Prediction of Sanitary Sewer Overflow Conditions and Mitigation Using a Remote Telemetry System Network

James A. Jacobs, P.G., C.H.G.
Principal Hydrogeologist

Olivia Jacobs, C.E.M.
President, Environmental Manager

Clearwater Group

Thank You

Lorien Fono, Ph.D., P.E., Executive Director
Bay Area Clean Water Agencies (BACWA)

Mary Cousins, Ph.D., P.E., Regulatory Program Manager
Bay Area Clean Water Agencies

for inviting us to give the talk

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Sewerage Agency of Southern Marin

Heather Abrams, General Manager
Tamalpais Community Services District

for encouraging us in sewer-groundwater issues

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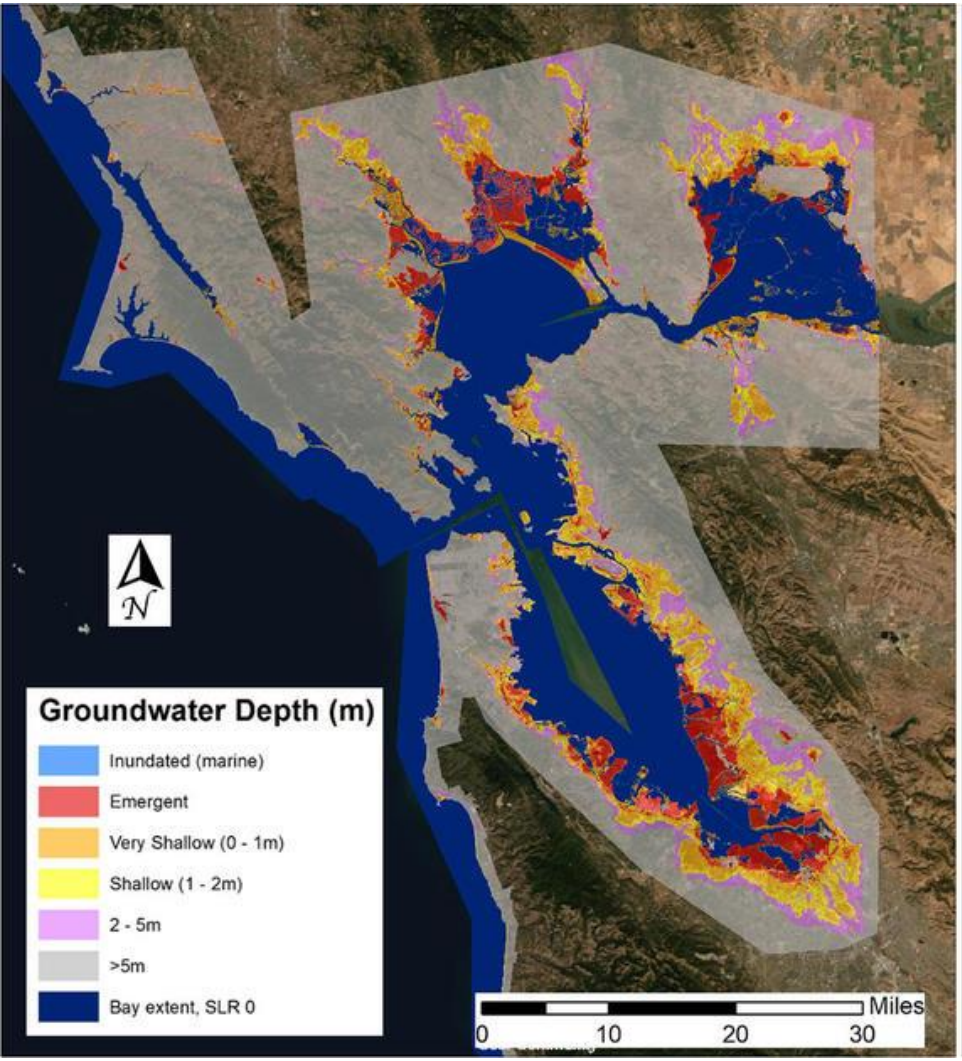
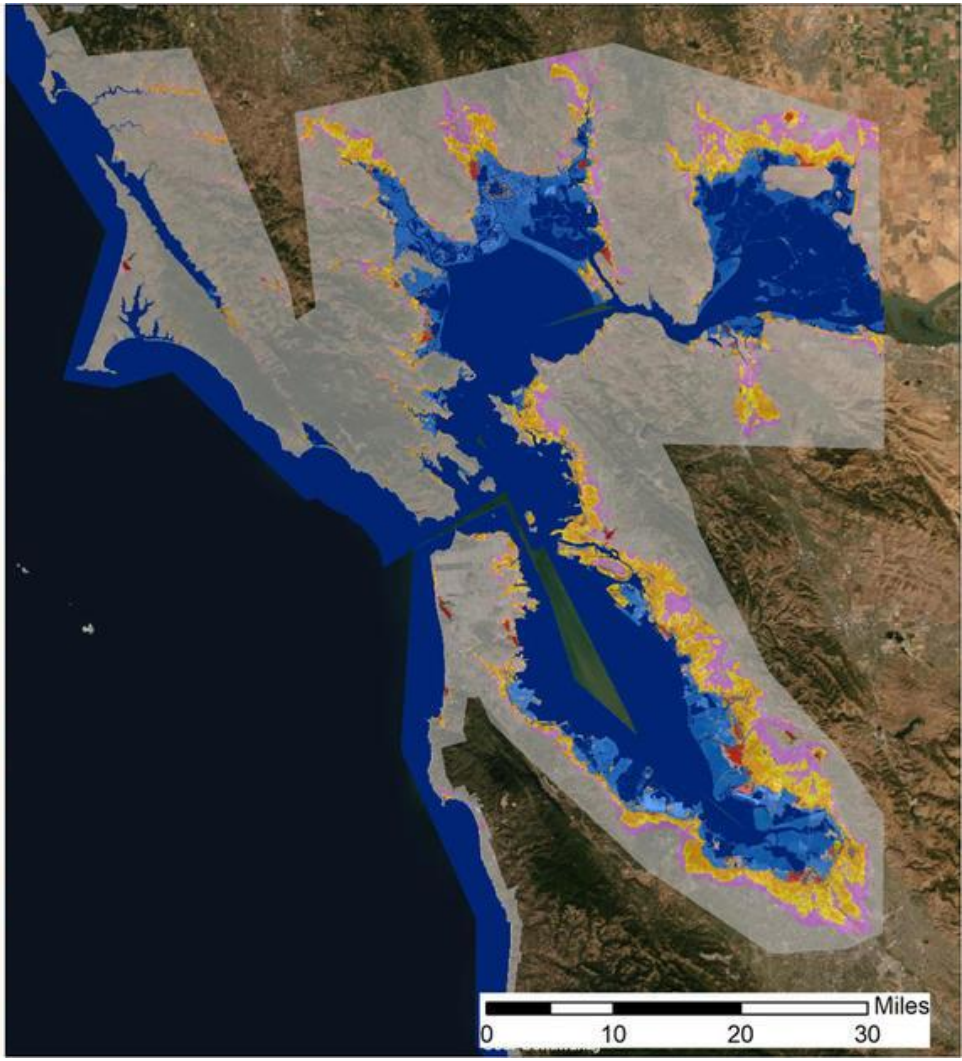
Sea Level Rise, Extreme Storms and Groundwater Inundation Based on Topography and SLR Changes

Current groundwater, groundwater inundation in red

Groundwater with 6 ft sea-level rise





(P. Barnard, USGS, CoSMoS-GW Mapping Project, San Francisco Bay

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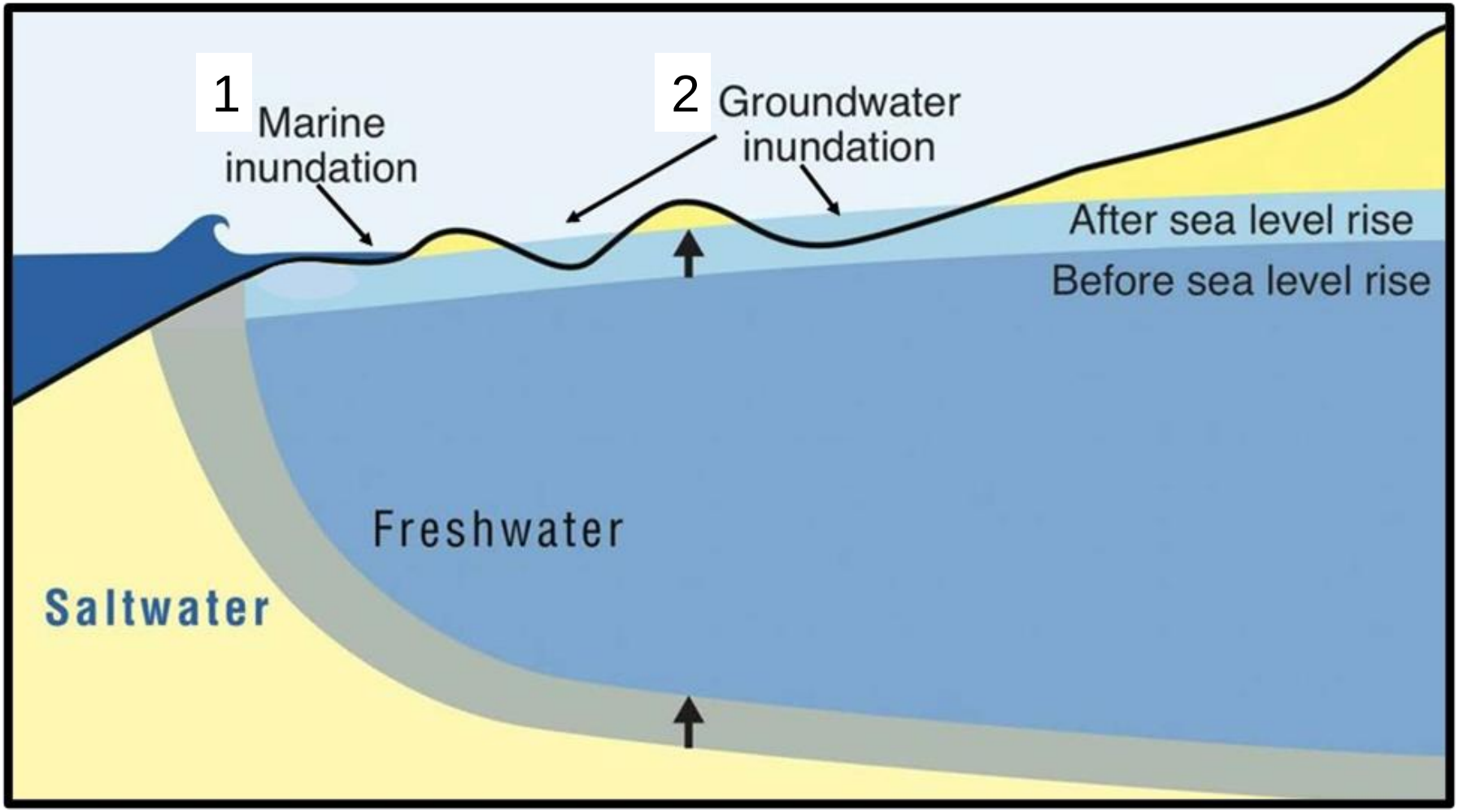
Sea Level Rise, Extreme Rain, and Groundwater Inundation:

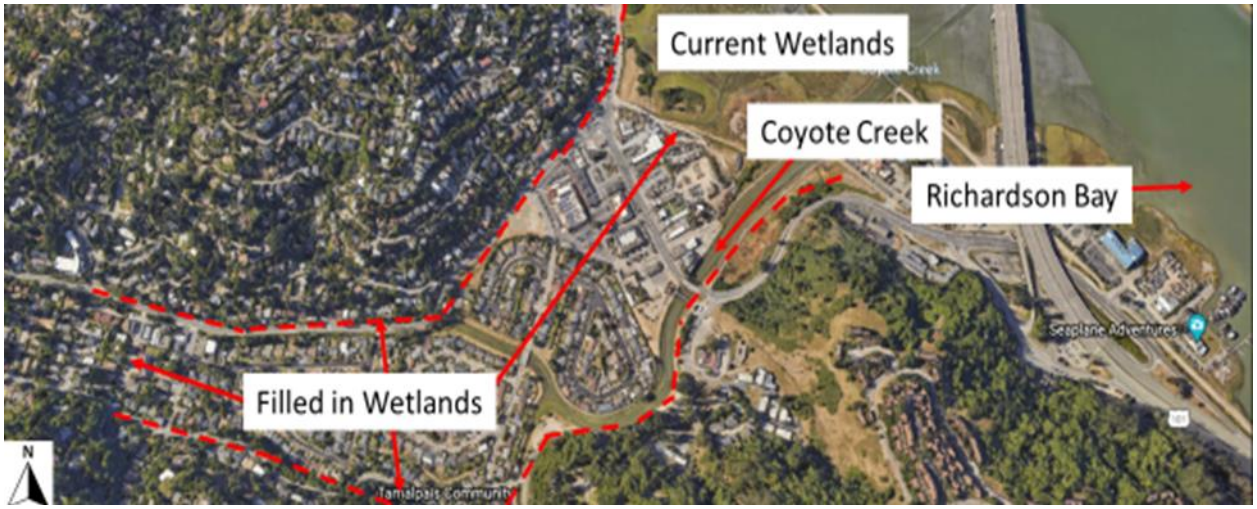
Two Manifestations of Sea Level Rise



From Univ. Hawaii, Manoa, Coastal Studies Group

Daily Tidal Effects predict what we should experience with SLR.

Evidence of Sea Level Rise and Extreme Storms
Tamalpais Valley, Southern Marin County, California



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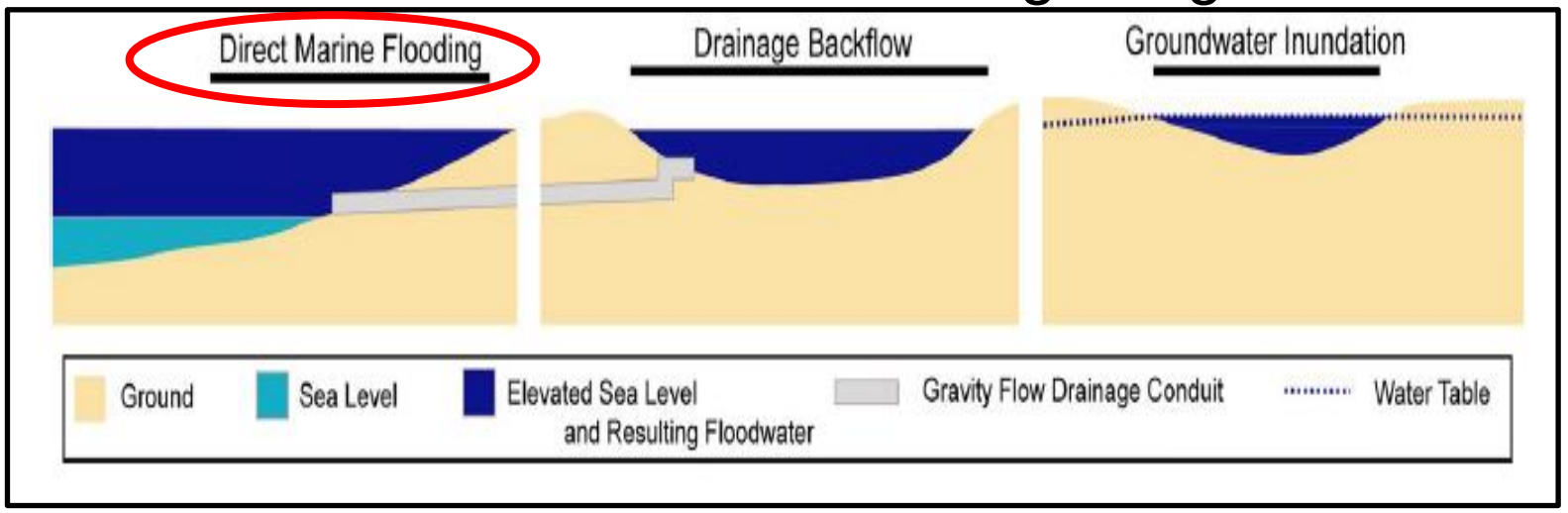
Evidence of Direct Flooding “King Tides”



