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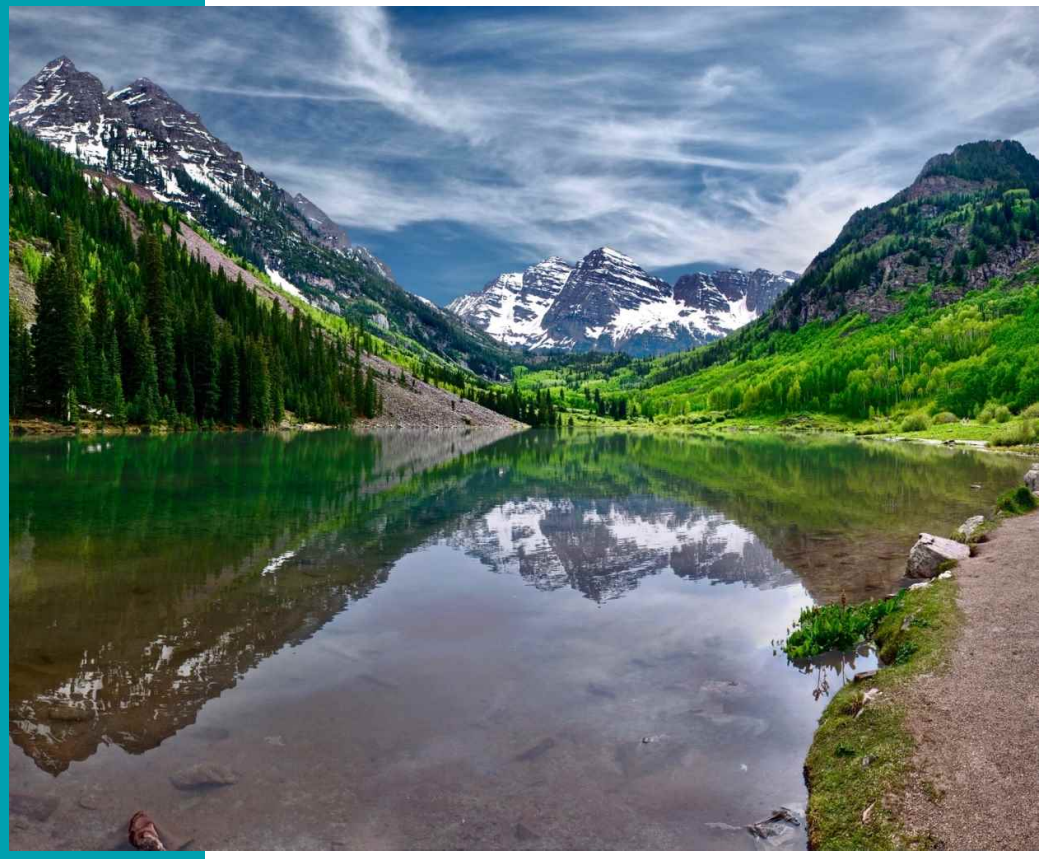
CREATIVE THINKING
EXCEPTIONAL SOLUTIONS

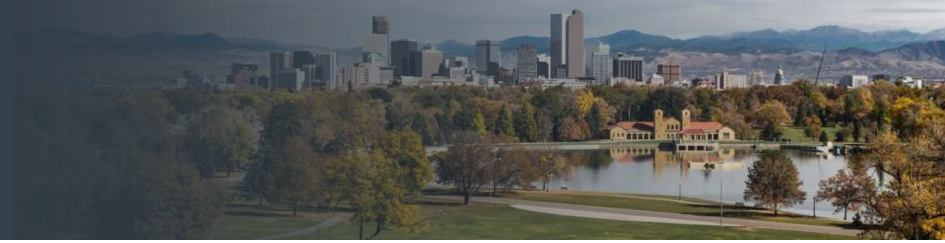


Vapor Intrusion Through Sewers: Sample Collection and Mitigation Methods

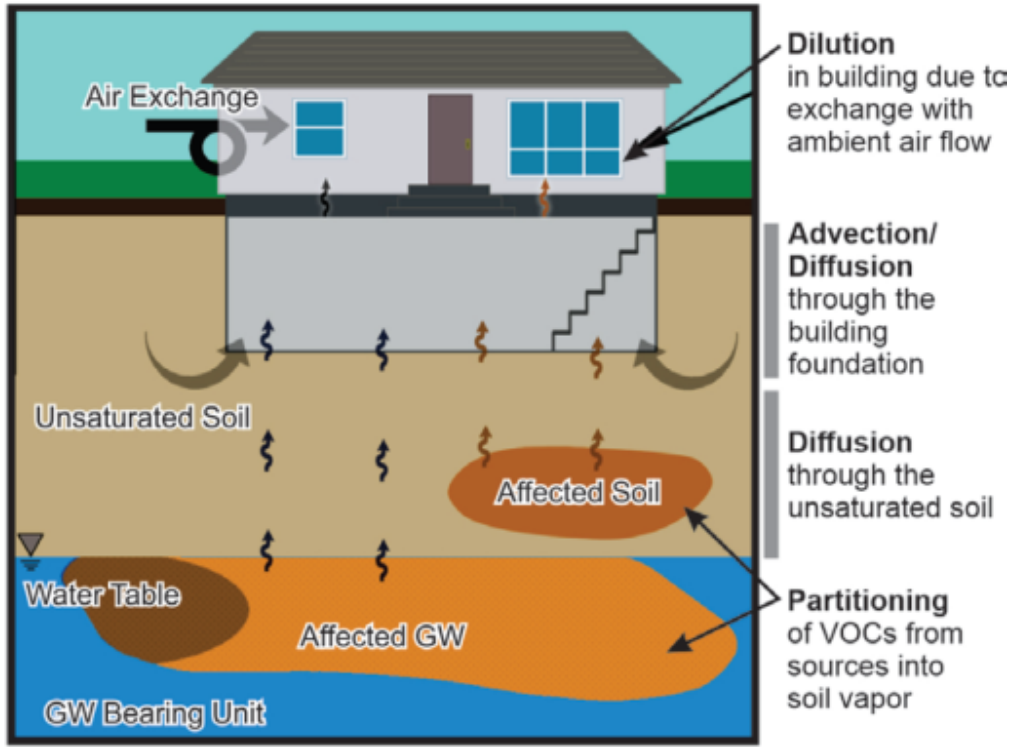
Presented by | Annie Lee

Co-Authors: David Bertrand, Nicholas Head, Paul Nicholson, Greg Johnson, Jeremiah Johnson, David Zolp

