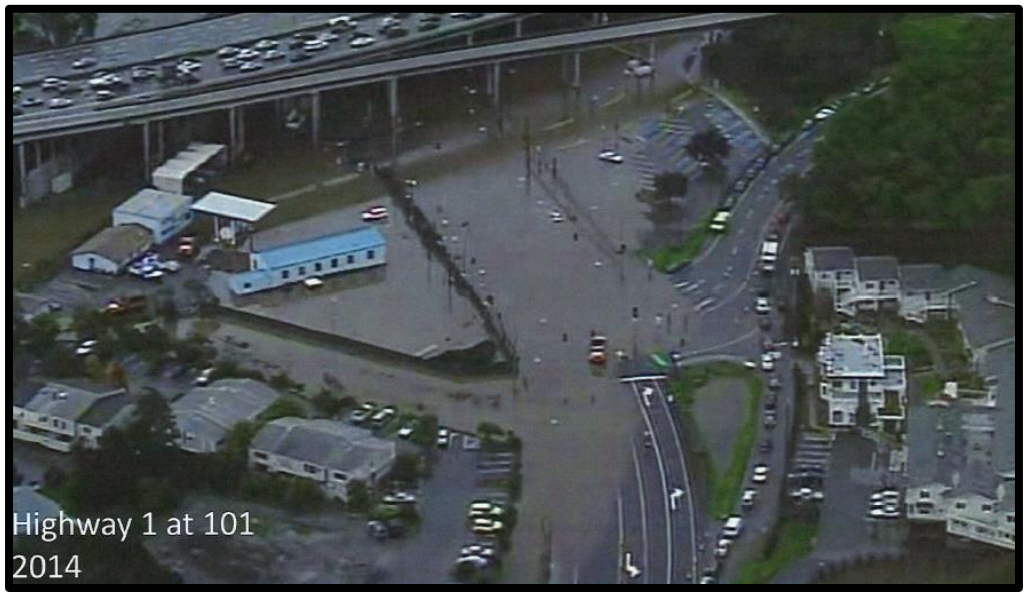
Atchison Village: Groundwater Flooding, Sea Level Rise (SLR), and Atmospheric River Conditions (ARCs)

March 12, 2023 presented to the Atchison Village Community at Atchison Village Hall, live and by Zoom

Jim Jacobs jaajacob@ucsc.edu

DRAFT- PRELIMINARY DATA

Putting Sea Level Rise Into Perspective and Developing a Plan



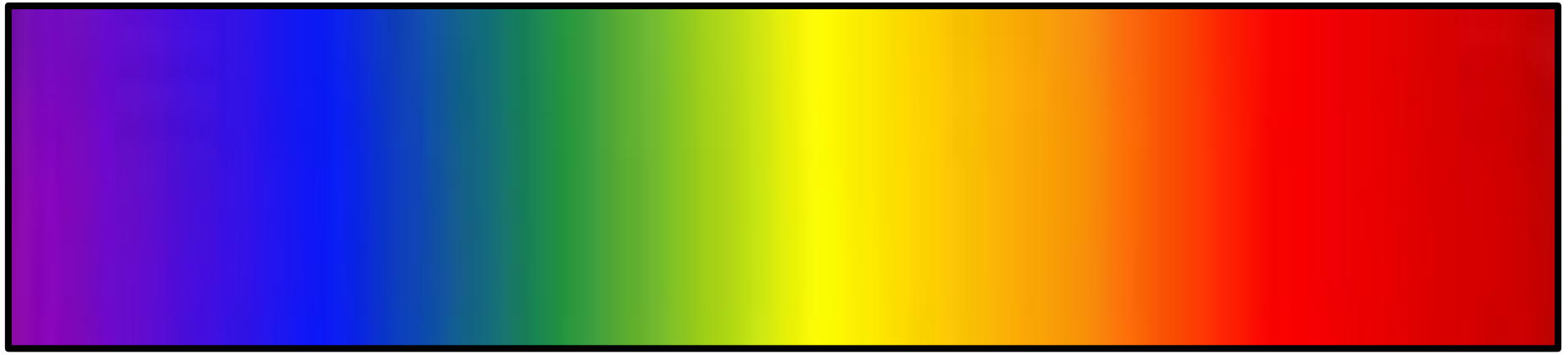
Top left, Chris Choo, County of Marin, 8/15/21 Talk to SASM; Manzanita – 101 intersection flooding, lower left, Wikipedia, right, NOAA

Concept of Stages – Days of High Tide Flooding (HTF)

Stage 1
Occasional Flooding
Nuisance

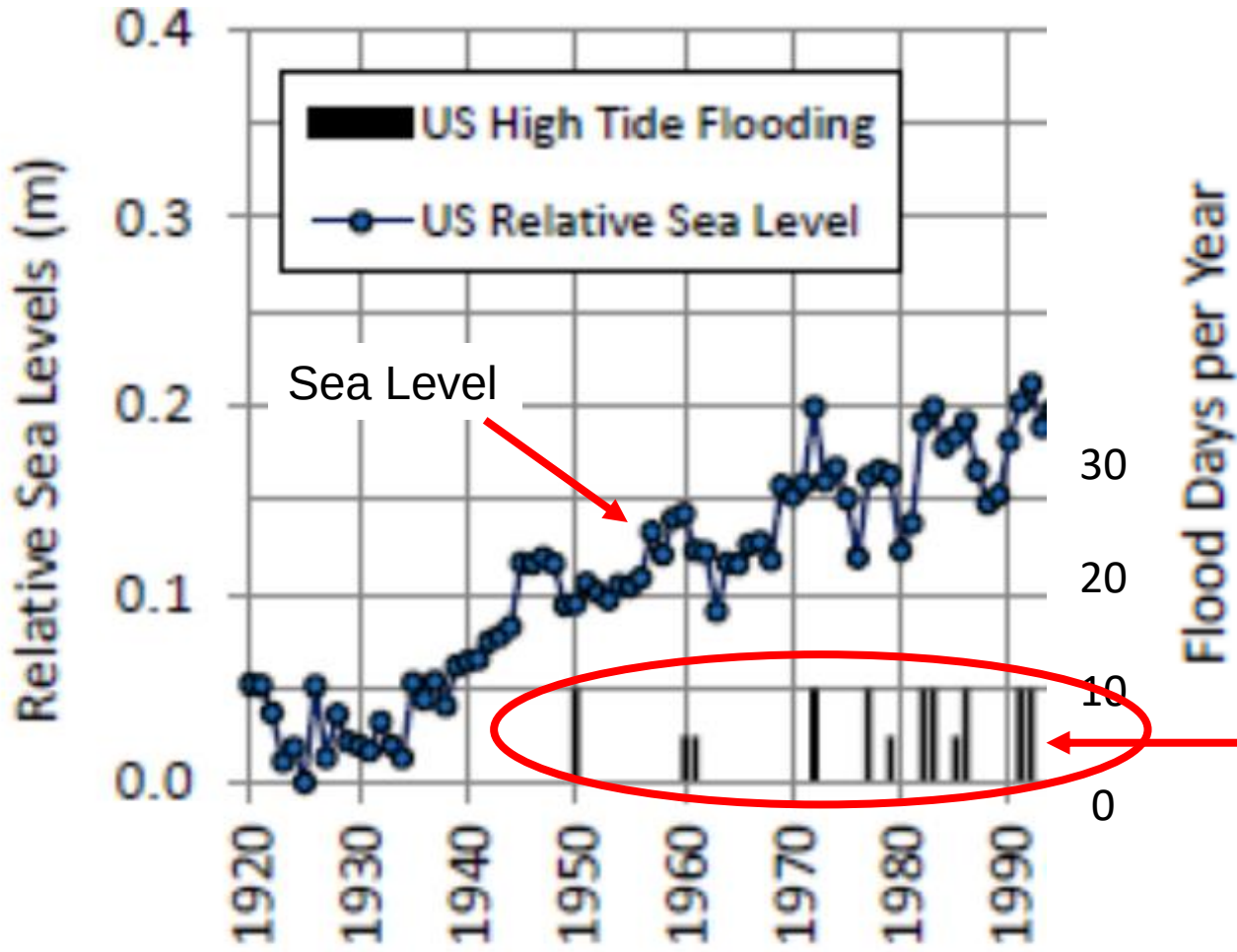
Stage 2
Common Flooding
Life Disrupting

Stage 3
Constant Flooding
Unlivable



Concept Stage 1 – Occasional Flooding, Nuisance
About once per month – flooded roads, occasional sewer spill
Richmond, CA, Tam Valley, CA

US High Tide Flooding and Sea Level



General Concept of Days of High-Tide Flooding; Stage 1

https://tidesandcurrents.noaa.gov/publications/2021_State_of_High_Tide_Flooding_and_Annua look_Final.pdf

Stage 1 – Occasional Flooding, Nuisance: What will I lose?

Richmond, CA (Atchison Village)

Barbara Postel

Concept of Stages – Days of High Tide Flooding (HTF)

Stage 1
Occasional Flooding
Nuisance

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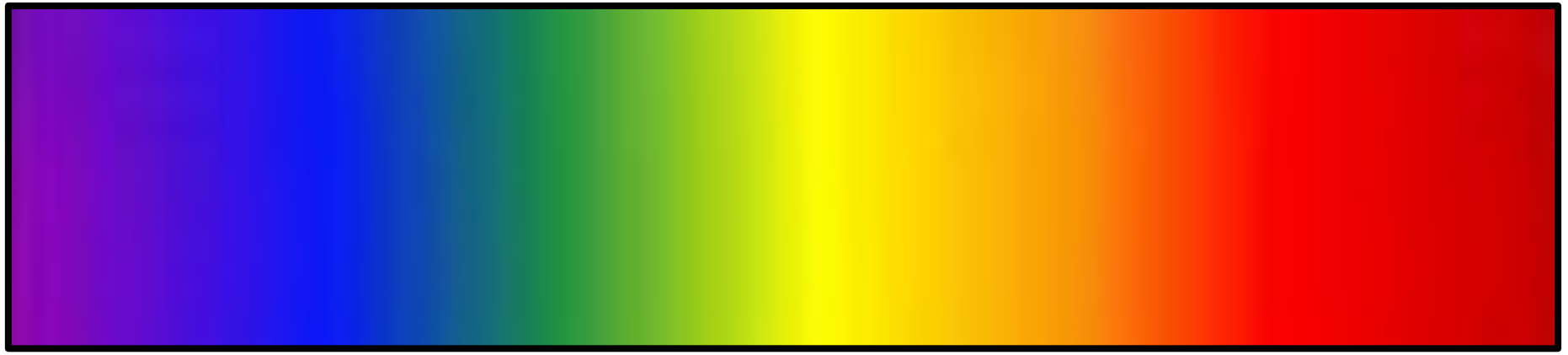
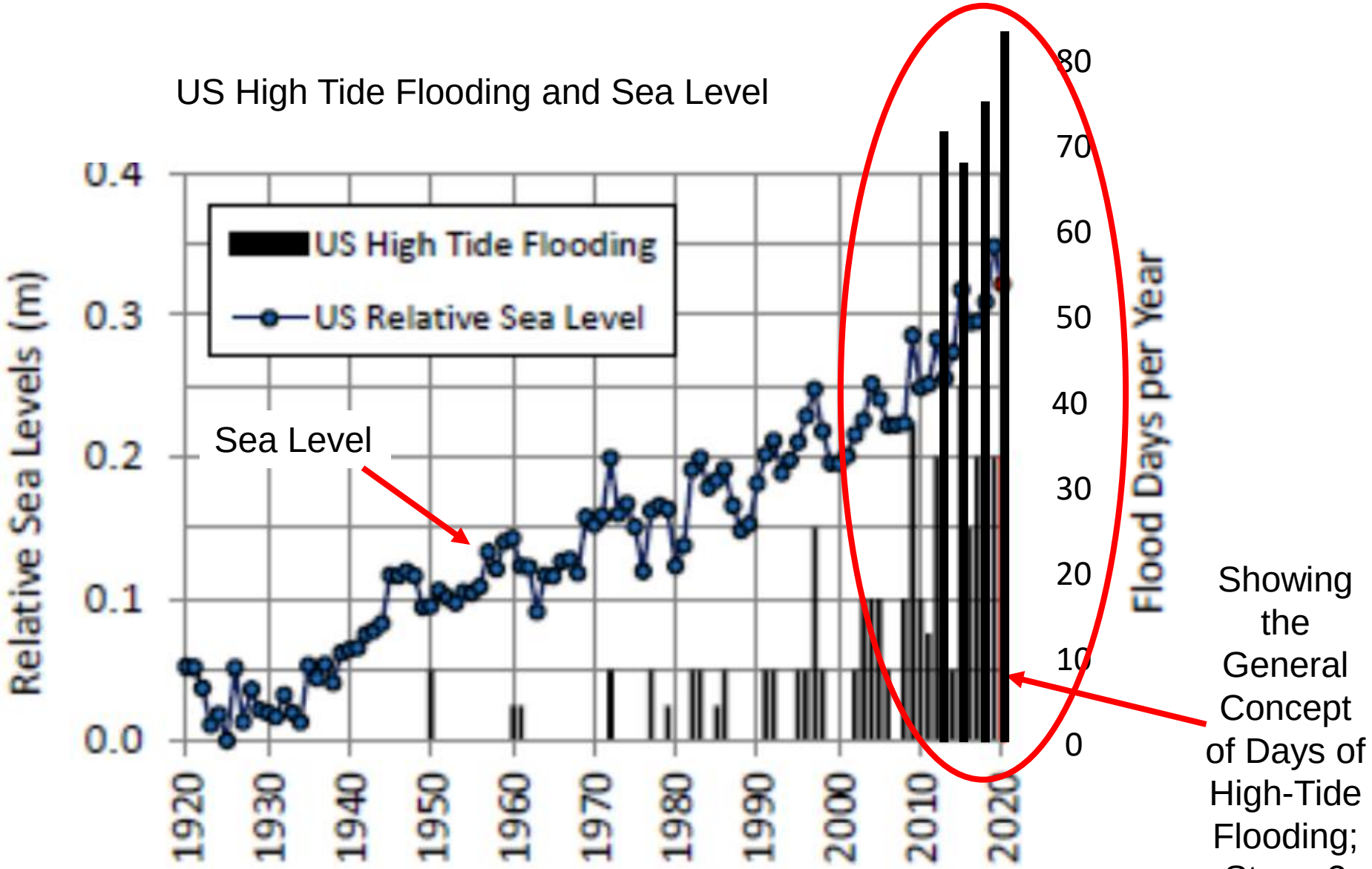
Life Disrupting

Stage 3
Constant Flooding
Unlivable



Concept Stage 2 – Common Flooding, Life Disrupting

Hampton, NH, Boston, MA, Annapolis, MD, Baltimore, MD, Charleston, SC, Miami, FL



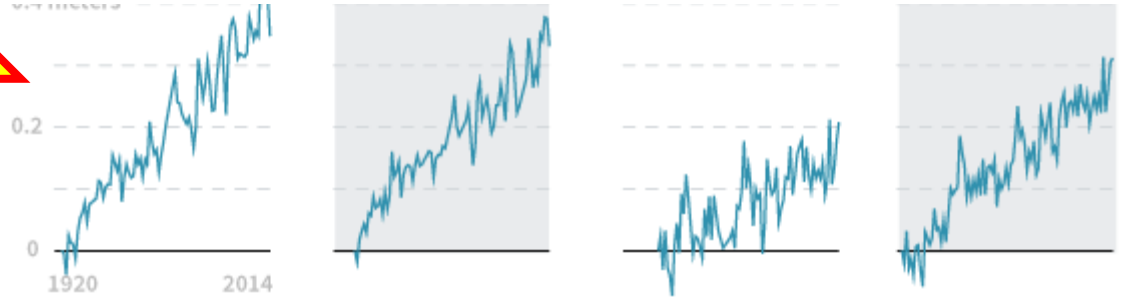
https://tidesandcurrents.noaa.gov/publications/2021_State_of_High_Tide_Flooding_and_Annual_Outlook_Final.pdf

Concept Stage 2 – Common Flooding, Life Disrupting
NOAA - Days of High-Tide Flooding By 4 East Coast Cities

Since 2001, water has reached flood levels an average of 20 days or more a year at the four tide gauges below. Before 1971, none averaged more than five days a year.

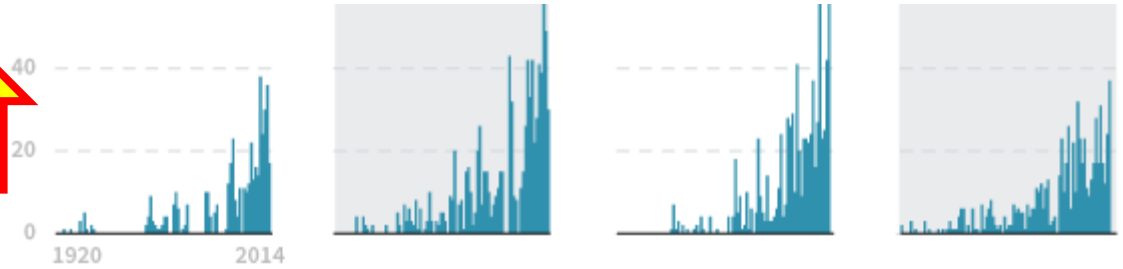
Atlantic City., NJ - Annapolis, MD - Wilmington, NC - Charleston, SC

Sea Level



Atlantic City., NJ - Annapolis, MD - Wilmington, NC - Charleston, SC

Days of High-Tide Flooding



Source: Reuters analysis of National Oceanic and Atmospheric Administration data

https://revolution-computing.typepad.com/.a/6a010534b1db25970b01a3fd3b5e69970b-pi

Concept Stage 2 – Common Flooding, Life Disrupting

NOAA – 2021 High Tide Flooding (HTF) Mapping:

How much longer can I live with this? Is it worth it?

Bay Waveland, MS

Charleston, SC

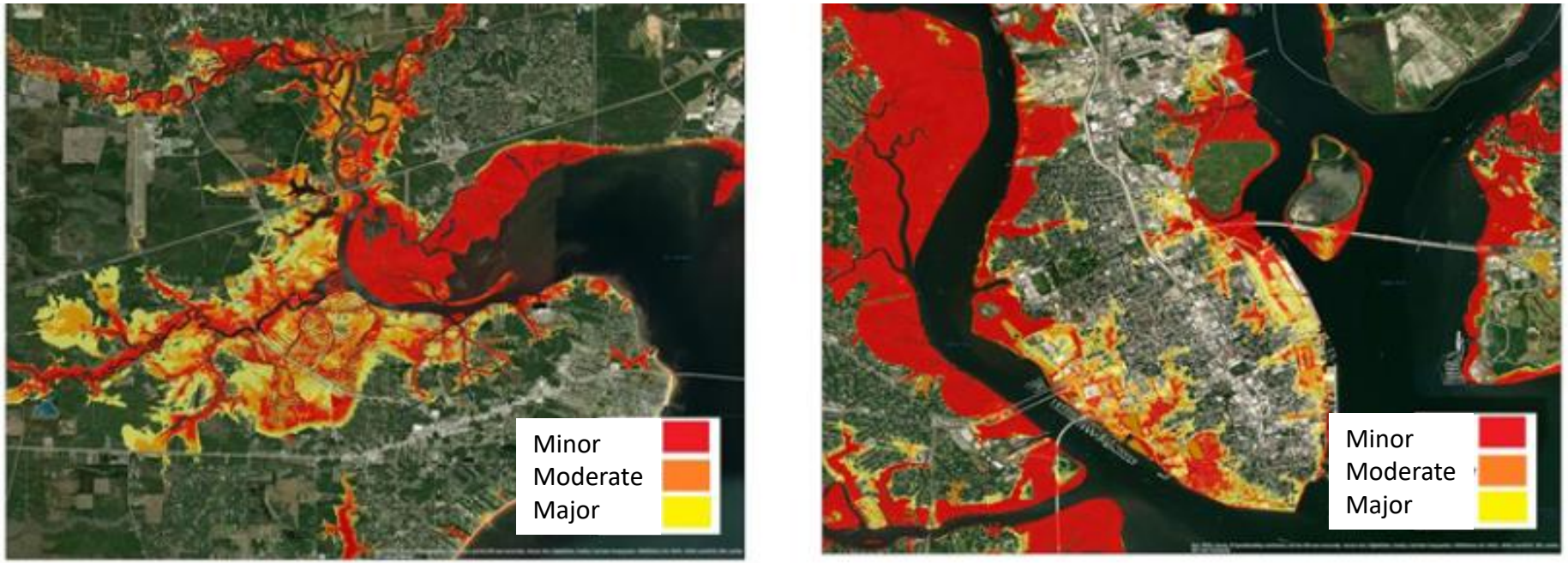


Figure 1. Map for minor (red), moderate (orange) and major (yellow) HTF layers for a) Bay Waveland, Miss. and b) Charleston, S.C. mapped by the same methods as NOAA's Sea Level Rise Viewer.[4] Red is used for the minor HTF layer since it will be flooded under all three HTF categories.

https://tidesandcurrents.noaa.gov/publications/2021_State_of_High_Tide_Flooding_and_Annual_Outlook_Final.pdf

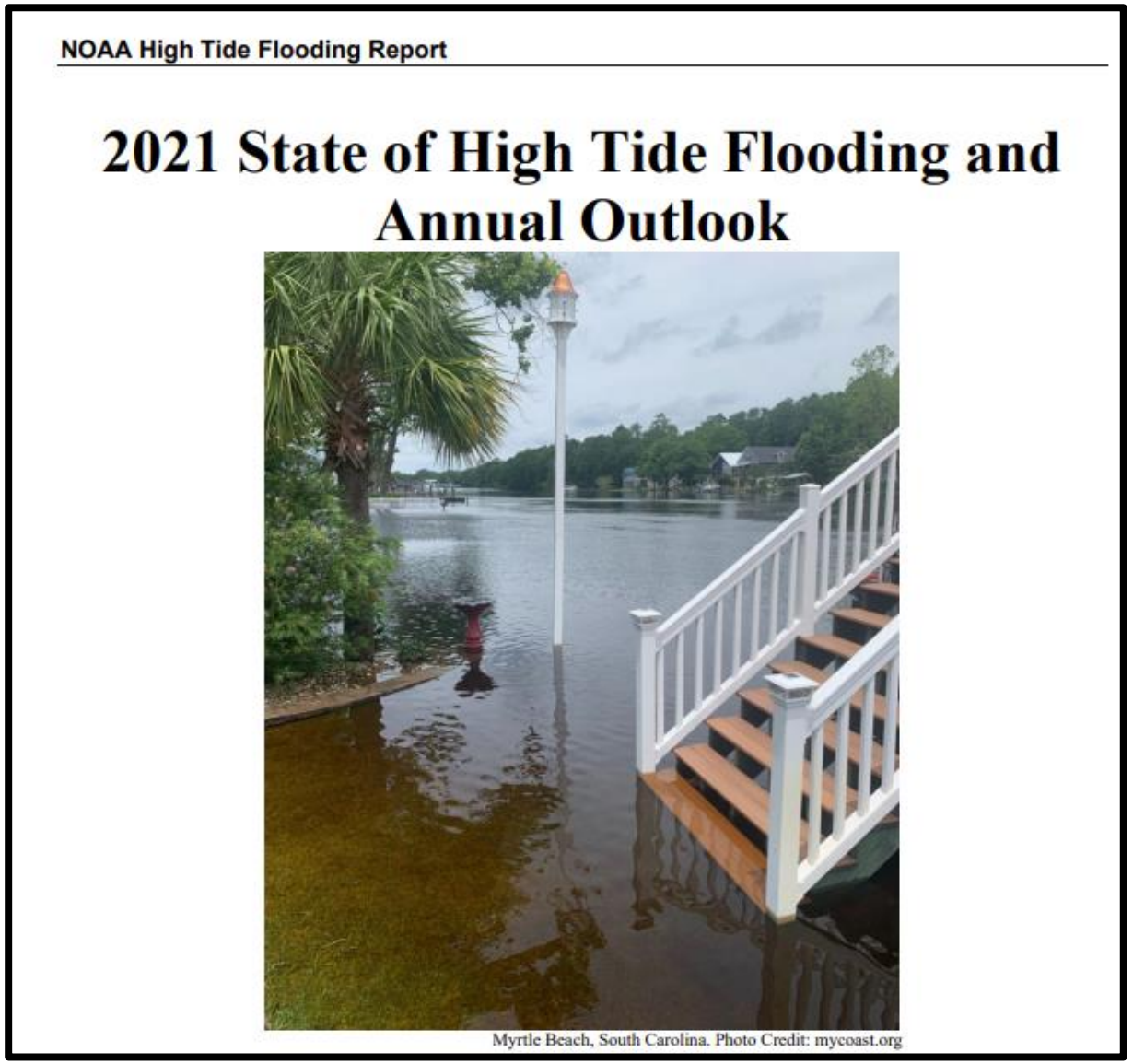
Concept Stage 2 – Common Flooding, Life Disrupting