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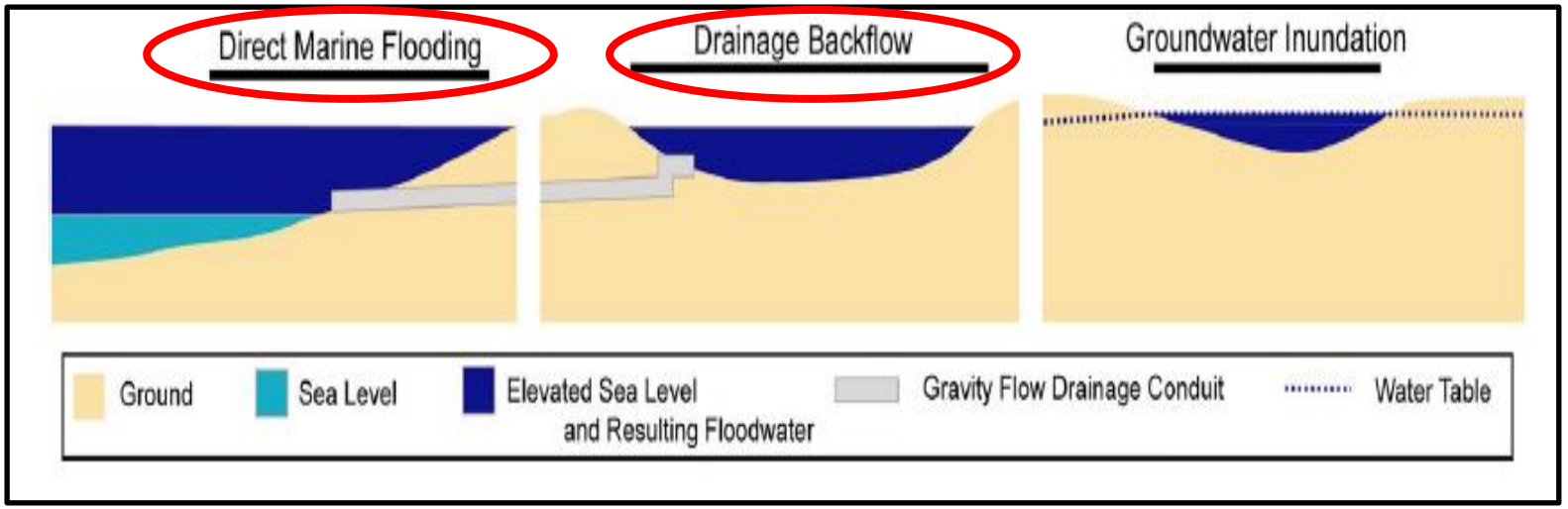
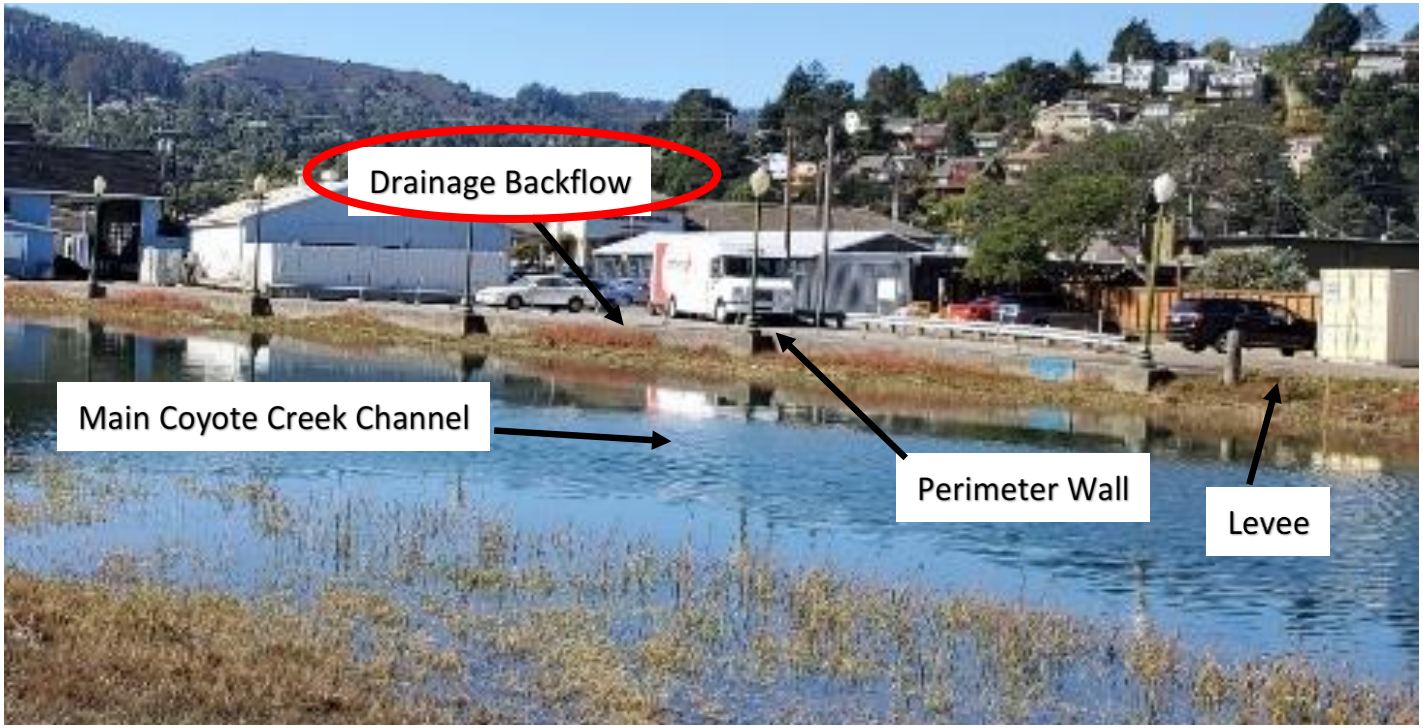
Evidence of Direct Flooding “King Tides”





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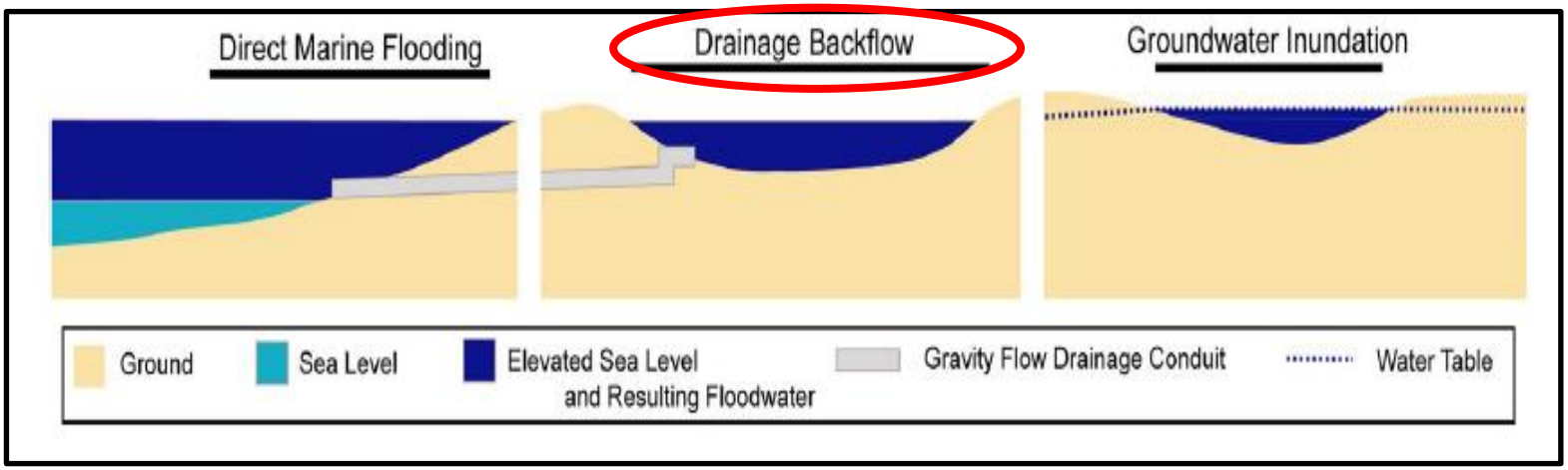
Evidence of Direct Flooding “King Tides”



Beginning of Drainage Backflow

During Drainage Backflow

End of Drainage Backflow

- Drainage backflow into parking lot
- Nearby, Caltrans ponded water does not match high tides
- Complex subsurface water connections

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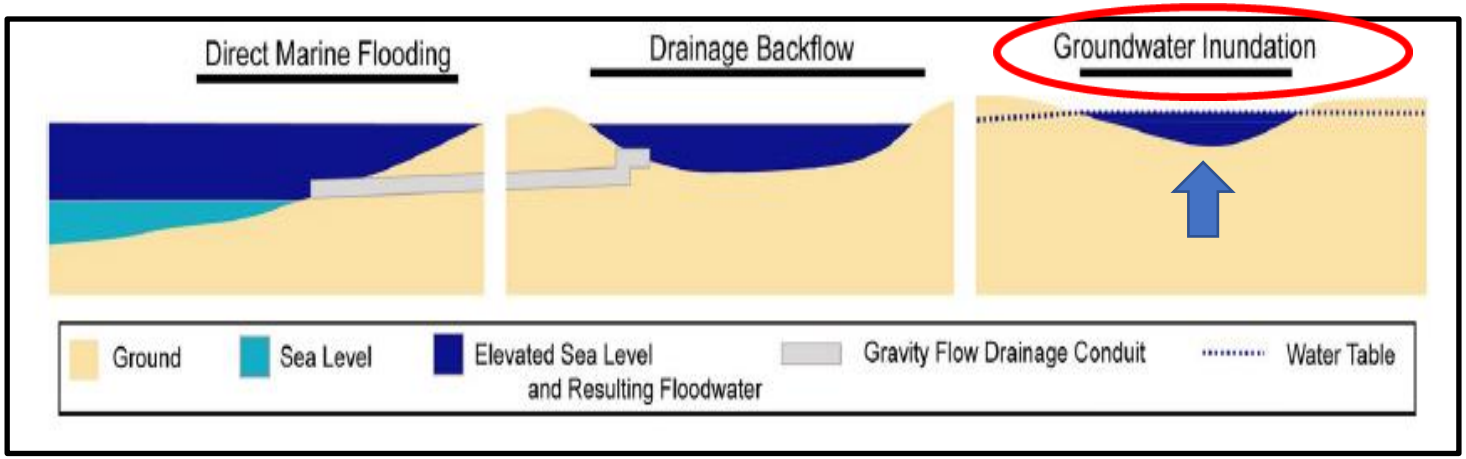
Evidence of Groundwater Inundation



- Ponding during period of drought
- Ponded water does not match high tides
- Complex subsurface water connections

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Evidence of Groundwater Inundation (During Drought)

Also Called: Groundwater Flooding, Emergent Groundwater

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Groundwater Inundation: Sump Pumps and Standing Water

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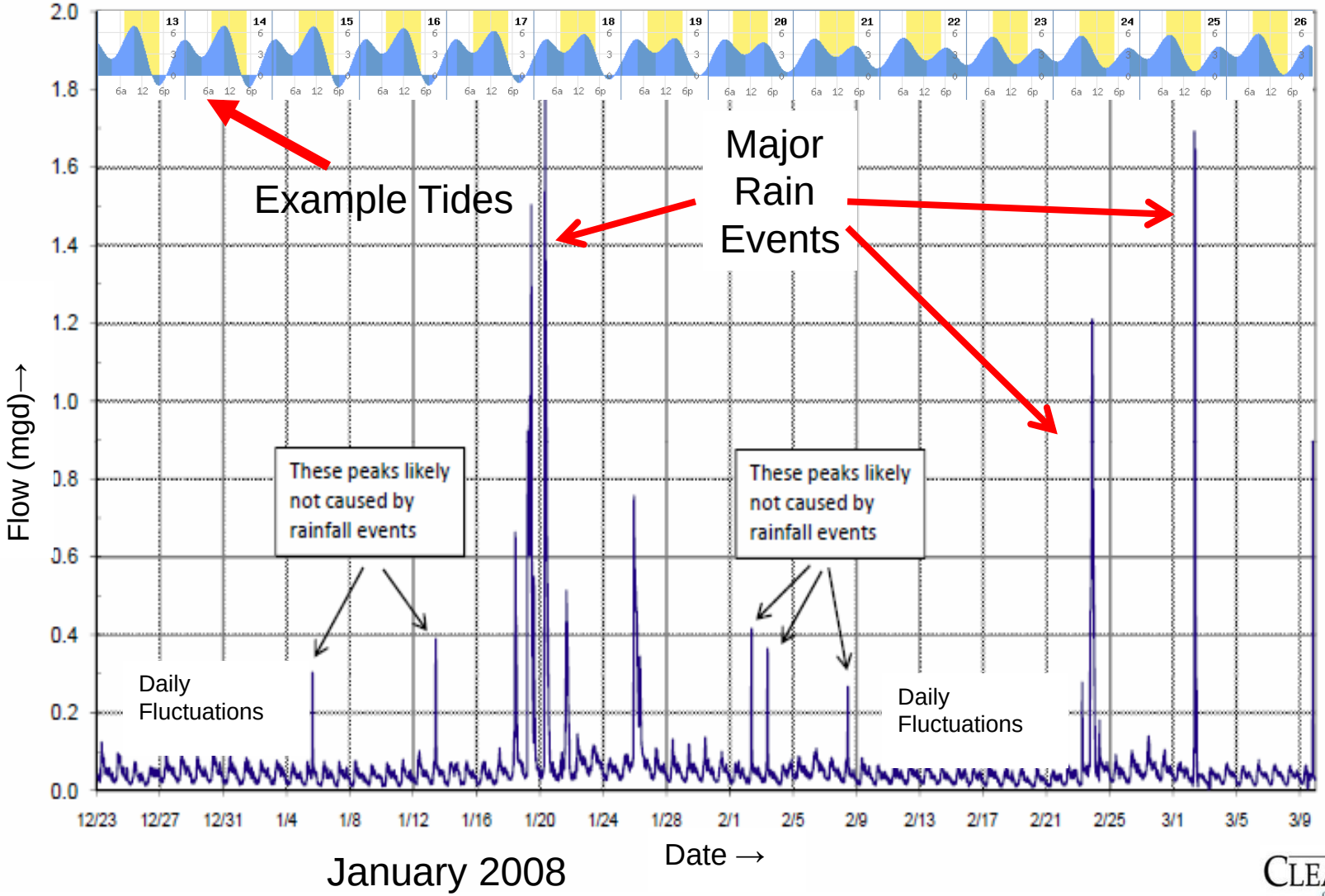
Consider Wide Tidal Ranges (Surrogate for Future Sea Level Rise) and Severe Storms Should Be Correlated with Real-Time Data



January 2008

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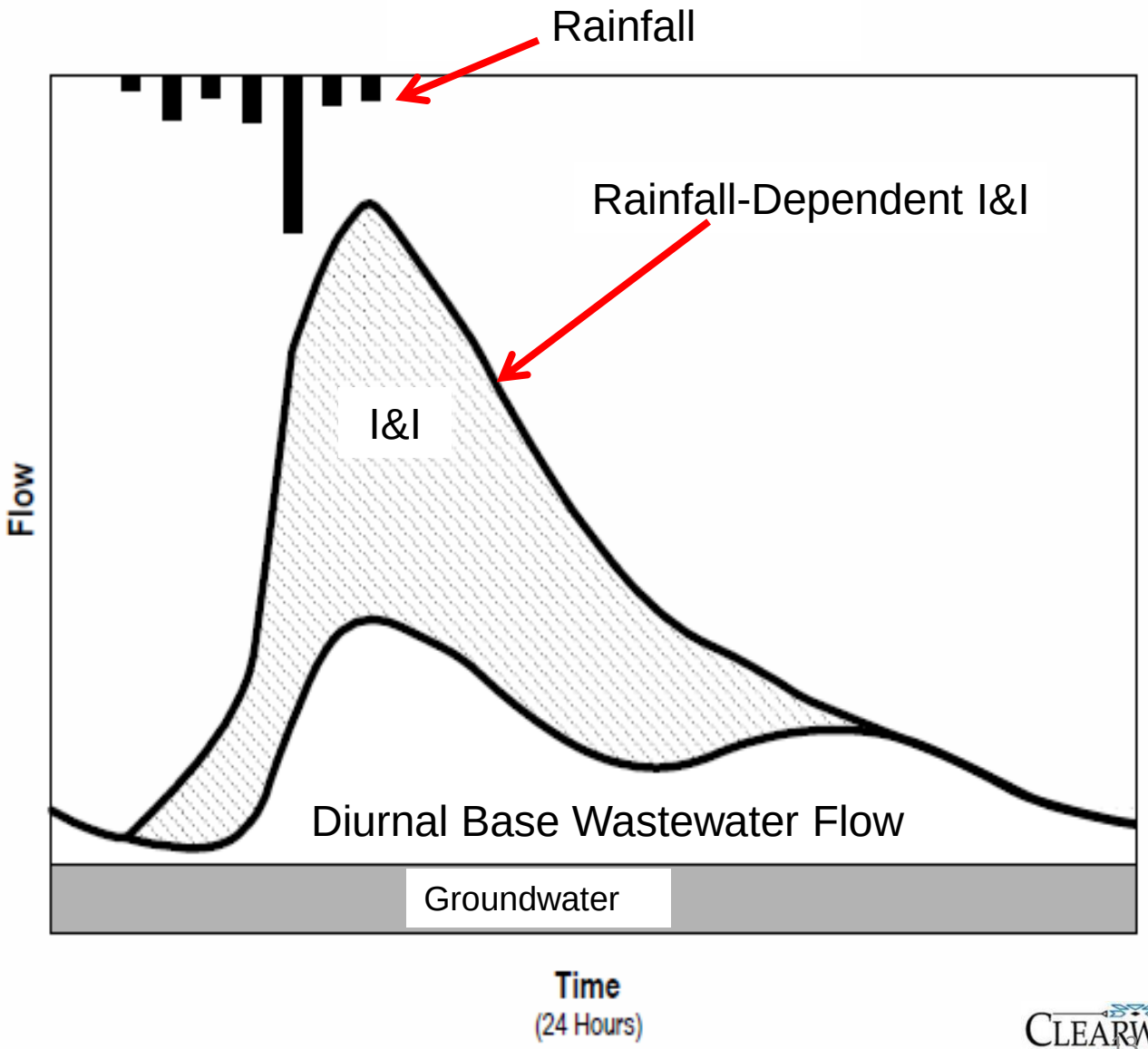
Extreme Rain: Wastewater Flow Components: Peaking Factor: 8 to 33 Times Normal Flow (Jan, 2008)