Vapor Intrusion Conceptual Site Model

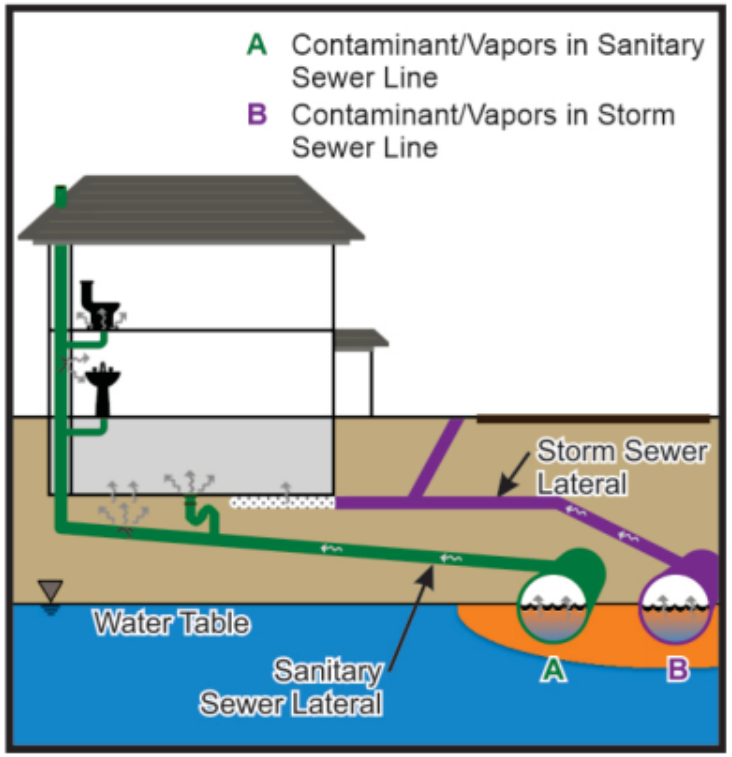


Conventional VI

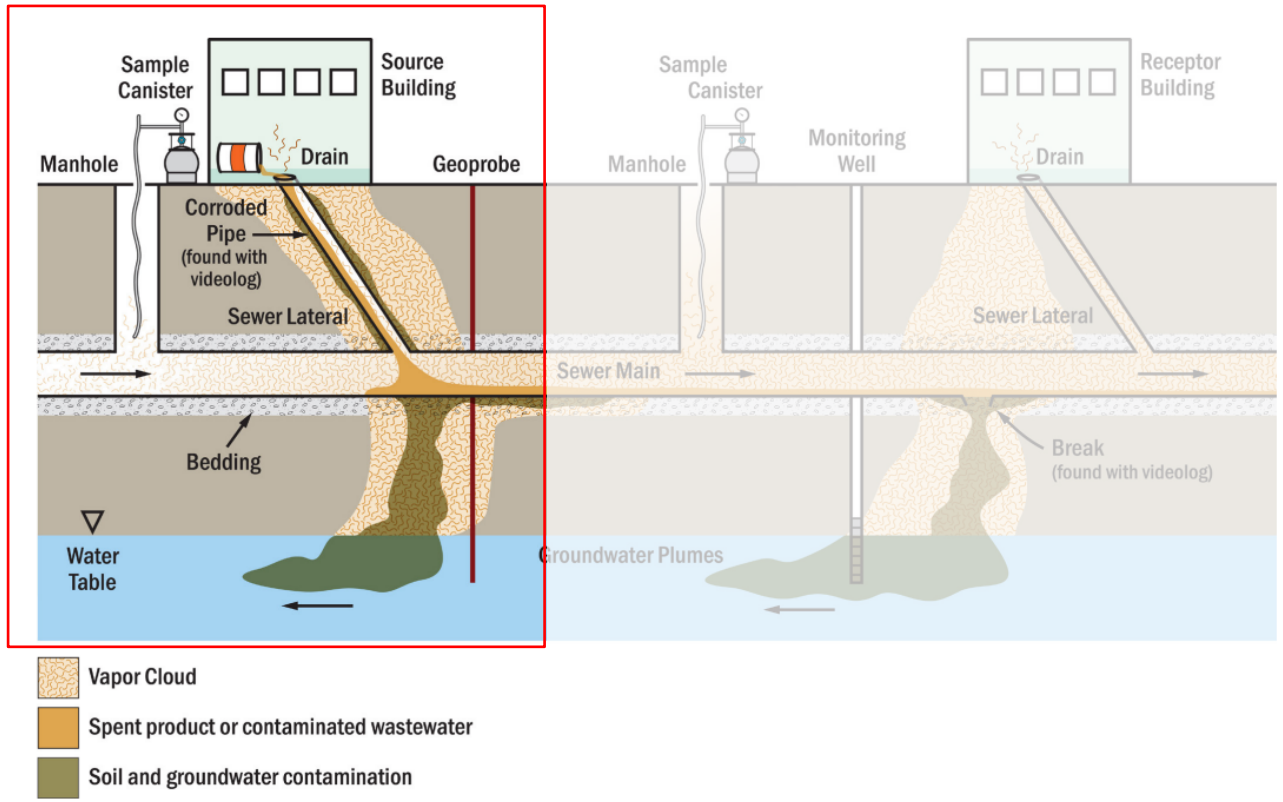


Source: Modified from McHugh et al., 2017

Preferential Pathway/ Sewer VI



Sewer Preferential Pathways

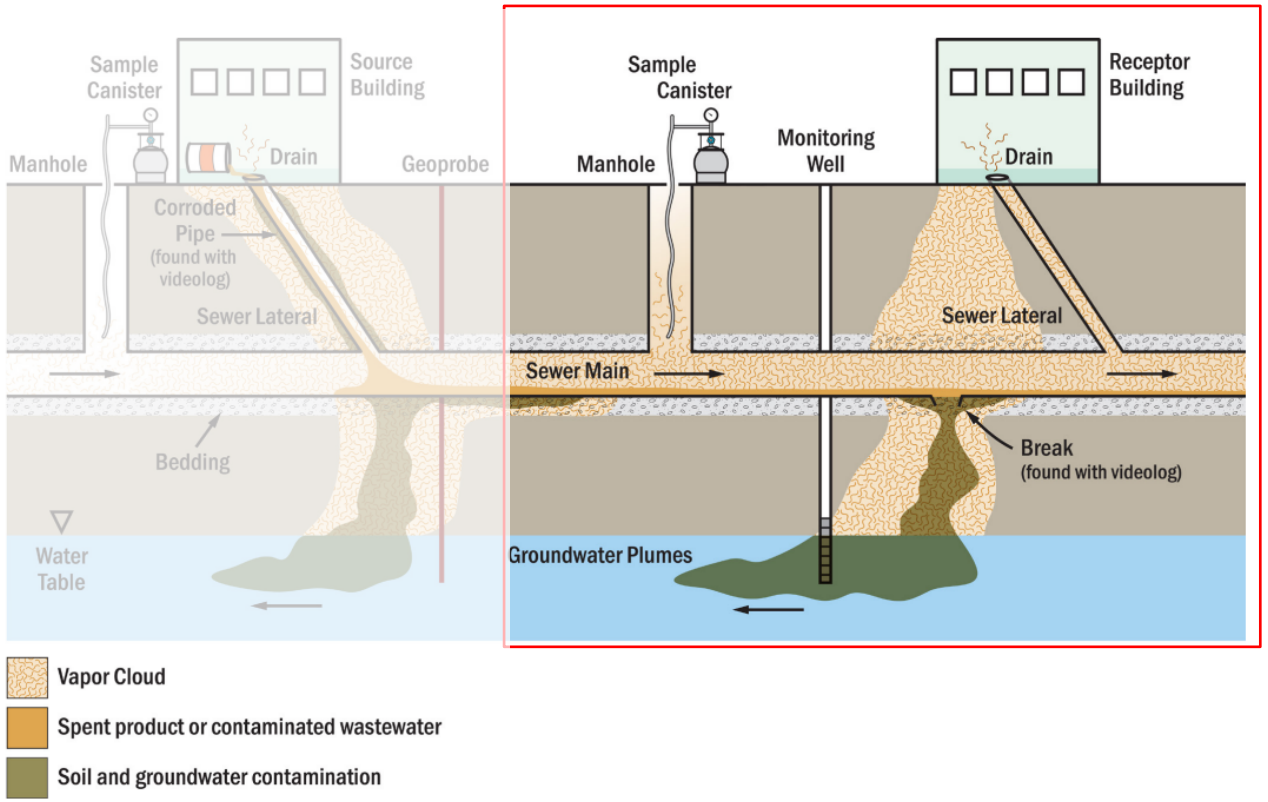


Source: Guidance for Documenting the Investigation of Human-made Preferential Pathway Including Utility Corridors, Wisconsin DNR, 2021. Publication RR-649

Contaminant Migration into Sewer Systems:

- Waste discharge into drains and sewer laterals
- Vapor migration into utility corridors