Annapolis, MD – one of most vulnerable US cities to sea level rise flooding

https://www.baltimoremagazine.com/section/sciencetechnology/the-sea-also-rises

Concept Stage 2 – Common Flooding, Life Disrupting

Myrtle Beach, SC



https://tidesandcurrents.noaa.gov/publications/2021_State_of_High_Tide_Flooding_and_Annual_Outlook_Final.pdf

Concept of Stages – Days of High Tide Flooding (HTF)

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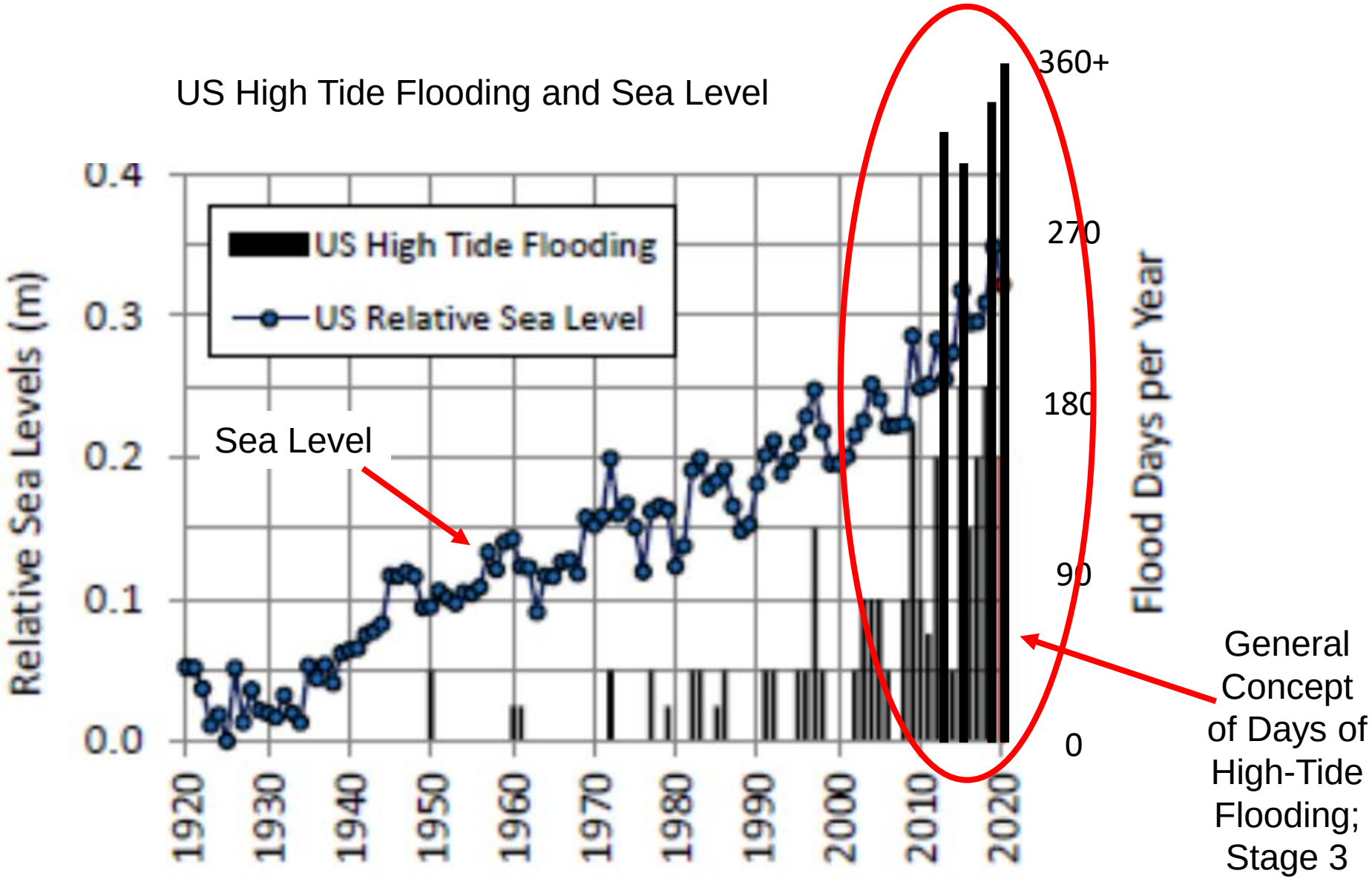
Nuisance

Stage 2
Common Flooding
Life Disrupting

Stage 3
Constant Flooding
Unlivable

Concept Stage 3 – Constant Flooding, Unlivable: Holland Island, Chesapeake Bay, MD



https://tidesandcurrents.noaa.gov/publications/2021_State_of_High_Tide_Flooding_and_Annual_Outlook_Final.pdf

Stage 3 - Last house on Holland Island in October 2009
The house fell into the Chesapeake Bay in October 2010

What can I save?

https://en.wikipedia.org/wiki/Holland_Island#/media/File:Holland_Island_house.jpg

(1888 - 2010)

Stage 3 – Holland Island Pine Tree in Chesapeake Bay, Maryland

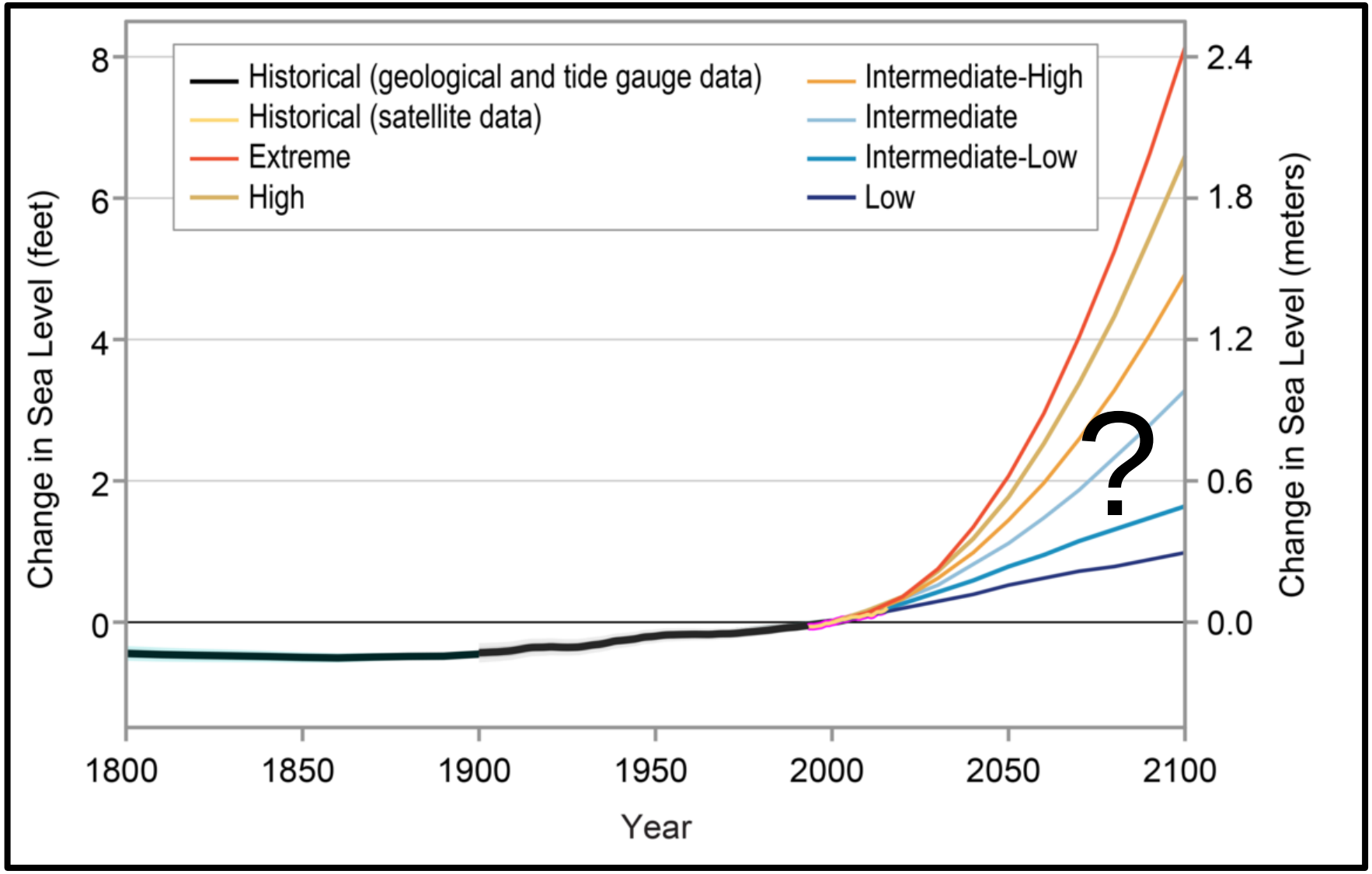
https://www.baltimoremagazine.com/section/sciencetechnology/the-sea-also-rises

Concept of Stages – Days of High Tide Flooding (HTF)

Stage 1	Stage 2	Stage 3
Occasional Flooding	Common Flooding	Constant Flooding
Nuisance	Life Disrupting	Unlivable

Willing to Lose	Tipping Point	Want to Salvage

Community Responses – Solutions and Planning



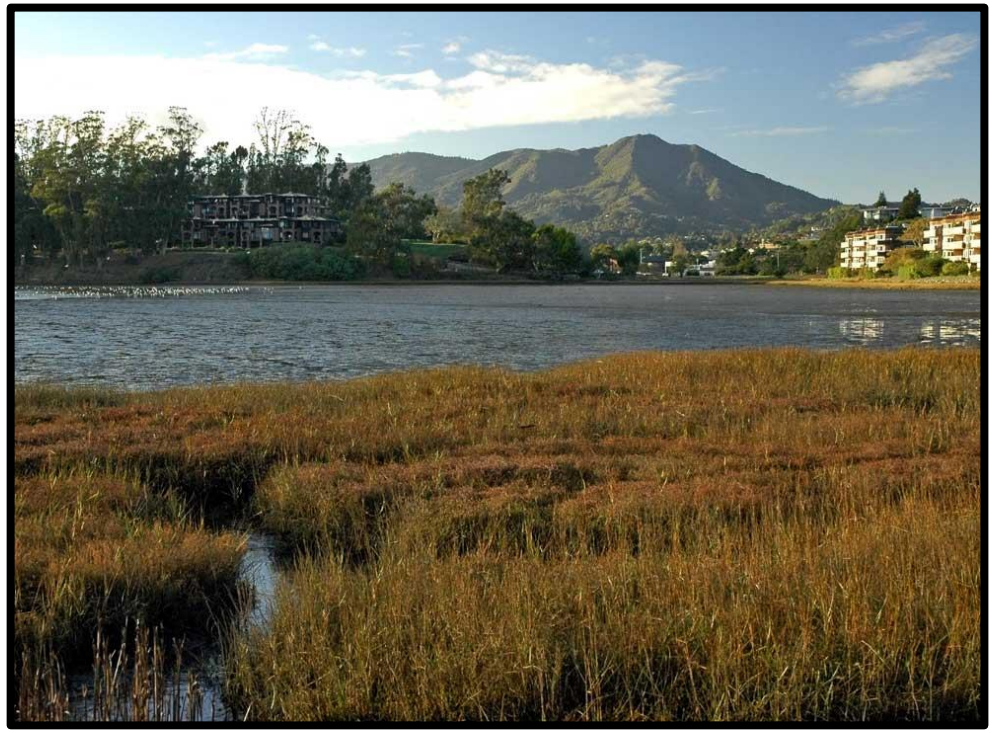
https://www.nrdc.org/experts/rob-moore/new-ipcc-report-sea-level-rise-challenges-are-growing

Community Responses – Communicate the Risk of Sea Level Rise

https://www.nrdc.org/experts/rob-moore/new-ipcc-report-sea-level-rise-challenges-are-growing

Community Responses – Green Infrastructure (Short Term)

Marshes and Wetlands:
Bothin Marsh, Tam Valley, CA



Green Infrastructure – cost effective and sustainable flood management to remove water at its source

- Open Spaces
- Marshes and Wetlands
- Rain Gardens and Bioswales
- Beach Dunes and Renourishment
- Natural Barriers

Modified after https://floodfactor.com/zip/94941/94941_fsid#community_solutions

Community Responses – Gray Infrastructure (Short Term – Medium Term)

Gray Infrastructure - Concrete and Steel Structures, Pumps

- Seawalls, Floodwalls, Rip-Rap
- Upgraded and Elevated Roadway Infrastructure
- Elevated or Floating Infrastructure
- Levees, Dams, Dikes, and Weirs
- Tide and Flood Gates
- Stormwater and Groundwater Pumps
- Upgraded Stormwater Systems
- Tight Wastewater Systems
- Control of Preferential Pathways
- Regular Operations and Maintenance

Modified after https://floodfactor.com/zip/94941/94941_fsid#community_solutions

Community Response – Resilience (Long Term)

Source: City of Pacifica Preliminary Draft Sea Level Rise Adaption Plan

Community Resilience – Major Adaptation to sea level rise

- Community Response Workplan (needs and concerns)
- Managed Retreat – property buyout plan, building relocation,
- Floodplain Ordinances (Planning and Zoning Dept.)

https://www.arcgis.com/apps/MapJournal/index.html?appid=bea8d4142fcf47bc90078e845e296d64

Atchison Village – Long History of Flooding

(Photo – Barbara Postel)

Richmond, CA (Atchison Village) – Lake Curry, Dec 1960

A CITY LAKE—This was Richmond after torrential rains, accompanied by lightning and gale force winds, pounded the city today. A typical scene as storm drains failed to cope with the downpour, was this picture taken at Chanslor Ave. and Curry St., in Atchison Village, showing cars isolated by sudden flash flooding.

—Independent photo

Photos courtesy of Barbara Postel

Richmond, CA (Atchison Village) – Lake Curry, March 2012

Photos courtesy of Barbara Postel

Winter 2016-2017

Richmond, CA (Atchison Village) – Flooding

December 2014

Historic flooding may be related to inoperable:

- Stormdrain systems
- Clogged drainage ditches and channels
- Tide gates blocked by sea water

Solution: Operations and Maintenance

Sidewalk flooding 1 week after rains

Photos courtesy of Barbara Postel

Causes of Atchison Village Flooding

- Sea Level Rise?
- King Tides?
- Extreme Rains?
- Inoperable Stormwater and Drainage Systems?
- Groundwater Emergence?

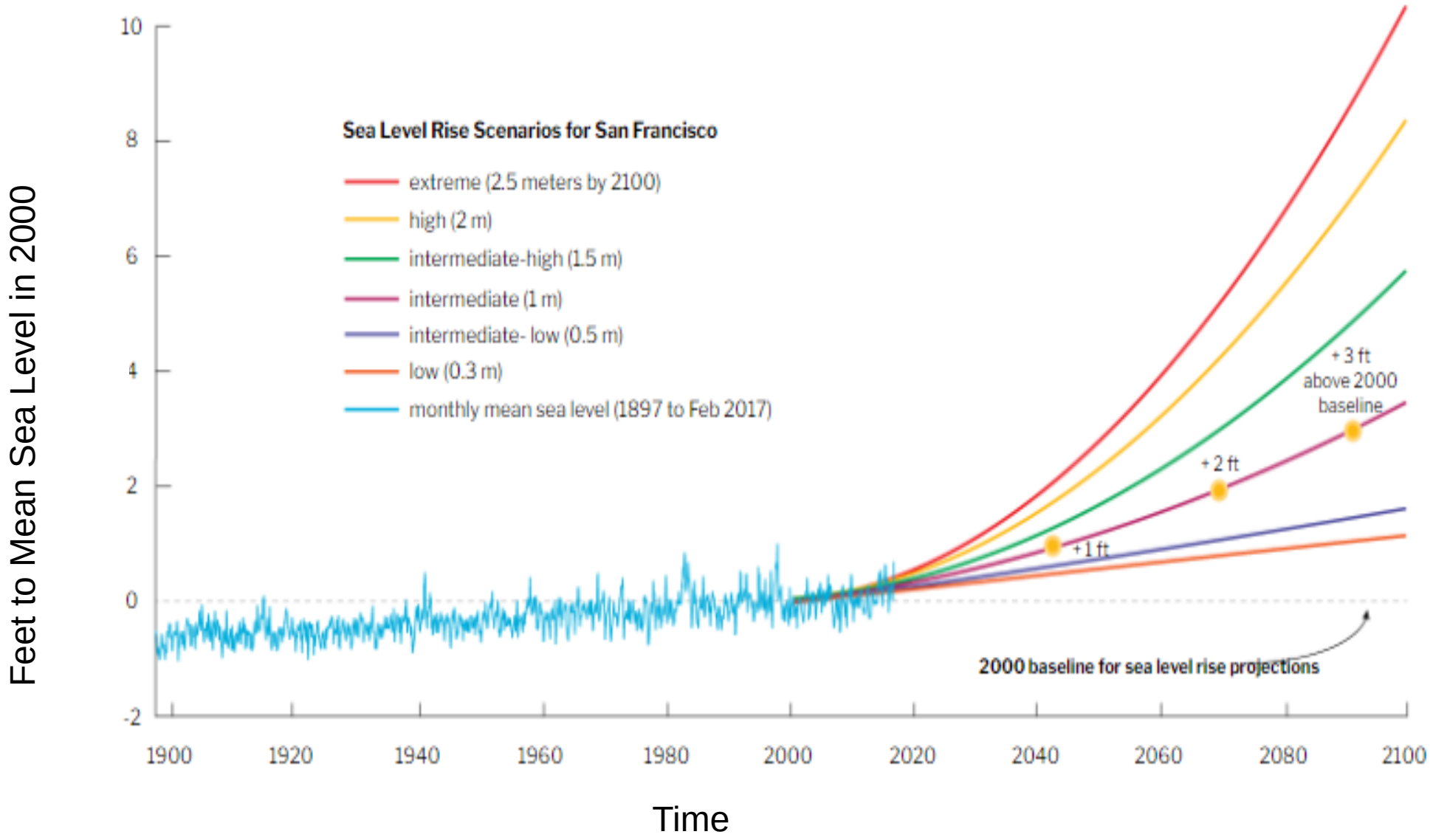
(Photo – Barbara Postel)

Atchison Village: Sea Level Rise (SLR), Groundwater Flooding, and Atmospheric River Conditions (ARCs)

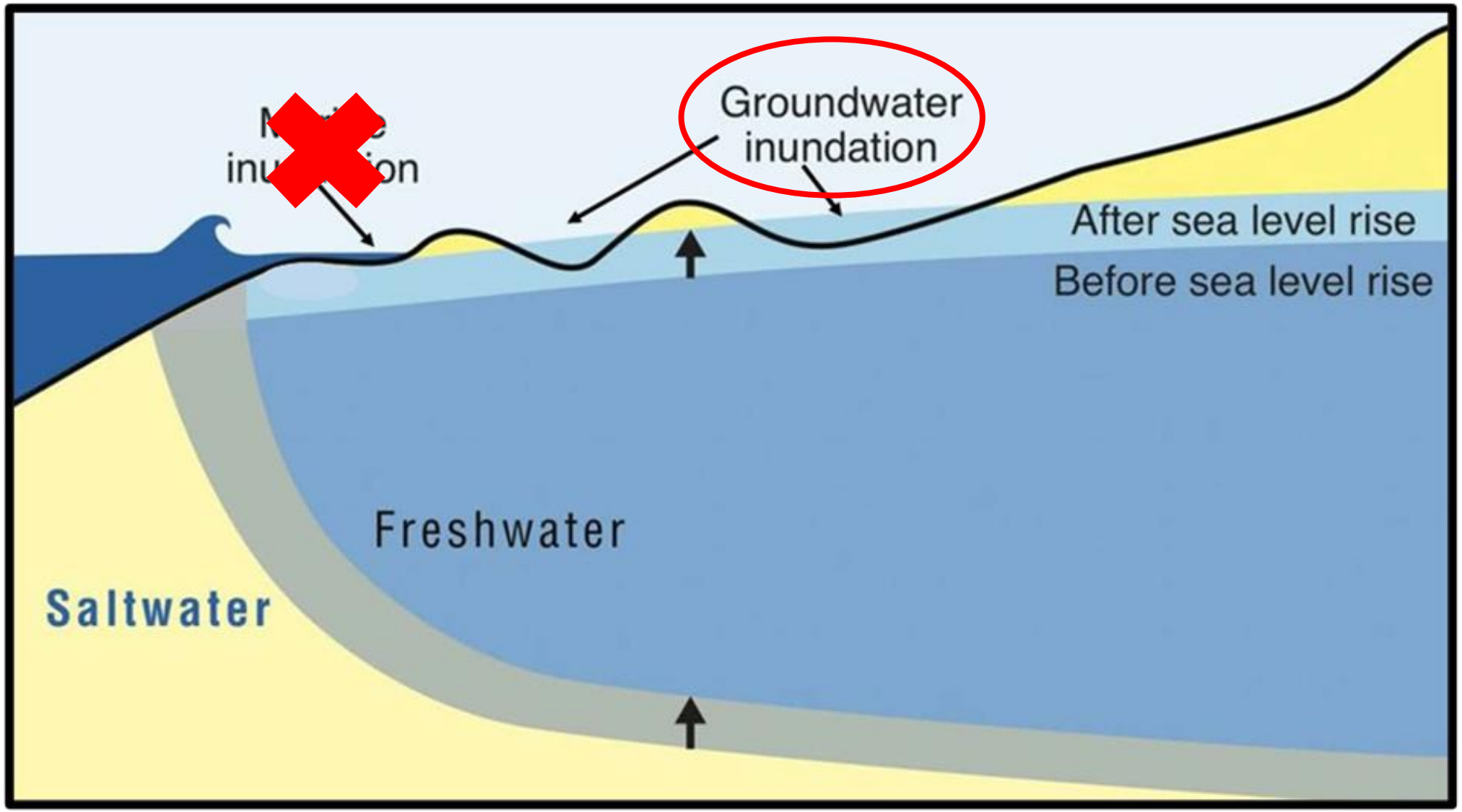
Jim Jacobs jaajacob@ucsc.edu

Question 1 - Will sea level rise (SLR) impact groundwater at Atchison Village, and can “king tides” be a proxy?