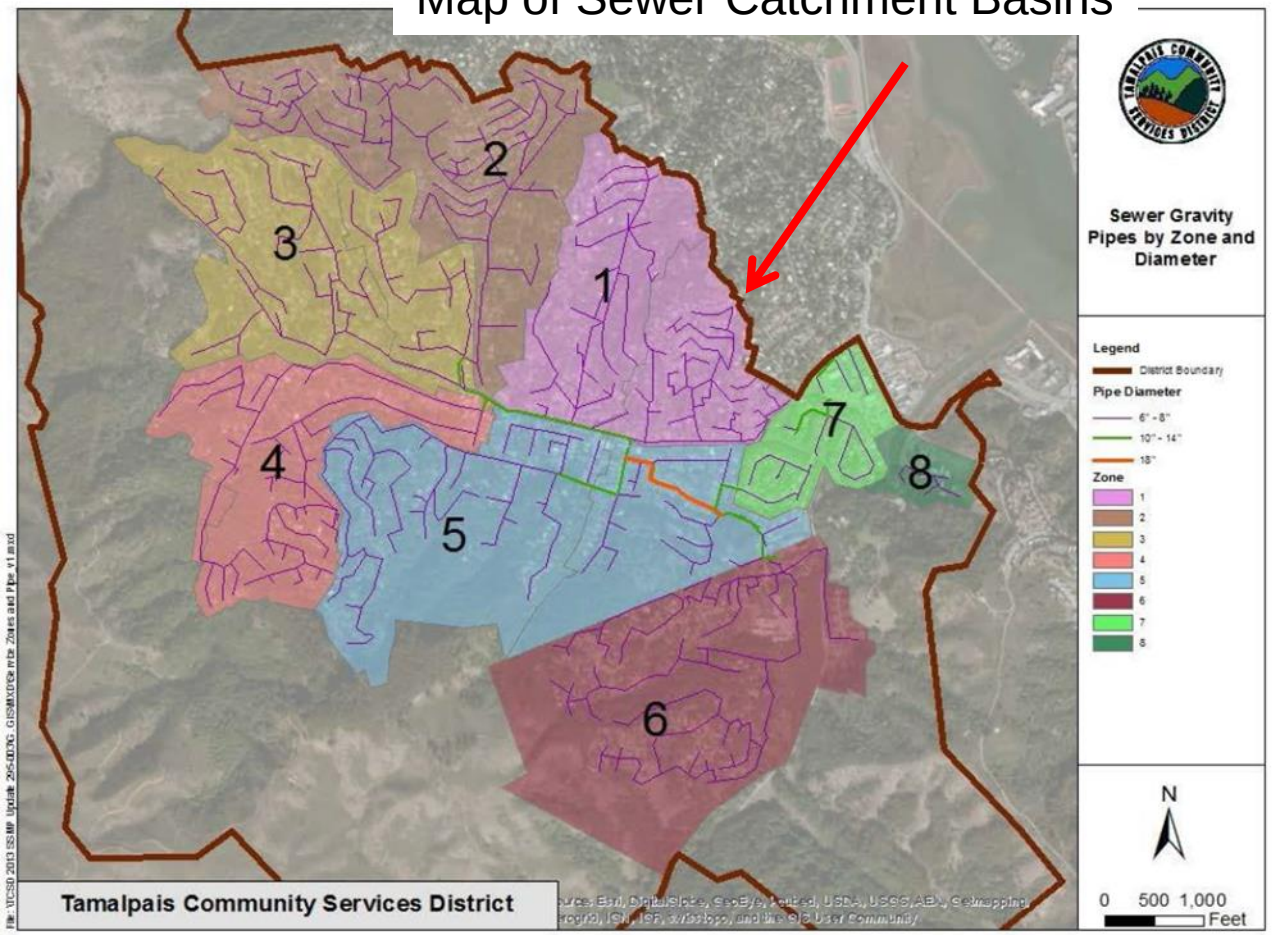


(SASM SSR; RMC; 2010)

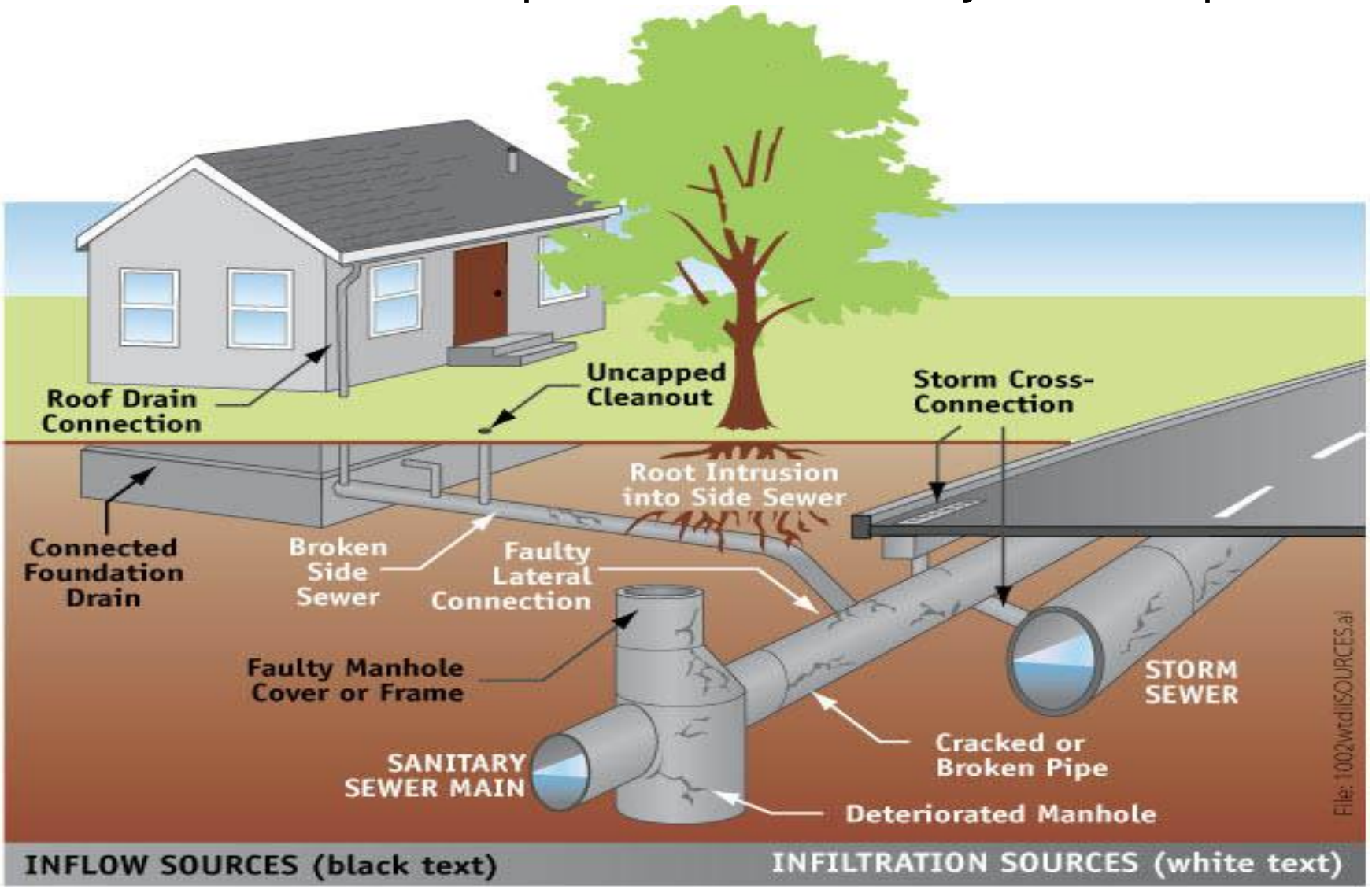
Groundwater Inundation Meets Sanitary Sewer Infrastructure

Figure 4-1: Sewer Service Zones and Pipe Diameter

Map of Sewer Catchment Basins



Current Site Conceptual Model of Leaky Sewer Pipes



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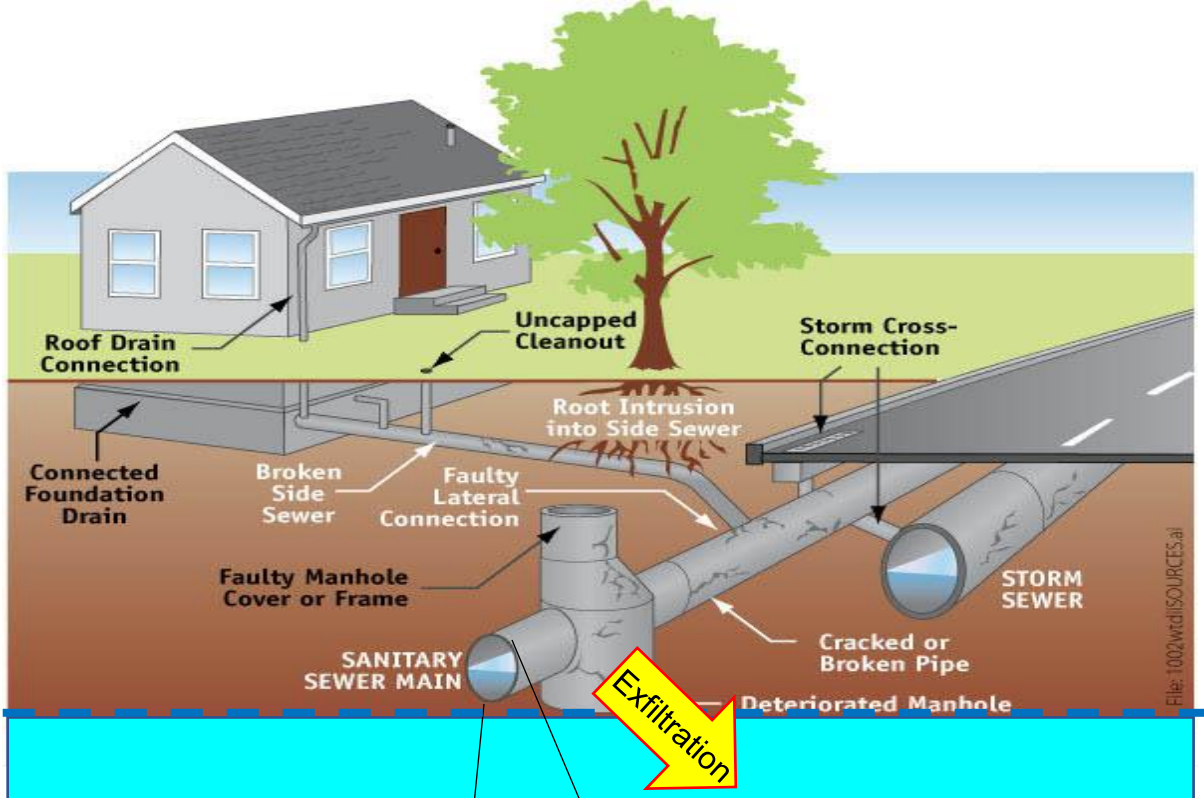
Leaky Sewer Pipes



Where pipes and junctions lie above groundwater, only rainwater and soil moisture enters pipe breaches.

Groundwater Elevation

Groundwater below pipe – Time 1

Rainwater and Soil Moisture

Sewage plus rainwater

Sewer Pipe

Exfiltration

Groundwater - Time 1

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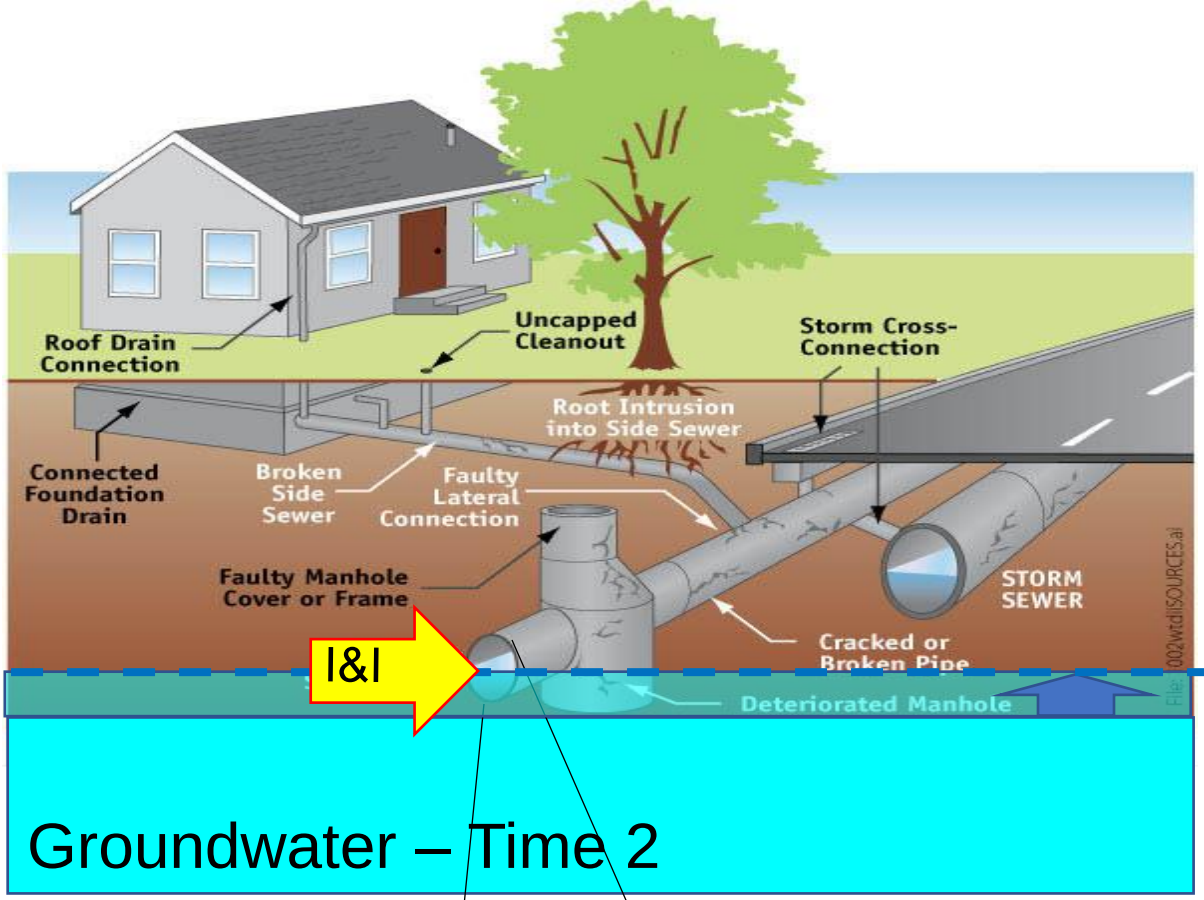
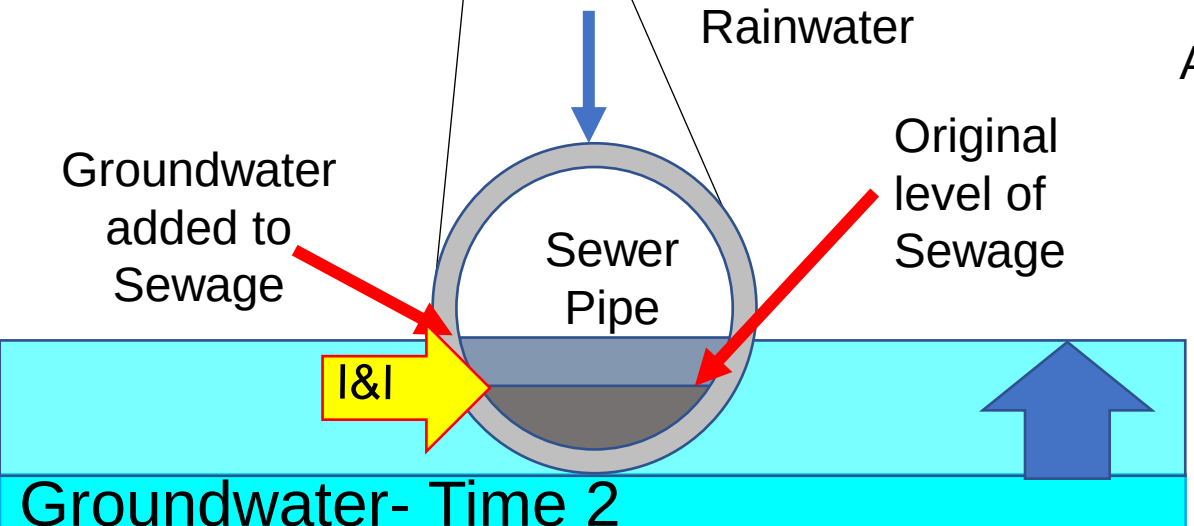
Leaky Sewer Pipes



