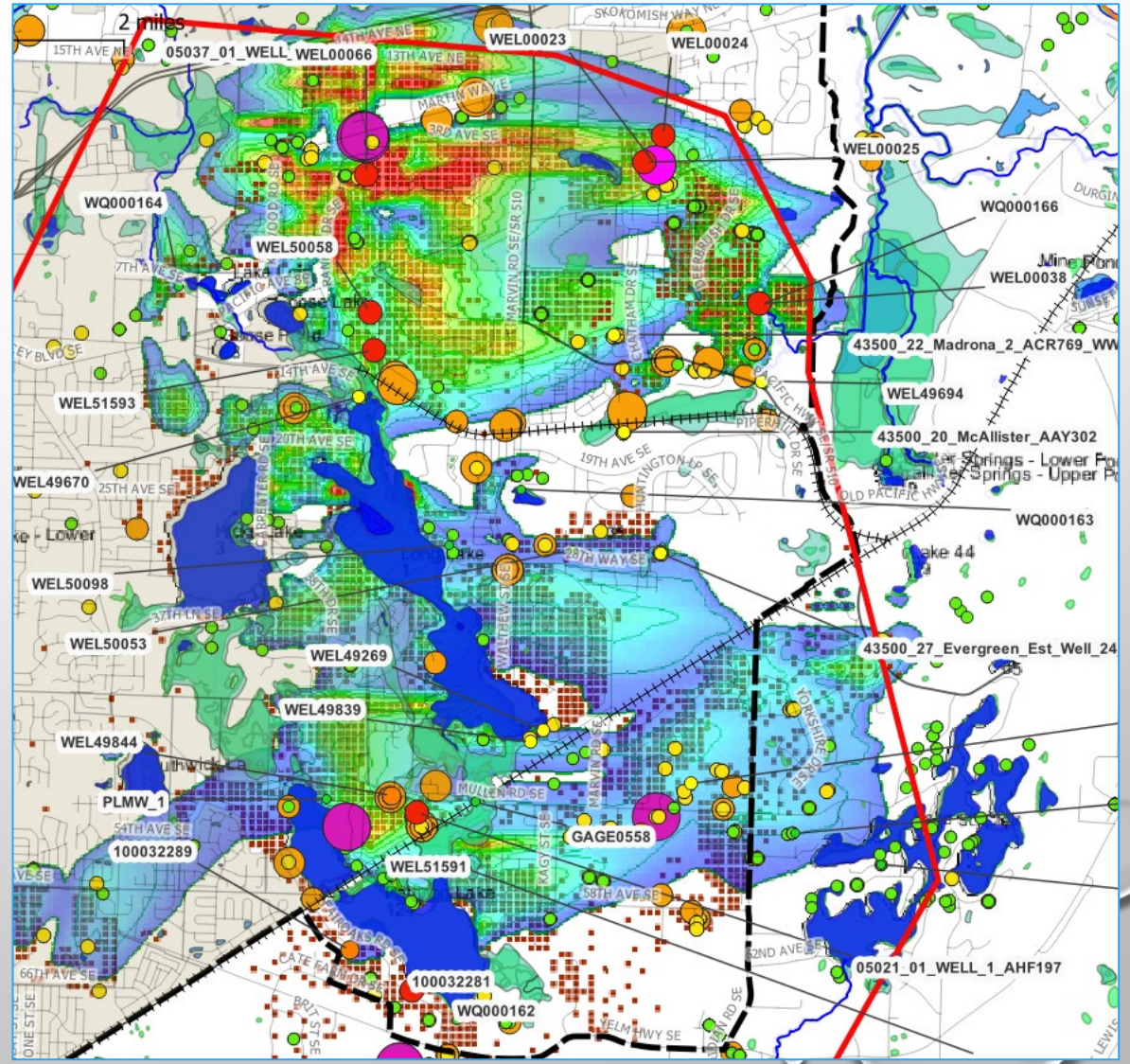
COMPARISON OF DETECTED NITRATE TO REGULATORY CRITERIA

	Group A	Group B	Domestic	Monitoring	Total
Exceeds MCL				1	1
Exceeds TRIGGER		1	4	4	9
Exceeds CAL		1	1	1	3
Exceeds EWL	6	3	6		15
Below BACKG	6	13	10	2	31

MCL: 10 mg/L
TRIGGER: Federal and State trigger level for increased monitoring: 5 mg/L
CAL: County Critical Action Level: 4 – 9.9 mg/L (only results 4 - <5 mg/L counted for this report)
EWL: County Early Warning Level: 2 – 3.9 mg/L
BACKG: County Background: < 2.0 mg/L