Rising Sea Level (in meters), San Francisco (NOAA data: San Francisco Area, NOAA, 2017



Sea Level Rise: Marine Overtopping or Groundwater Inundation (Emerging Groundwater)

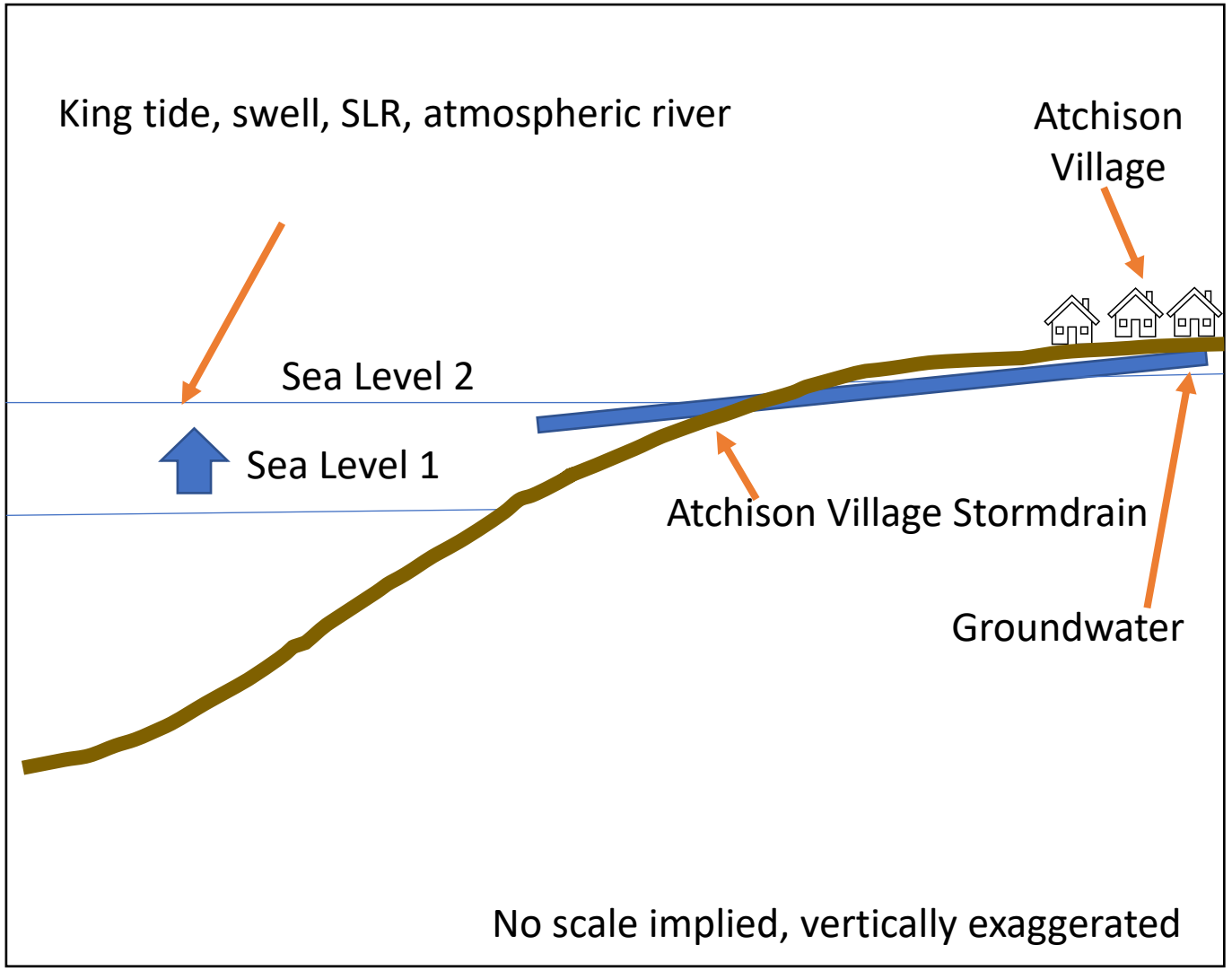


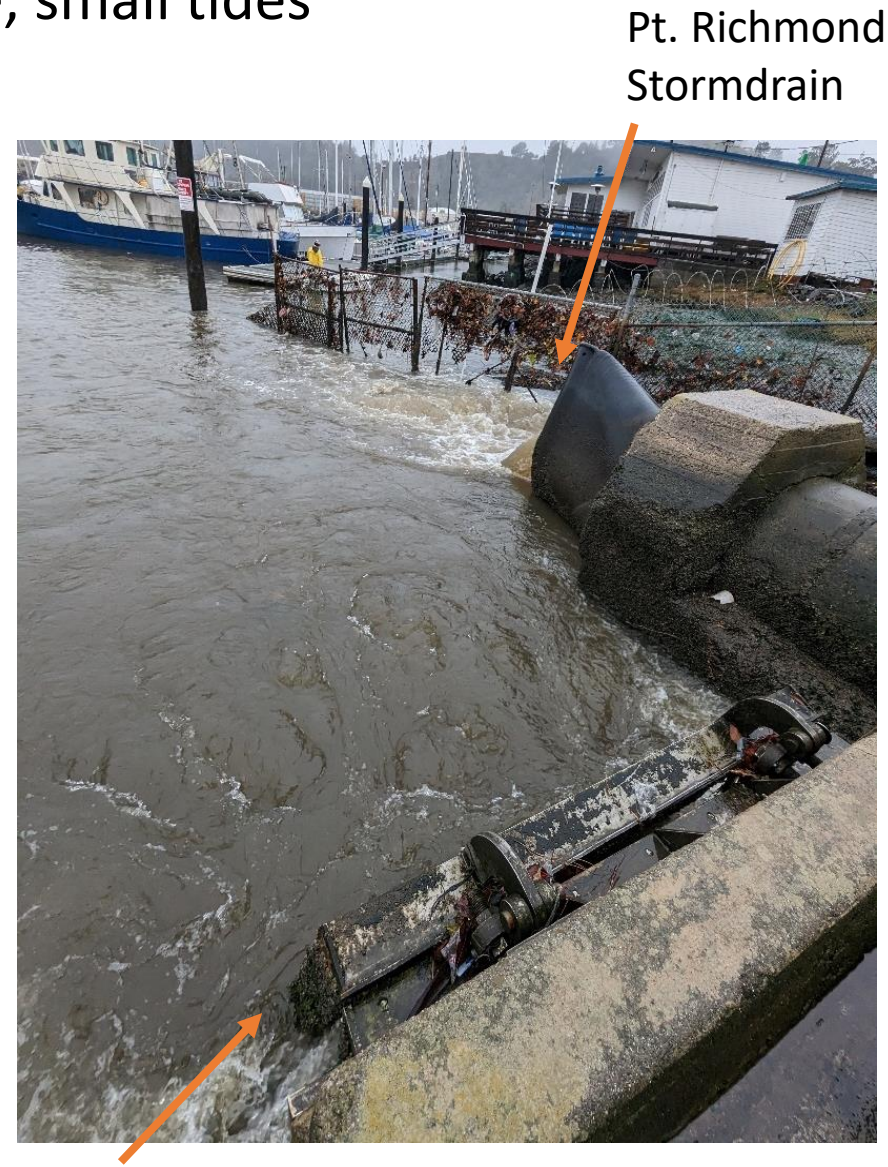
From Univ. Hawaii, Manoa, Coastal Studies Group

Atchison Village – 0.5 Miles from Santa Fe Channel; 12-15 feet above sea level

Atchison Village and the Atmospheric River; Richmond Yacht Harbor at Stormdrain Outflow; 12/31/22 (Barbara Postel)

Lack of discharge elevation – king tides, SLR, storm surge, small tides





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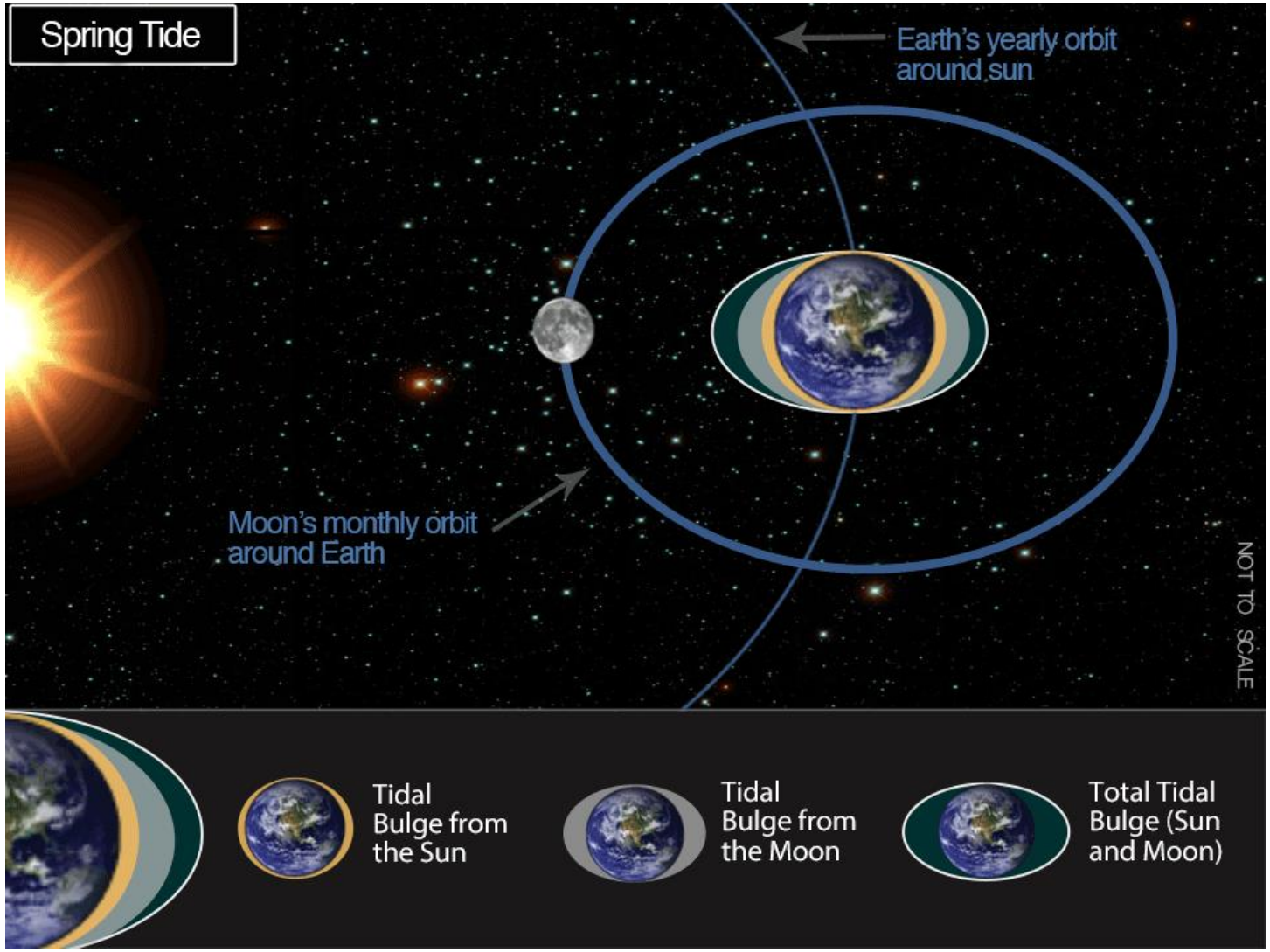
Causes of Atchison Village Flooding

- Sea Level Rise?
- King Tides?
- Extreme Rains?
- Inoperable Stormwater and Drainage Systems?
- Groundwater Emergence?

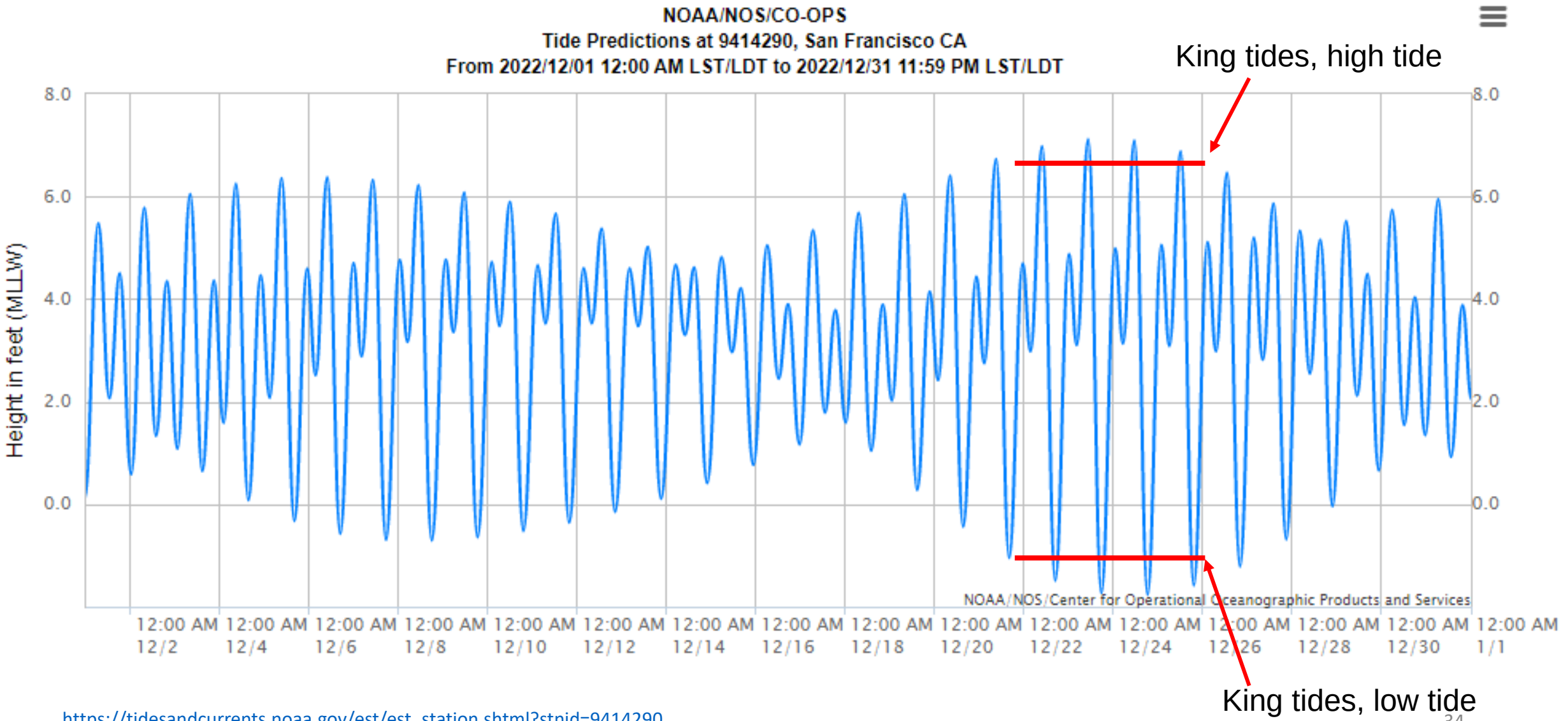
(Photo – Barbara Postel)

Question : Can Highest Astronomical Tides (‘king tides”) be a proxy for future higher sea level?



“Spring tide” means springing forth,
highest tides, during new moons (“king tides”)
https://oceanservice.noaa.gov/facts/springtide.html

San Francisco; 12/1/22 to 12/31/22 (NOAA data) highest monthly tides from 12/22/22 to 12/24/22; rainless;
Question: With sea level rise, can king tides be a proxy for future average tides?



https://tidesandcurrents.noaa.gov/est/est_station.shtml?stnid=9414290

Tides and Atchison Village – AVW2; King Tide on 12/24/22

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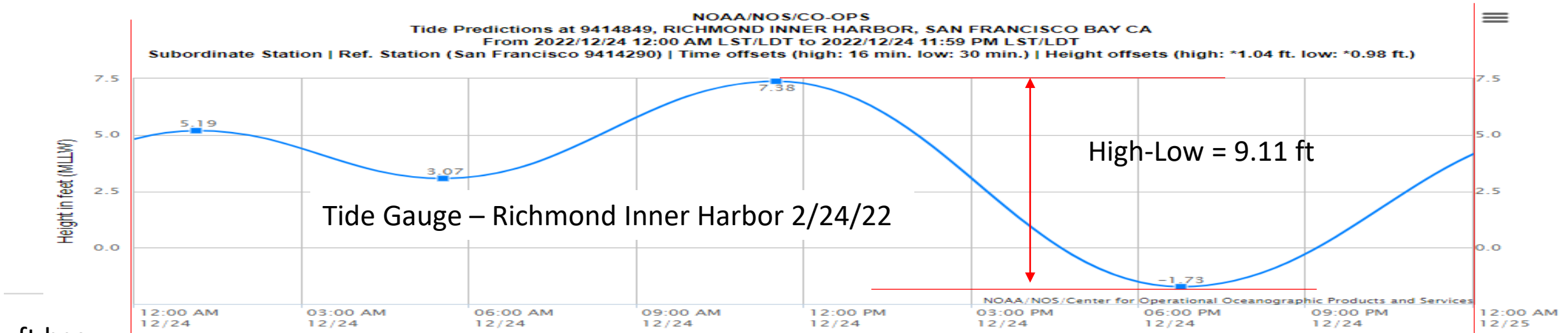
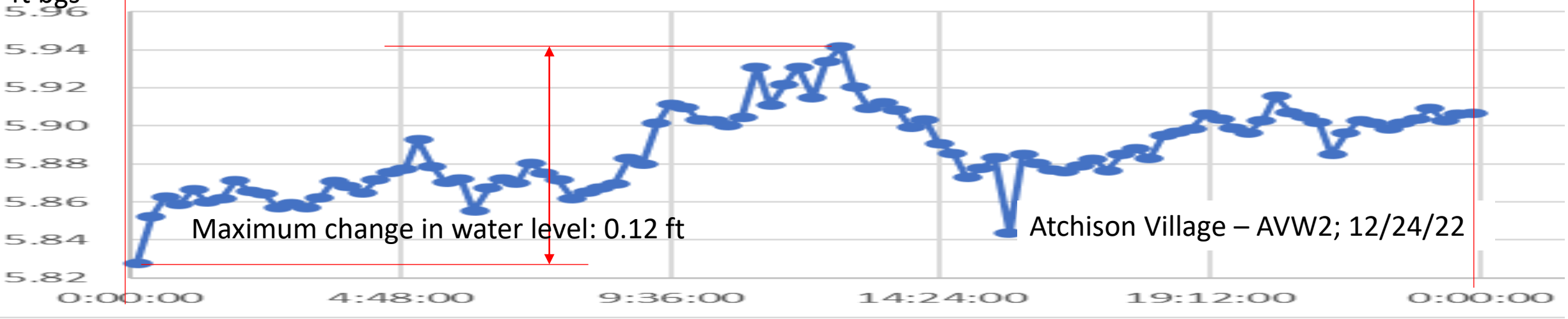
ft AMSL



ft bgs



Causes of Atchison Village Flooding

- Sea Level Rise?
- King Tides?
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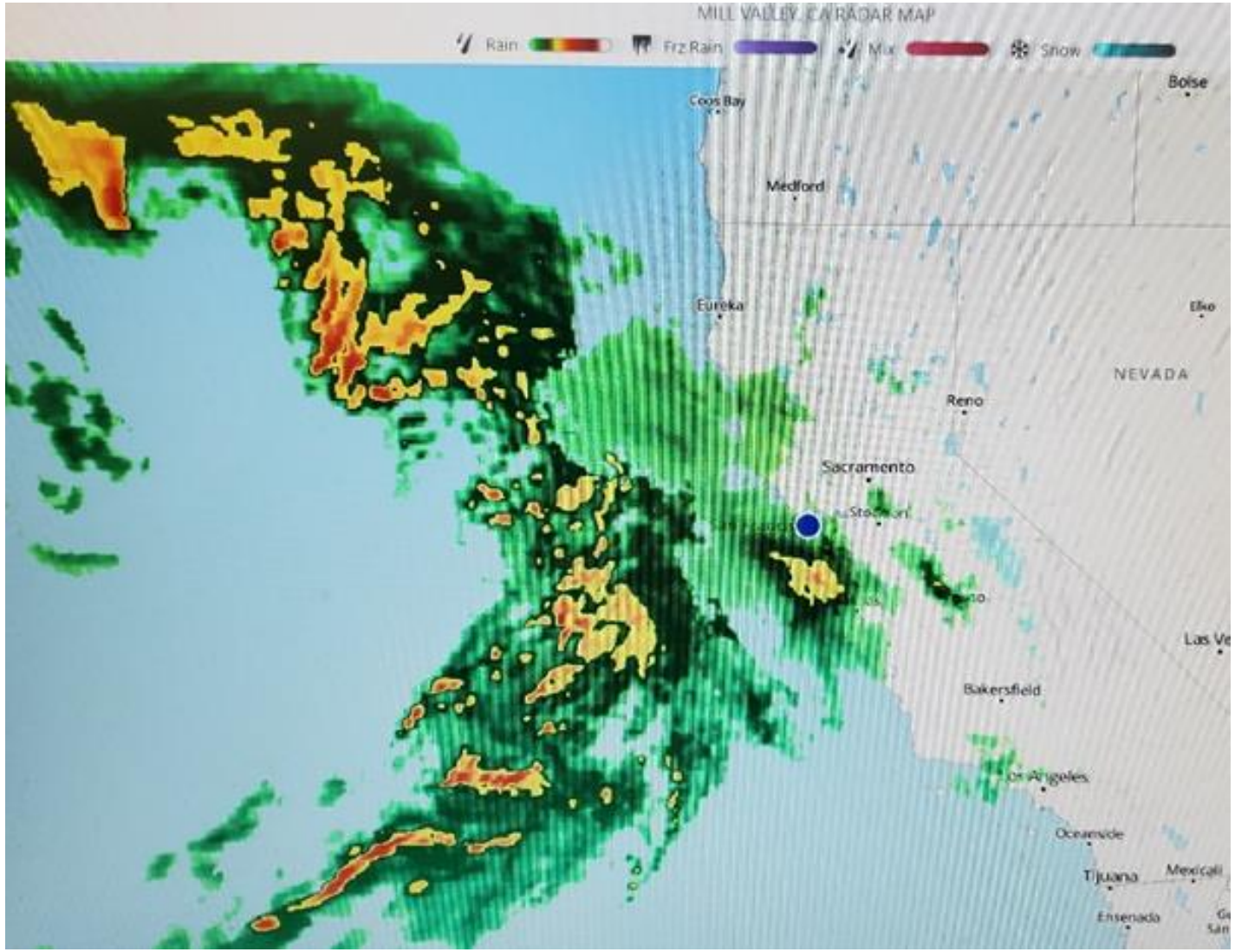
- Inoperable Stormwater and Drainage Systems?
- Groundwater Emergence?