Where pipes lie in saturated soil, groundwater enters sewer pipes as inflow and Infiltration (I&I) at pipe breaches

Groundwater Elevation



Assumes homogeneous porous, “layer-cake” sediments

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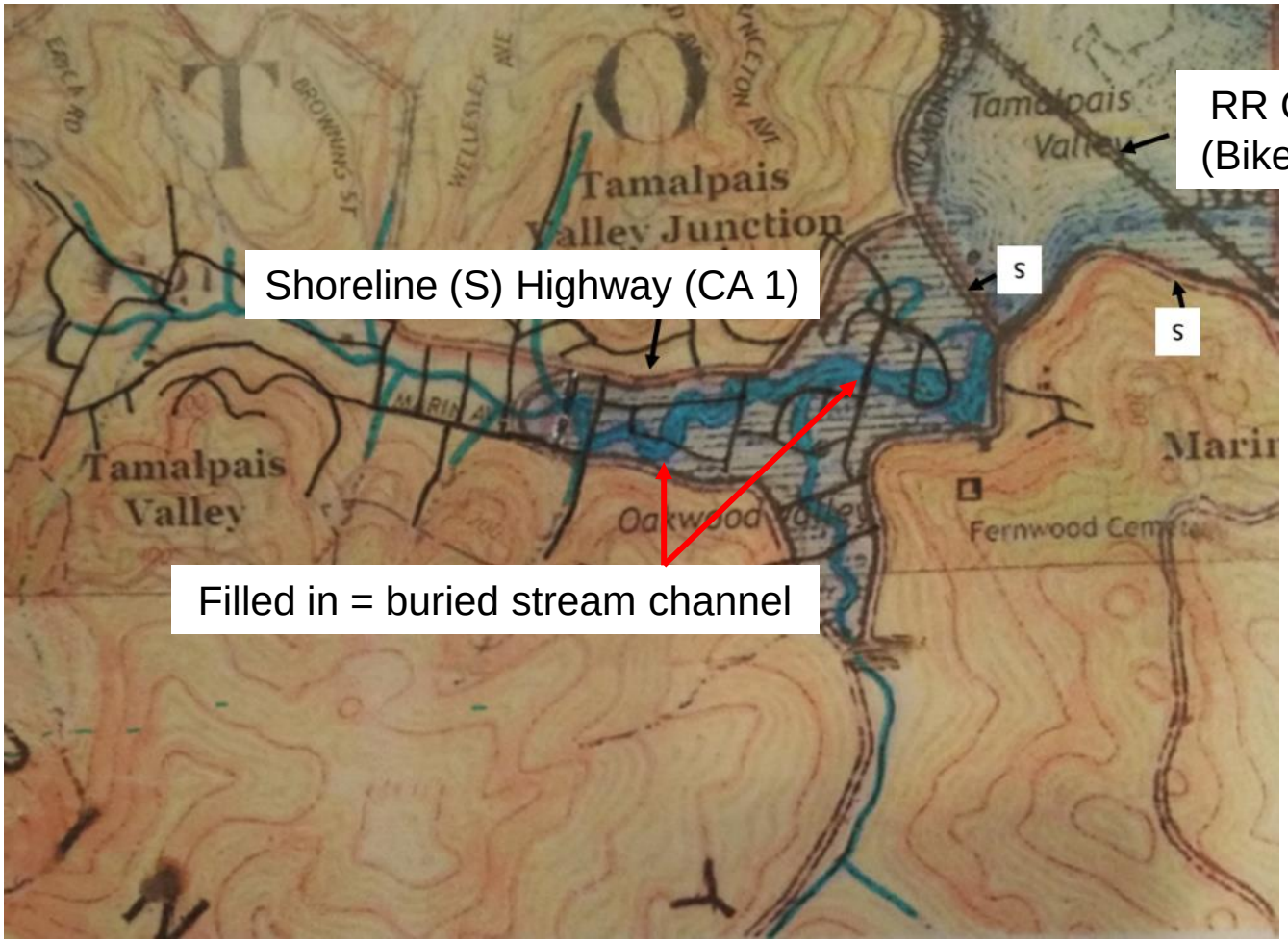
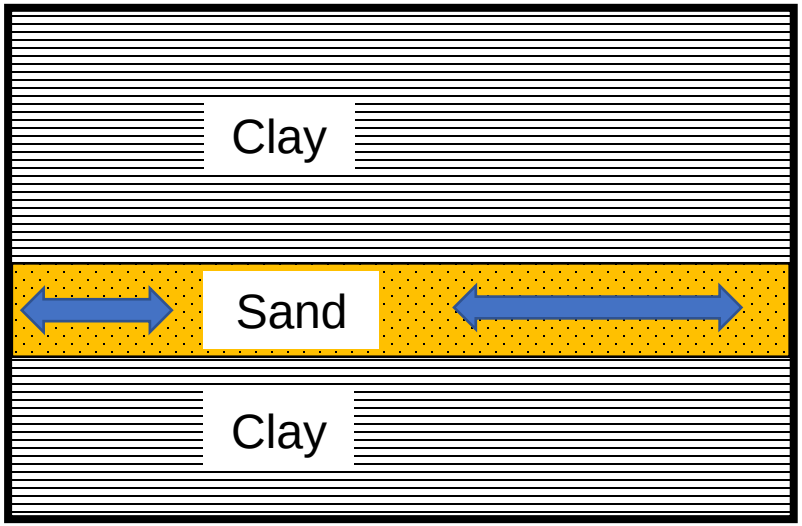
Tamalpais Valley – Filled Wetlands and Buried Stream Channels



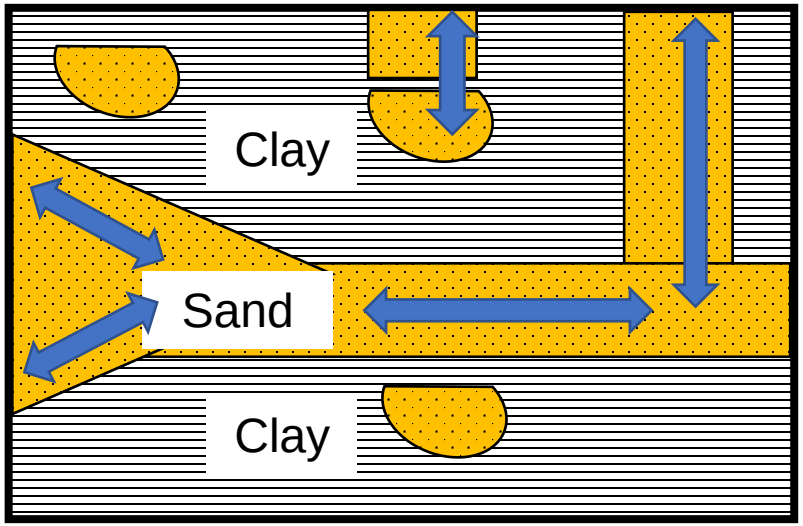
1911 historic map is overlain with current street locations (in black). Shoreline Highway is (S) (State Route 1) and the railroad (RR) causeway is now a bike path.

Complex Hydrogeologic Conditions

Simple Layer-Cake Geology



Actual Complex Subsurface

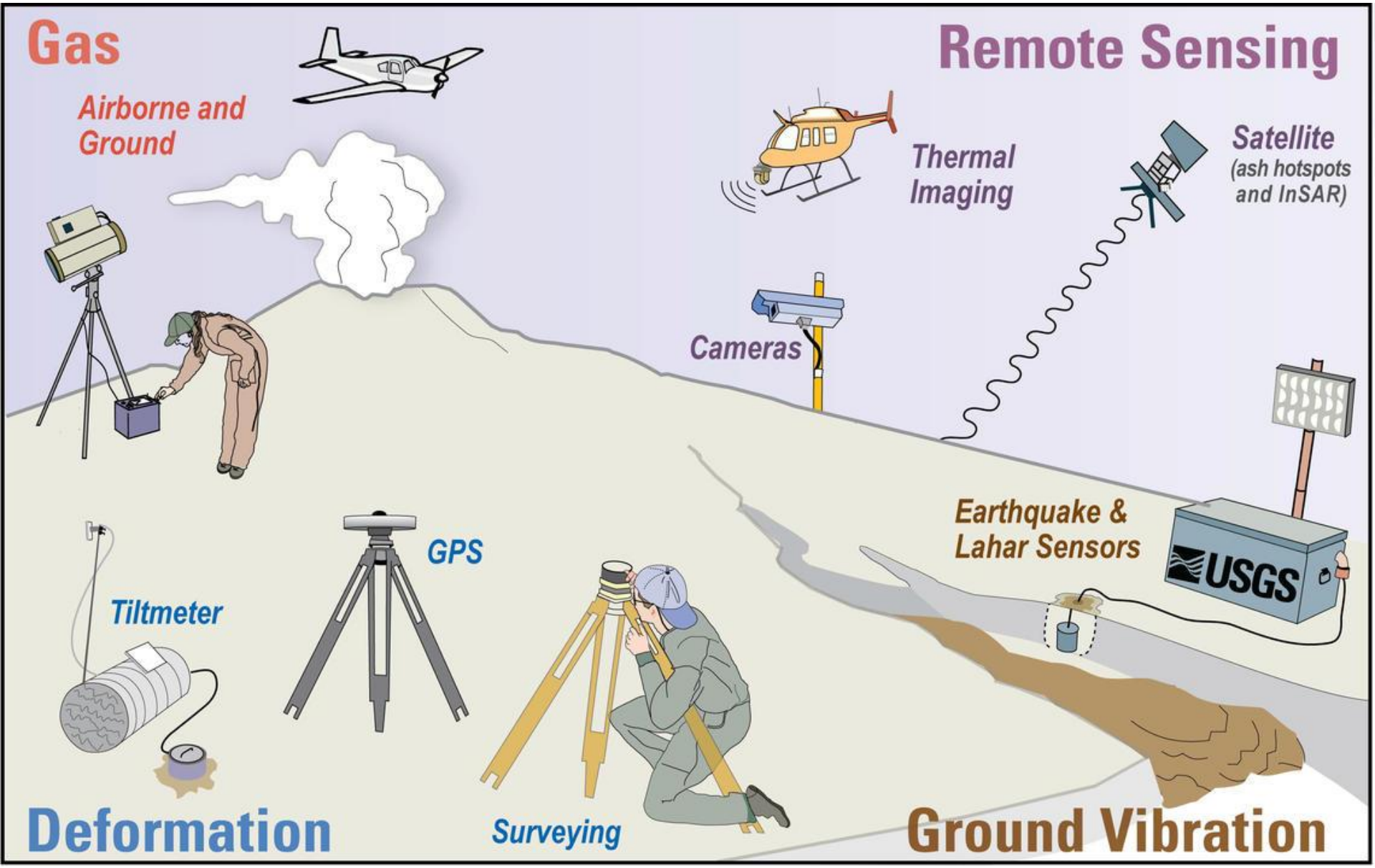


Groundwater Flow

Buried Stream Channels

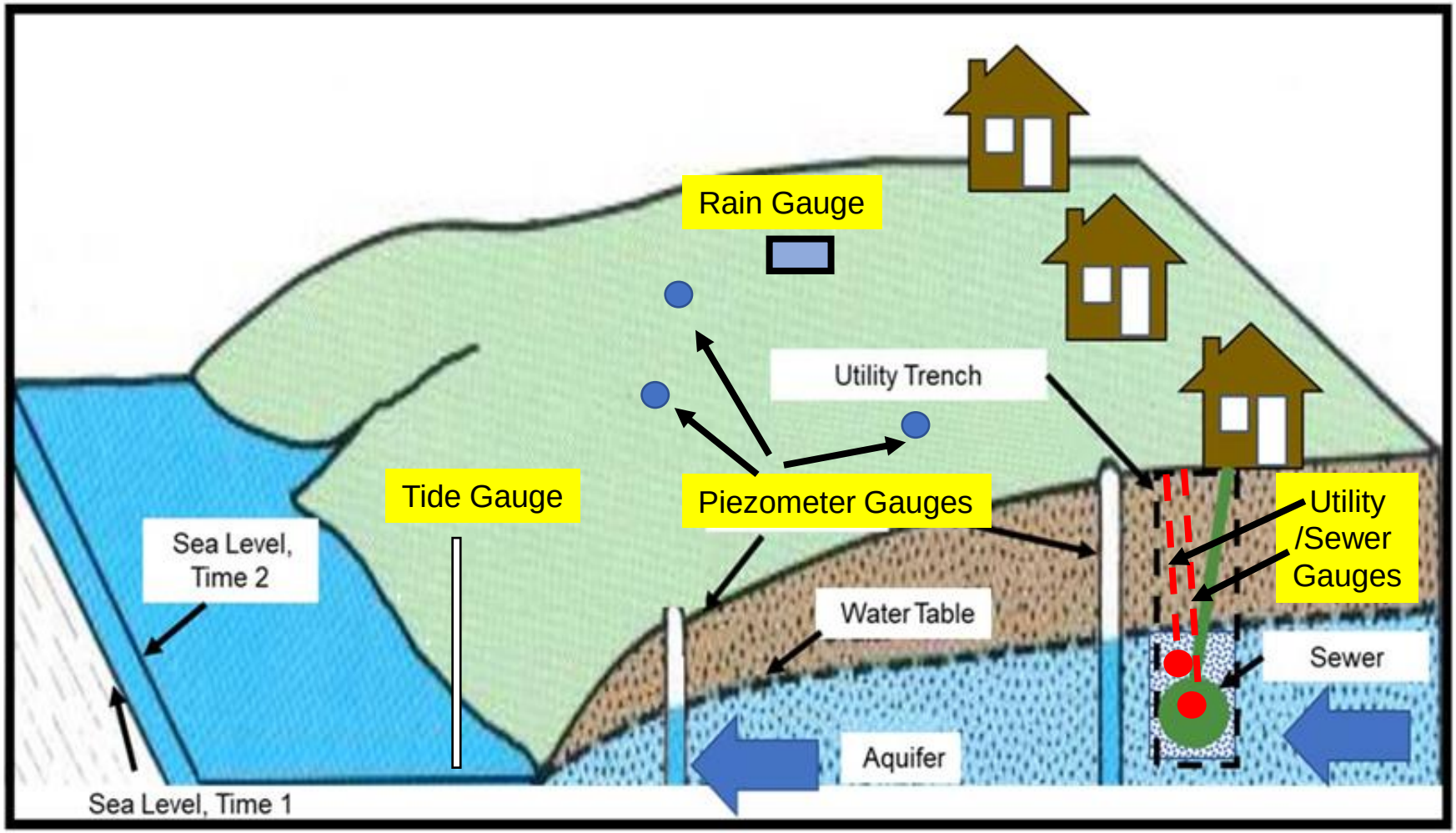
Utility Trench, French Drains

Measuring Water Elevation, Conductivity, and Temperature



(USGS)