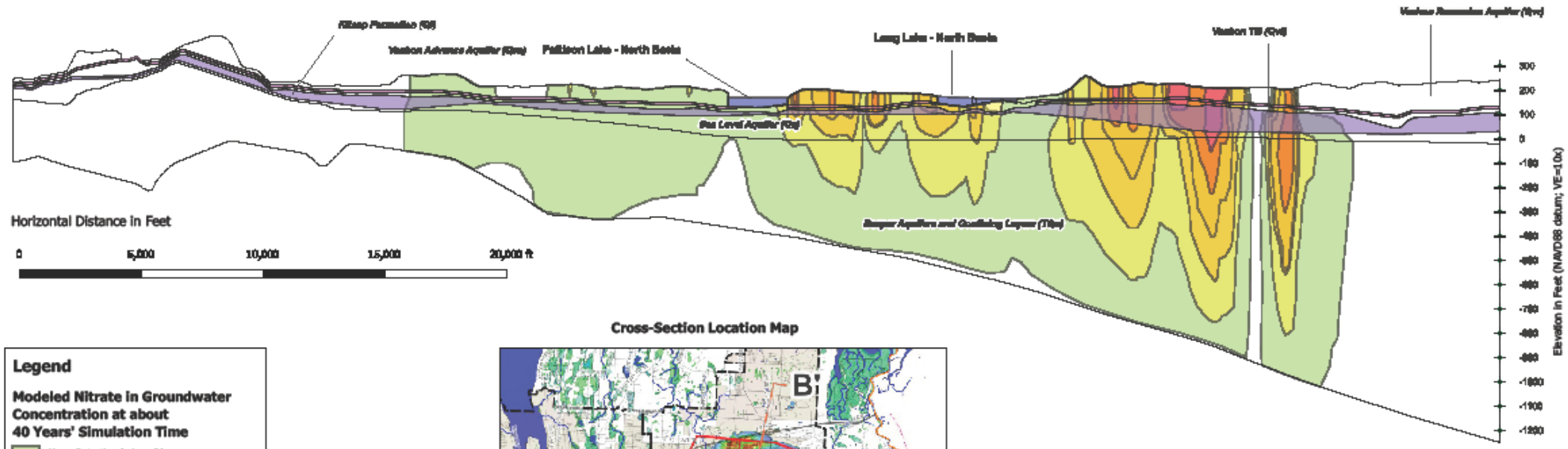
MODEL COMPARISON WITH ALL AVAILABLE NITRATE DATA



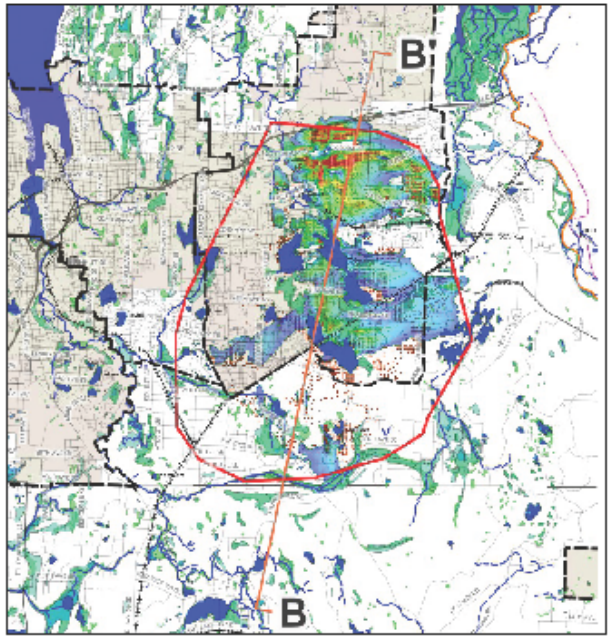


B South

B' North



Cross-Section Location Map



Legend

Modeled Nitrate in Groundwater Concentration at about 40 Years' Simulation Time

- Above Detection (>1 mg/L)
- Above 2 mg/L
- Above 4 mg/L
- Above 6 mg/L
- Above 8 mg/L
- Above 10 mg/L
- Pattison Lake - North Basin
- Long Lake - North Basin

Major Aquifers in Study Area (USGS)

- Vashon Recession Aquifer (Qvr)
- Vashon Till (Qvt)
- Vashon Advance Aquifer (Qva)
- Kitsap Formation (Qf)
- Sea Level Aquifer (Qc)
- Deeper Aquifers and Confining Layers (TQu)

Figure 12

Hydrogeologic cross-cection B-B' from south to north crosscutting the flow model (MODFLOW v253) and transport model (MT3D v23).

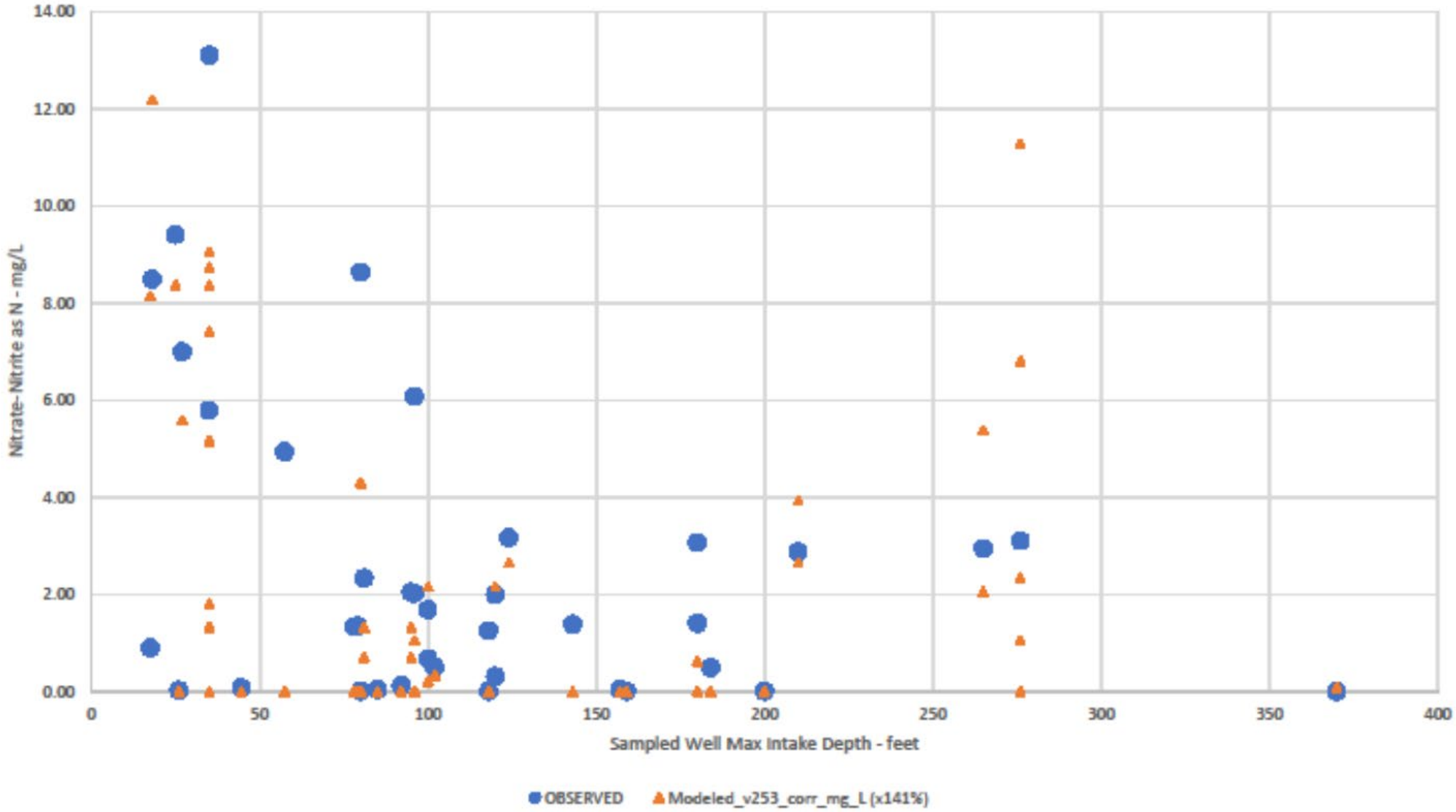
Modeled concentrations of nitrate from 14,600 days elapsed simulation time (~40 years) in the low-recharge scenario.

Vertical Exaggeration 10x

K.Hansen LHg. 4/5/2023

SHOW ANIMATION

Figure 11
Comparison of Observed and Modeled Nitrate+Nitrite (as N) vs Well Depths
Modeled Data includes a Minimim-Error x1.41 Multipier
Tri Lakes Project, Thurston County WA



WHY DID SAMPLES HAVE 40% MORE 'NITRATE' TRACER THAN MODELED?