(Photo – Barbara Postel)

Radar graphic from January 8, 2023 of an atmospheric river condition (ARC) which produced 0.72-inches of rain in Richmond, California on that date and 0.85-inches on 1/9/23

Atmospheric River Condition (ARC)

Similar concept for 43-day ARC in 1861 and great flood of 1862



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www.accuweather.com

Causes of Atchison Village Flooding

- Sea Level Rise?
- King Tides?
- Extreme Rains?
- Inoperable Stormwater and Drainage Systems?
- Groundwater Emergence?

(Photo – Barbara Postel)

Atchison Village: Sea Level Rise (SLR), Groundwater Flooding, and Atmospheric River Conditions (ARCs)

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Reduce impacts of ARCs and high groundwater:

1) Fix French drain system
2) Develop a large-scale pumping plan
3) Sewer trench dewatering
4) Maintenance of storm drains
5) Improve Richmond Yacht Harbor outflow flapper

Improvements in Drainage - Atchison Village – Maintenance (week of 11/21/22) and Operations of Stormdrain System

Maintenance and Operations

(Photos Barbara Postel)

RR1 location prior to maintenance (11/17/22)

RR1 location after maintenance (12/31/22)

Less Surface Flooding: Atchison Village and the Atmospheric River; 12/31/22 and 1/14/23

Reduced December 2022-January 2023 flooding due to maintenance and operations

"Lake Curry" on 12/31/22

"Lake Curry" on 1/14/23

(photos: Barbara Postel)

James Jacobs jaaajacob@ucsc.edu

Causes of Atchison Village Flooding

- Sea Level Rise?
- King Tides?
- Extreme Rains?
- Inoperable Stormwater and Drainage Systems?
- Groundwater Emergence?

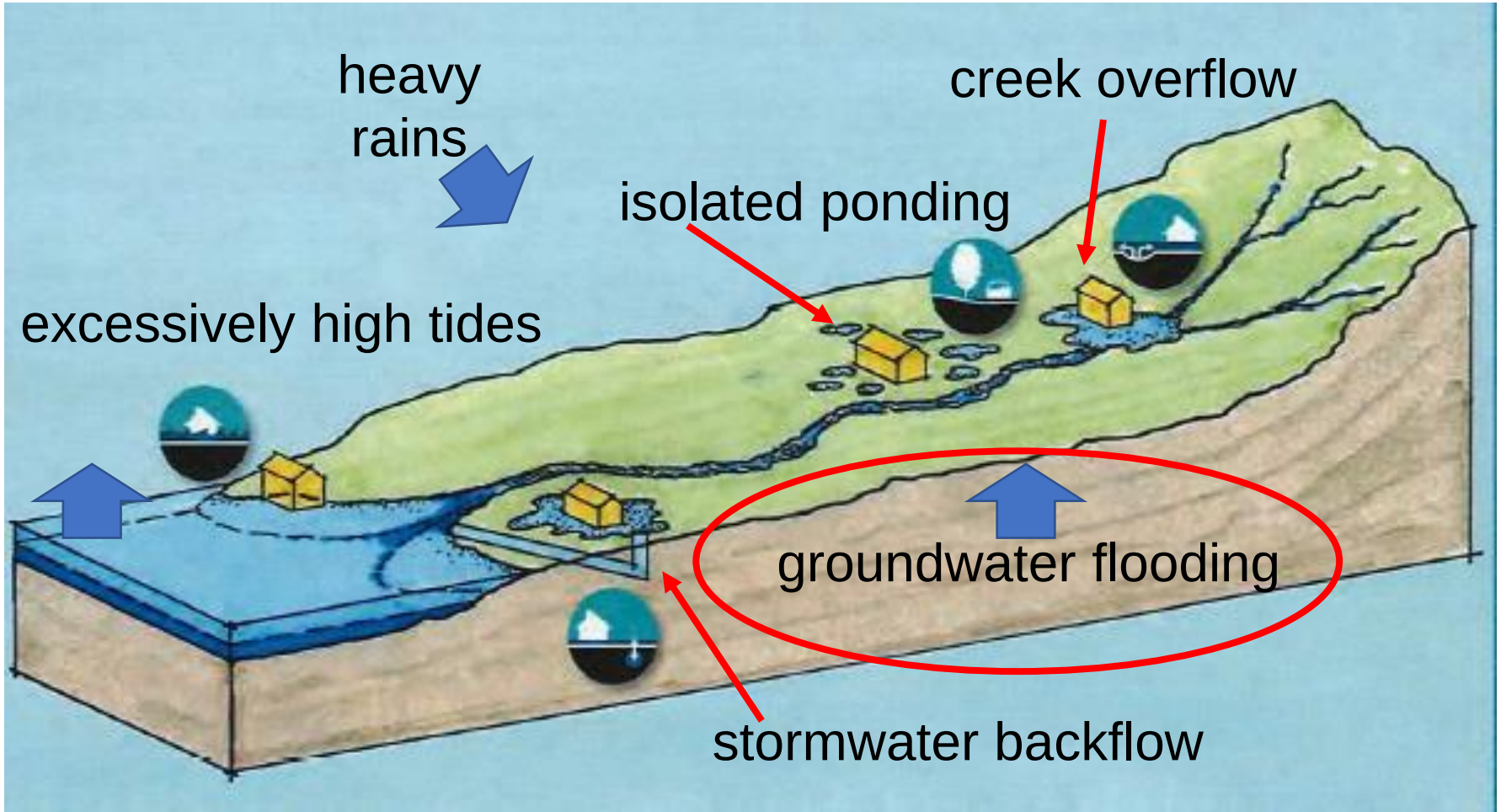
(Photo – Barbara Postel)

Selected Flood Factors Impact Wastewater and Transit Infrastructure

sea level rise (no ebb)
groundwater flooding (days to months)
isolated ponding (days to months)
heavy rain (days to weeks)
barometric pressure (low)

stormwater backflow (hours to days)
excessively high tides (king tides) (hours)
creek overflow (hours)
lunar nodal cycle (18.6 years; 2025 = +6 cm)
wind direction (toward shore) (hours to days)

Overtopping and groundwater emergence



Flooding in the BSNF railroad property near sample RR2 (center, right) shows groundwater mixing with rainwater and stormwater on 12/31/22

Causes of Atchison Village Flooding

- Sea Level Rise?
- King Tides?
- Extreme Rains?
- Inoperable Stormwater and Drainage Systems?
- Groundwater Emergence?

- or rainwater sitting on clay?

(photo: Barbara Postel)

Sources of Water:

Water isotopes

Dissolved Salts (calcium, sodium, magnesium, etc.)

Atchison Village: Sea Level Rise (SLR), Groundwater Flooding, and Atmospheric River Conditions (ARCs)

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Question 2 - Can community science volunteers make a meaningful contribution to the study?

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Participation and Assistants

Part of the NOAA grant was to encourage community involvement. Several volunteers from Atchison Village have participated in helping the project. Most notable is the resident historian, field volunteer, and photographer Barbara Postel. Barbara has also corresponded with residents of the ongoing field work. Other community science volunteers include Breana George, past president of the AVMHC, Kaylynn Schreve who has provided flood photographs, and Ellis McCauley, who has allowed access for soil boring on her property. Martin and Estela Gutierrez and Allen Schaaf have pre-existing irrigation wells on their property and have allowed access for sampling.

Kevin Pope

Barbara Postel

Atchison Village: Sea Level Rise (SLR), Groundwater Flooding, and Atmospheric River Conditions (ARCs)

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Introduction to Atchison Village

Atchison Village in the City of Richmond – Blue flood zones in 3 ft of Sea Level Rise

Atchison Village

https://coast.noaa.gov/slr/#/layer/vul-soc/4/-13630431.20059246/4570058.172637184/12/satellite/none/0.8/2050/interHigh/midAccretion

NOAA Sea Level Rise Viewer – Richmond, CA (Atchison Village)
1 ft Sea Level Rise – No Flooding

Atchison Village

Richmond, CA (Atchison Village) – Victory Ships and Rosie the Riveter

Historic 1941 Atchison Village Photographs (Warnecke Archives, Healdsburg, California)

Thanks to Barbara Postel for her historic research

Atchison Village: Sea Level Rise (SLR), Groundwater Flooding, and Atmospheric River Conditions (ARCs)

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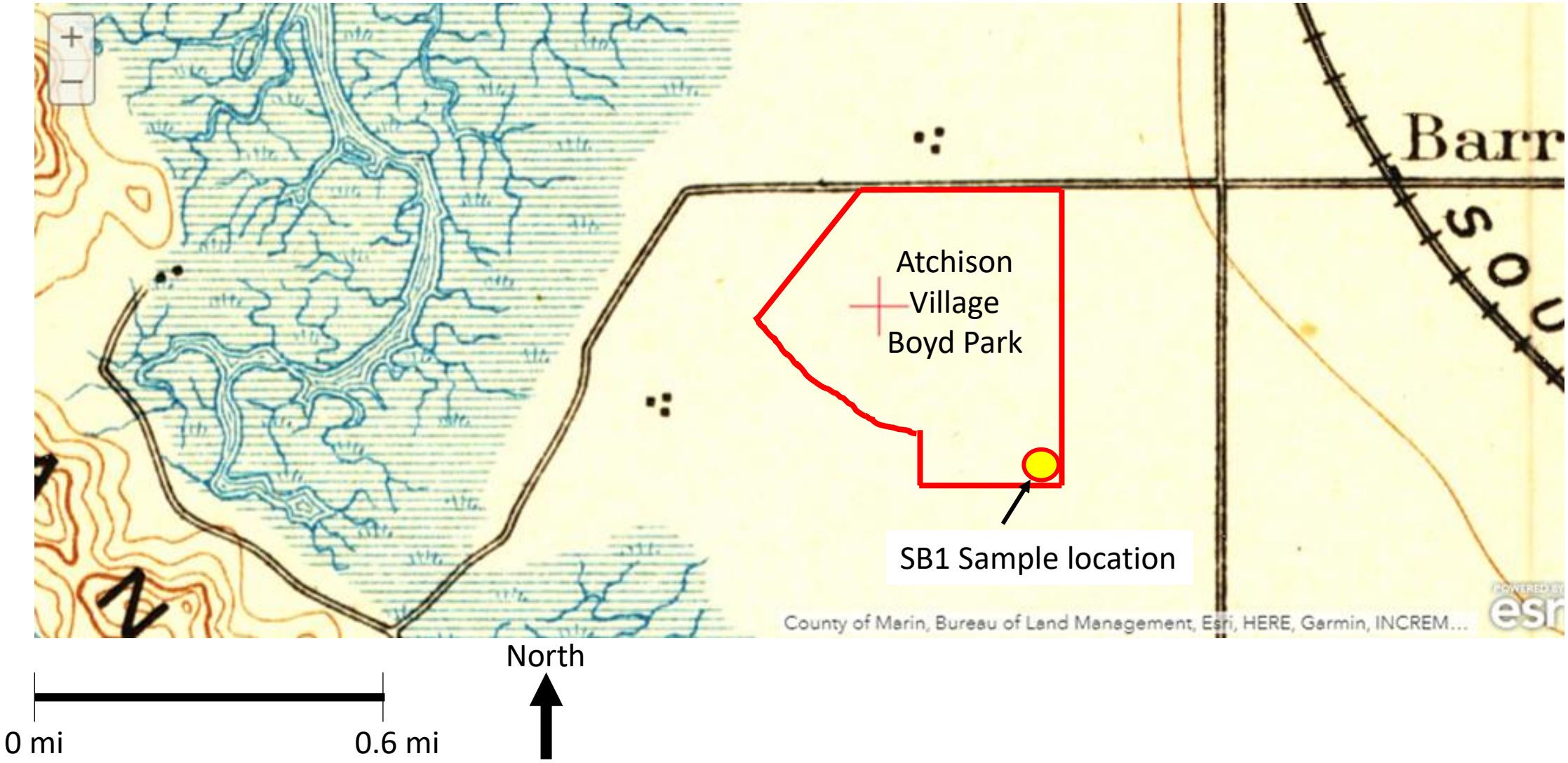
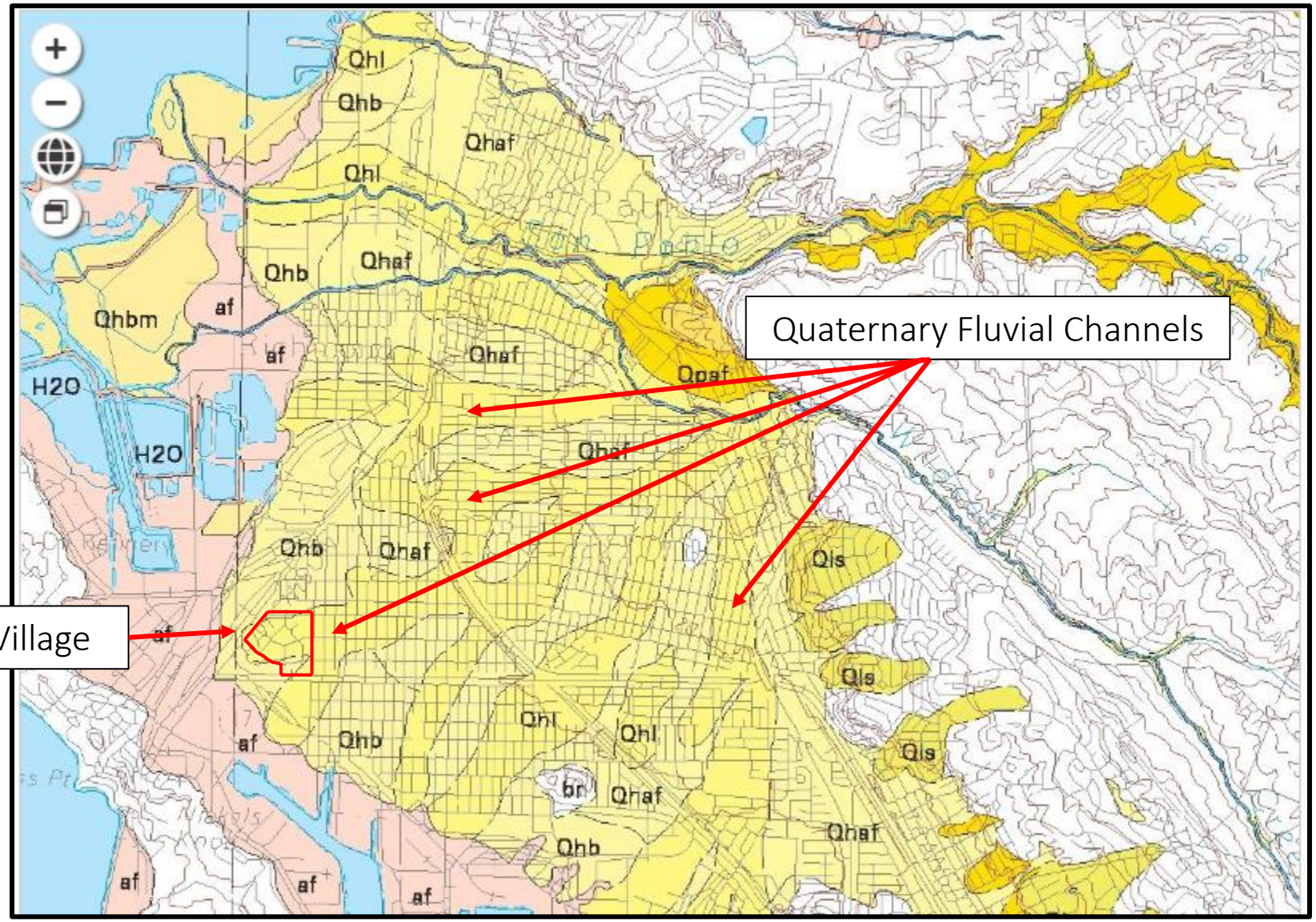
Atchison Village Geologic Setting

Atchison Village – flood plain adjacent to historic wetlands; plastic clays at 2.00 ft below ground surface



Geology of Richmond, California featuring Quaternary fluvial channels



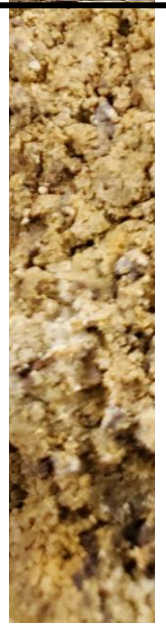
https://ngmdb.usgs.gov/Prodesc/proddesc_18709.htm; USGS, 1997 OFR-OF-97-98; Helley, E.J. and Graymer, R.W.

Atchison Village
Soil Boring SB1

Fill, sandy clay (CL) with red brick shards @ 2.0 ft

Native gray clay (CH), plastic, moist; 2.0 - 3.0 ft

Sandy clay (CL), moist; 3.0 – 4.9 ft



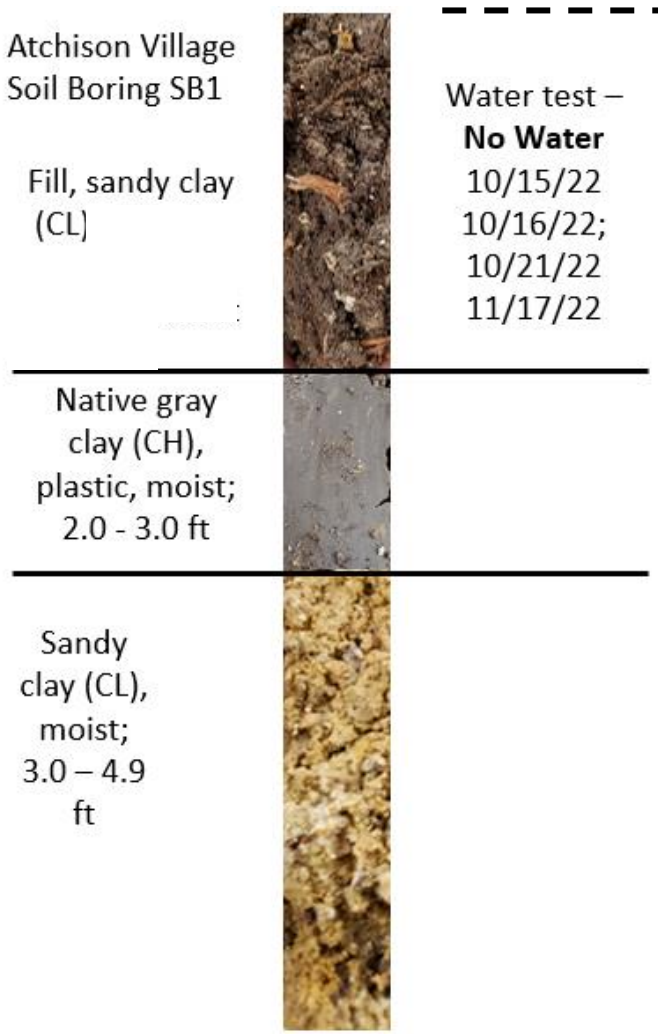
Water test – no water
10/15/22
10/16/22;
10/21/22
11/17/22

SB1 at 12 West Chanslor Ct., within sewer easement – brown gravely clay (GC) with 1-inch pebbles 0.0 to 2.0 ft

Limited access pilot test: 10/15/22: hand auger to 4.9 ft in 1 hour

Atchison Village

Atchison Village
Soil Boring SB1

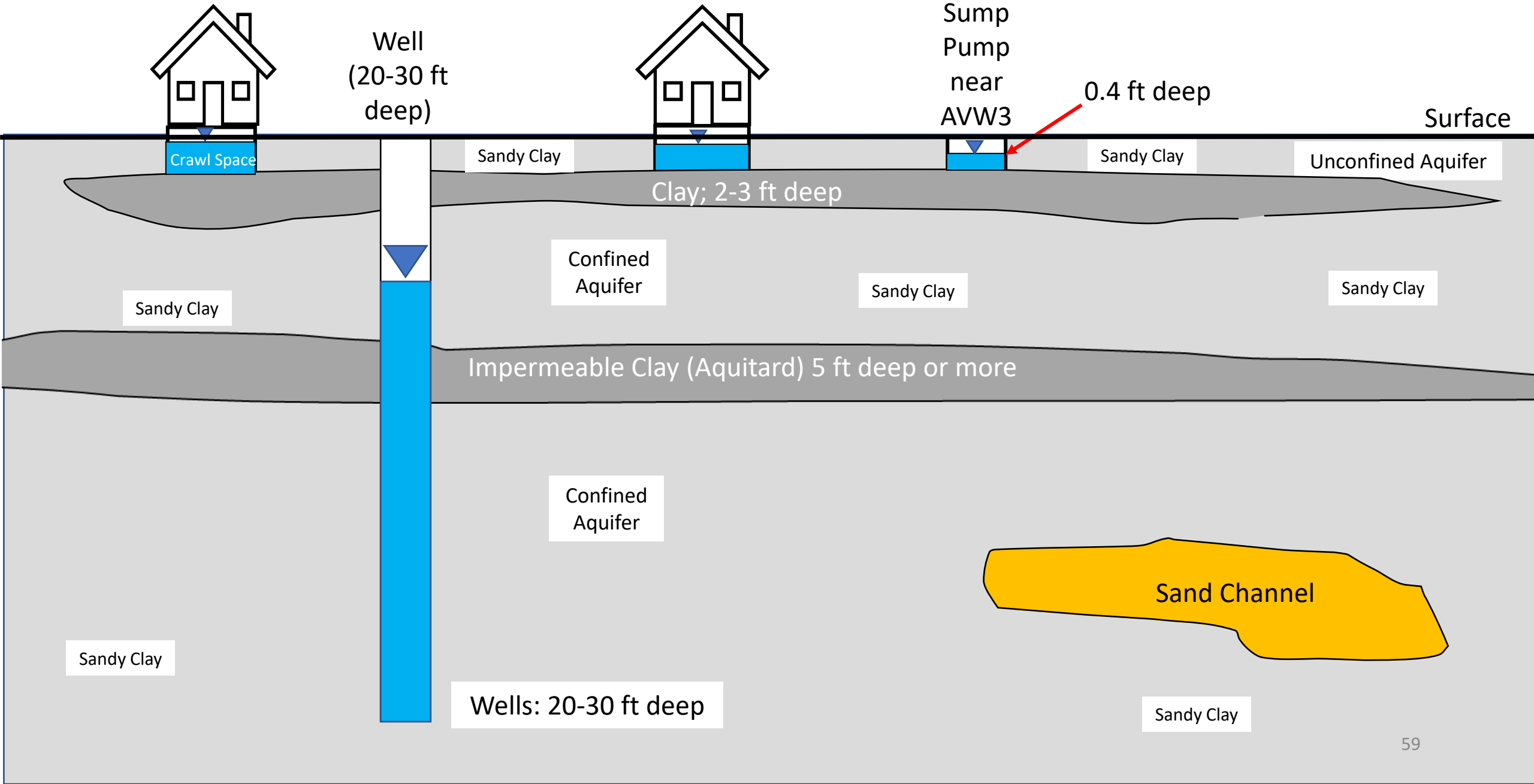


Water test –
No Water
10/15/22
10/16/22;
10/21/22
11/17/22

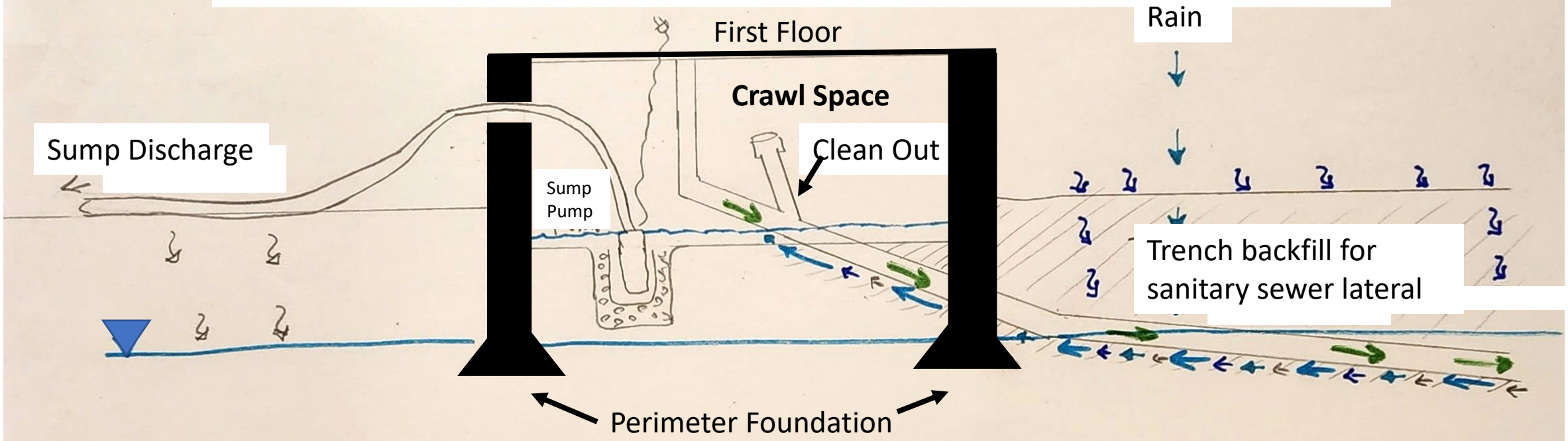
Atchison Village
Soil Boring SB2
2/11/23