Concept: Piezometers with Battery-Powered, Cellular, Real-Time Data Loggers



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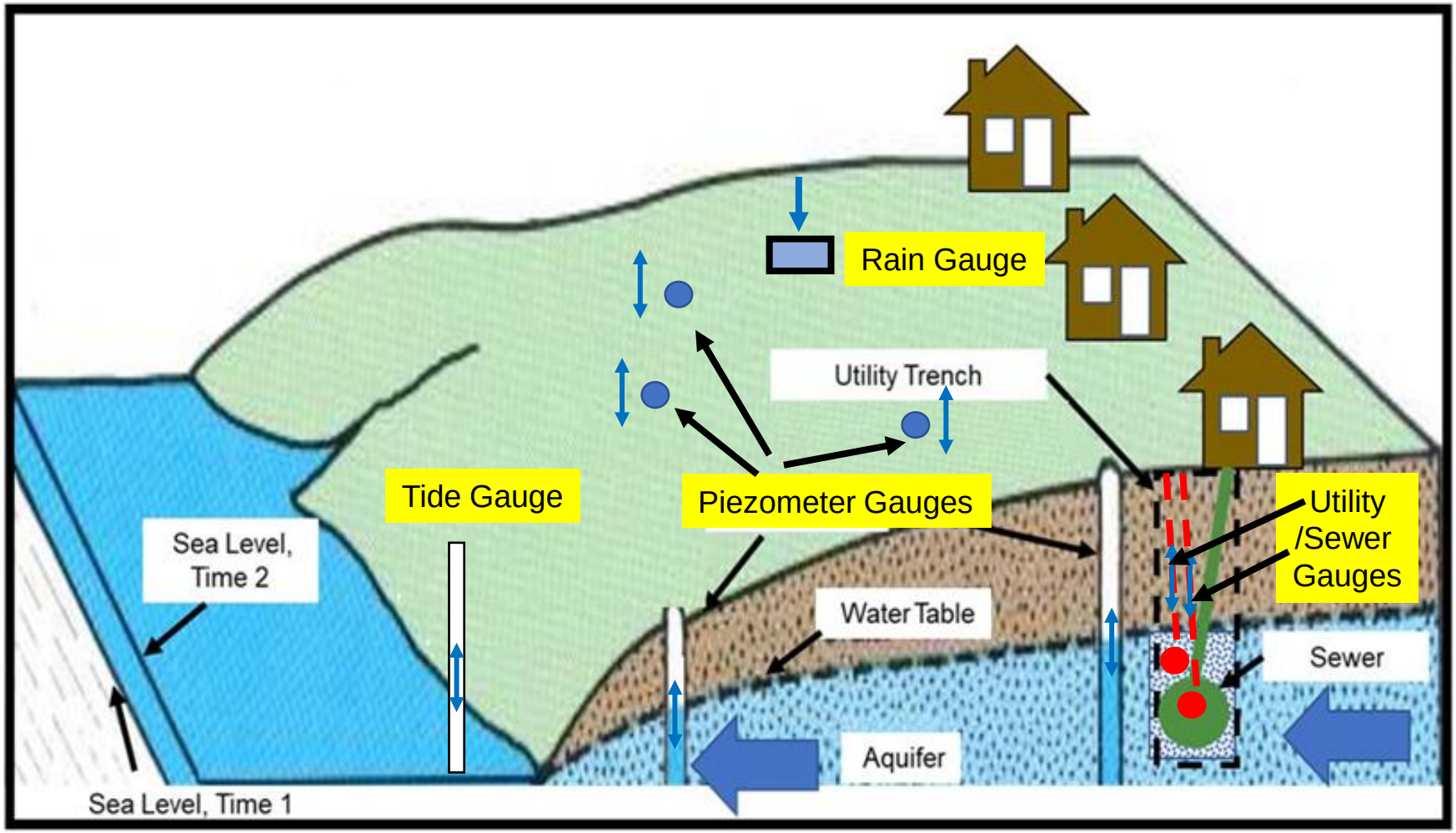
Concept: Piezometers with Battery-Powered, Cellular, Real-Time Data Loggers



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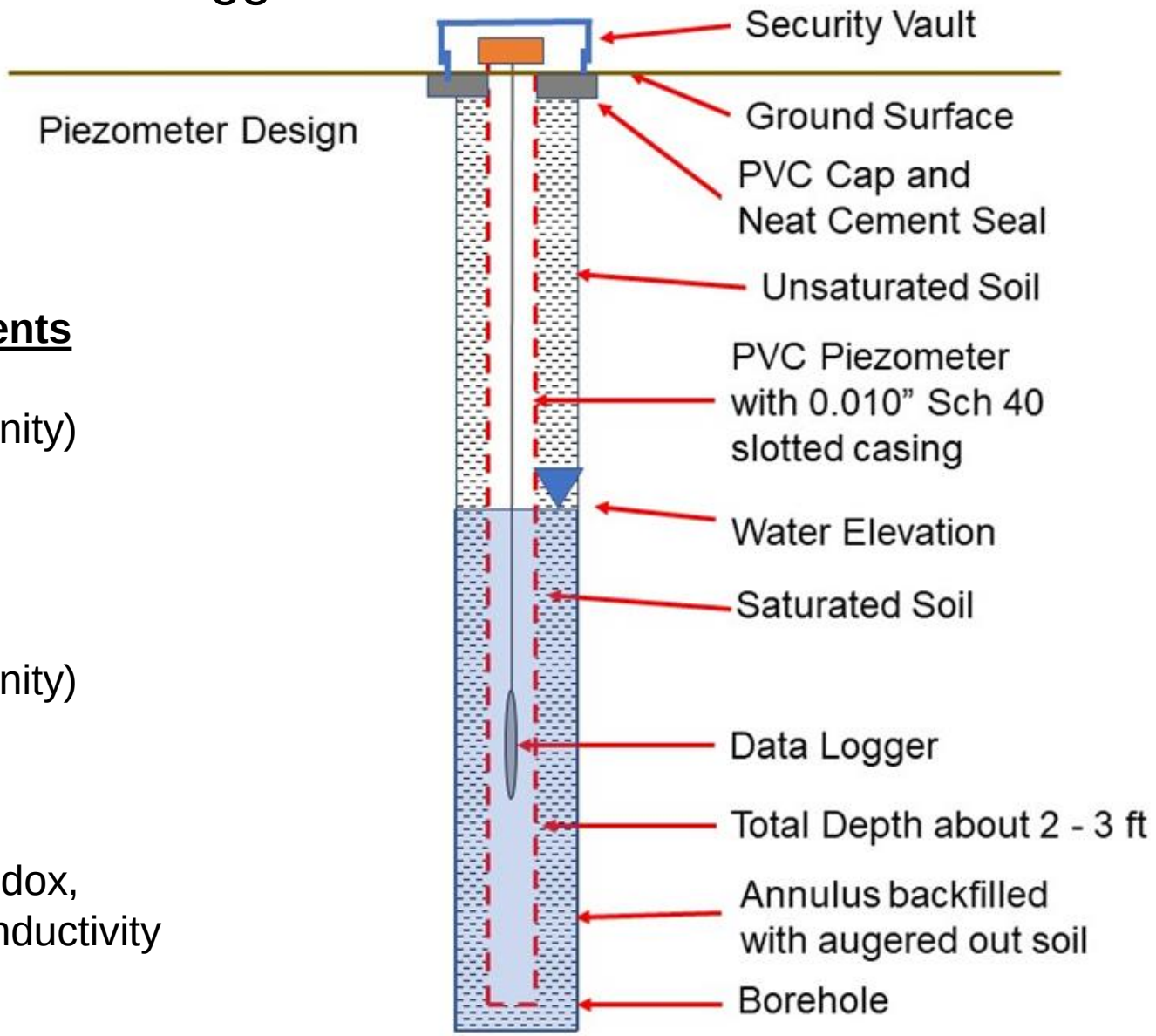
Piezometer with Data Logger

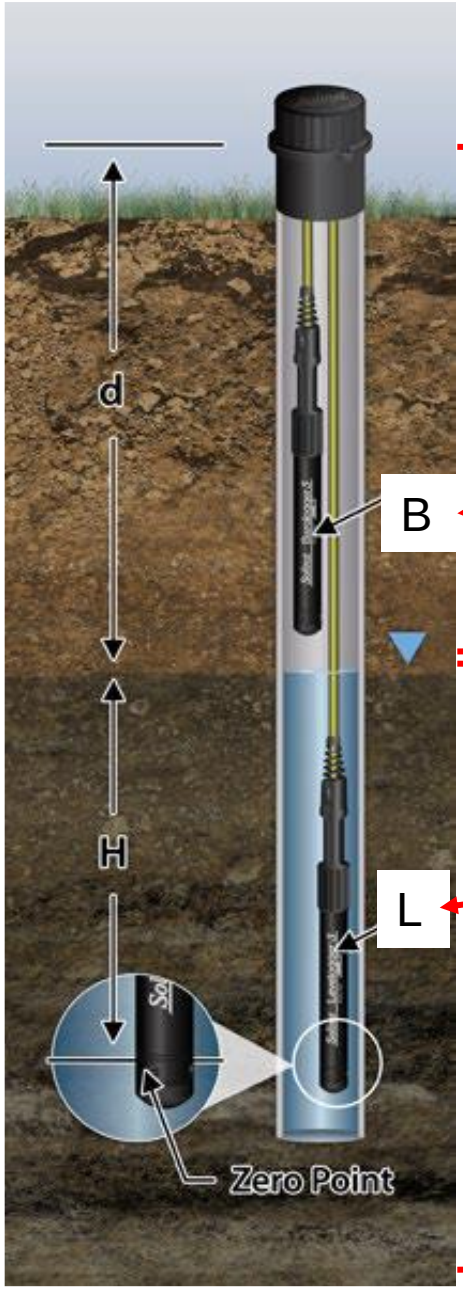
Manual Measurements
- Water Depth
- Conductivity (Salinity)
- Temperature

Dataloggers
- Water Depth
- Conductivity (Salinity)
- Temperature

Field Meters
- DO, pH, ORP, Redox,
- Temperature, Conductivity



Piezometer with Data Logger: Automated, Remote Monitoring



Top of Piezometer casing surveyed by Licensed Surveyor

Surface to top of water (d)

Solinst Barometric Pressure Logger (B)

Top of Water Table

Solinst Leveloggers (L)

Height of Water Column (H)

Solinst®

Project Instrumentation Sponsor

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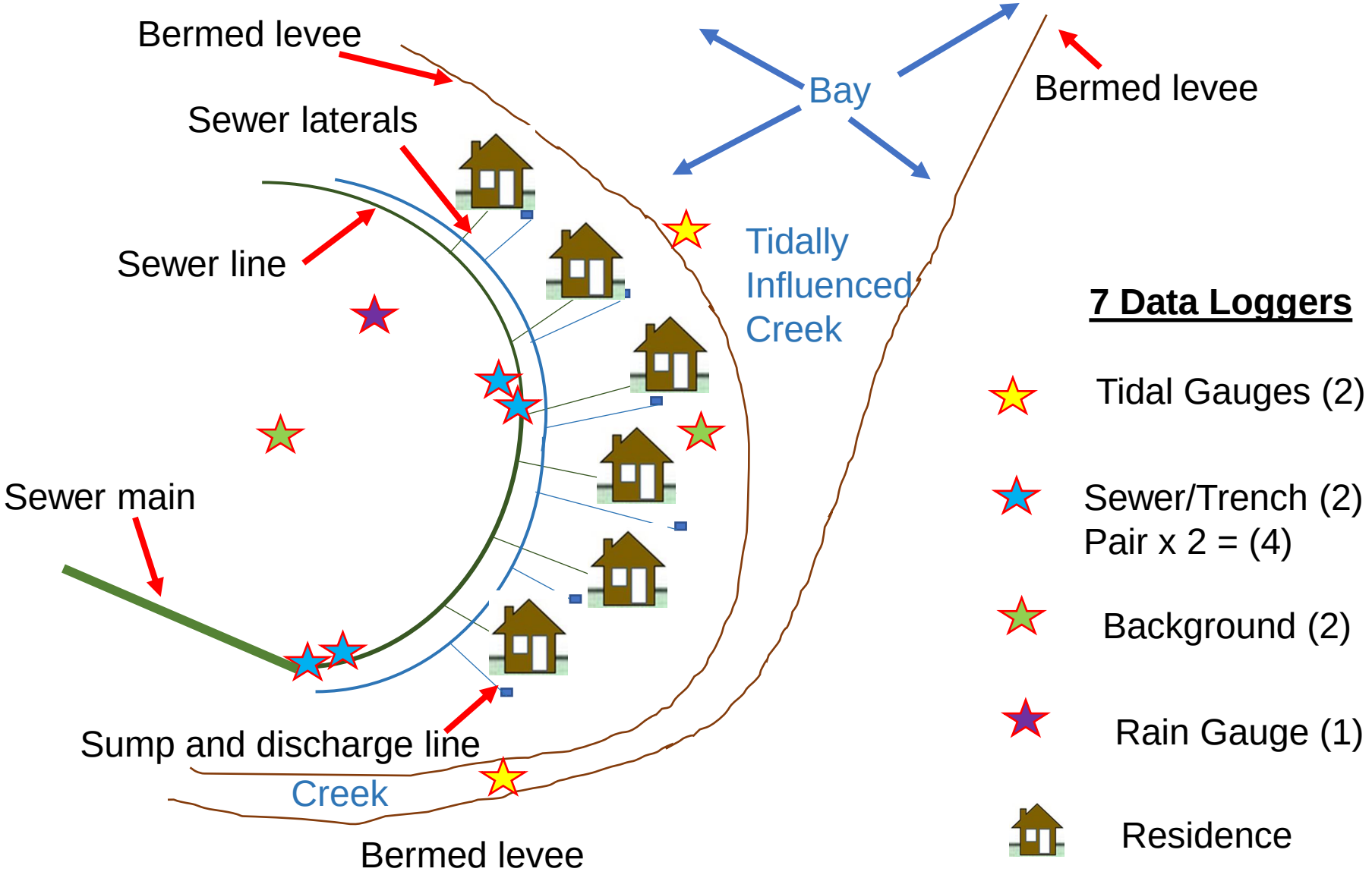
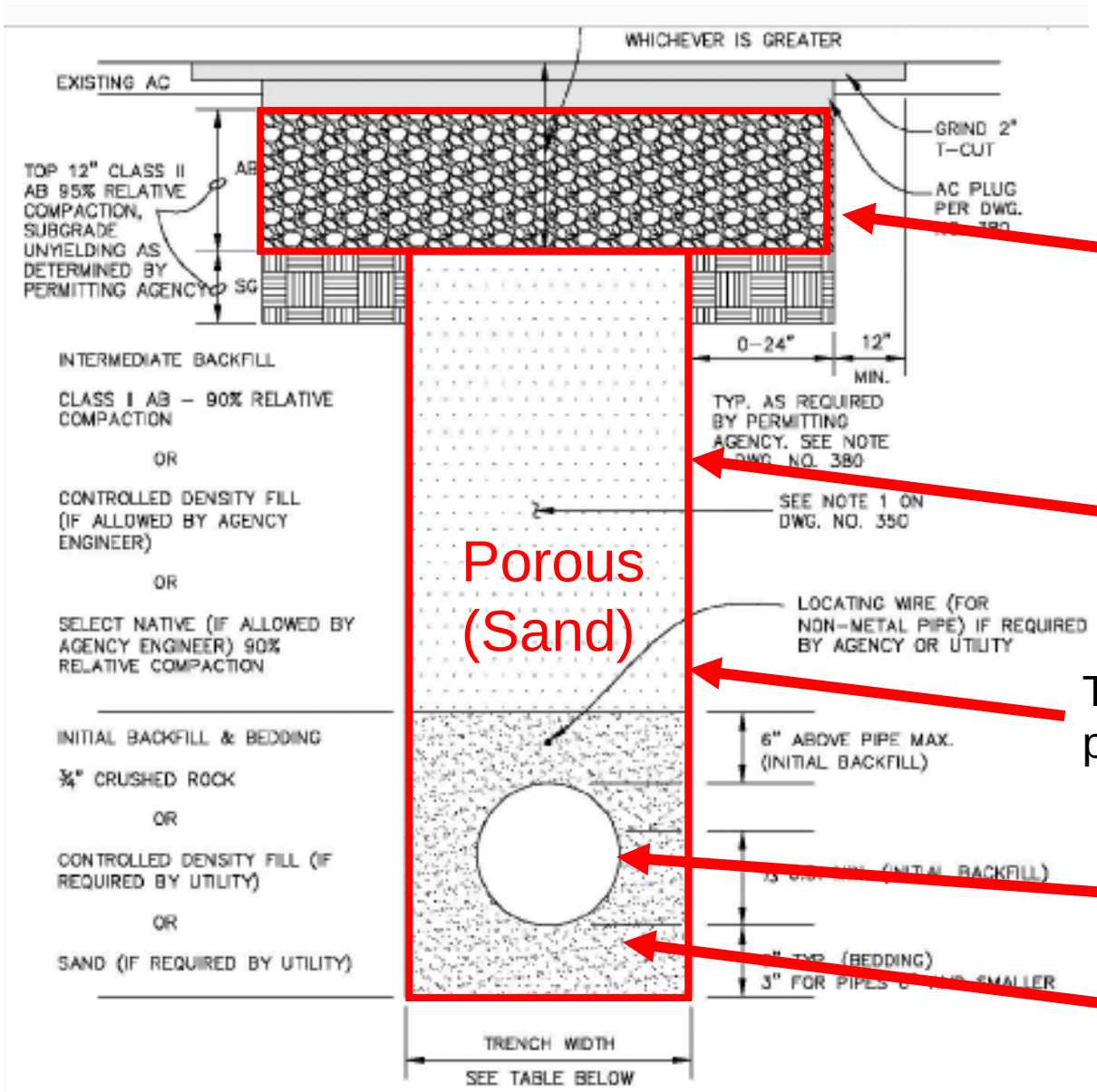
Example Study Project Layout For Real-Time Data Collection