- Groundwater intrusion of sewers below the water table

Sewer Preferential Pathways



Source: Guidance for Documenting the Investigation of Human-made Preferential Pathway Including Utility Corridors, Wisconsin DNR, 2021. Publication RR-649

Preferential Pathway for Vapor Intrusion:

- Sewer laterals and drains (p-traps not functioning)
- Migration through utility corridors to below slab

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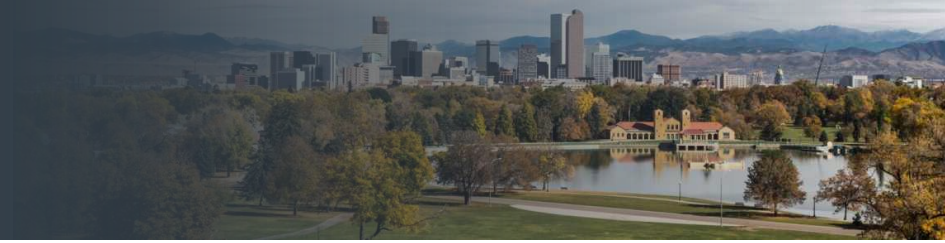
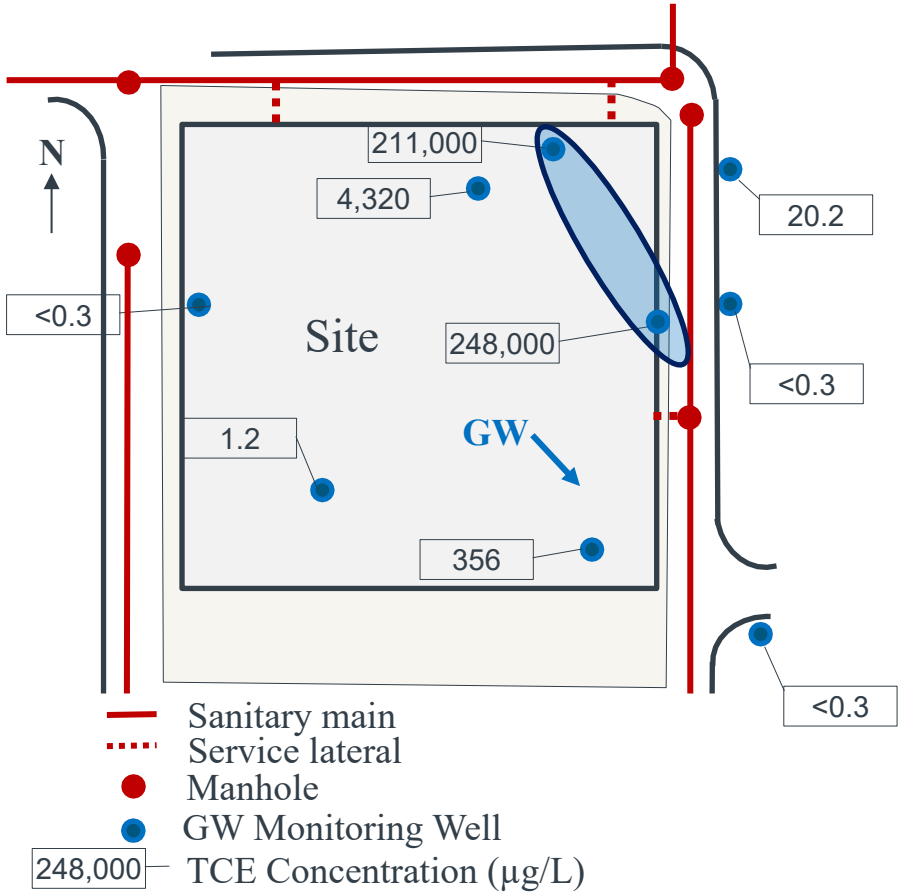
EXCEPTIONAL SOLUTIONS