Fill material on floodplain with variable water levels

Atchison Village: Concept diagram; clay layers and multiple water table depths (NOT TO SCALE)



Atchison Village: Dynamic environment: deposition, erosion, chemical processes
Concept diagram; clay layers and multiple water table depths



Irrigation water
Sump Discharge
Groundwater
Groundwater Table

Rainwater

Thus, crawl space water = Rain + Groundwater/Trenchwater +
Irrigation + sump discharge water

NOTES: Sewer laterals and sewer mains were partially upgraded by pipe bursting (2011-2015); original trench backfill from 1941

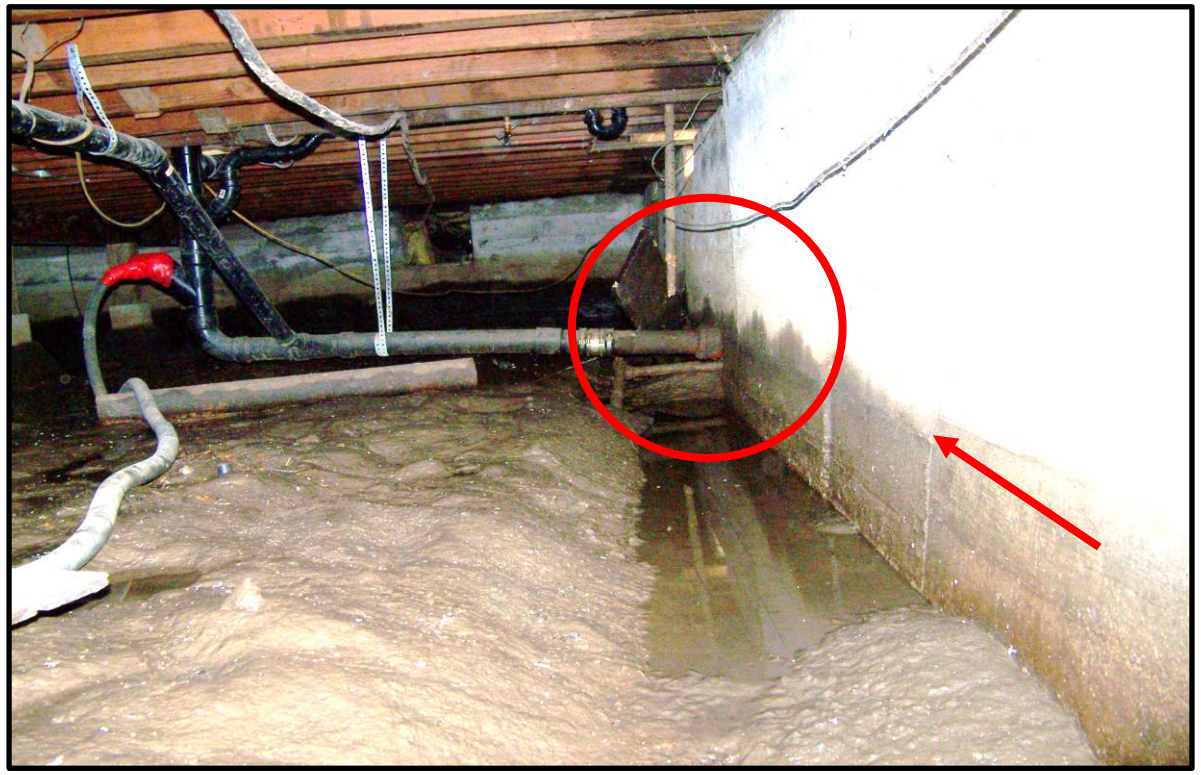
Atchison Village: Crawl spaces and sewer pipe exiting foundation walls (photos by Barbara Postel)

Crawl spaces beneath Atchison Village houses: dynamic environment as evidenced by undulating surfaces

Photos courtesy of Barbara Postel

Crawl space left (7/11/17) and right (9/18/14) showing sewer pipes exiting through foundation walls with evidence of sitting water (photos, Barbara Postel)

Engineered penetration for sewer line, gas line, and water line through the perimeter foundation wall



Current discharge of some sump pumps – pumps in almost all of the 163 buildings, all crawl spaces wet to varying degrees

Sump pump hose to lawn

(photo Barbara Postel)

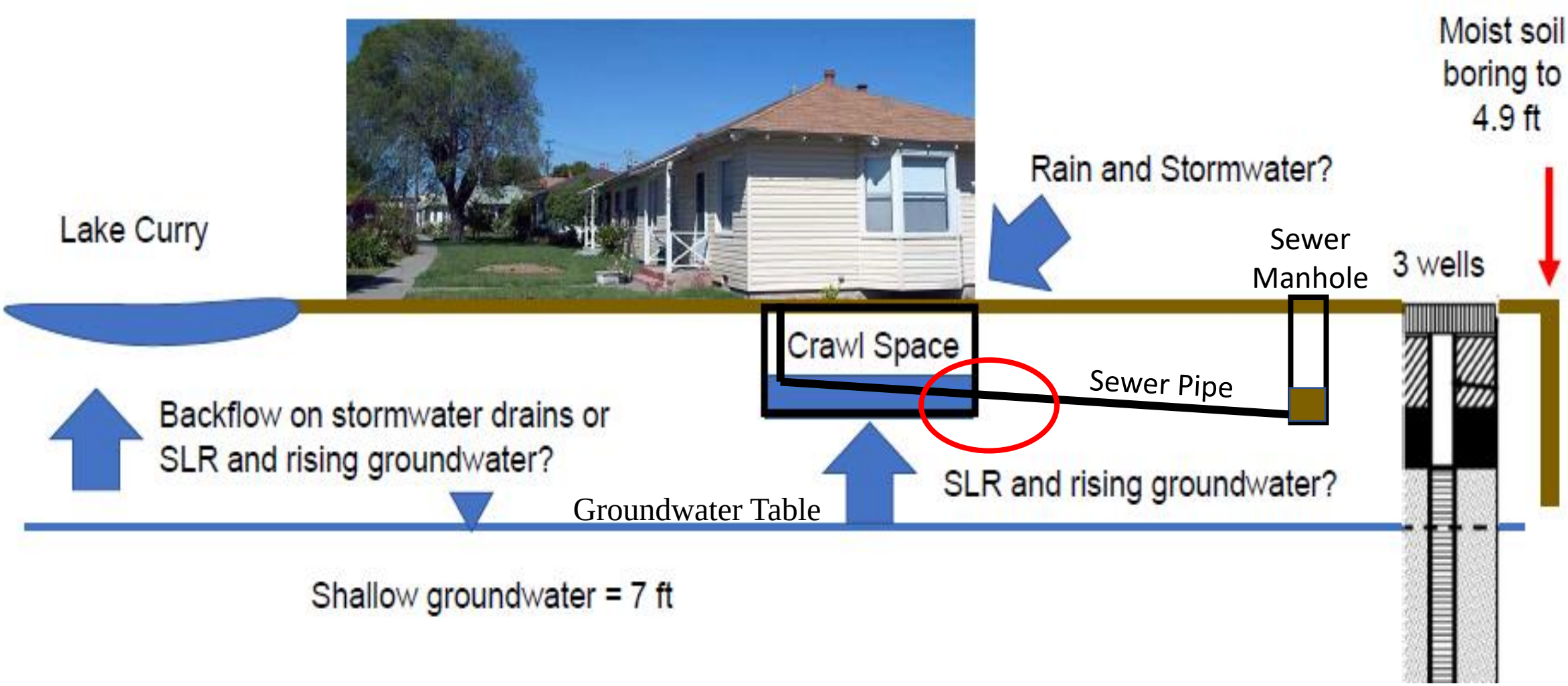
Desiccation cracks and accumulated salts reflect wet and dry periods in crawl spaces. The water lines are clearly visible on the concrete post on the left and side perimeter wall on the right.

Crawl space beneath in Atchison Village house, Richmond, California; 12/22/22 (king tides); pre-ARC

Question: What is the source of the water in the crawl space?

Photos courtesy of Barbara Postel

Conceptual model (pre-ARC) for water sources for crawl space flooding, including groundwater, rainwater, irrigation water, sewer water, sewer trench water, and leaky potable water lines.



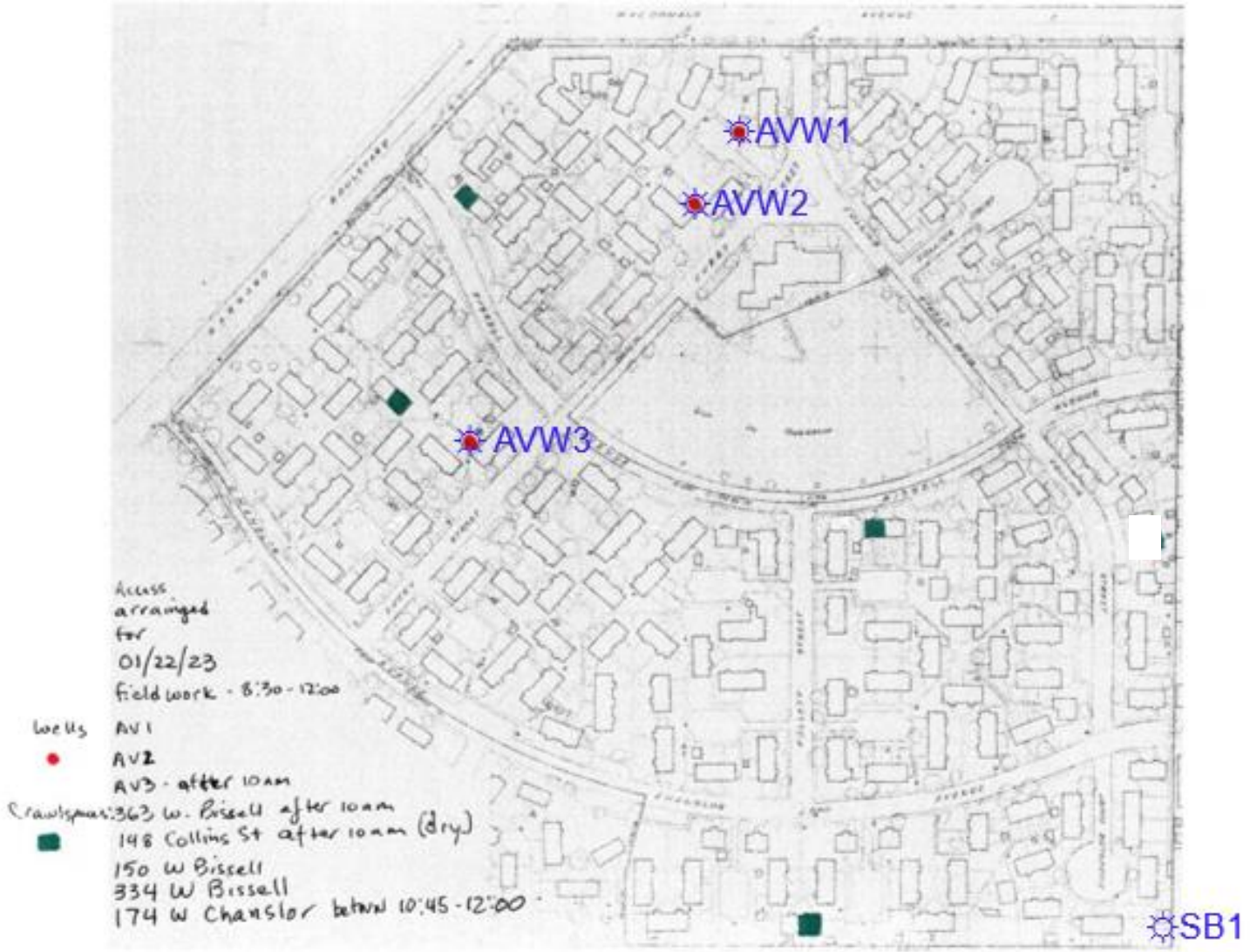
Atchison Village: Sea Level Rise (SLR), Groundwater Flooding, and Atmospheric River Conditions (ARCs)

Jim Jacobs jaajacob@ucsc.edu

Question 3 - Can isotopes and water conditions and measurements be used to estimate water sources for crawl space water?

Wells and crawl space sample locations for the 1/22/23 sampling event

Crawl spaces sampled (green squares)

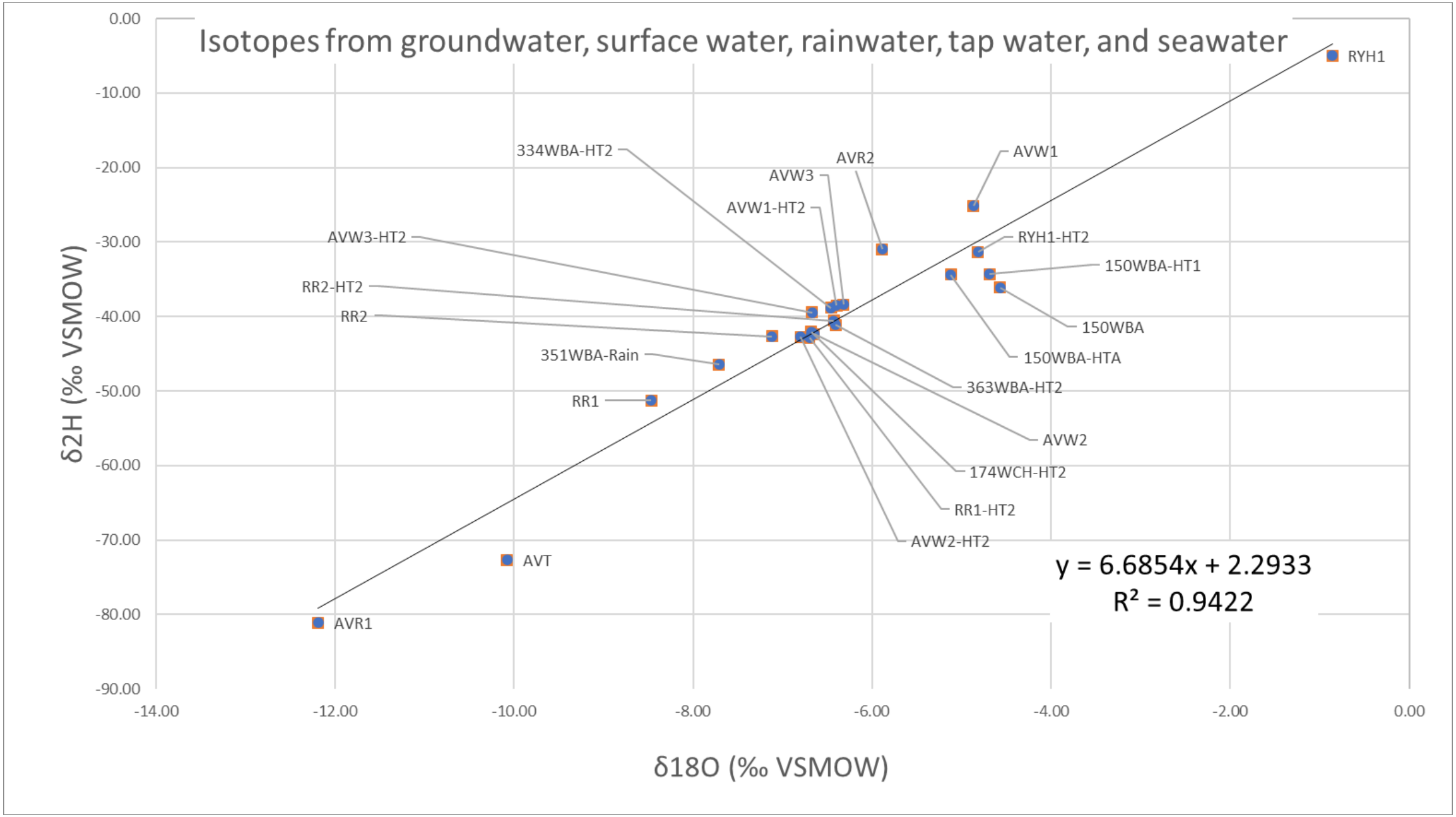


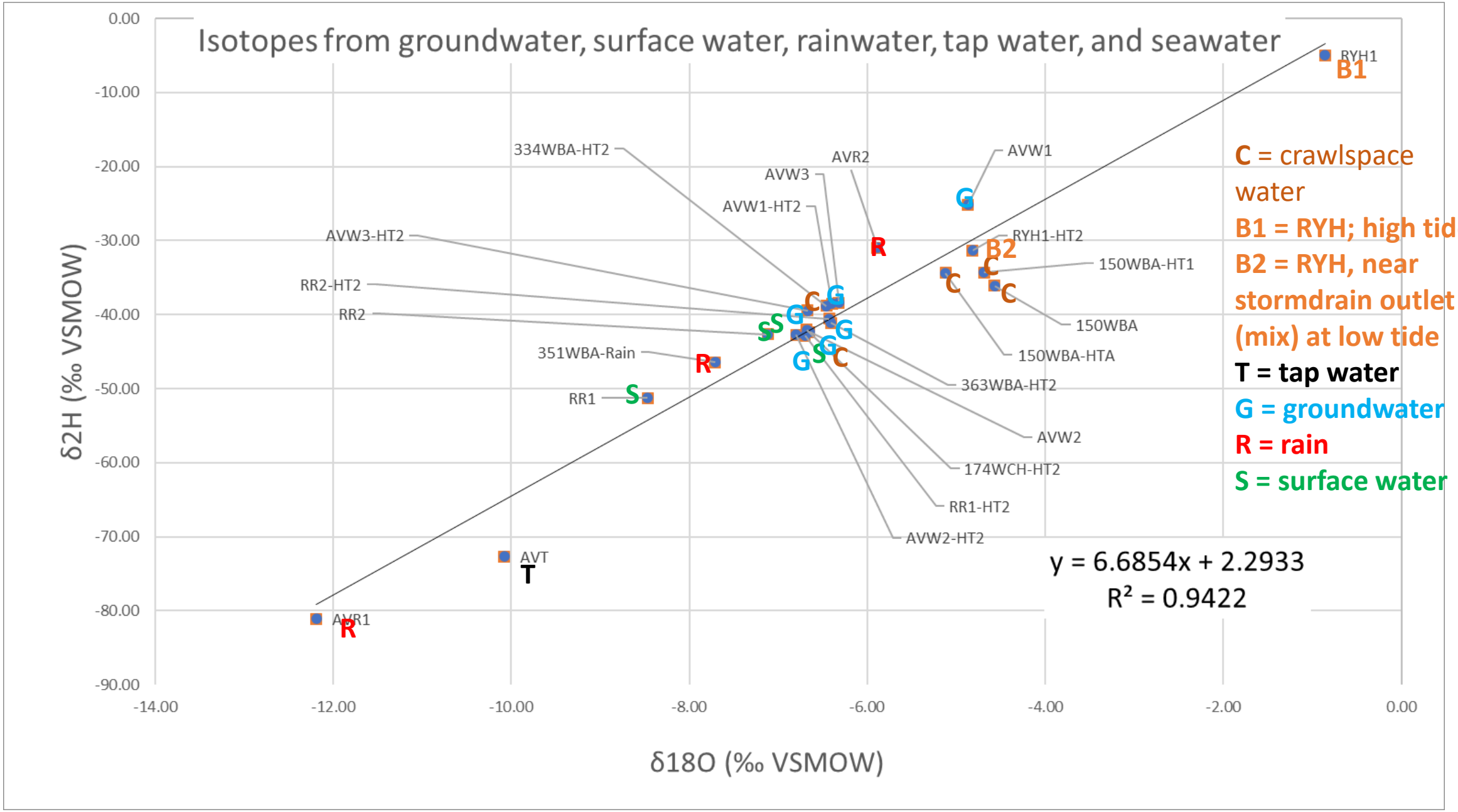
Courtesy of Barbara Postel

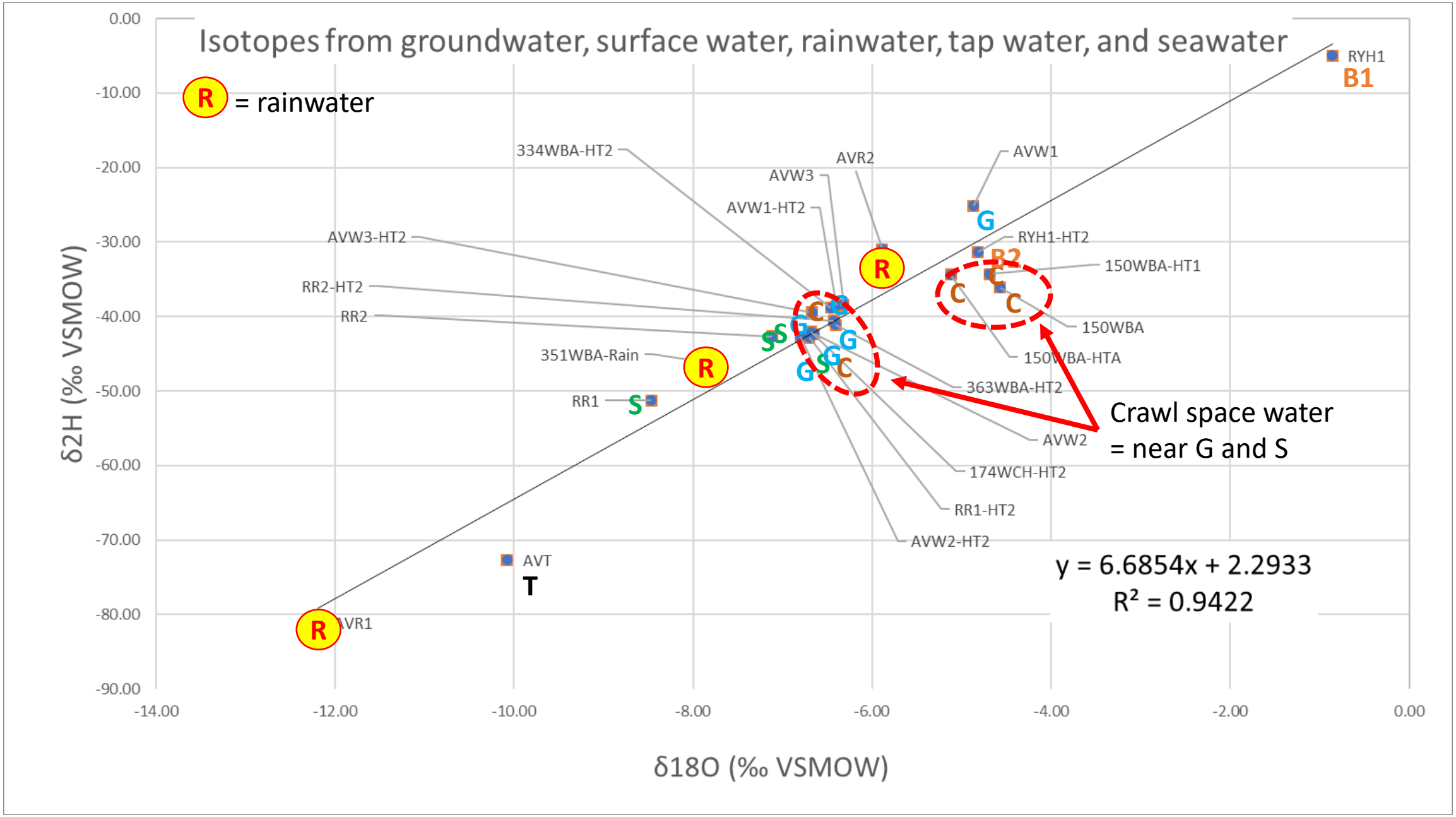
☼AVW1 – pre-existing well; water at about 7 feet below ground surface; LTC datalogger installed 10/16/22.