Utility Trench as a Water Conduit or Preferential Pathway



Crushed Class II AB

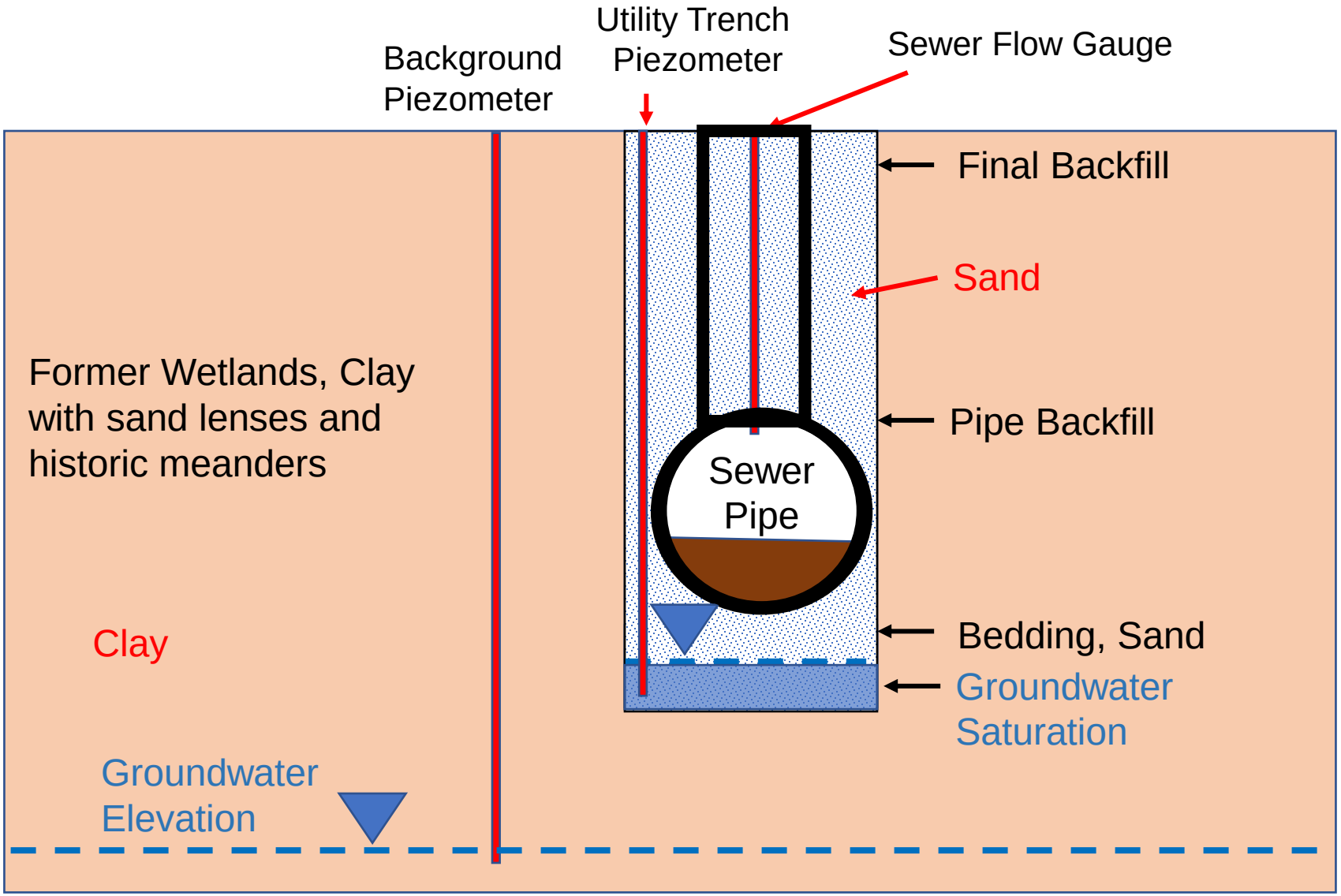
Crushed Rock, Native Soil or Other

Trench is a preferentially porous pathway

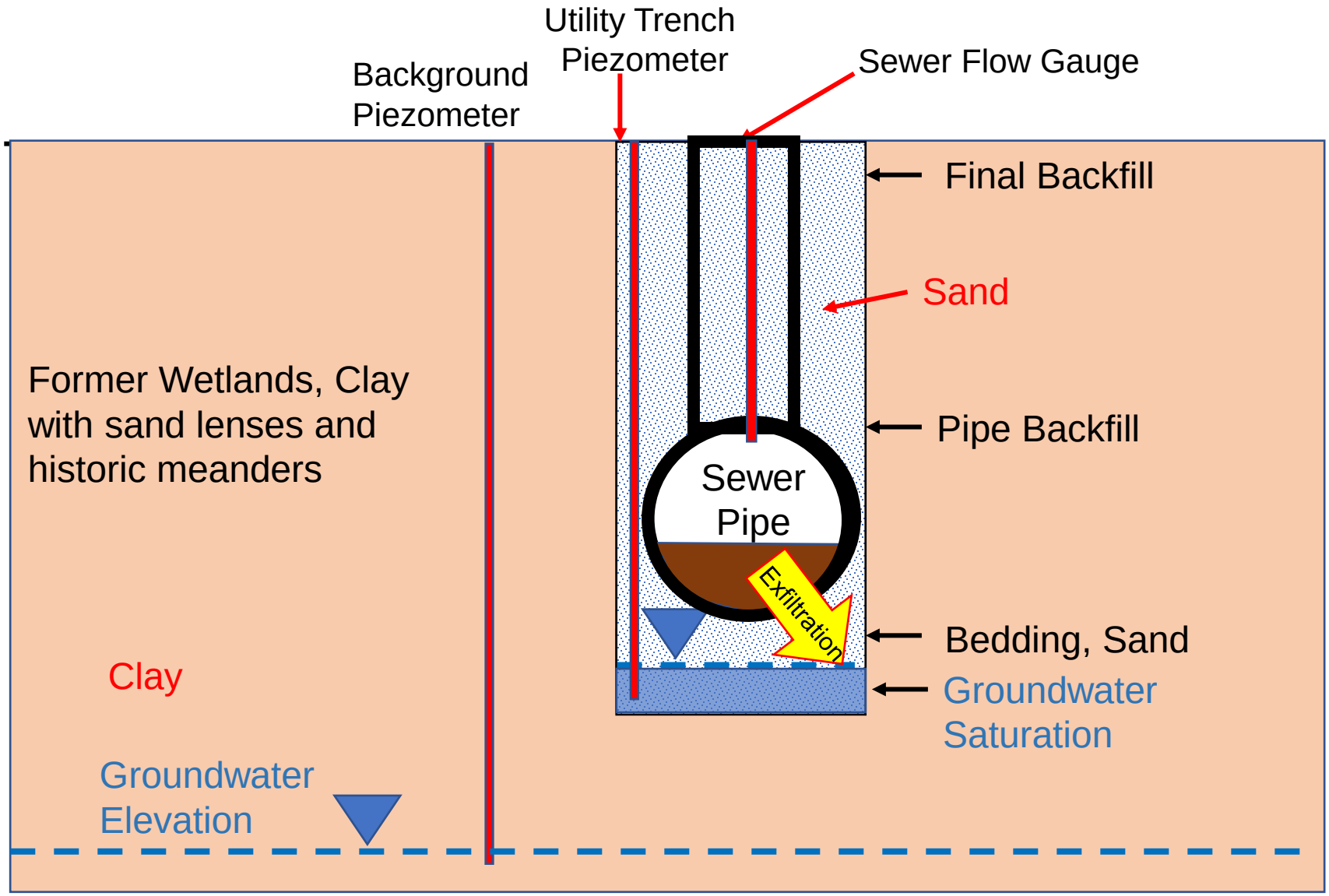
Sewer Pipe

Crushed Rock, Sand, or Other

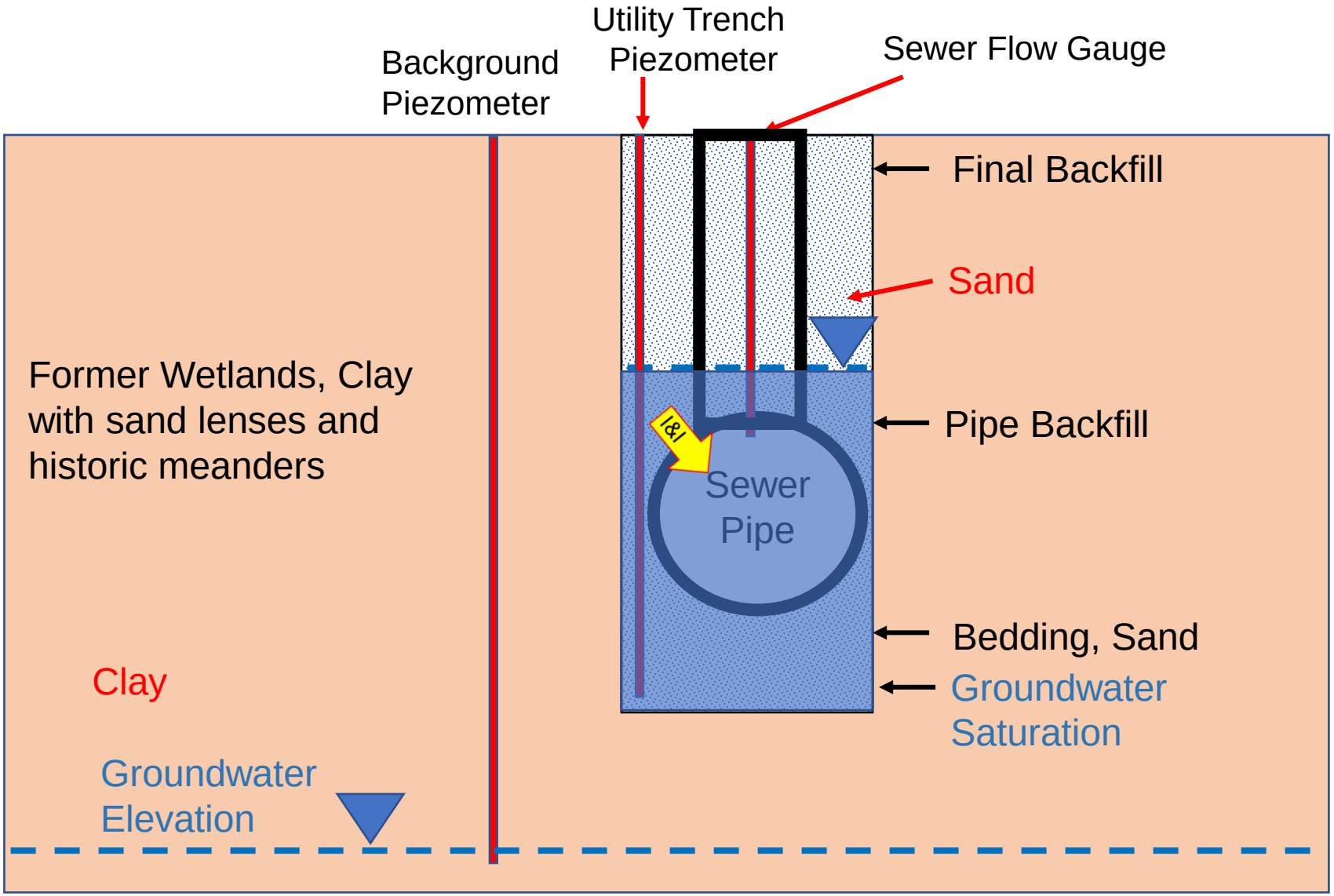
Ex. 1 - Groundwater Below Sewer Pipe, Trench contains Water



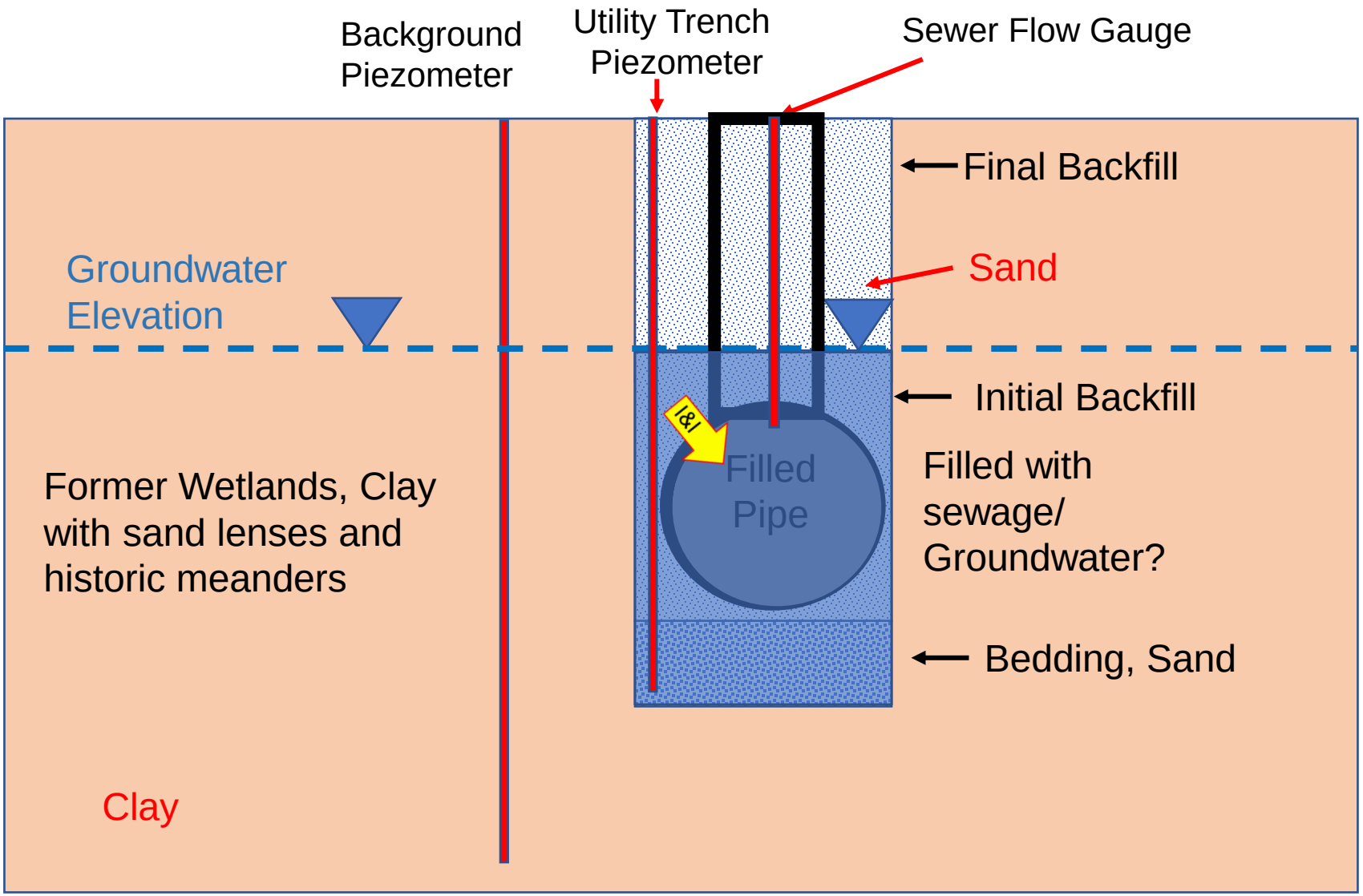
Ex. 2 - Exfiltration Below Leaking Sewer Pipe