Case Study: Sewer Gas Preferential Pathway Investigation and Mitigation

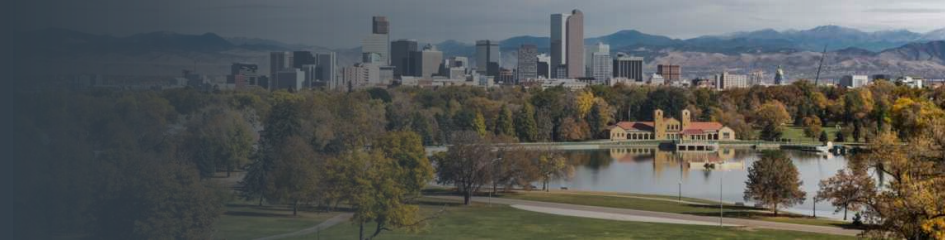
Case Study Site Background





- TCE in groundwater up to 250,000 µg/L
- Groundwater flows to southeast
- Existing sub-slab depressurization system
- Sanitary sewer mains to north, east, and west
  - Sewer laterals from the Site discharge to the north and east

TCE in Vapor



- Low TCE vapor action levels
- Concentrations of concern can result from trace levels of TCE in water

TCE in air (µg/m³)	Equilibrium TCE in water* (µg/L)
2.1	0.01
70	0.34
1,020	5

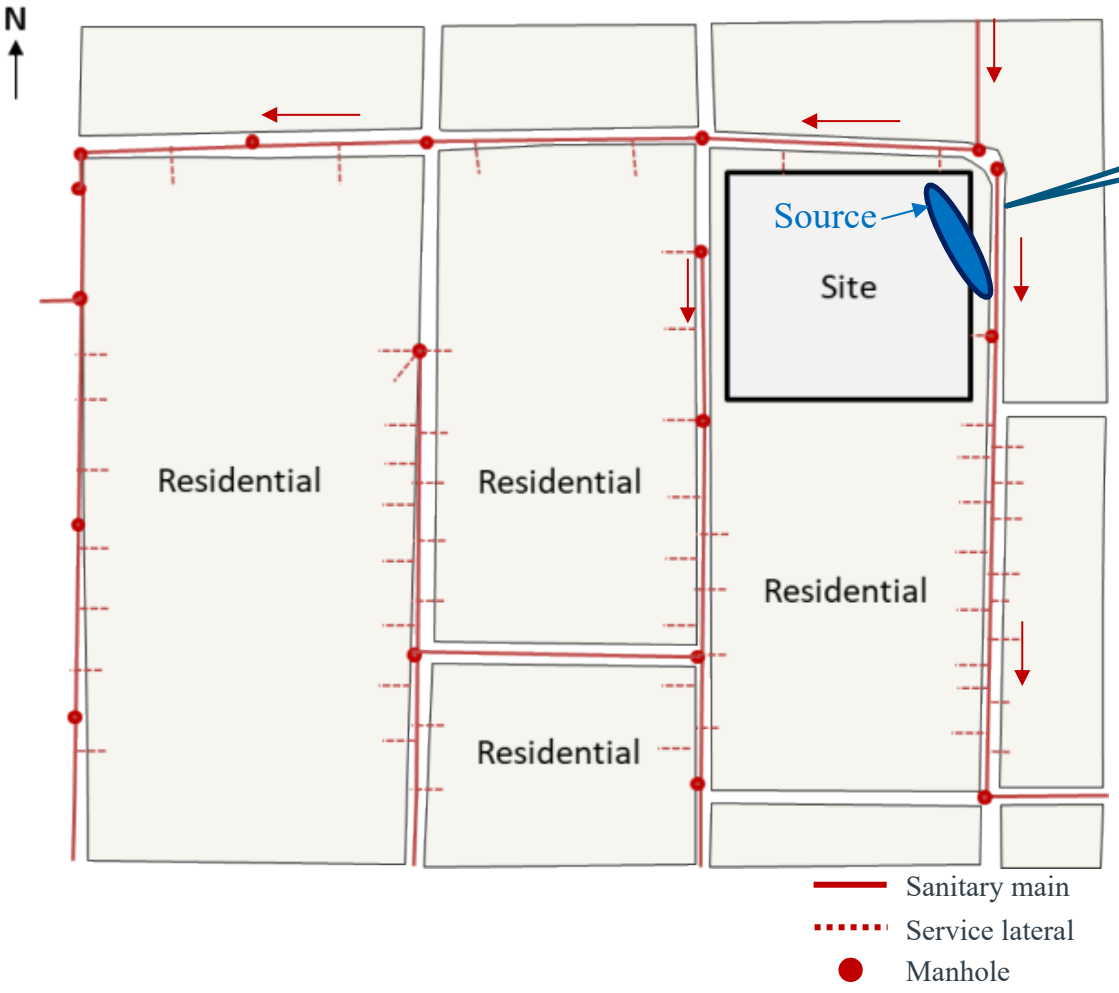
*based on Henry's Law constant for TCE at 10 deg C