1. RECHARGE:
   - HIGHER-RECHARGE, HIGHER-K, FAST SOLUTE MOVEMENT – BIDLAKE & PAYNE STEADY-STATE RECHARGE?

     VS.
   - LOWER-RECHARGE, LOWER-K, SLOWER SOLUTE MOVEMENT – SWB TRANSIENT RECHARGE?

2. SEPTIC WASTEWATER COULD HAVE MORE NITRATE THAN MODELED DEFAULT 'SOURCES'?

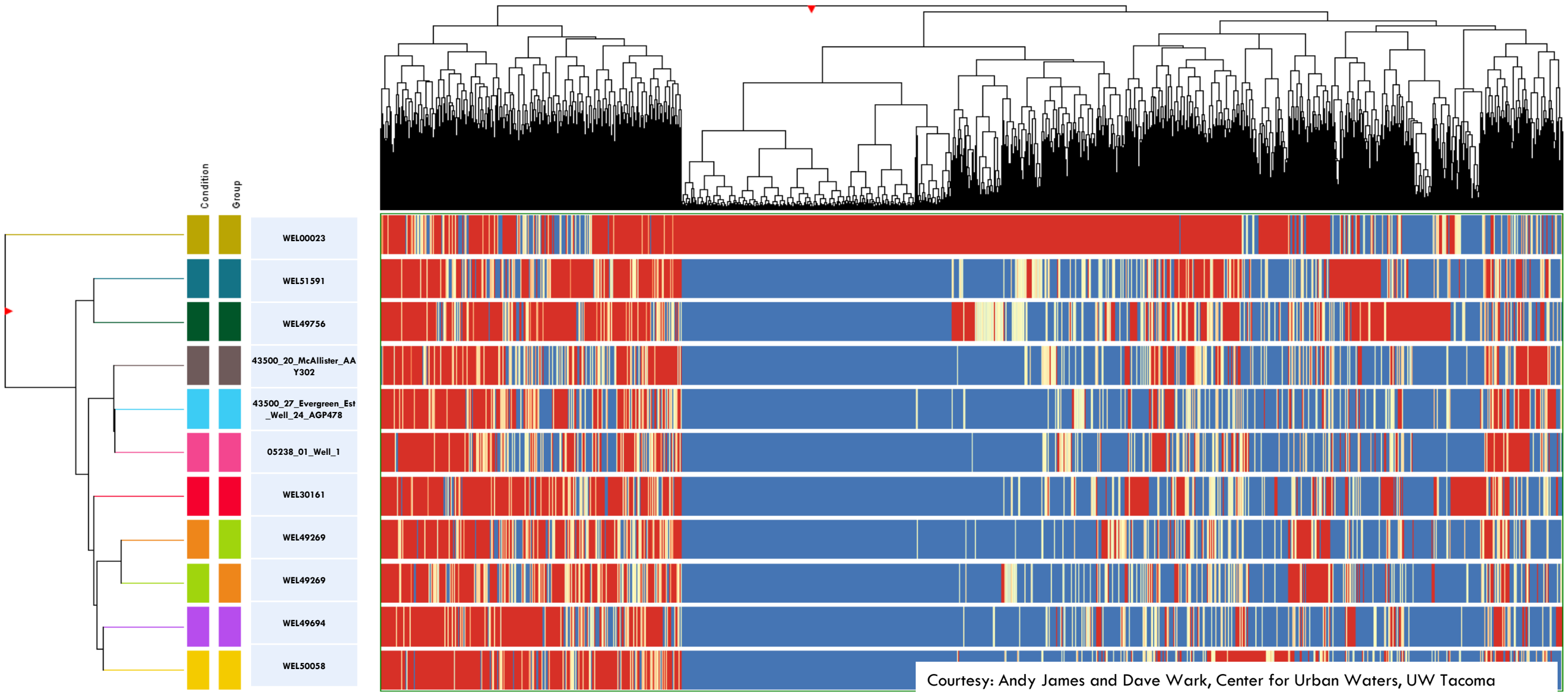
   MY OPINION: LESS LIKELY BECAUSE WE HAVE GOOD ENFORCEMENT + EDUCATION IN THIS WATERSHED

3. OTHER SOURCES ARE CONTRIBUTING NITRATE:
   - LAWNS/YARDS?
   - ANIMAL WASTE?
   - AGRICULTURE?
   - STORMWATER?

WHAT DID WE FIND? – PART 2
CHEMICALS OF EMERGING CONCERN (CEC)