Ex. 3 - Groundwater Above Sewer; Area-Wide Groundwater Lower

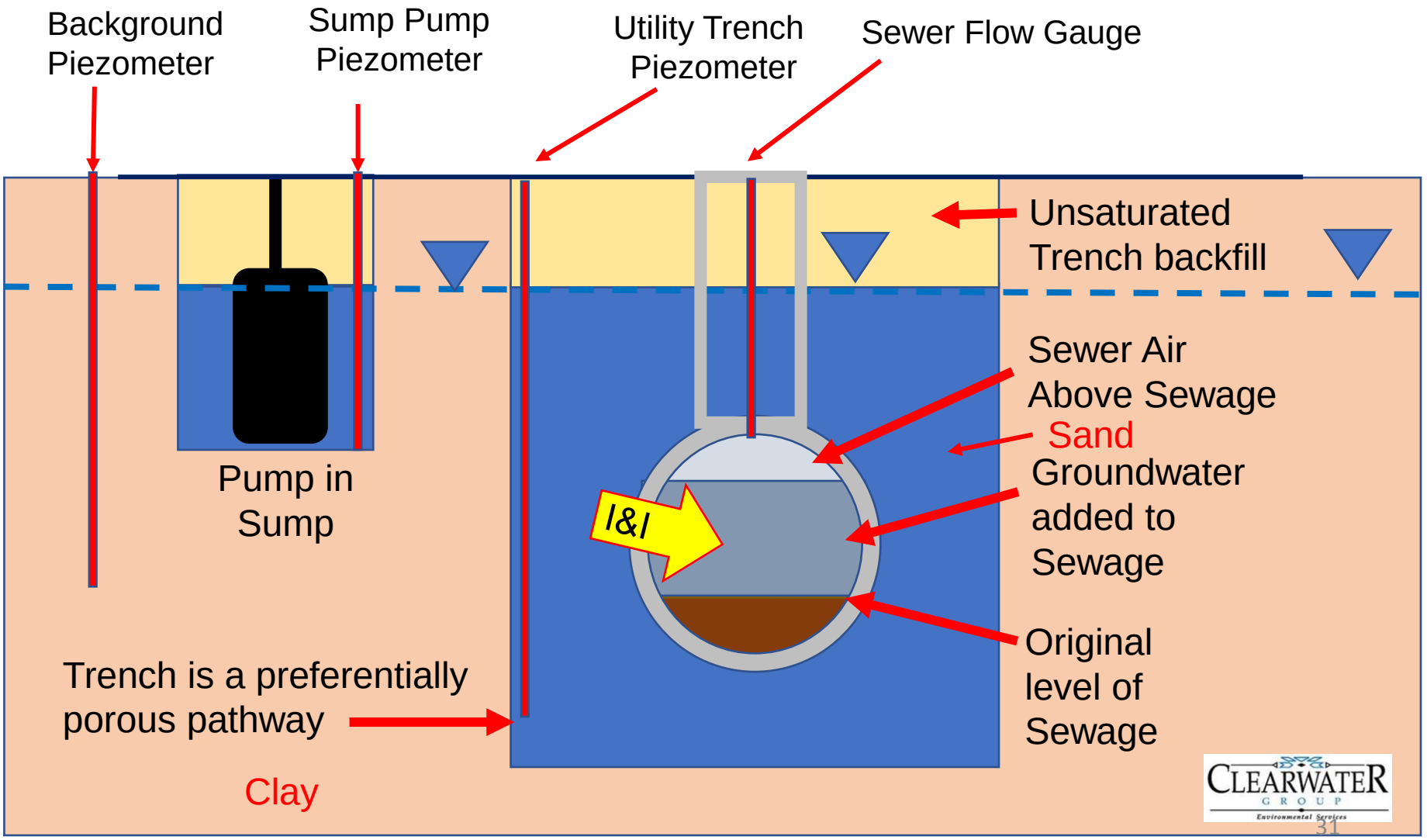


Ex. 4 - Groundwater Elevation: Area-Wide, Rises with Rain or Tides

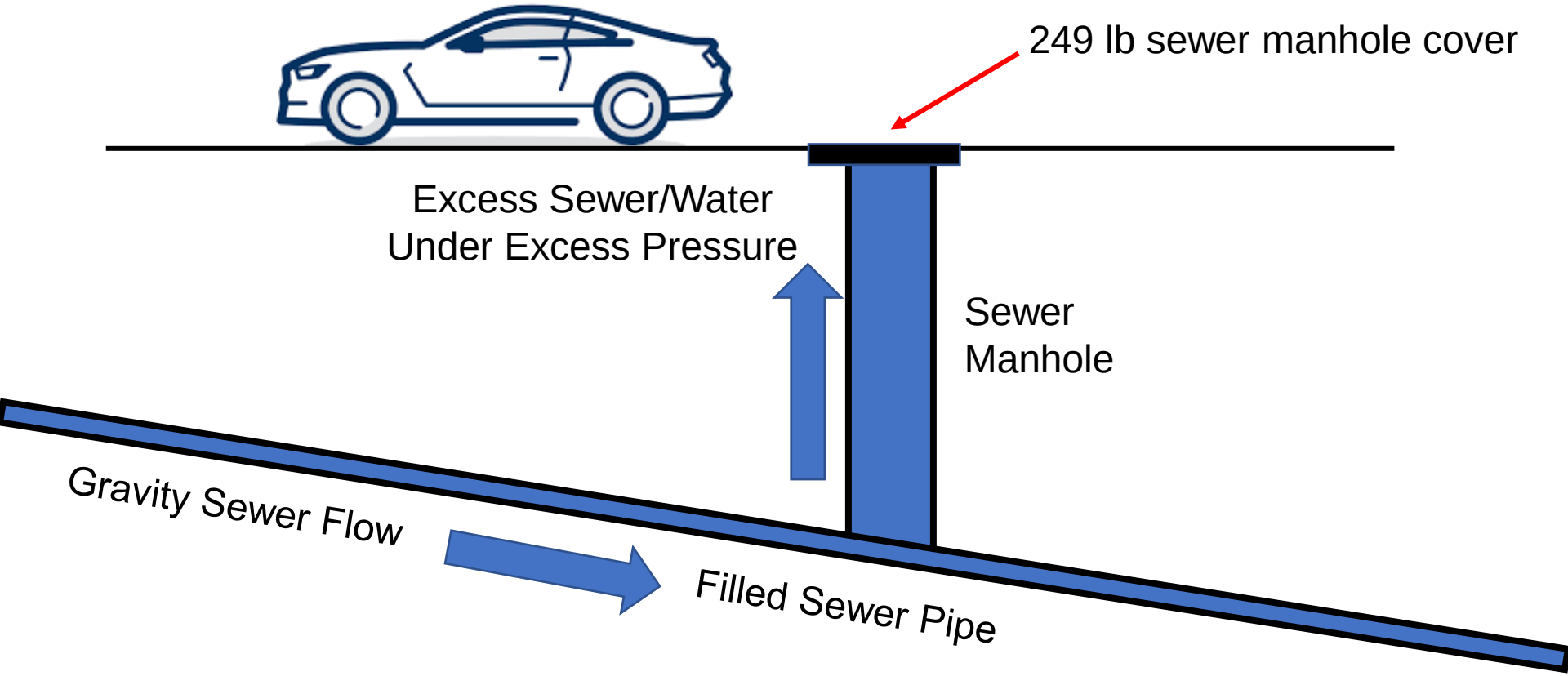


Time 2 – Groundwater Above Sewer Pipe

Ex. 5 - Area-Wide Groundwater with I&I Entering Leaking Sewer Pipe

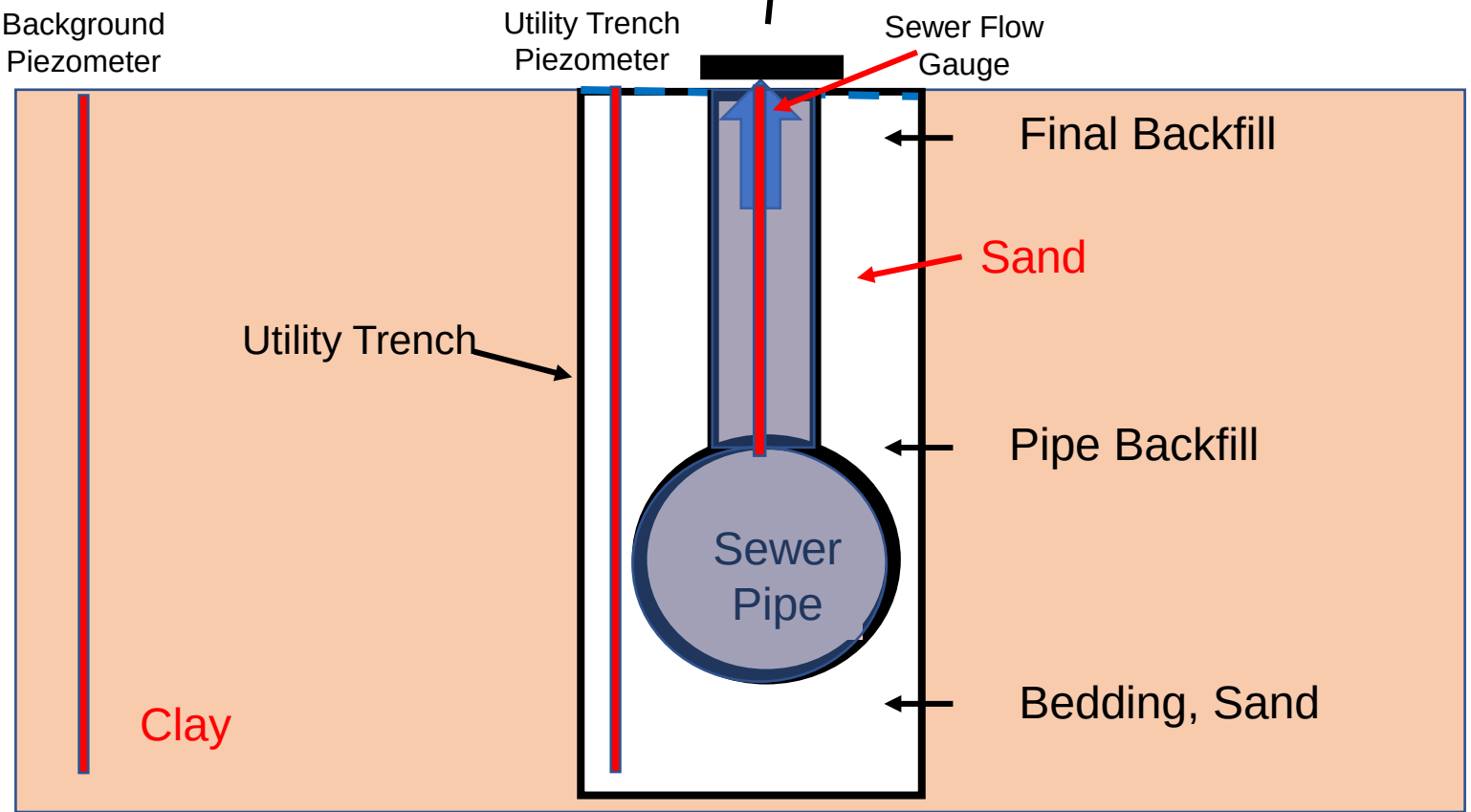


Causes of Sanitary Sewer Overflows (SSOs)

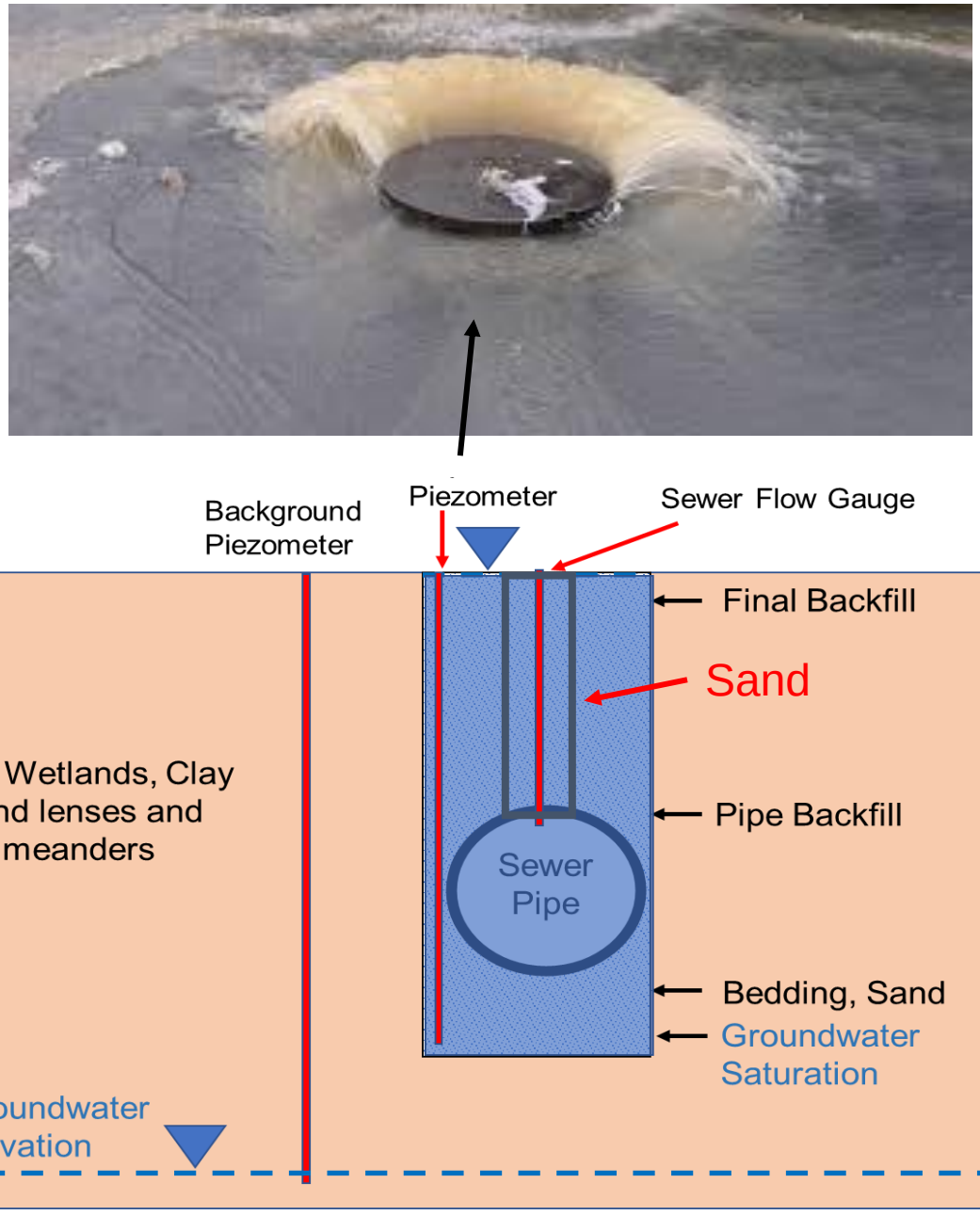


Ex.1 - Causes of SSO: Filled Sewer Pipe

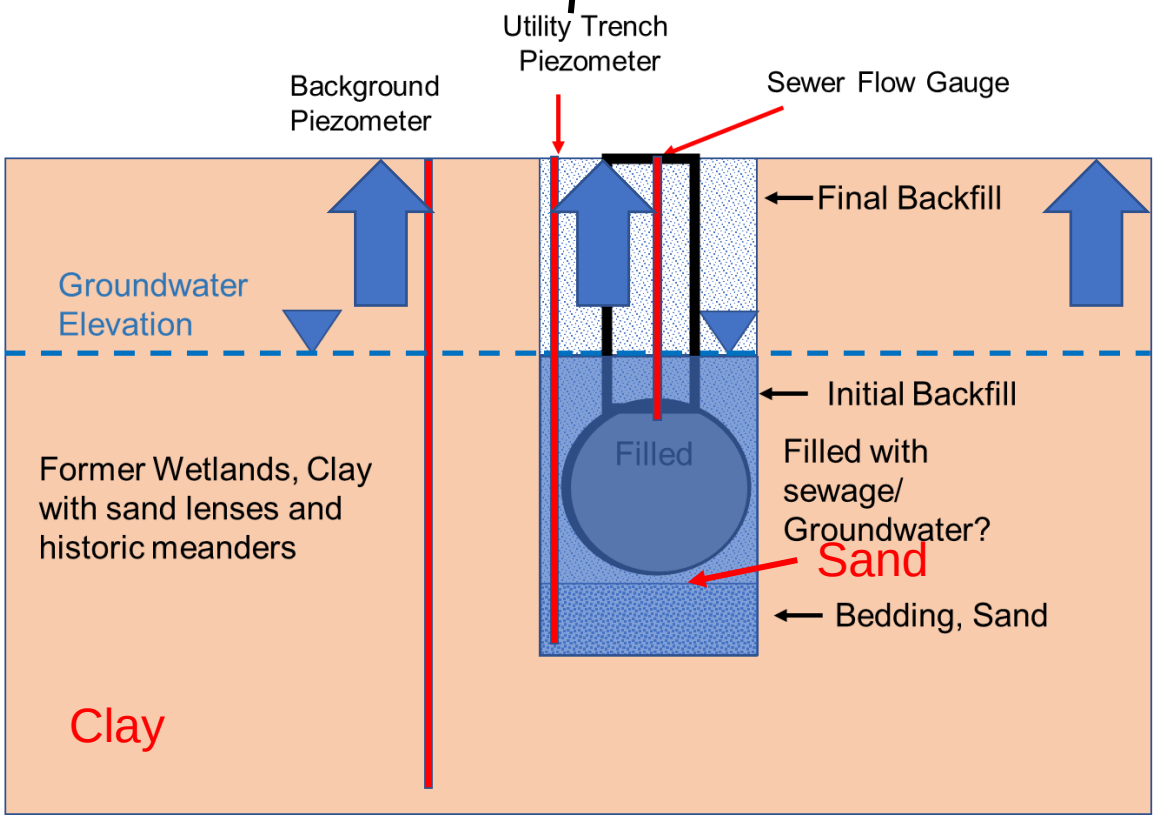
Lifting 249 lb
sewer manhole cover



Ex. 2 - Causes of SSO: Filled Sewer Pipe and Utility Trench

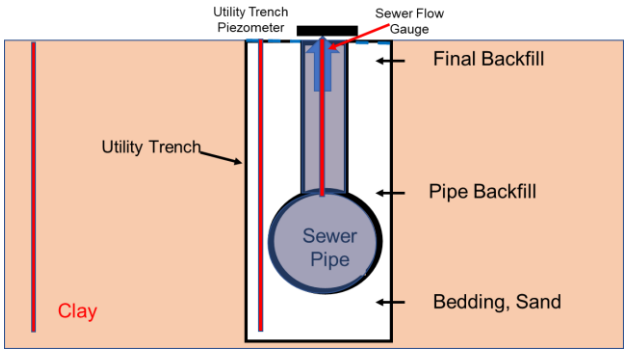


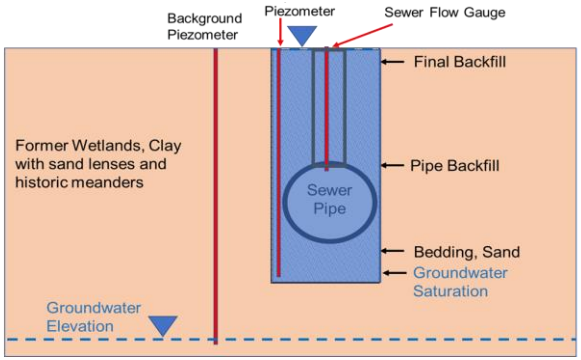
Ex. 3 - Causes of SSO: Upwelling Area-Wide Groundwater