WDNR Residential Indoor Air Vapor Action Level

WDNR Residential Sanitary Sewer Gas Screening Level

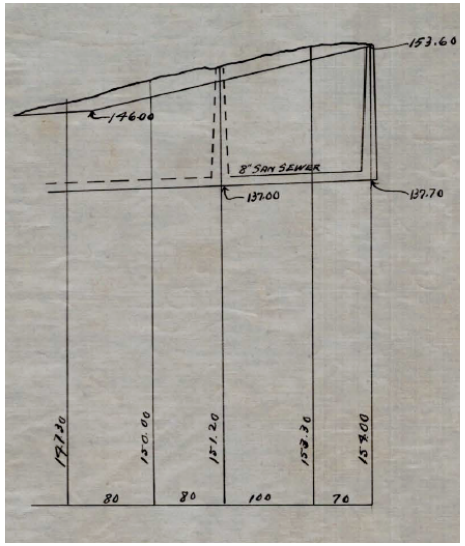
Groundwater MCL

Sewer Construction Due Diligence

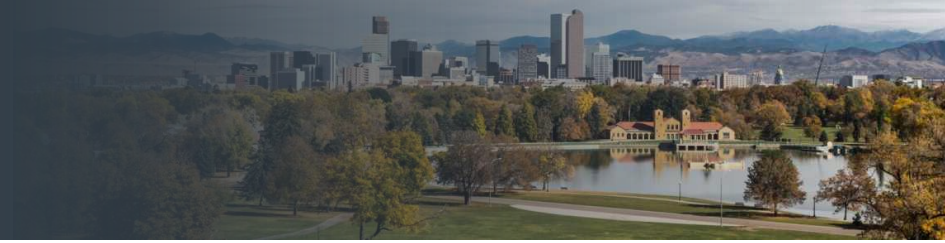


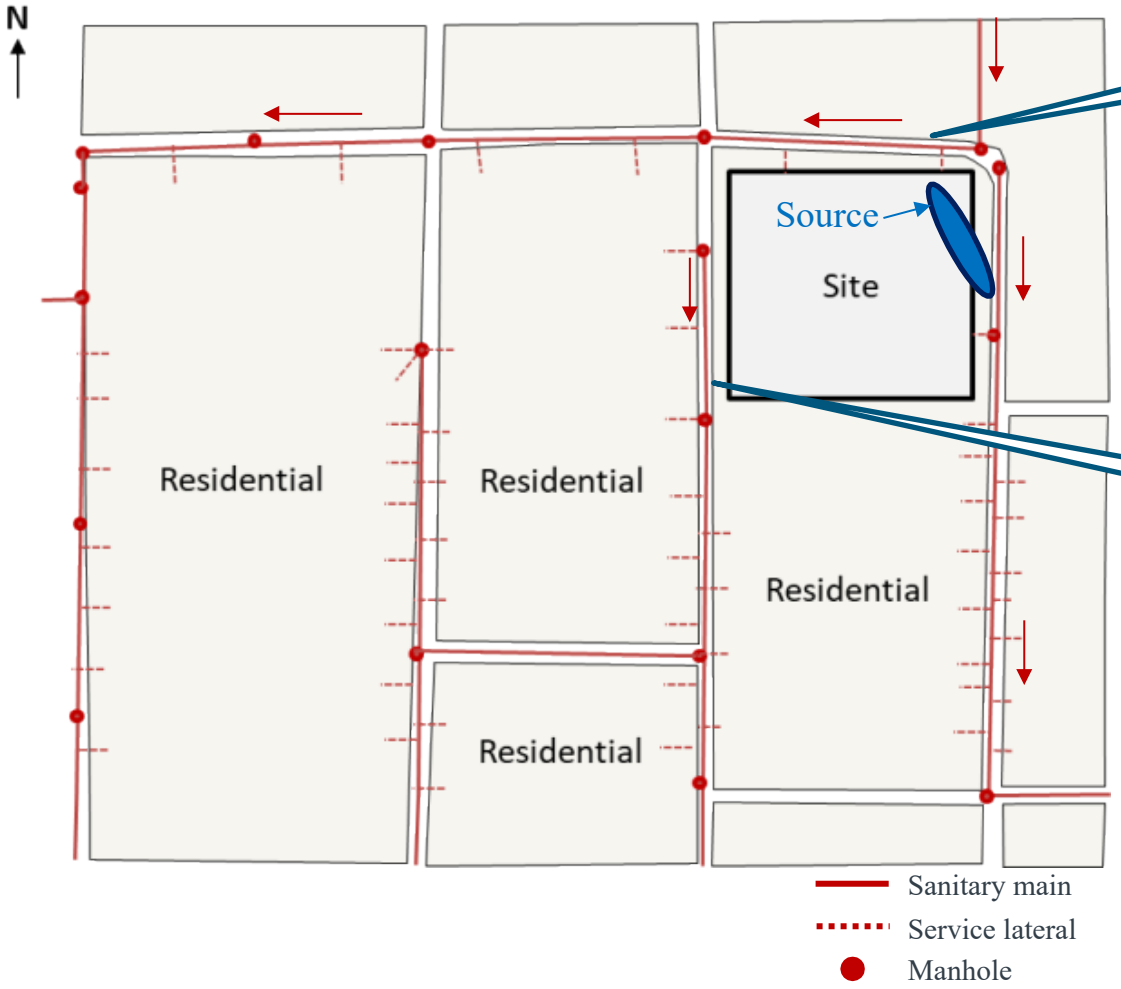
Eastern Sanitary Sewer

- Intersects groundwater plume
- Receives flow from legacy sewer laterals
- Constructed of vitrified clay in 1911
- Reviewed video inspection footage



Sewer Construction Due Diligence





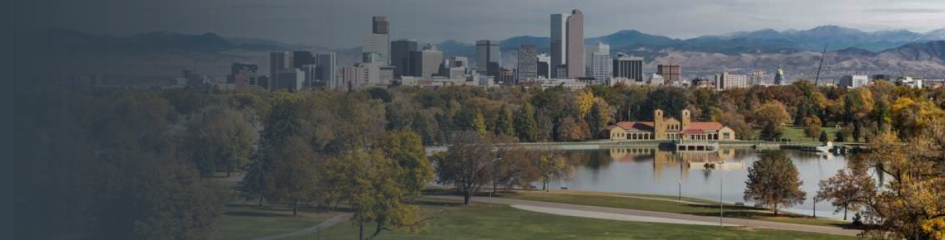
Northern Sanitary Sewer

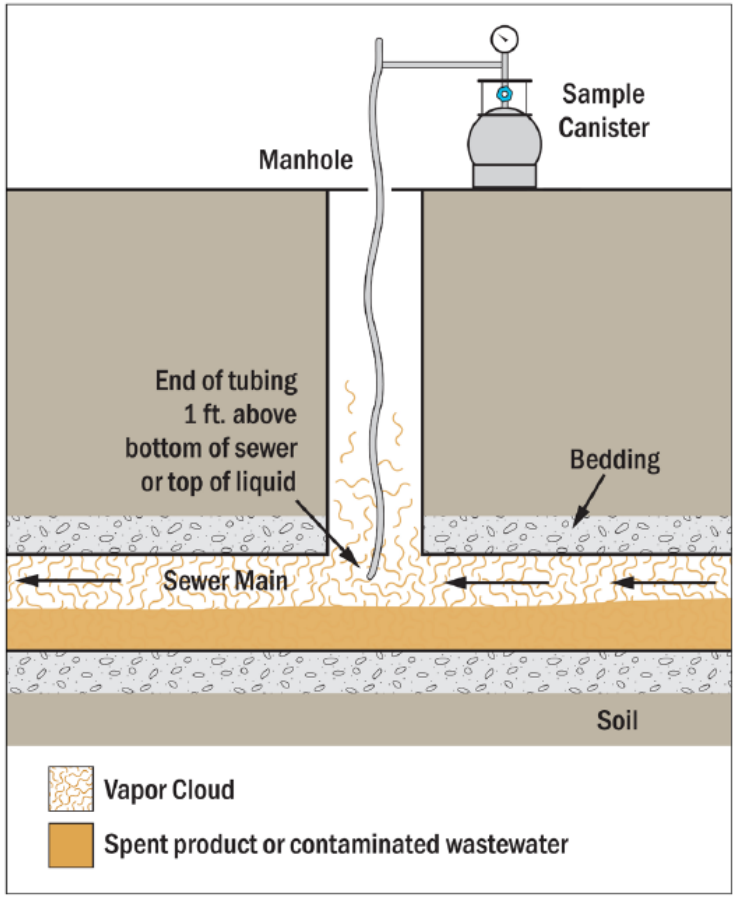
- Receives flow from active sewer laterals
- Constructed of PVC in 2019
- Reviewed video inspection footage