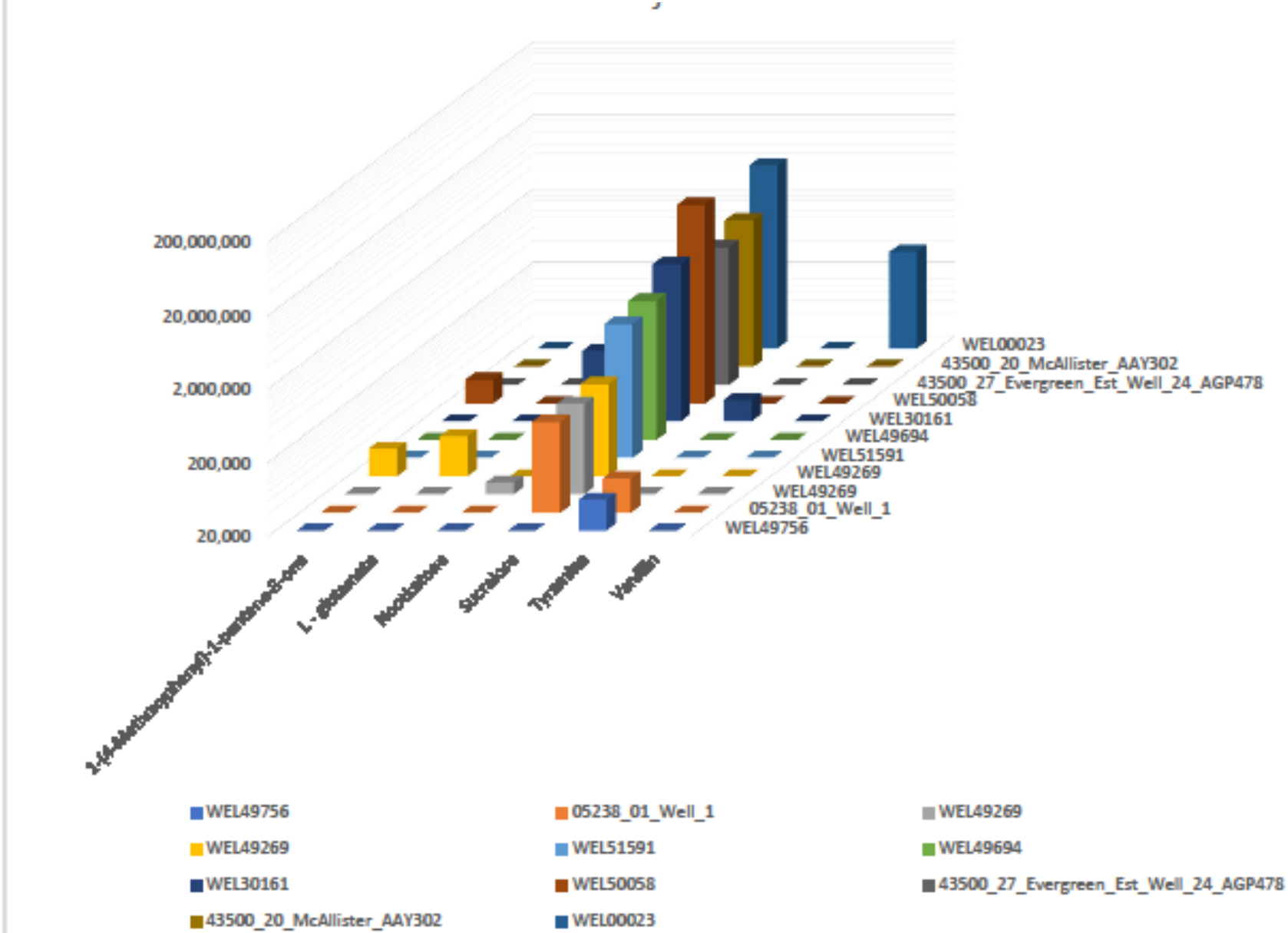
- ADDITIONAL ANALYSIS OF A SUBSET OF TEN WELLS
- LABORATORY: CENTER FOR URBAN WATERS, UW TACOMA
- **NEW METHOD - NOT "CONCENTRATIONS" - RELATIVE INSTRUMENT RESPONSES ONLY**
- ANALYSIS FOR 64 CEC SUBSTANCES:
  - 6 FOOD ADDITIVES
  - 12 COMMERCIAL CHEMICALS
  - 25 INDUSTRIAL CHEMICALS
  - 9 PESTICIDES AND HERBICIDES
  - 12 PHARMACEUTICALS