☼SB1 – hand augered to 4.99 ft 10/15/22; no water 10/15/212, 10/16/22, 10/21/22, or 11/17/22

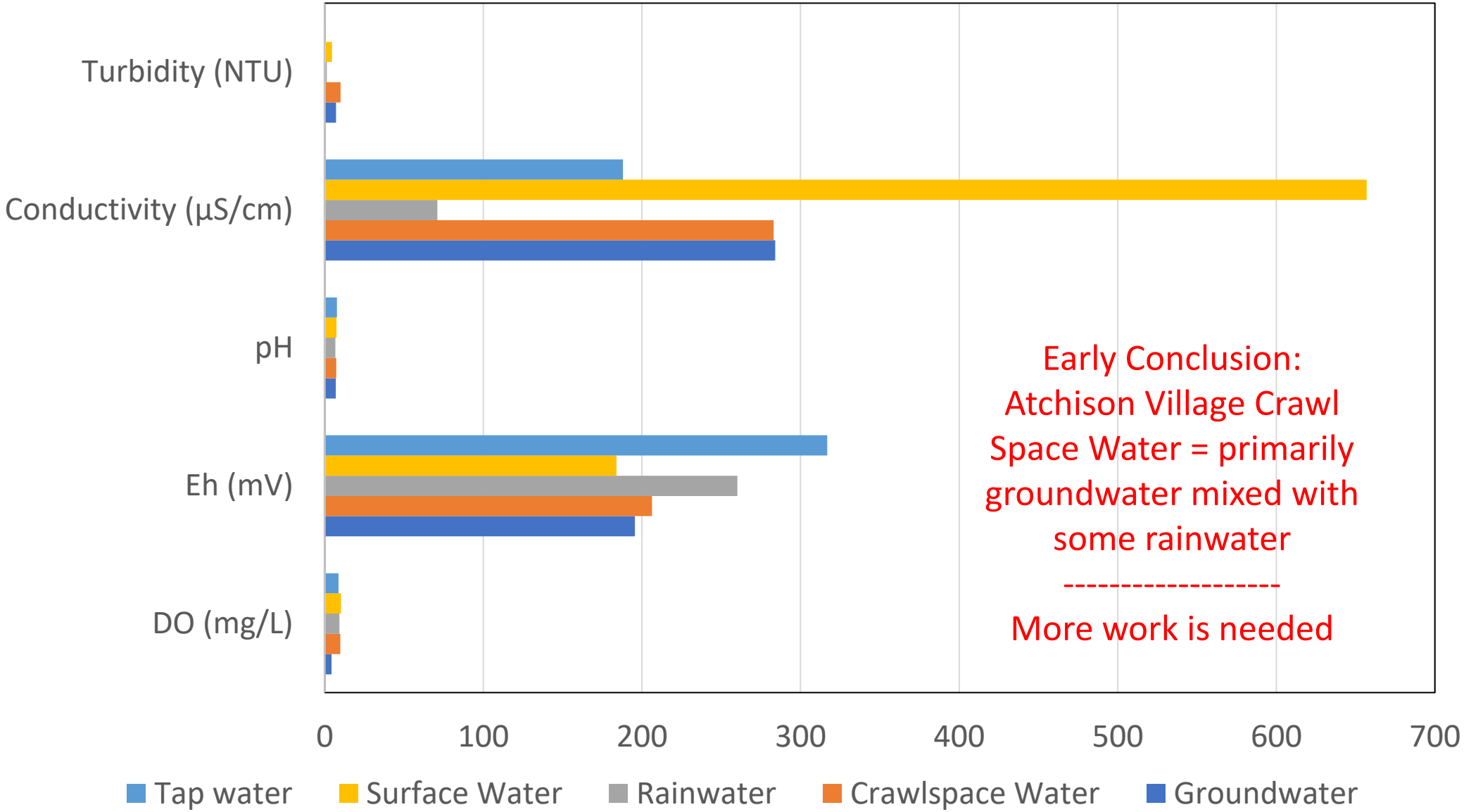
NOTES: Houses in green in sampling plan for 1/22/23


Isotopes from groundwater, surface water, rainwater, tap water, and seawater
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
-80.00
-90.00
δ2H (‰ VSMOW)
-14.00
-12.00
-10.00
-8.00
-6.00
-4.00
-2.00
0.00
δ18O (‰ VSMOW)
RYH1
334WBA-HT2
AVR2
AVW1
AVW3
AVW1-HT2
AVW3-HT2
RYH1-HT2
150WBA-HT1
RR2-HT2
RR2
150WBA
351WBA-Rain
150WBA-HTA
363WBA-HT2
RR1
AVW2
174WCH-HT2
RR1-HT2
AVW2-HT2
AVT
AVR1
y = 6.6854x + 2.2933
R² = 0.9422


Isotopes from groundwater, surface water, rainwater, tap water, and seawater
δ2H (‰ VSMOW)
δ18O (‰ VSMOW)
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
-80.00
-90.00
-14.00
-12.00
-10.00
-8.00
-6.00
-4.00
-2.00
0.00
RYH1
B1
334WBA-HT2
AVR2
AVW1
AVW3
AVW1-HT2
AVW3-HT2
RYH1-HT2
B2
150WBA-HT1
RR2-HT2
RR2
150WBA
150WBA-HTA
351WBA-Rain
363WBA-HT2
RR1
AVW2
174WCH-HT2
RR1-HT2
AVW2-HT2
AVT
T
AVR1
y = 6.6854x + 2.2933
R² = 0.9422
C = crawlspace water
B1 = RYH; high tide
B2 = RYH, near stormdrain outlet (mix) at low tide
T = tap water
G = groundwater
R = rain
S = surface water


Isotopes from groundwater, surface water, rainwater, tap water, and seawater
R = rainwater
RYH1
B1
334WBA-HT2
AVR2
AVW1
AVW3
AVW1-HT2
AVW3-HT2
RYH1-HT2
150WBA-HT1
RR2-HT2
RR2
150WBA
351WBA-Rain
150WBA-HTA
363WBA-HT2
RR1
AVW2
174WCH-HT2
RR1-HT2
AVW2-HT2
AVT
T
AVR1
Crawl space water
= near G and S
y = 6.6854x + 2.2933
R² = 0.9422
δ2H (‰ VSMOW)
δ18O (‰ VSMOW)
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
-80.00
-90.00
-14.00
-12.00
-10.00
-8.00
-6.00
-4.00
-2.00
0.00

Atchison Village Freshwater (Conductivity < 750 µS/cm) Characteristics: Averaged per Water Source



YSI Meter: DO, ORP (Eh), pH, Conductivity. Hanna Inst. Turbidity Meter: Turbidity; All samples 1/22/23, except (1) tap water and (1) crawlspace, tap water and (1) rainwater (2/3/23); only includes data from <1,000 µS/cm conductivity.

Atchison Village: Sea Level Rise (SLR), Groundwater Flooding, and Atmospheric River Conditions (ARCs)

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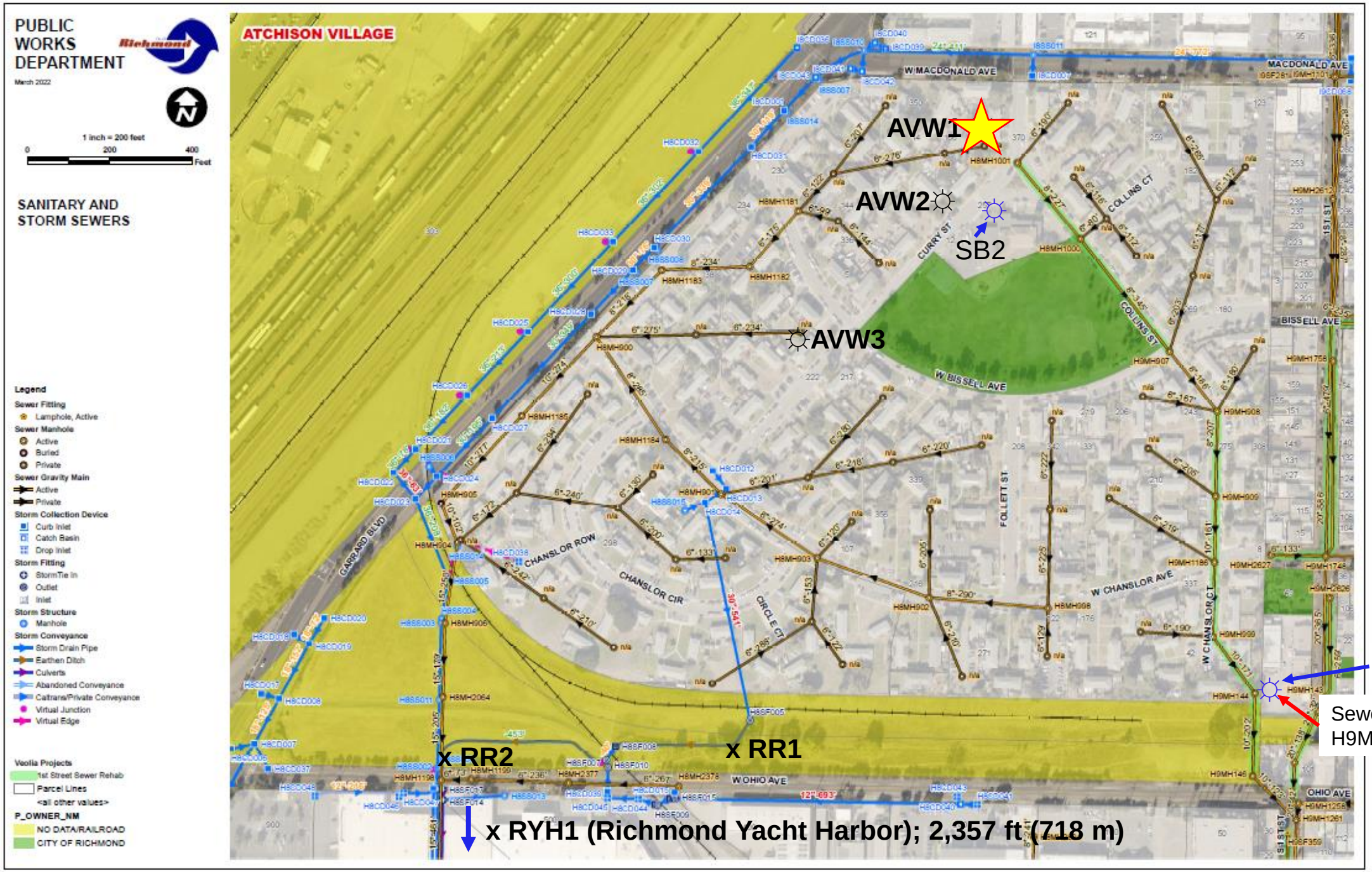
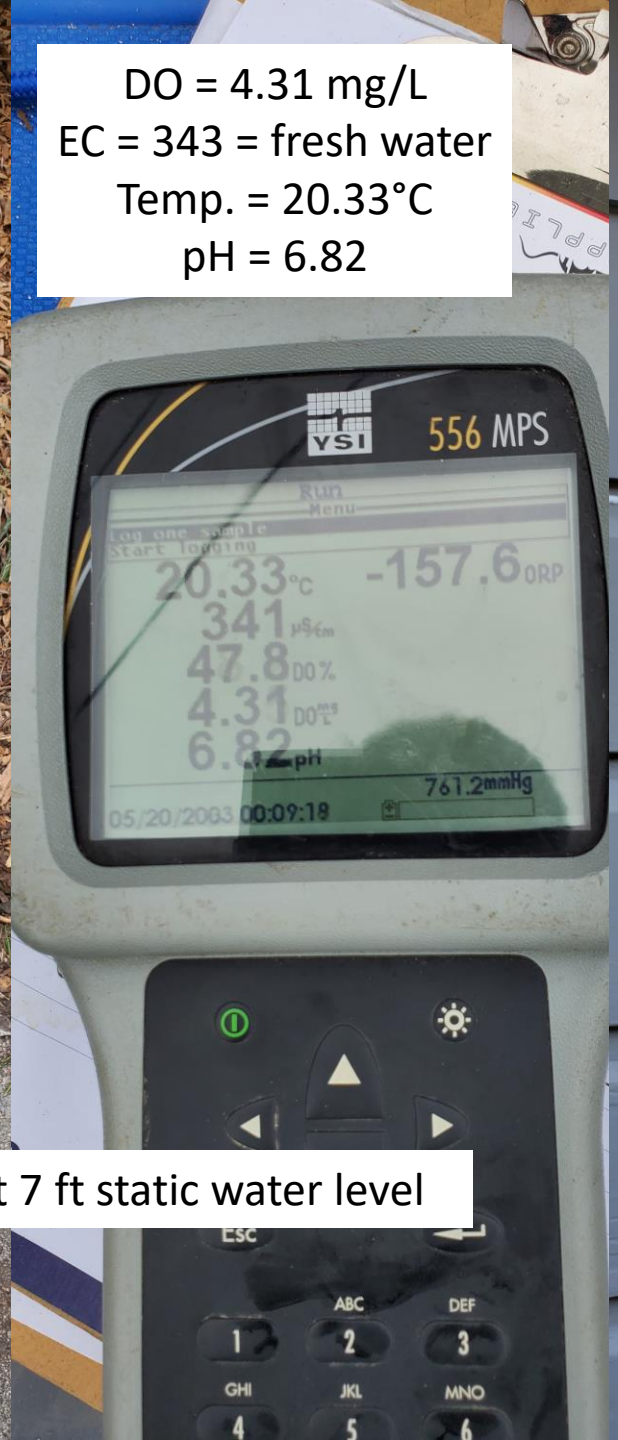
Groundwater Information



Location map of wells, soil borings, sample locations, and sanitary sewer system, Atchison Village (City of Richmond)

DO = 4.31 mg/L
EC = 343 = fresh water
Temp. = 20.33°C
pH = 6.82



10/16/22: install LTC sensor in well, and baro nearby

10/15/22: repair AVW1; 20 ft (6-in diameter) well, about 7 ft static water level

Atchison Village

Atchison Village – AVW1 (285 Curry St., Richmond, California) (10/16/22 to 11/29/22) highest water = 6.47 ft below ground surface (11/16/22)

Solinst Levelogger Software

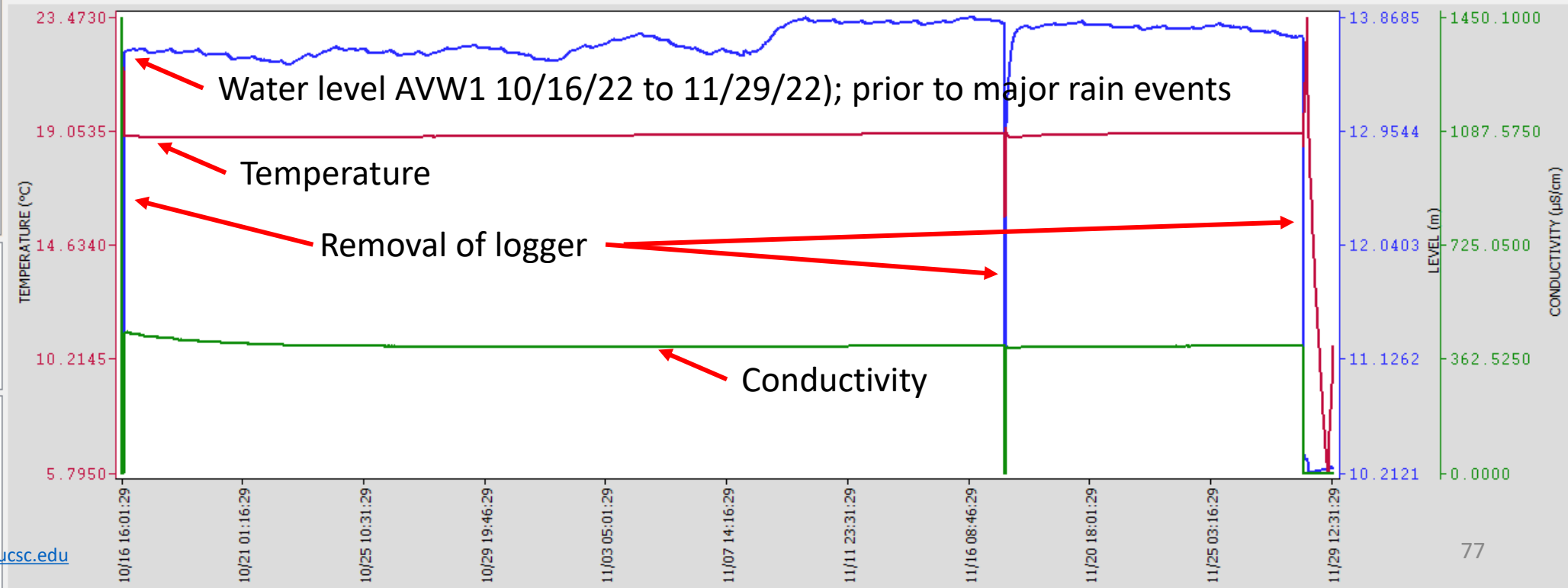
AVW1 1076949__2022_10_16_155937

Logger
- Serial Number: 1076949
- Firmware Version: 1.003
- Project ID
- Location
- Latitude: N/A
- Longitude: N/A
- LEVEL
  - Unit: m
  - Offset: 0.0000 m
- TEMPERATURE
  - Unit: °C
- CONDUCTIVITY
  - Unit: µS/cm

Combined Plot

	Date	Time	LEVEL (m)	TEMPERATURE (°C)	CONDUCTIVITY (µS/cm)
39	10/17/2022	01:31:29.0 AM	13.6035	18.831	440.3
40	10/17/2022	01:46:29.0 AM	13.6032	18.830	440.2
41	10/17/2022	02:01:29.0 AM	13.6045	18.829	439.8
42	10/17/2022	02:16:29.0 AM	13.6051	18.828	439.9
43	10/17/2022	02:31:29.0 AM	13.6054	18.827	439.8
44	10/17/2022	02:46:29.0 AM	13.6058	18.826	439.6
45	10/17/2022	03:01:29.0 AM	13.6052	18.826	439.5
46	10/17/2022	03:16:29.0 AM	13.6047	18.826	439.4
47	10/17/2022	03:31:29.0 AM	13.6040	18.825	439.4