Western Sanitary Sewer

- Constructed of PVC in 2021
- No additional investigation performed
  - Not connected to sewers in Site building
  - Does not intersect groundwater plume

Active Sewer Vapor Sampling

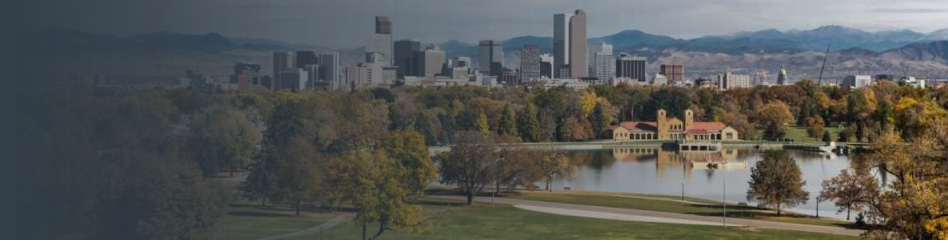


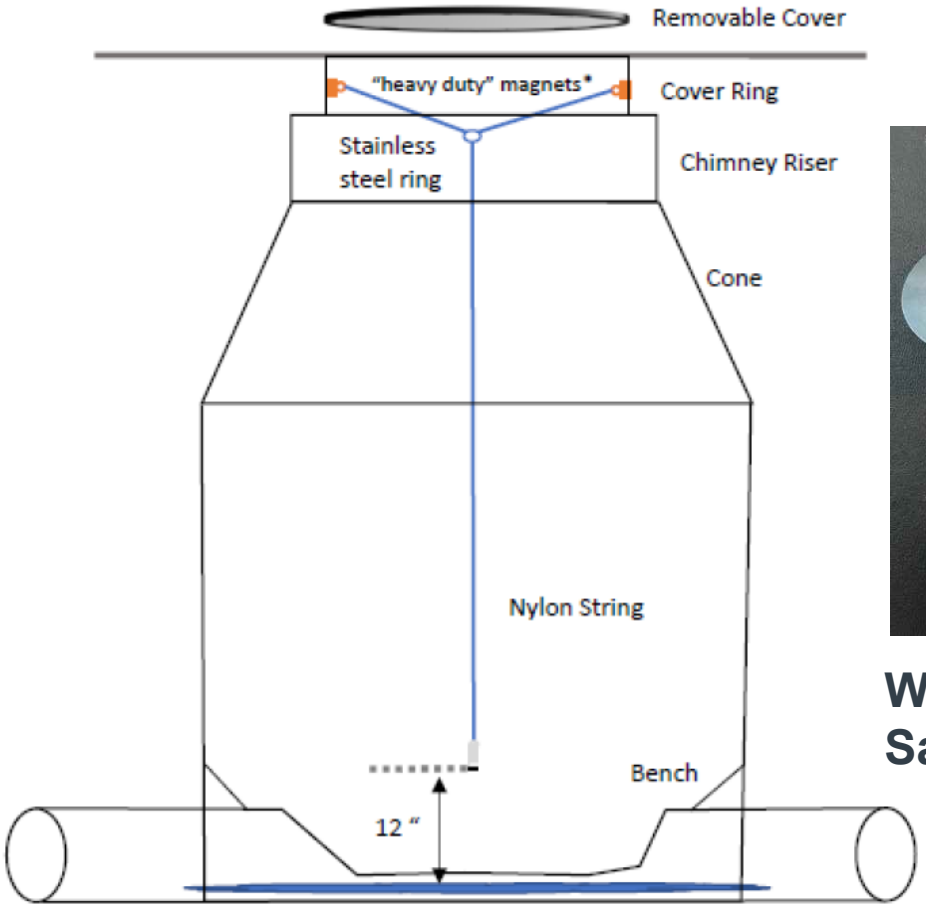


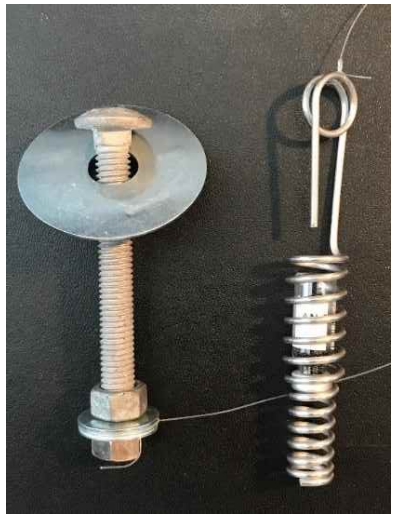
Summa canister

- Short-duration grab sample
- Potential temporal variability
- Access limitations due to traffic during sample deployment
- Availability of canisters can restrict scheduling of sampling programs