RAW RESULTS
RED/ORANGE BARS ARE TENTATIVE DETECTIONS

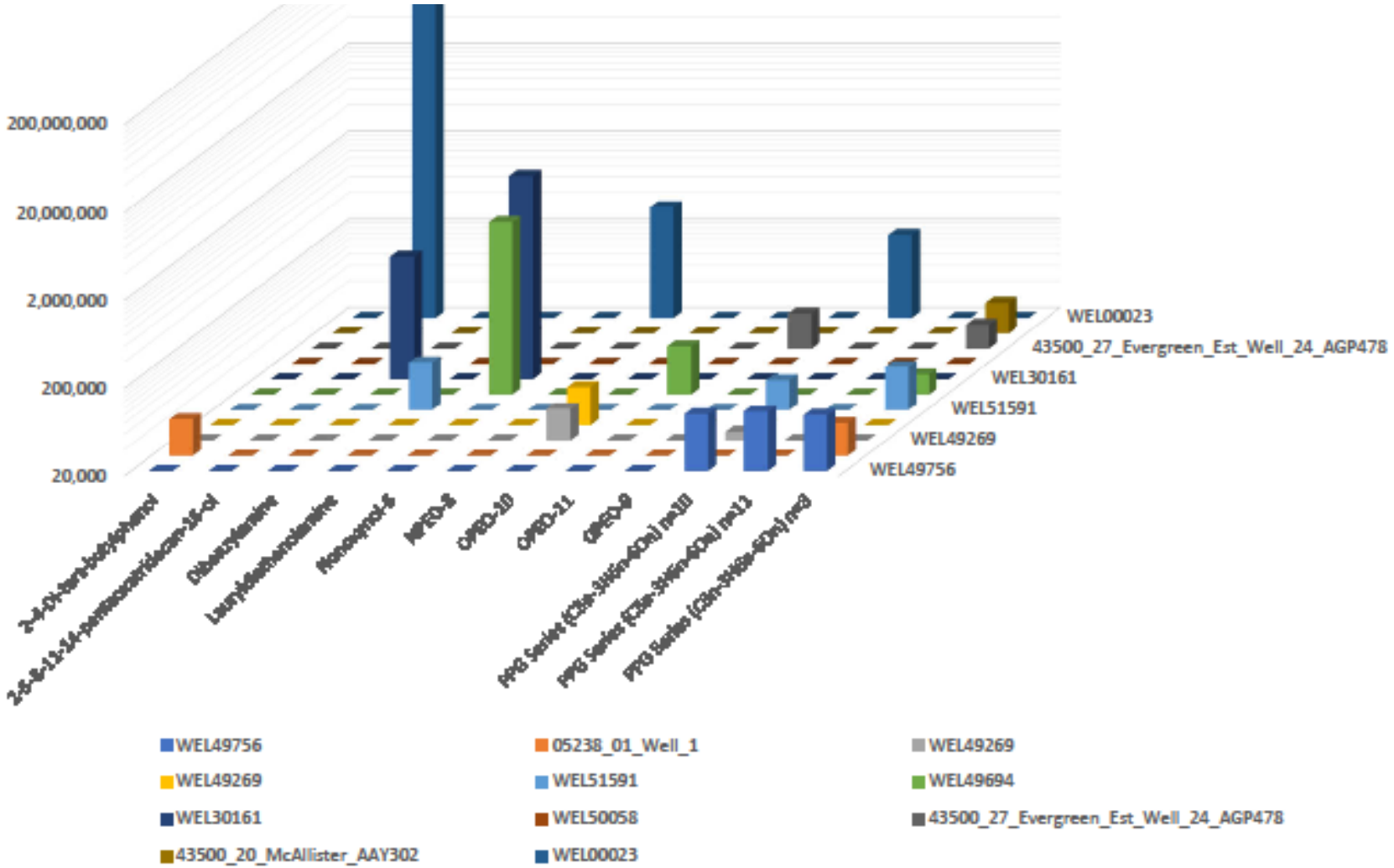


Courtesy: Andy James and Dave Wark, Center for Urban Waters, UW Tacoma

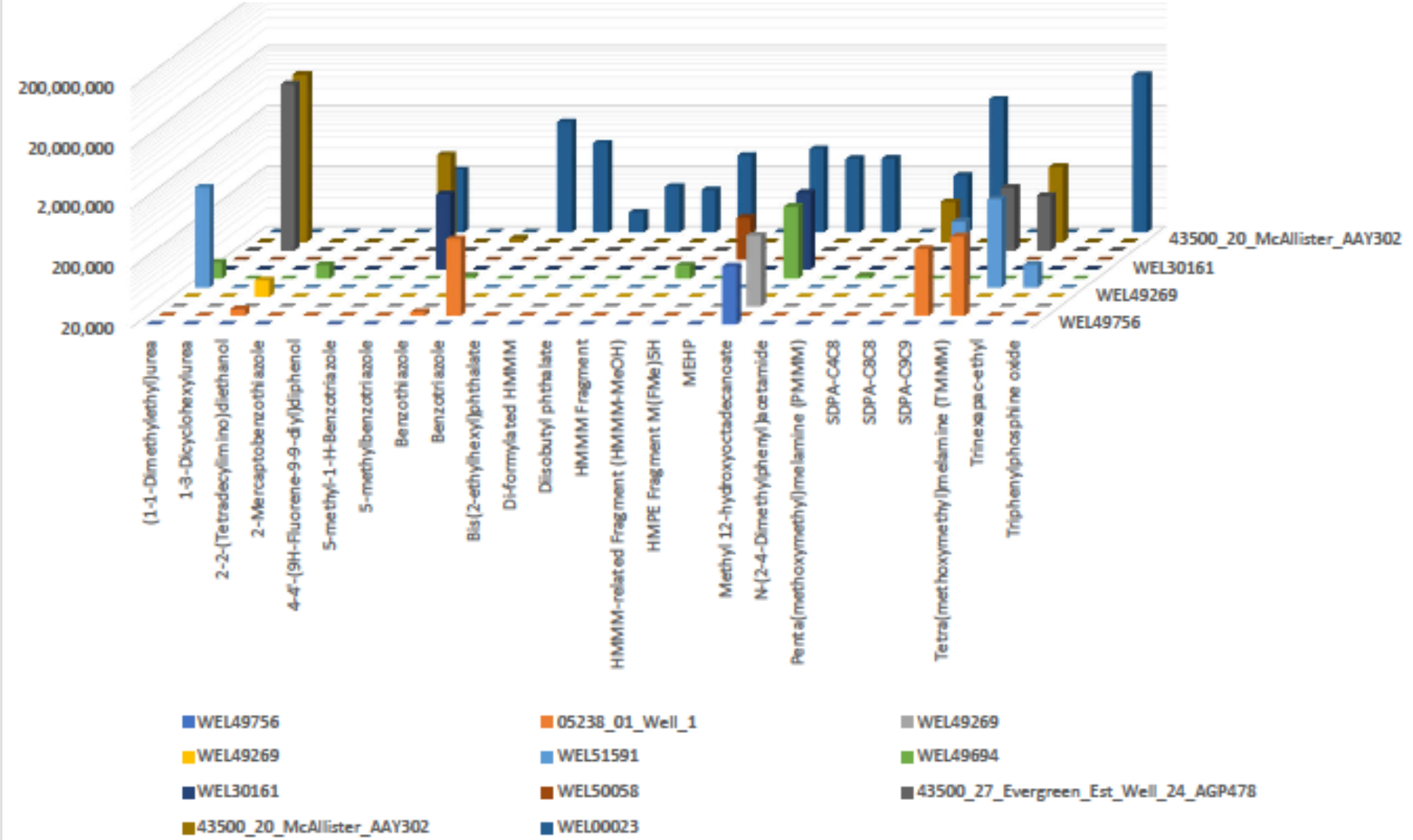
Food Additives Tentatively Detected



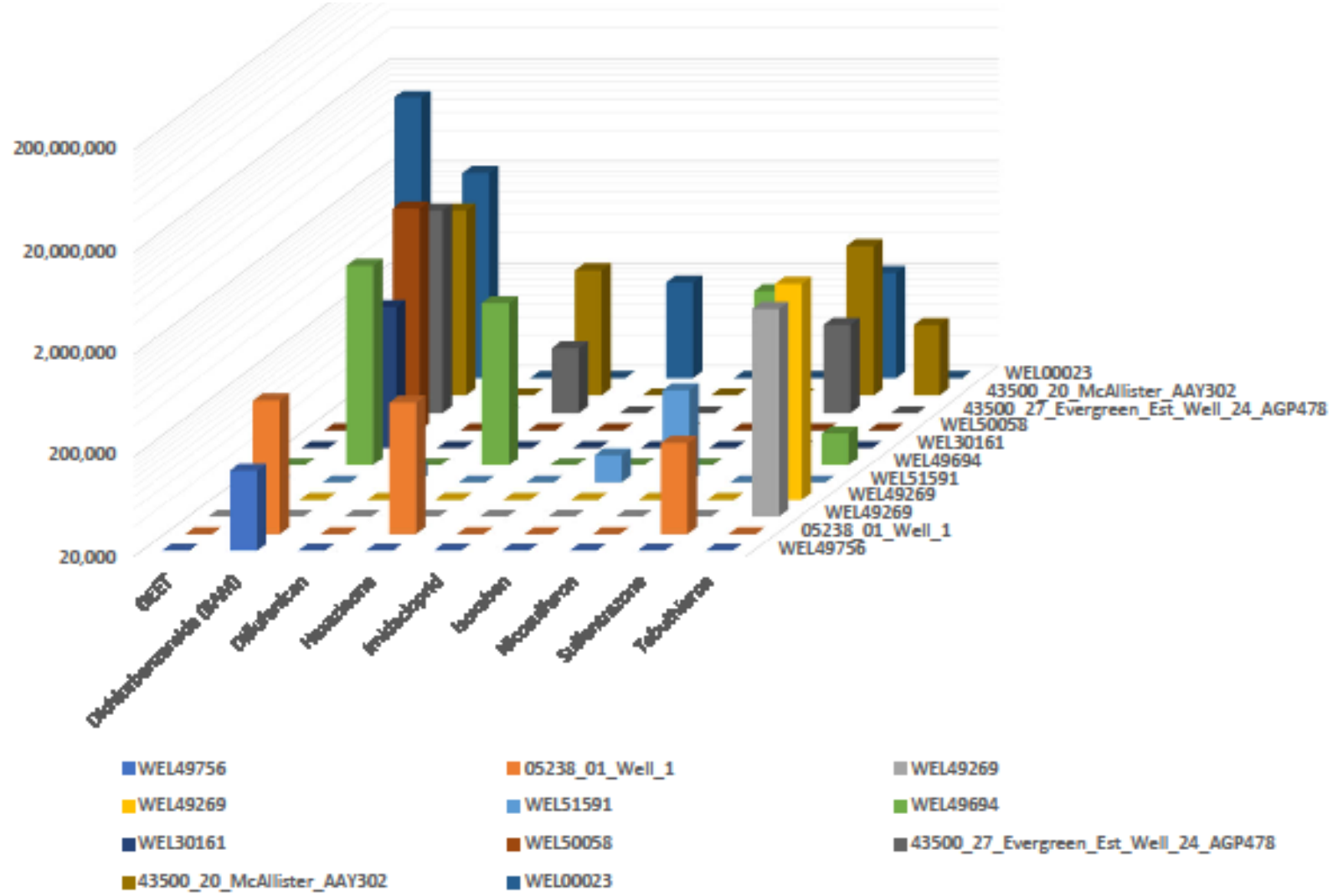
Commercial Chemicals Tentatively Detected