Highest water = 6.47 ft bgs @ 11/16/22



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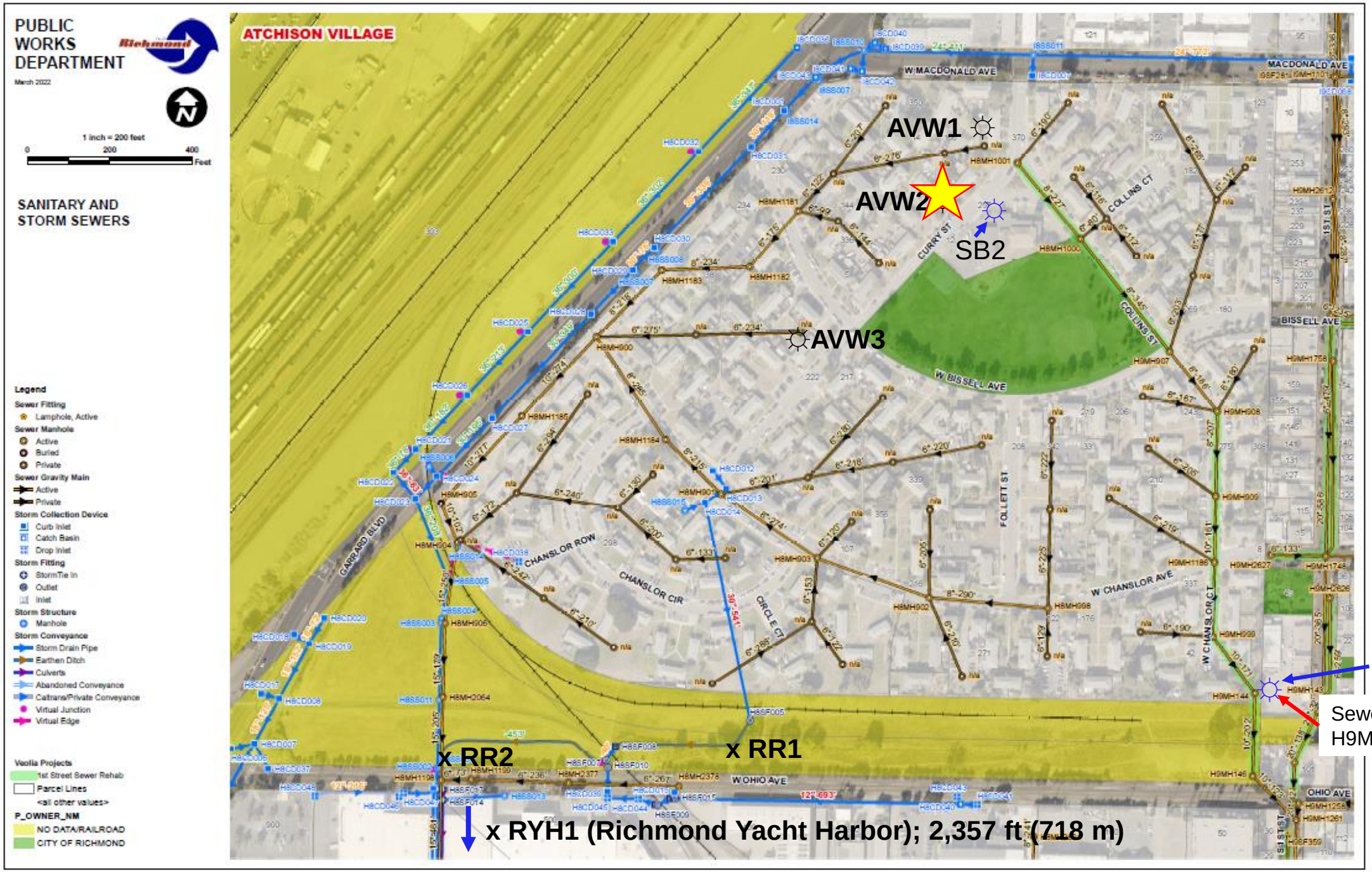
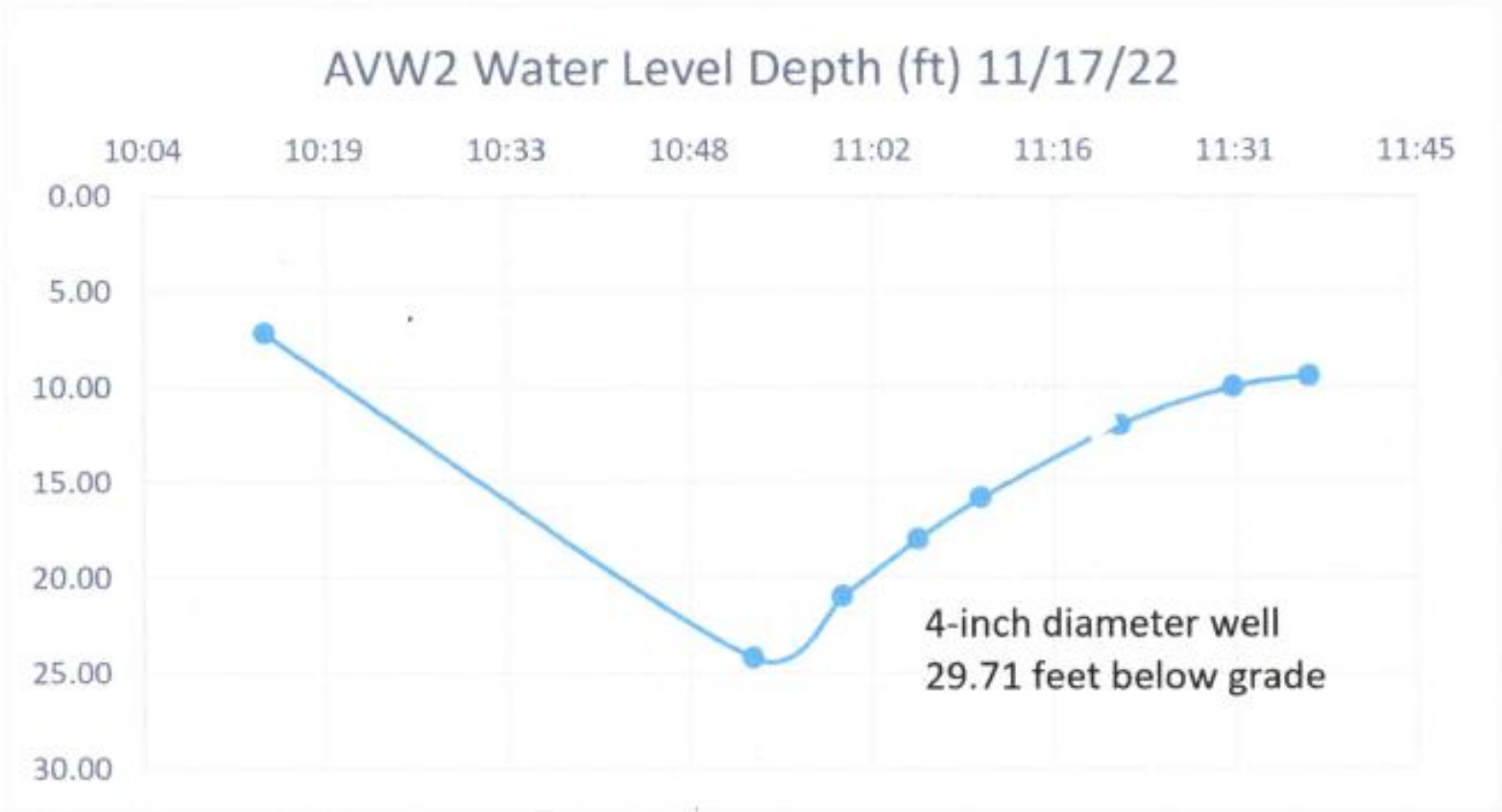


Location map of wells, soil borings, sample locations, and sanitary sewer system, Atchison Village (City of Richmond)

Atchison Village AVW2 – Pump and Recovery Test; Drawdown 17.01 ft; 76% recovery in 83 minutes

Gal Removed	Time	Depth (ft)
0	10:14	7.21
44	10:53	24.22
	11:00	21.00
	11:06	18.00
	11:11	15.87
	11:22	12.00
	11:31	10.00
	11:37	9.45



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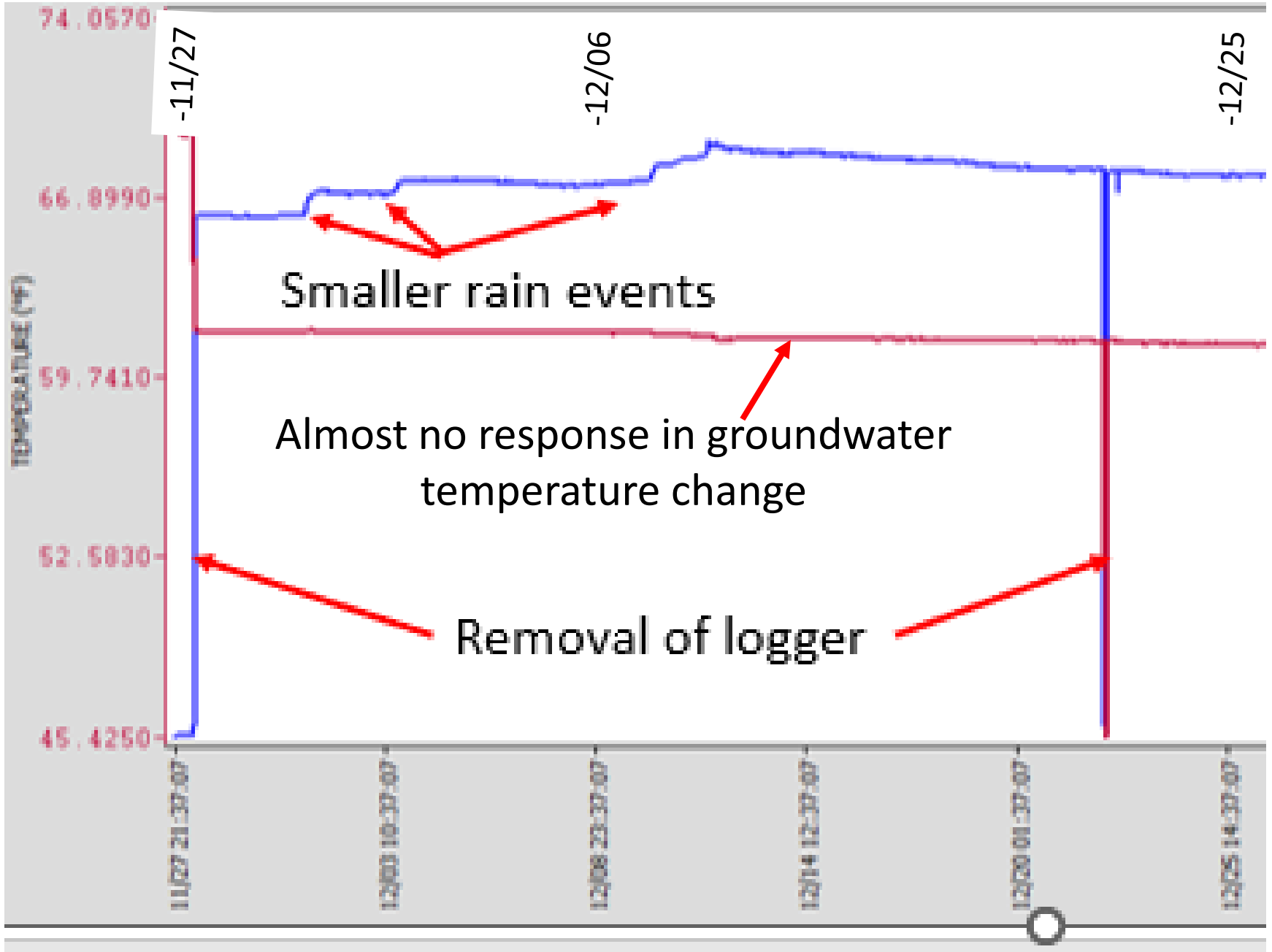
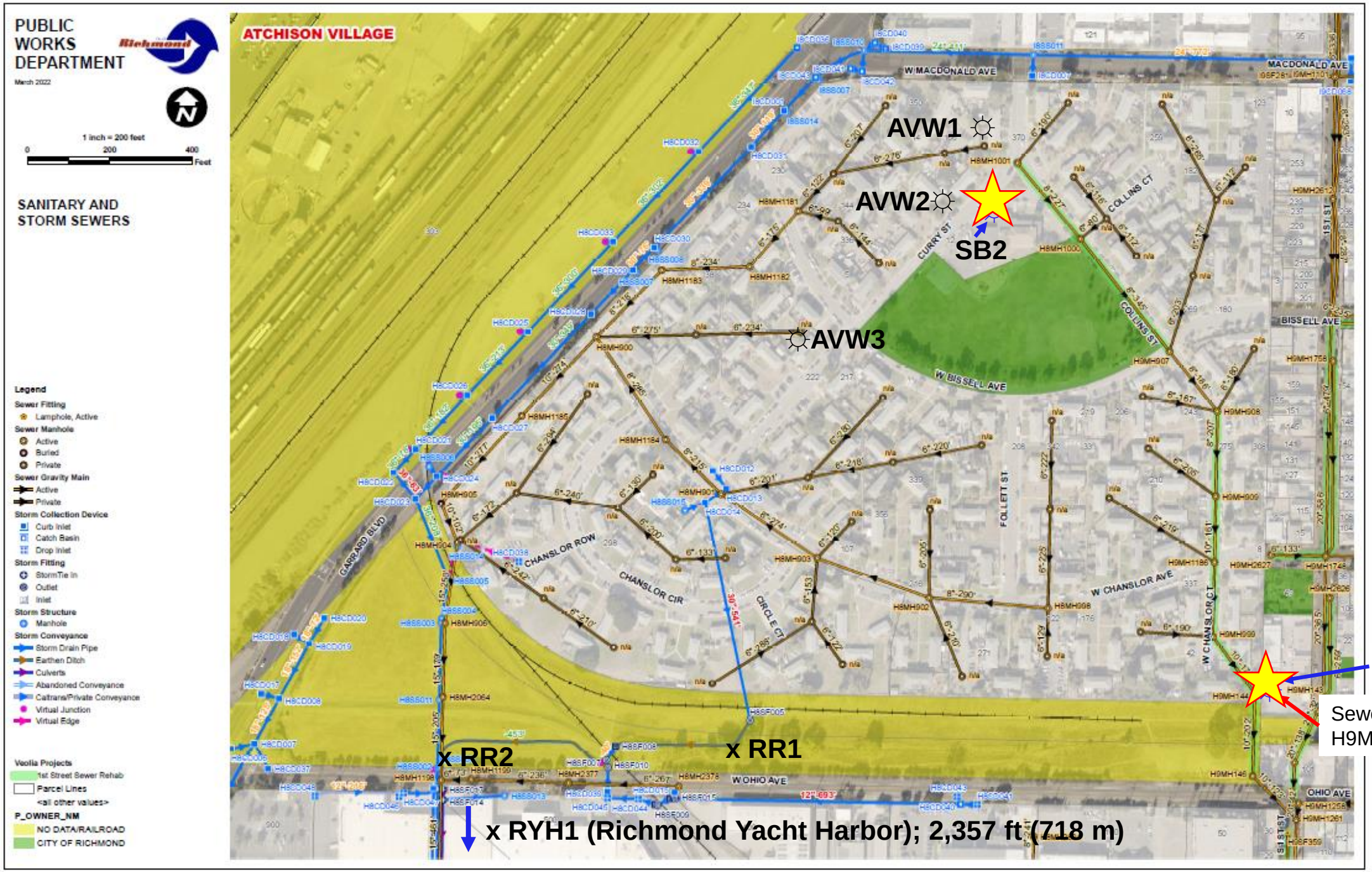
Atchison Village – AVW2 (253 Curry St., Richmond, California); Pre-Atmospheric River Condition

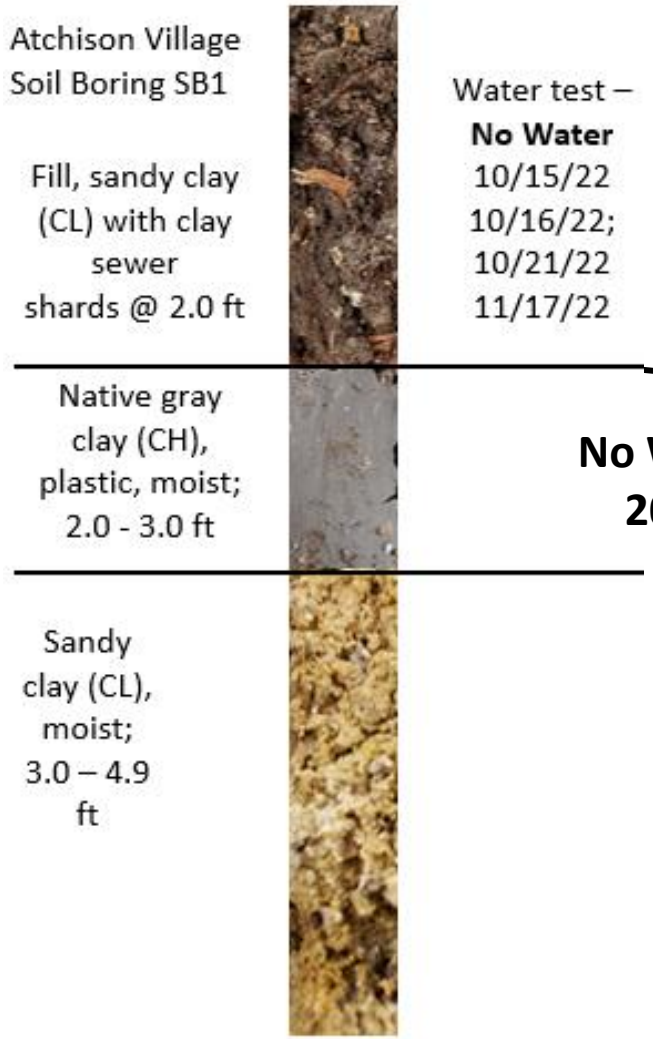




Location map of wells, soil borings, sample locations, and sanitary sewer system, Atchison Village (City of Richmond)

Atchison Village Soil Boring SB1; 10/16/22

Atchison Village Soil Boring SB2; 2/11/23



Water test –
No Water
10/15/22
10/16/22;
10/21/22
11/17/22

No Water 2022

Atchison Village: Sea Level Rise (SLR), Groundwater Flooding, and Atmospheric River Conditions (ARCs)

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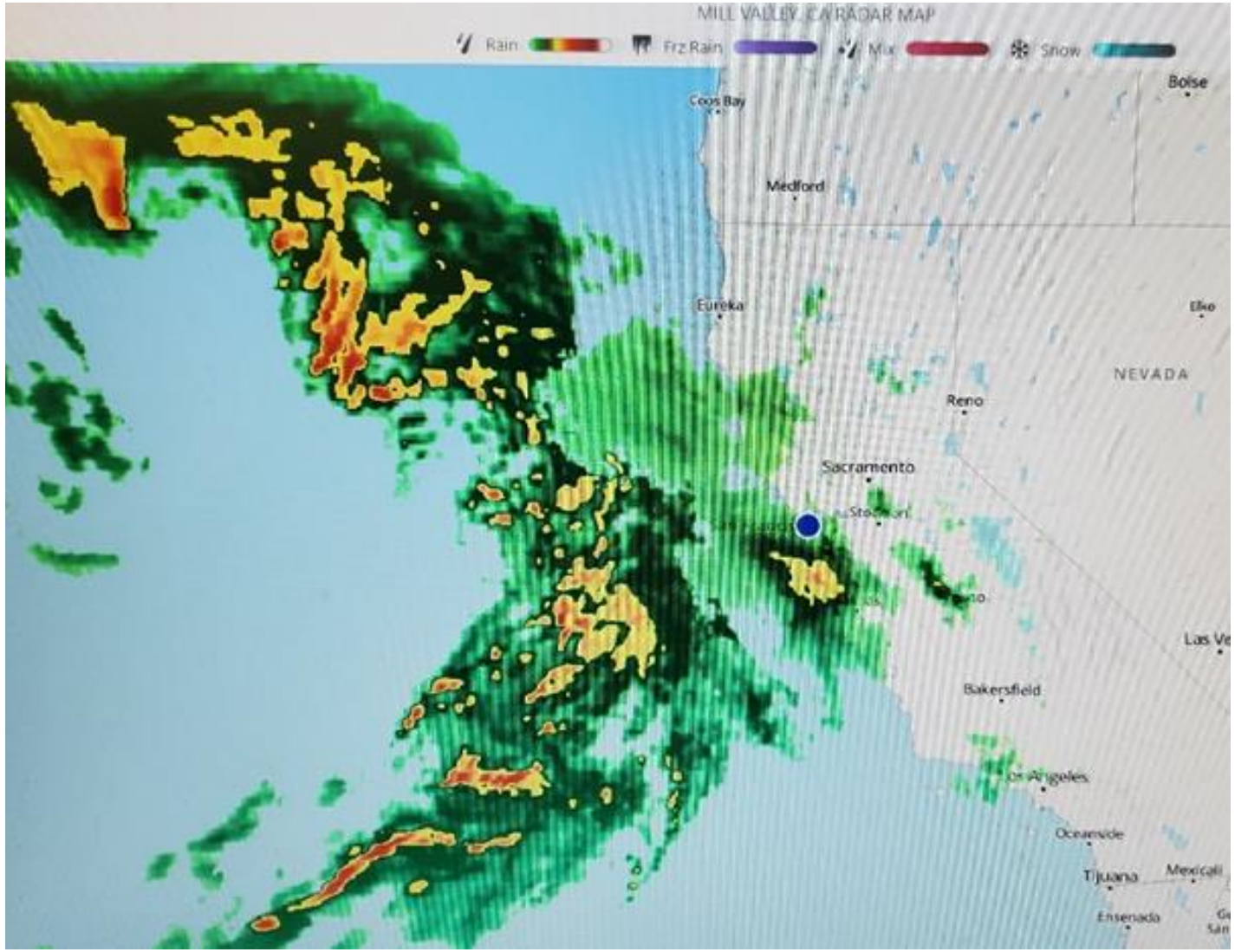
Question 4 - What were the Atmospheric River Conditions (ARC) impacts of groundwater emergence in Atchison Village?