Passive Sewer Vapor Sampling





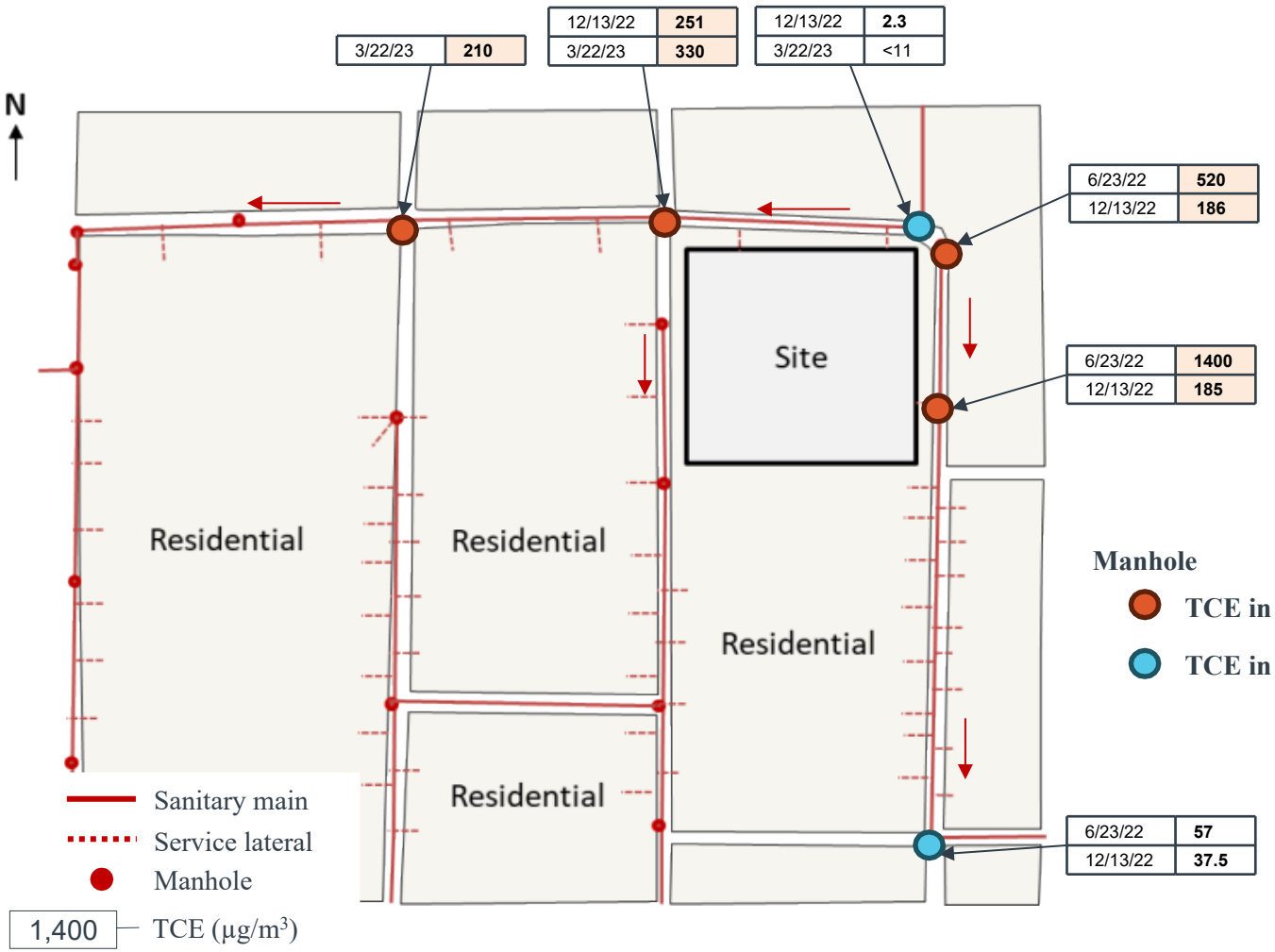


Waterloo Membrane Sampler (WMS)

Passive Sampler

- Reliable quantitative data and low reporting limits
- Smaller, easier to transport and deploy
- Longer deployment time (weeks) provides average vapor concentrations which may address concerns of temporal variability
- Requires a return visit
- Consider sampler applicability based on site constituents of concern