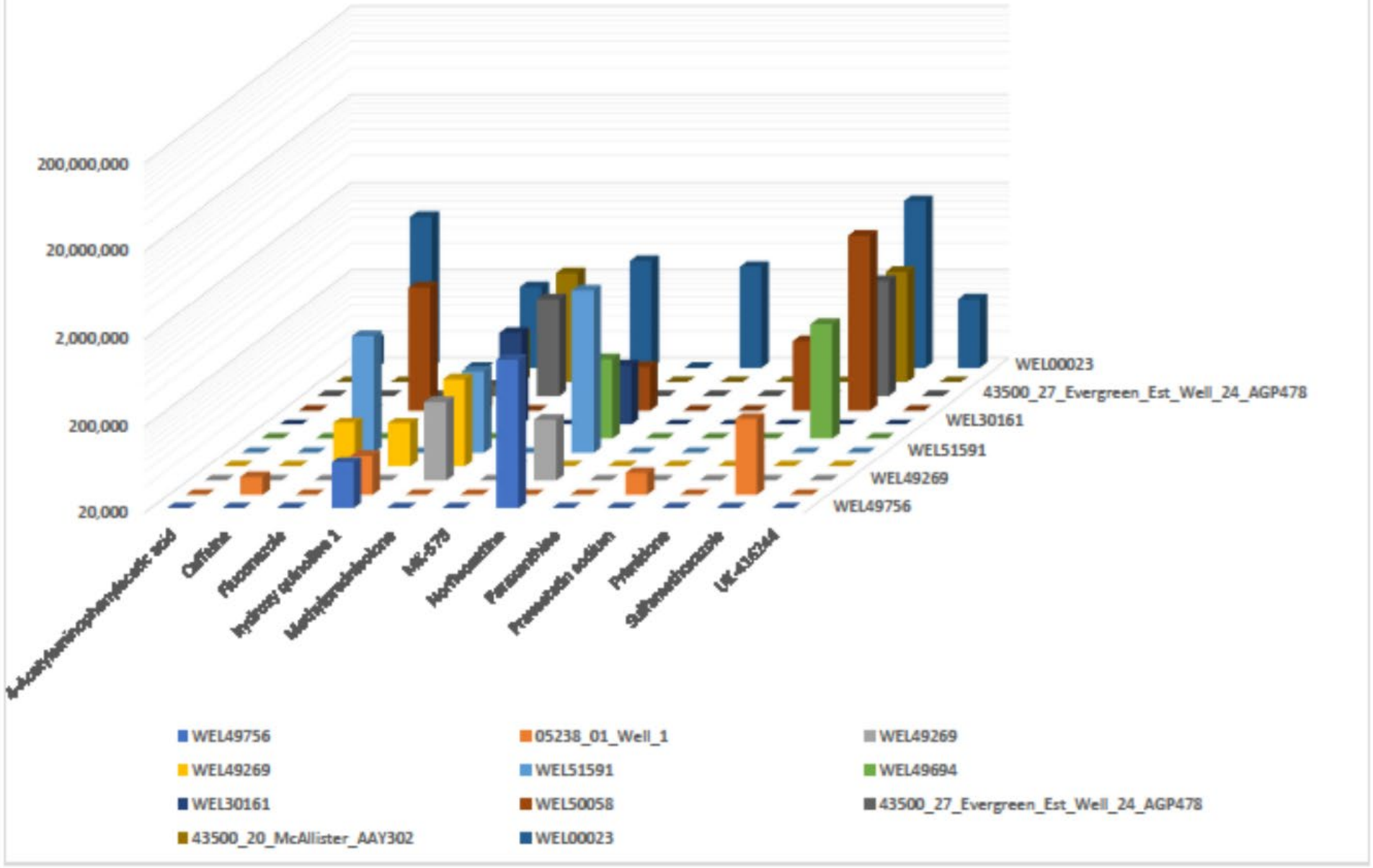
Industrial Chemicals Tentatively Detected