Radar graphic from January 8, 2023 of an atmospheric river condition (ARC) which produced 0.72-inches of rain in Richmond, California on that date and 0.85-inches on 1/9/23

Atmospheric River Condition (ARC)

Similar concept for 43-day ARC in 1861 and great flood of 1862



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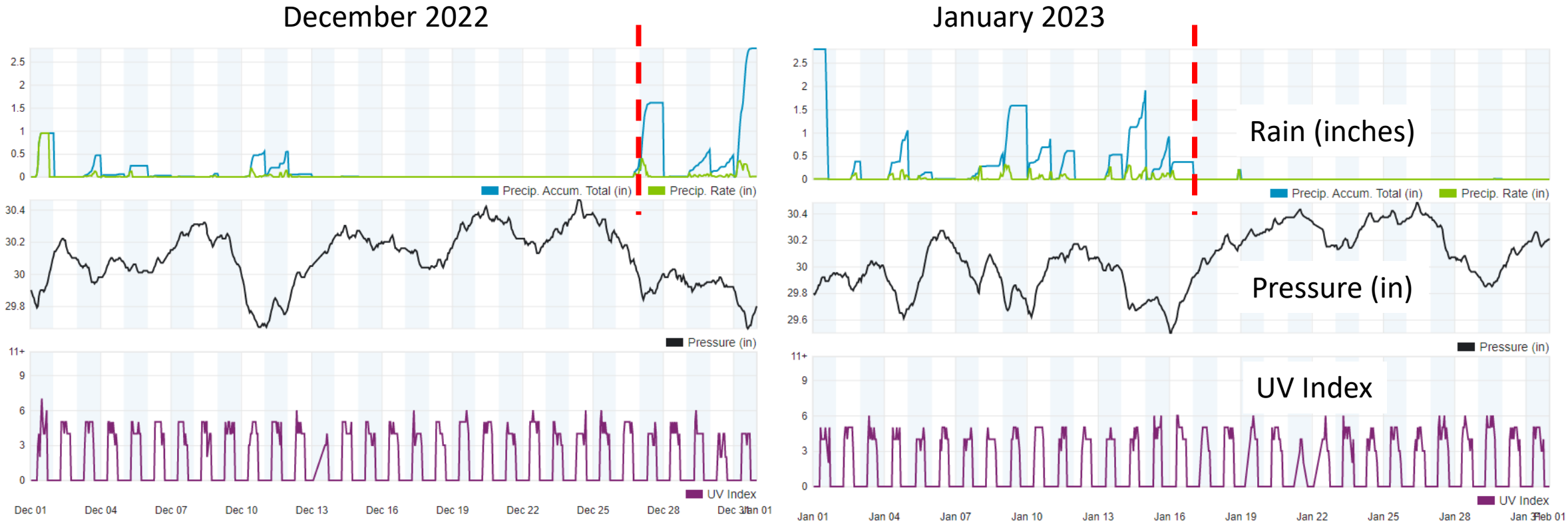
www.accuweather.com

Atchison Village and the Atmospheric River Condition

"Normal" Rainy Season

Atmospheric River (12/26/22 – 1/16/23)

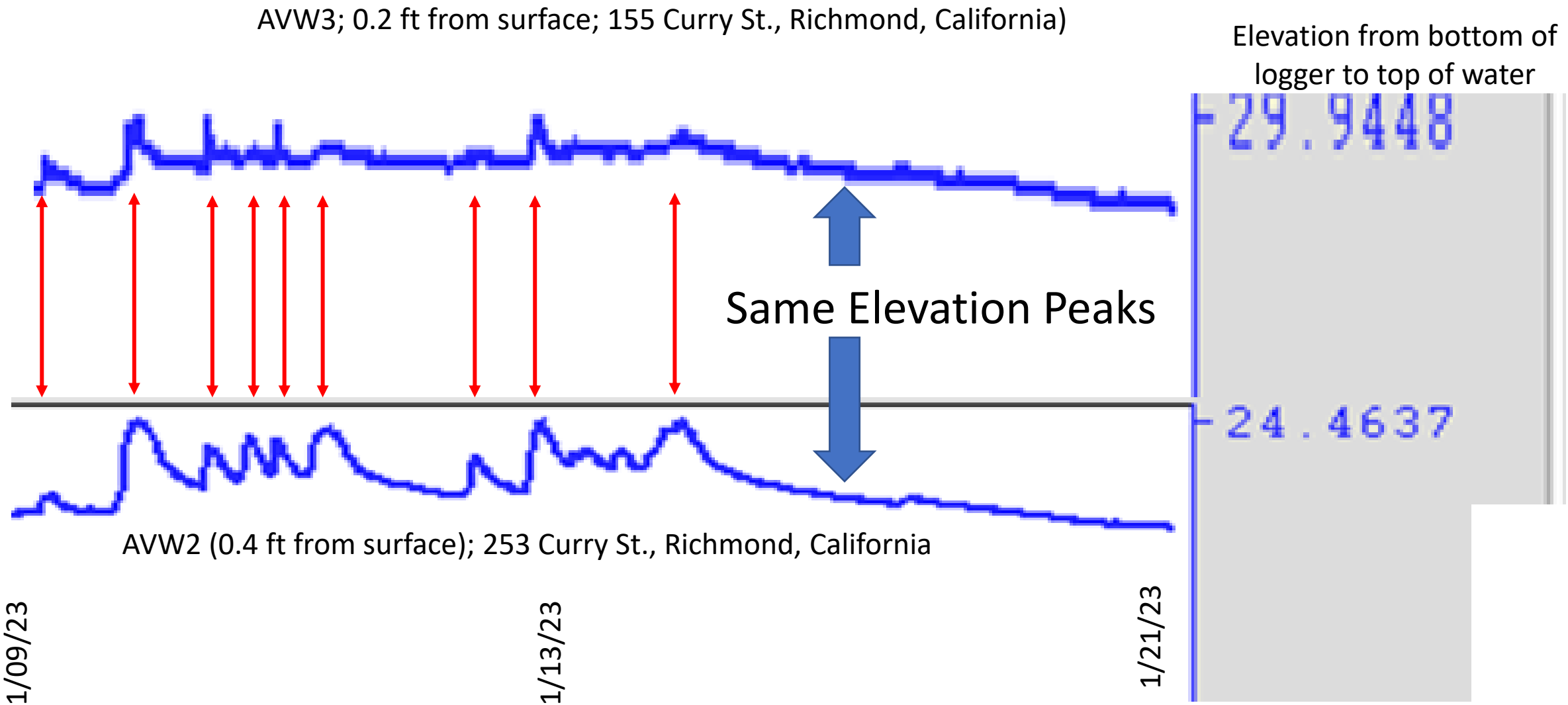
"Normal" Rainy Season



12/1/22 | 12/15/22 | 1/1/23 | 1/15/23 | 2/1/23

https://www.wunderground.com/dashboard/pws/KCARICHM101/graph/2023-01-31/2023-01-31/monthly ; Marina Bay Station, Elev **45** ft, **37.91** °N, **122.35** °W

Atchison Village –Differences relate to logger sensitivity (M5 versus M30); AVW2 to AVW3 = 554 ft (169 m)



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HOBOware

Atchison Village – AVW2 (253 Curry St., Richmond, California)

James Jacobs jaaajacob@ucsc.edu

Water is freshwater, Water depth is 6.5 ft (12/22/22) and 2.4 ft below the top of the well box (1/22/23)

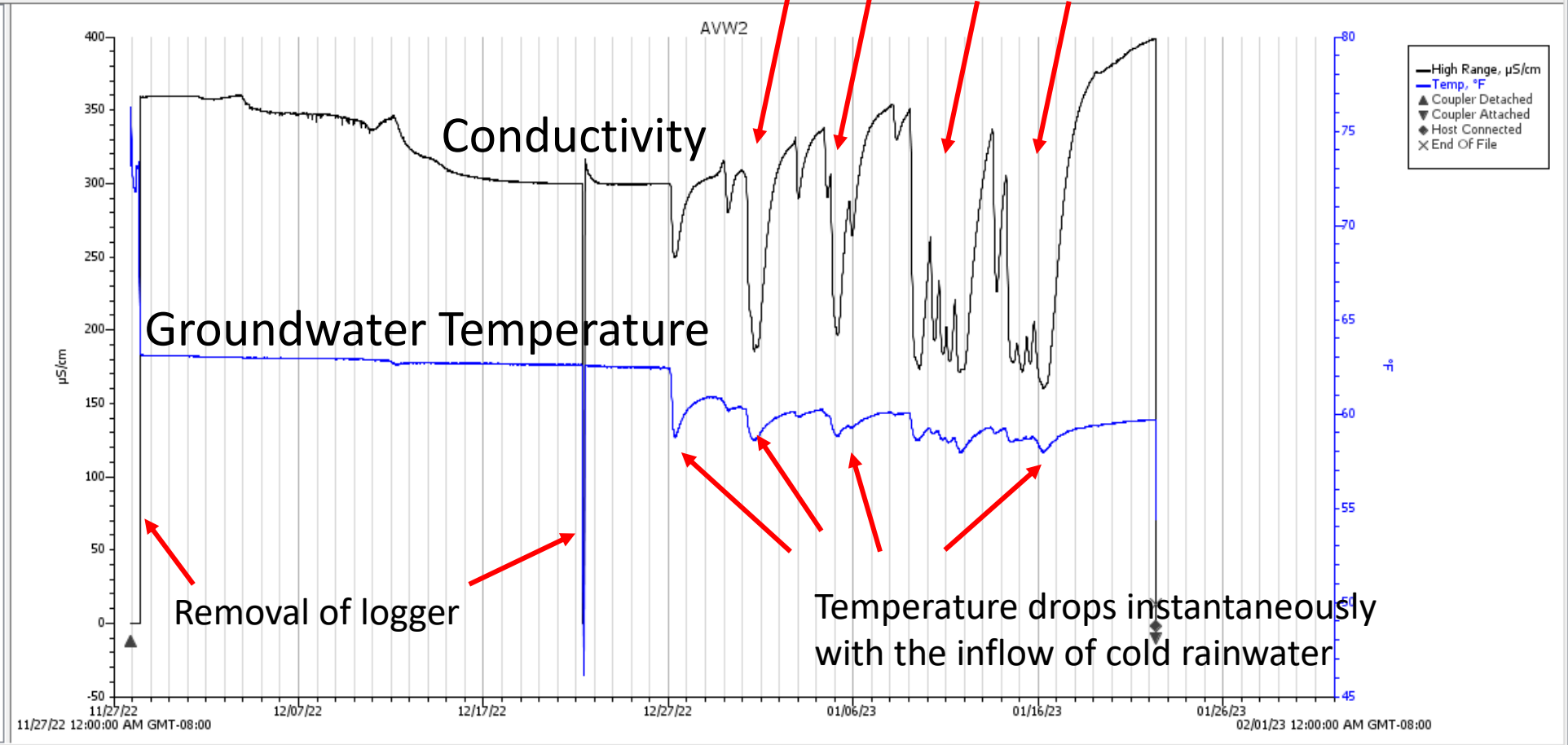
#	Time, GMT-08:00	High Range, µS/cm	Temp, °F	Coupler Detached	Coupler Attached	Host Connected	End Of File
1	11/27/22 10:25:34 PM	0.0	73.18				
2	11/27/22 10:25:41 PM			Logged			
3	11/27/22 10:40:34 PM	0.0	76.28				
4	11/27/22 10:55:34 PM	0.0	75.22				
5	11/27/22 11:10:34 PM	0.0	74.55				
6	11/27/22 11:25:34 PM	0.0	74.01				
7	11/27/22 11:40:34 PM	0.0	73.58				

Examples of major rain events; lowering the salt content (conductivity) in the groundwater

Expand All | Collapse All

Details

- Series: High Range, µS/cm
- Series: Temp, °F
- Event Type: Coupler Detached
- Event Type: Coupler Attached
- Event Type: Host Connected
- Event Type: End Of File



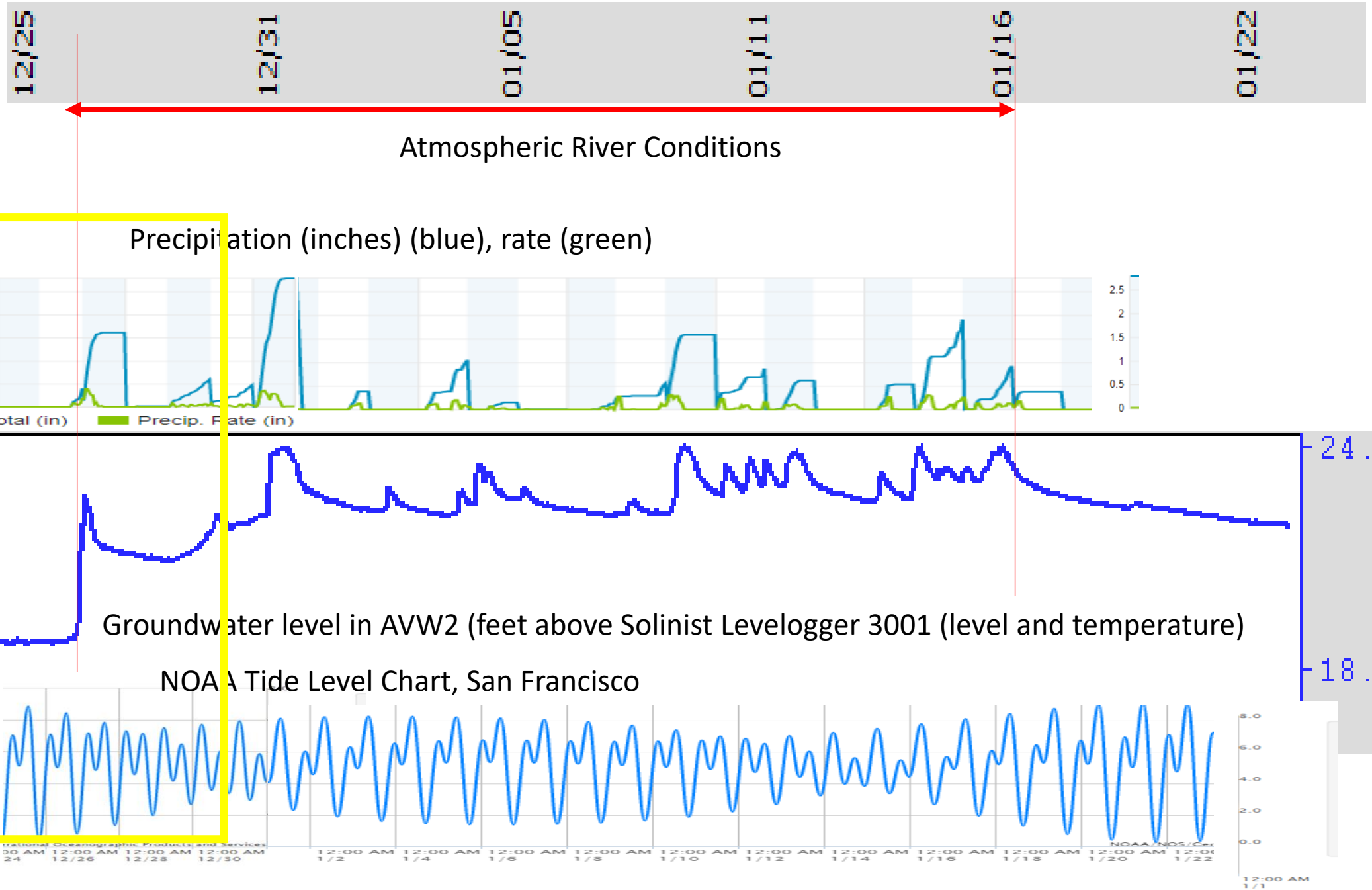
Ready.

Dev: No device selected...

No devices connected

Atchison Village – AVW2; 12/25/22 to 1/22/23

James Jacobs jaaajacob@ucsc.edu



Pre-Atmospheric River Condition, Tides and Atchison Village – AVW2; King Tide on 12/24/22

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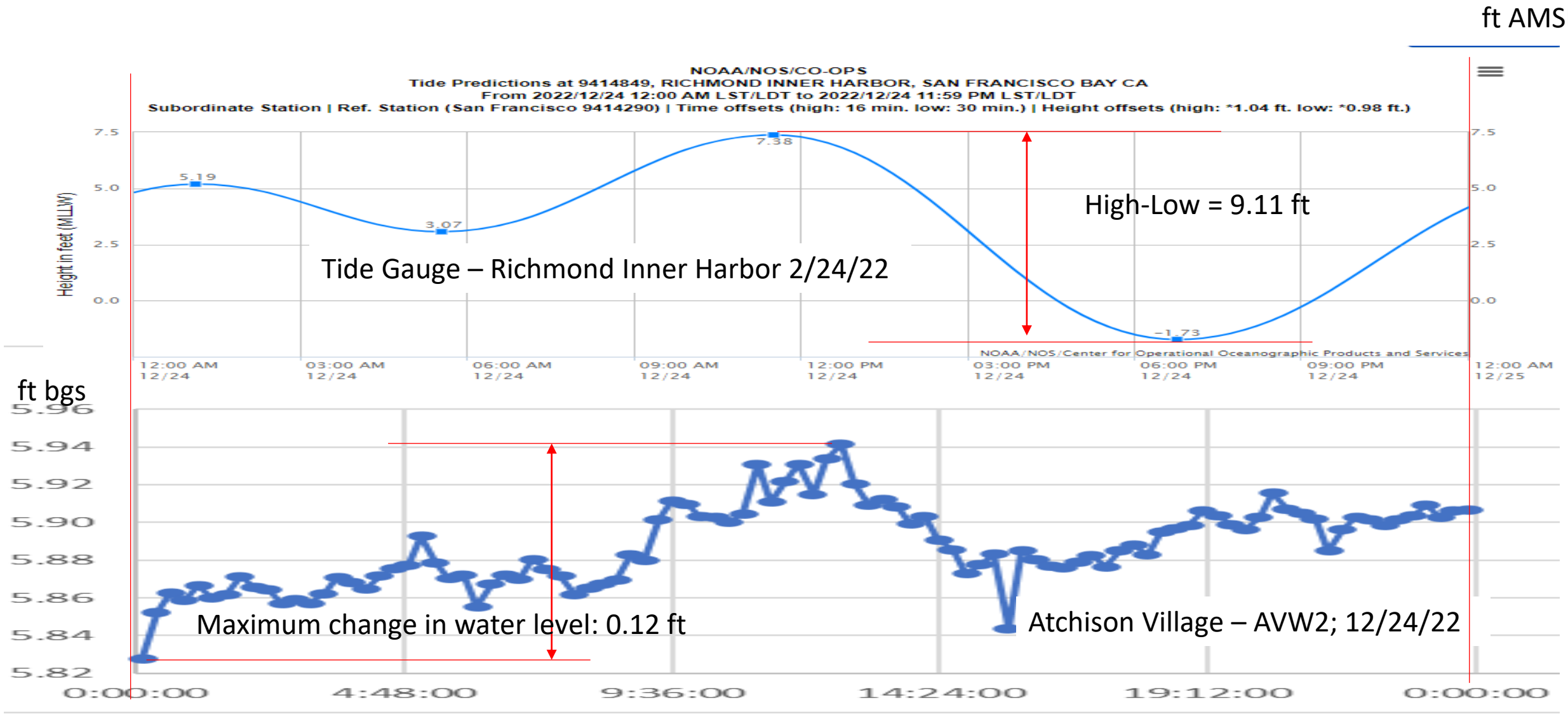

Atchison Village – AVW2; Tidal Response for 12/24/22 (pre-ARC) and ARC response for 12/27/22

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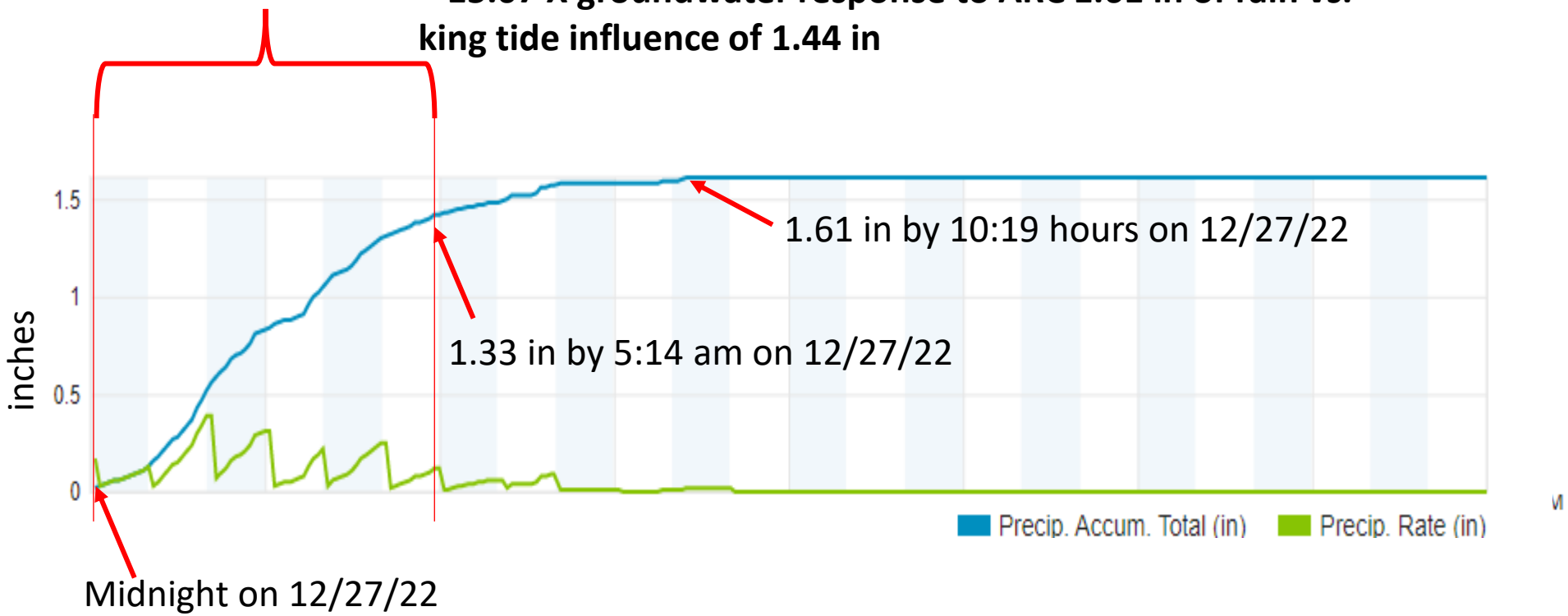
King Tide Influence (Pre-ARC); minor tidal influence (0.12 ft = 1.44 in on 12/24/22) from 9.11 ft of tidal change (king tide)

Well AVW2

ARC event; 12/26/22; 0:07:07 to 05:22:07 (5:15 hours = 1.878 ft (= 21.70 inches)

= 15.07 X groundwater response to ARC 1.61 in of rain vs. king tide influence of 1.44 in

Richmond Marina Tower Weather Station 12/27/22: 24-hr: 1.61 in of rain



Causes of Atchison Village Flooding

- ~~Sea Level Rise – not a large factor~~
- ~~King Tides – not a large factor~~
- Extreme Rains
- Inoperable Stormwater and Drainage Systems
- Groundwater Emergence

(Photo – Barbara Postel)

Atchison Village: Sea Level Rise (SLR), Groundwater Flooding, and Atmospheric River Conditions (ARCs)

Conclusions:

- Sea level rise does impact groundwater at Atchison Village, in a small way; no overtopping
- Atmospheric River Conditions significantly influence groundwater elevation rise (1” rain = 21” groundwater elevation rise)
- An historic ARC occurred in northern California between December 26, 2022 to January 16, 2023
- Early results show isotopes and water characteristics showed crawl space water is mostly groundwater and rain; more research is ongoing
- Community science volunteers have made a meaningful contribution to the study

References

Befus, K.M., Barnard, P.L., Hoover, D.J., Finzi Hart, J.A., and Voss, C.I., 2020, Increasing threat of coastal groundwater hazards from sea-level rise in California: Nature Climate Change, v. 10, p. 946–952, doi:10.1038/s41558-020-0874-1.

May, C.L., Mohan, A., Hoang, O., Mak, M., and Badet, Y., 2020, The Response of the Shallow Groundwater Layer and Contaminants to Sea Level Rise. Report by Silvestrum Climate Associates for the City of Alameda, California.: 153 p., https://doi.org/10.13140/RG.2.2.33390.69445.

Plane, E., Hill, K., and May, C., 2019, A Rapid Assessment Method to Identify Potential Groundwater Flooding Hotspots as Sea Levels Rise in Coastal Cities: Water, v. 11, p. 2228, doi:10.3390/w11112228.

Plane, E., Hill, K., and May, K., 2019, Minimum Depth to Groundwater for the Coastal San Francisco Bay Area: , p. 560658287 bytes, doi:10.6078/D1W01Q.

Warnecke, C., and Hass, A., 1941, Complete 1941 Atchison Village Defense Housing Project Blueprints, with other documents, Federal Works Agency, U.S. Housing Authority in cooperation with Housing Authority of the City of Richmond, 66 p.

Website Links

https://www.nesdis.noaa.gov/news/atmospheric-rivers-hit-west-coast

https://www.mercurynews.com/2023/01/17/california-storms-the-past-three-weeks-were-the-wettest-in-161-years-in-the-bay-area/

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Questions

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Thank You