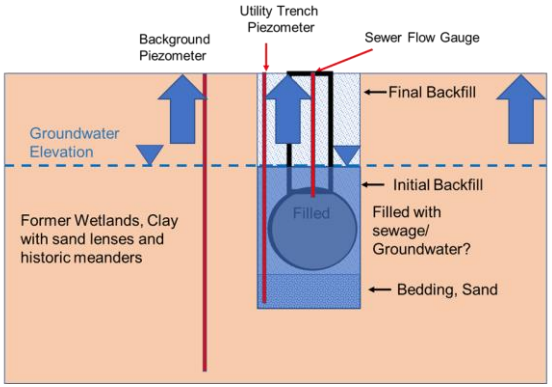


Goal – Identify Causes of SSOs Through Real-Time Monitoring

- **Source Of Water**
- Rainwater
- Groundwater Inundation
- Sea Water
- Irrigation Water/Leaky Water Pipes
- Surface Water (creeks)







Only Sewer Pipe Flooded

Trench and Background not flooded

Issue: Root ball

Mitigation: Remove sewer clog

Only Utility Trench Flooded

Background not flooded

Issue: Preferential Pathway Flooding

Mitigation: Strategic Pumping

Entire Area Flooded

Too Much Groundwater and Rain

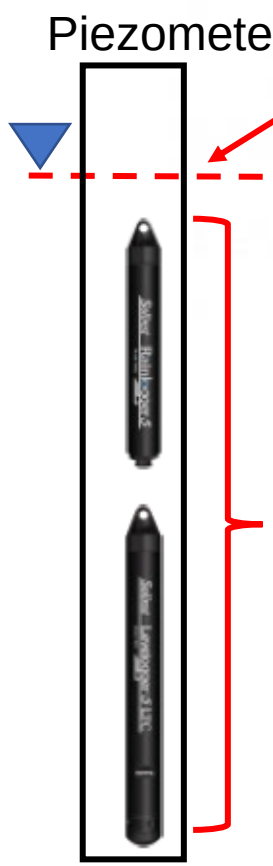
Mitigation: Large-Scale Pumping

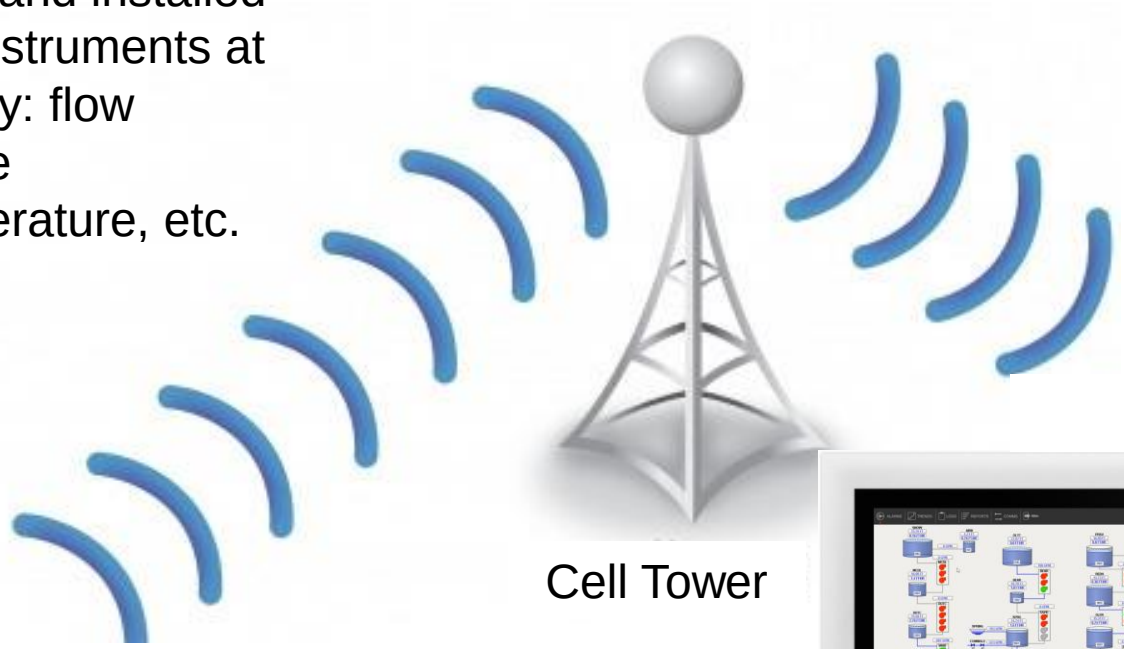
Preemptive pumping

Aquifer storage – preemptive gentle pumping prior to a flooding event to create subsurface capacity for excess rainwater or high tides

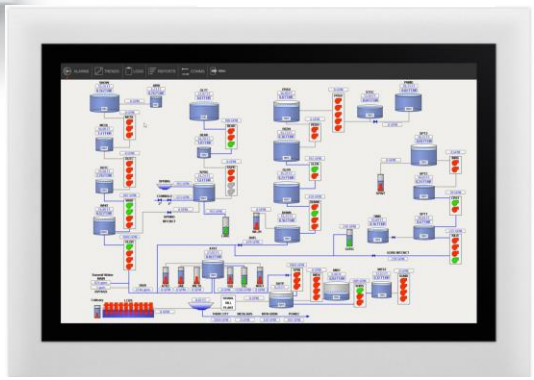
Concept: Integrated, Real-Time Data for Preventing SSOs

The Team designed and installed remote monitoring instruments at biogas facility at dairy: flow meters, pH, methane concentration, temperature, etc.





Cell Tower



Computer Interface

- Groundwater Gauges (Elev., Cond., Temp.)
- Rainwater Gauges
- Tidal/Bay Gauges
- Barometric Pressure Gauges
- Sewer Flow Meters (touchless)
- Other parameters: methane, pH, etc.

Alert prior to SSO based on water elevation data

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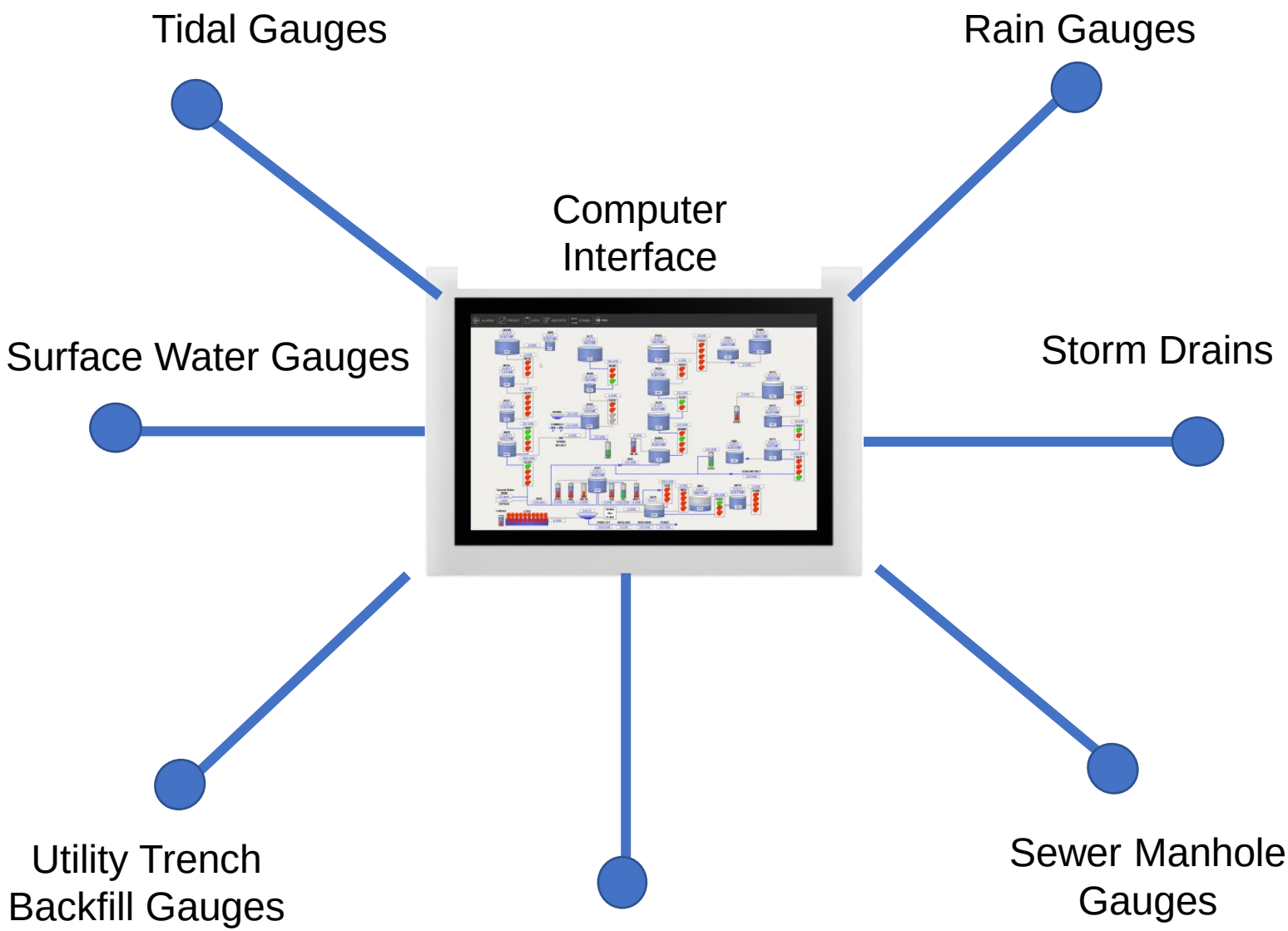
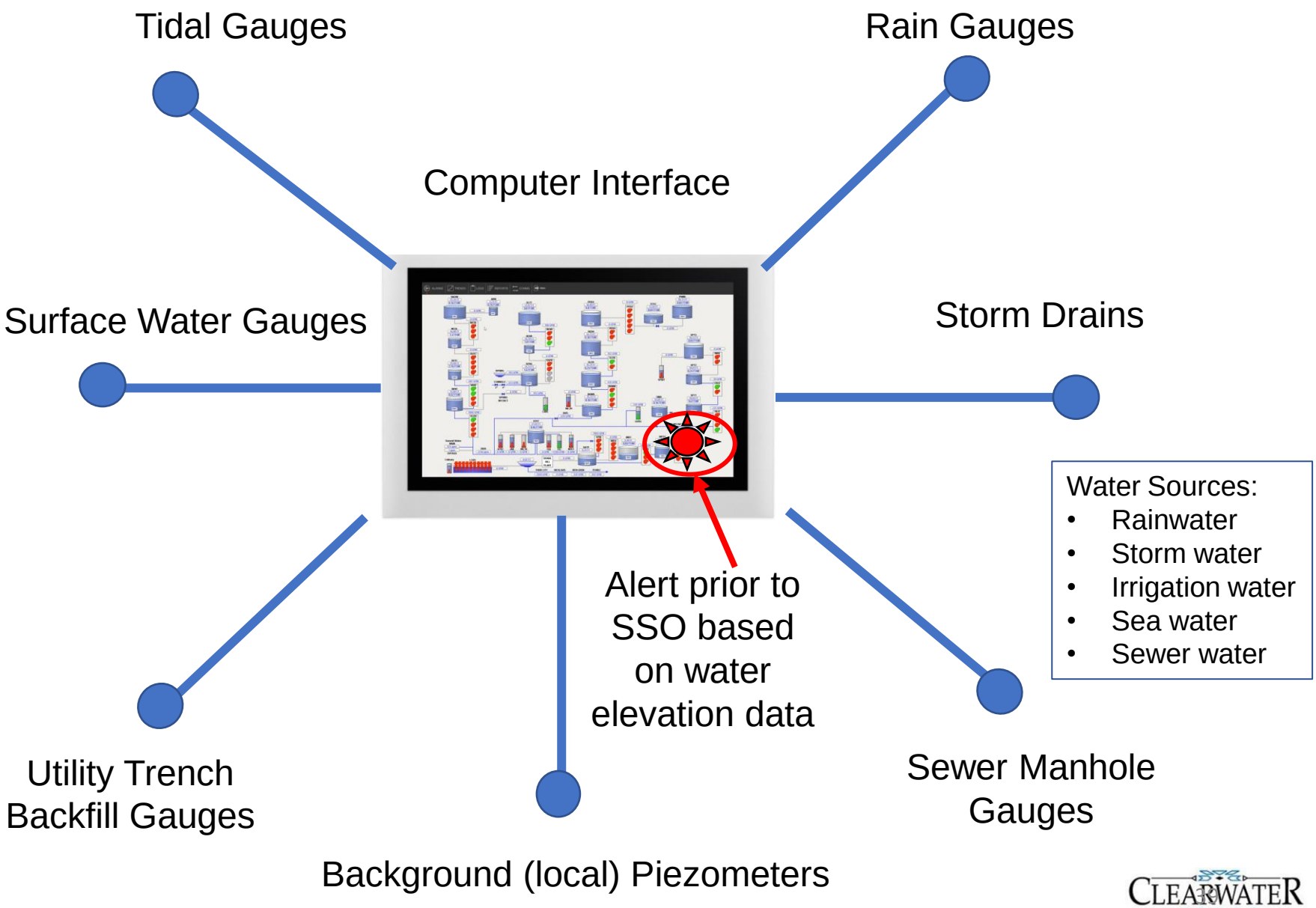
Concept: Integrated, Real-Time Data for Preventing SSOs

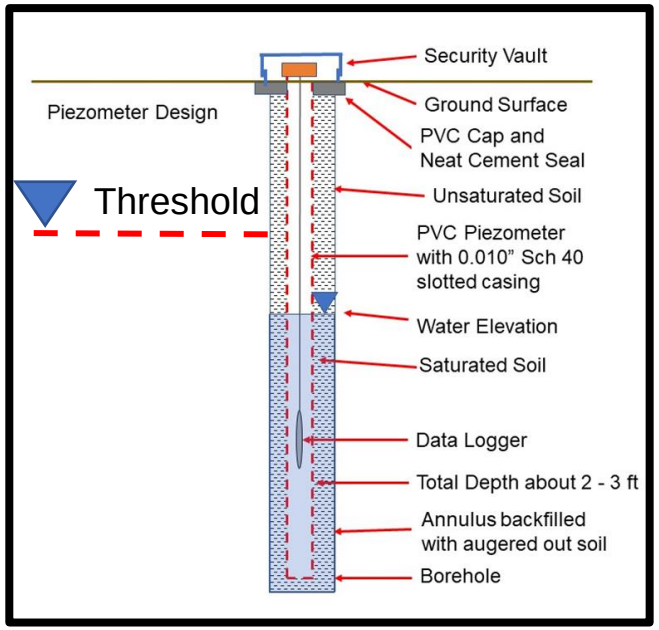


Concept: Integrated, Real-Time Data for Preventing SSOs



Conclusion: Integrated, Real-Time Data for Preventing SSOs

Impacts of the Future:
- Sea Level Rise (SLR)
- Groundwater Inundation
- Extreme Rain (ER) Events



Using These Integrated Tools:
- Prevent SSOs
- Improve Water Quality
- Mitigate/Warn of Area Flooding
- Monitor for security of system

Decisions based on Data:

<u>Identify Subsurface Conditions in Real-Time</u>
- Dataloggers: Water Elevation, Temperature, Conductivity, Barometric Pressure
- Field Meters: DO, ORP, Conductivity, pH, Turbidity, etc.

<u>Identify Subsurface Conditions with a Short Turn-Around Time</u>
- Lab: *e coli*, groundwater contaminants

Conclusion: Eliminate I&I and SSOs Using Accurate Data

1. The Team to customize projects for device automation to control and monitor remote water/parameter monitoring instruments

2. Research project with corporate and agency sponsors with emphasis on investigating subsurface water flow, preferential pathways, and groundwater inundation

3. Collect data using State-of-the-Art Instrumentation for real-time analysis

4. Integrated information sent to decision makers/emergency workers

5. Prioritize repairs of leaky sewer using real-time data

6. Mitigation Actions: based on improved information

    - Trenchless Sewer Repair (Epoxy - Pipe Hardening) to reduce I&I
    - Design and install strategic pumping (gentle) and dewatering
    - Design and install groundwater flow barriers, as needed

Thank You

James A. Jacobs
Professional Geologist/Certified Hydrogeologist
jjacobs@clearwatergroup.com

Olivia Jacobs
Certified Environmental Manager
ojacobs@clearwatergroup.com

Clearwater Group
229 Tewksbury Ave.
Pt. Richmond, CA 94801
510-307-9943
www.clearwatergroup.com