Pesticides/Herbicides Tentatively Detected

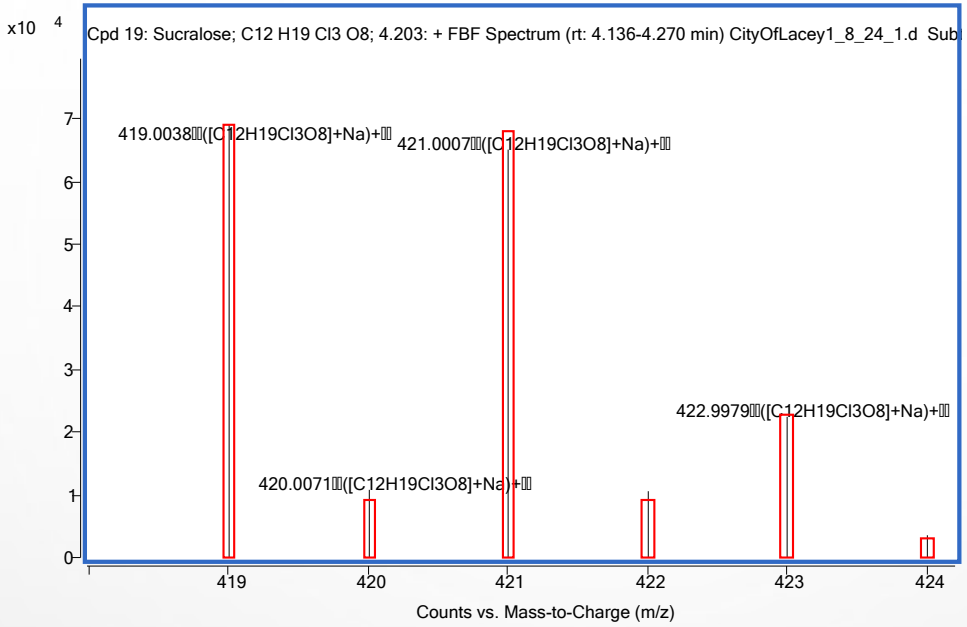


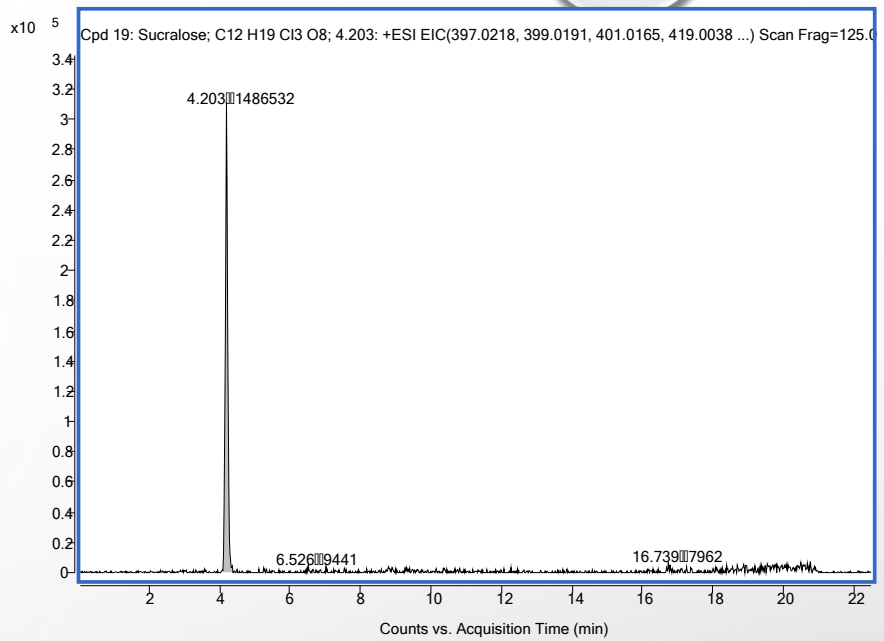
Pharmaceuticals Tentatively Detected



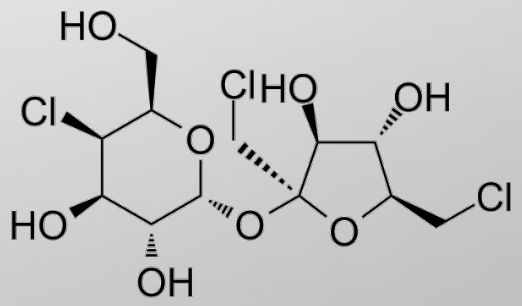
WHAT DID WE FIND? – PART 3
SOME VERY COMMON TENTATIVE DETECTIONS

- SUCRALOSE - (FOOD ADDITIVE)
- CAFFEINE - (FOOD ADDITIVE)
- 2,6-DICHLORBENZAMIDE (BAM) - ("CASORON" HERBICIDE BREAKDOWN PRODUCT)
- SULFAMETHOXAZOLE - (ANTIBIOTIC)
- OTHER COMPOUNDS ALSO TENTATIVELY DETECTED
  - TARGETED COMPOUNDS WERE CHOSEN FROM CANDIDATES DISCOVERED DURING INITIAL SCREENING
  - ESTIMATED QUANTIFICATION – BASED ON CALIBRATION CURVES, BUT NOT A COMPLETE QUANTITATIVE METHOD

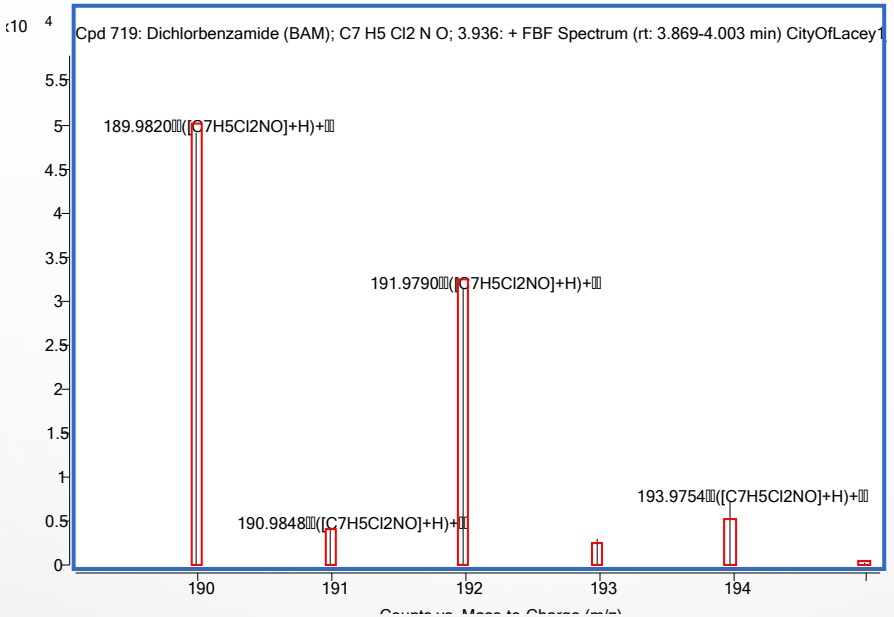


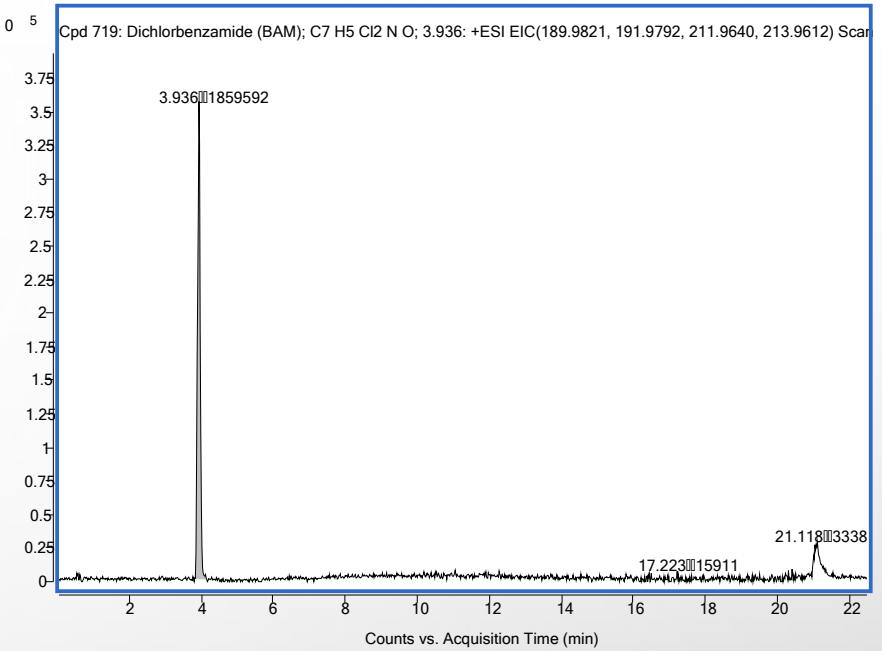


Sucralose is a widely-used persistent artificial sweetener that is a commonly used indicator for wastewater or septic tank infiltration of groundwater (Robertson et al., 2016)



Courtesy: Andy James and Dave Wark, Center for Urban Waters, UW Tacoma

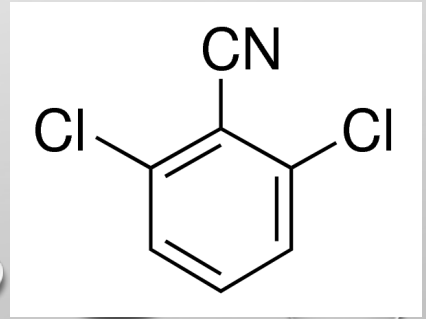


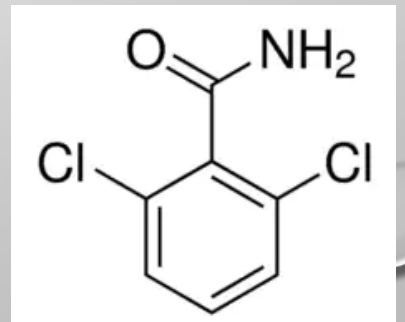


2,6-Dichlorbenzamide (BAM) is the primary metabolite of Dichlobenil, an herbicide used to control weeds and grasses sold under various brand names including Casoron and Noxall.

BAM is known to be a persistent groundwater contaminant (Ellegaard-Jensen et al., 2017).

Dichlobenil





2,6-Dichlorbenzamide

Courtesy: Andy James and Dave Wark, Center for Urban Waters, UW Tacoma

TENTATIVELY DETECTED CONCENTRATIONS NANOGRAMS PER LITER (NG/L)

Compound	43500_27_	43500_20_	WEL30161	WEL00023	WEL49269	WEL49269	WEL51591	05238_01_Well_1	WEL49756	WEL49694	WEL50058
Caffeine	5			800							
Dichlorbenzamide (BAM)	700	500	150	900				150	40	650	1000
Sucralose	40	55	75	200	5	5	30	5		40	250
Sulfamethoxazole	<1	<1		3				<1		<1	3
Concentrations are semi-quantitative estimates, given in ng/L with a potential +/-50% variance.											

Courtesy: Andy James and Dave Wark, enter for Urban Waters, UW Tacoma

SUMMARY OF GROUNDWATER SAMPLING RESULTS

- 47% OF SAMPLES EXCEEDED THE COUNTY 'EARLY WARNING' LEVEL FOR NITRATE
- 15% OF SAMPLES EXCEEDED THE WA DOH TRIGGER CRITERIA OF 5 MG/L FOR NITRATE
- NUMEROUS CECS WERE DETECTED IN GROUNDWATER SAMPLES, SOME IN SEVERAL WELLS:
  - PESTICIDES/HERBICIDES
  - INDUSTRIAL CHEMICALS
  - COMMERCIAL CHEMICALS
  - PHARMACEUTICALS
  - FOOD ADDITIVES

CEC DETECTIONS IN SALISH SEA WATER ARE SIMILAR TO THOSE DETECTED IN TRI LAKES GROUNDWATER

Environmental Science & Technology pubs.acs.org/est Article

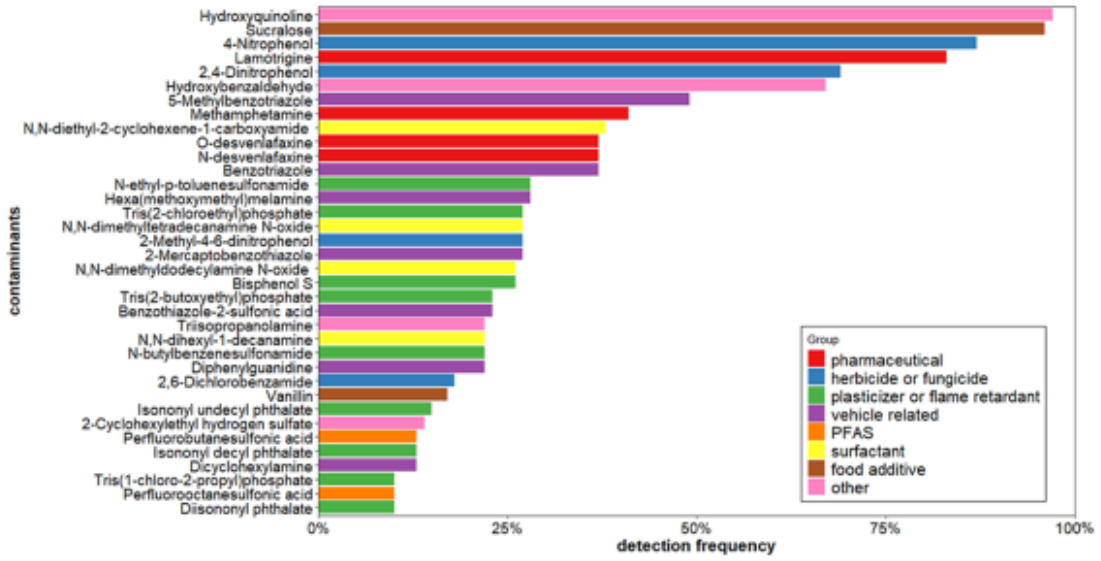


Figure 2. CECs detected in Puget Sound nearshore marine water, with detection frequency above 10% (n = 78, only including compounds with identification levels S1 and S2).

ASK AGAIN:
WHY DID SAMPLES HAVE 40% MORE NITRATE THAN MODELED?

MORE LIKELY REASONS:

1. SEPTIC WASTEWATER COULD BE MORE CONTAMINATED THAN MODELED 'SOURCES' (NOTE: LESS LIKELY B/C GOOD ENFORCEMENT + EDUCATION IN WOODLAND CREEK WATERSHED)
2. ADDITIONAL SOURCES:
   - **LAWNS/YARDS…**
   - **STORMWATER…**
     - ANIMAL WASTE?
     - AGRICULTURE?