Sanitary Manhole Sample Results

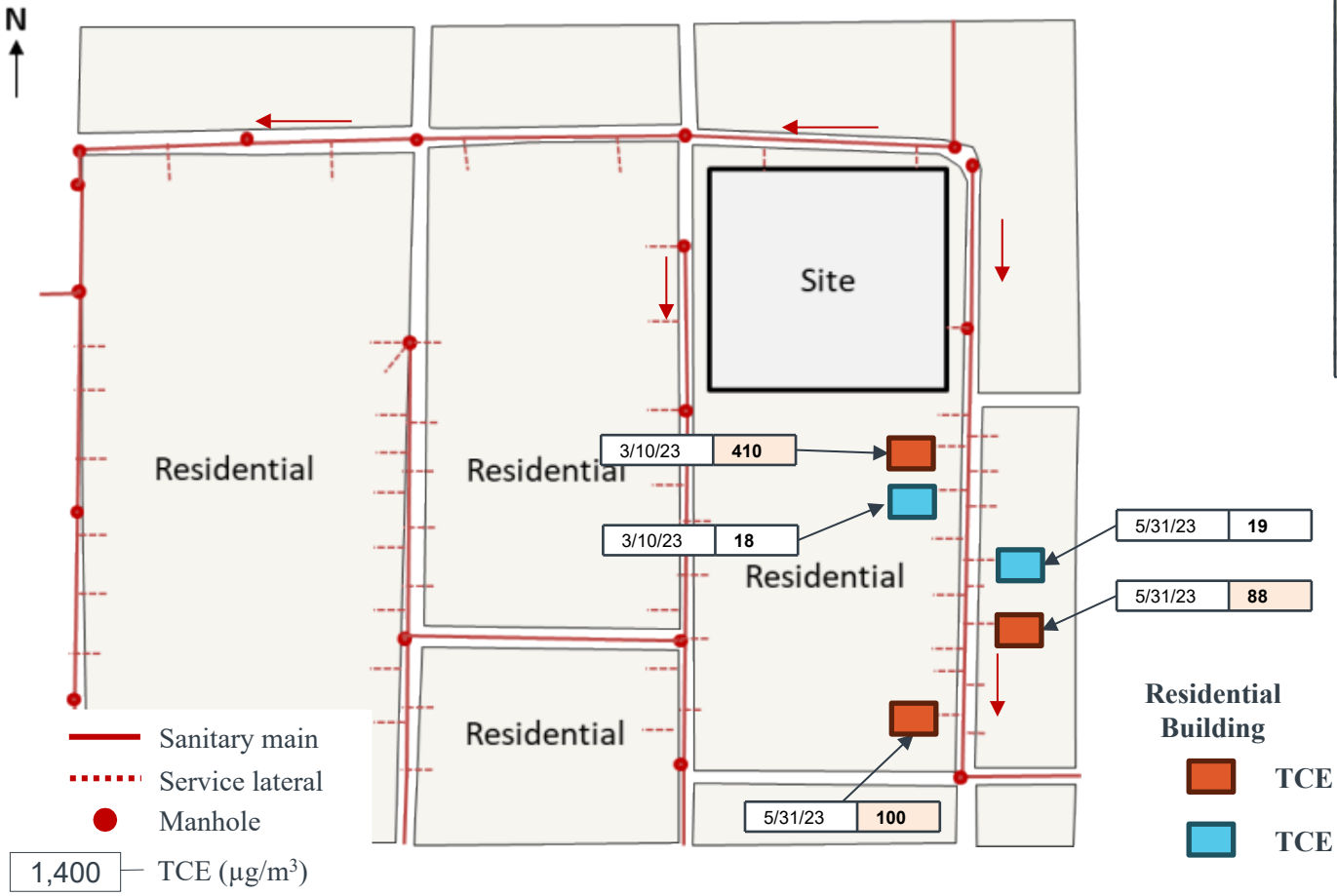


Manhole

- TCE in Sewer Gas > 70 µg/m³
- TCE in Sewer Gas < 70 µg/m³

- Data indicate sanitary mains likely acting as preferential pathway

Residential Cleanout Sample Results

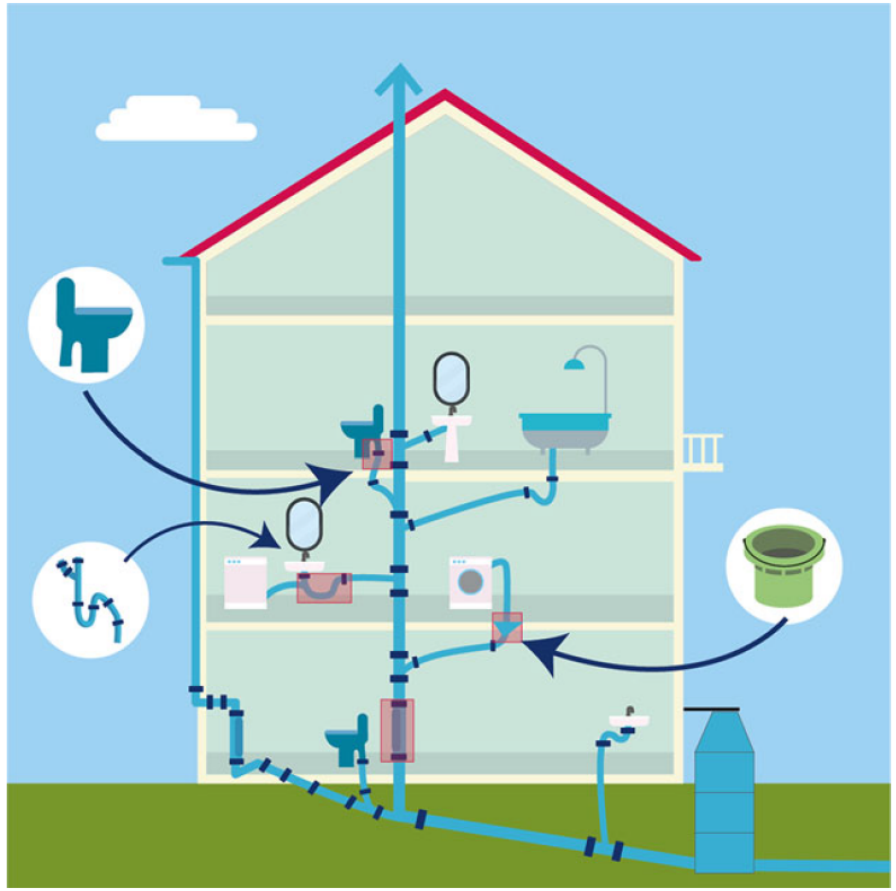


- Potential VI risk from sewer laterals
  - Plumbing inspections completed
  - No exceedances of applicable screening levels (2.1 µg/m³) in indoor air samples collected concurrently

Sewer Gas Pathway Mitigation Measures

Options for Remediation/Mitigation of Sewer Gas Pathway

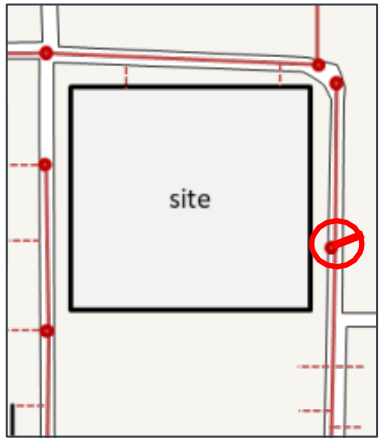
- Removing contaminant source
- Lining or replacement of sewer pipes
- Sealing the plumbing system in the building
- Passive venting of manholes
- Active venting of sewer headspace



Source: Nielsen and Hvidberg 2017

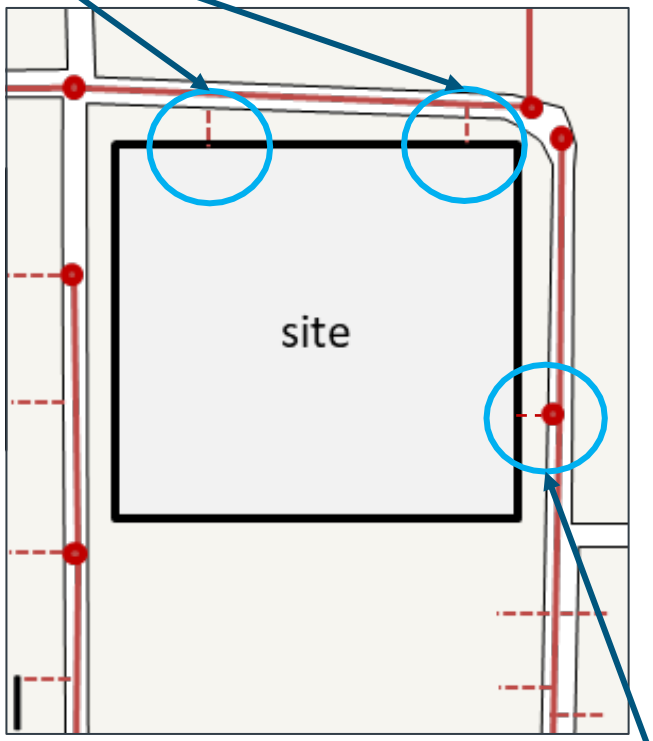
Pilot Venting Test

- Extraction test on eastern sanitary main to support design of sewer venting system
  - Step 1: 10 CFM for 1 hour
  - Step 2: 150 CFM for 1 hour
- Investigate TCE distribution and mass flux into sewer



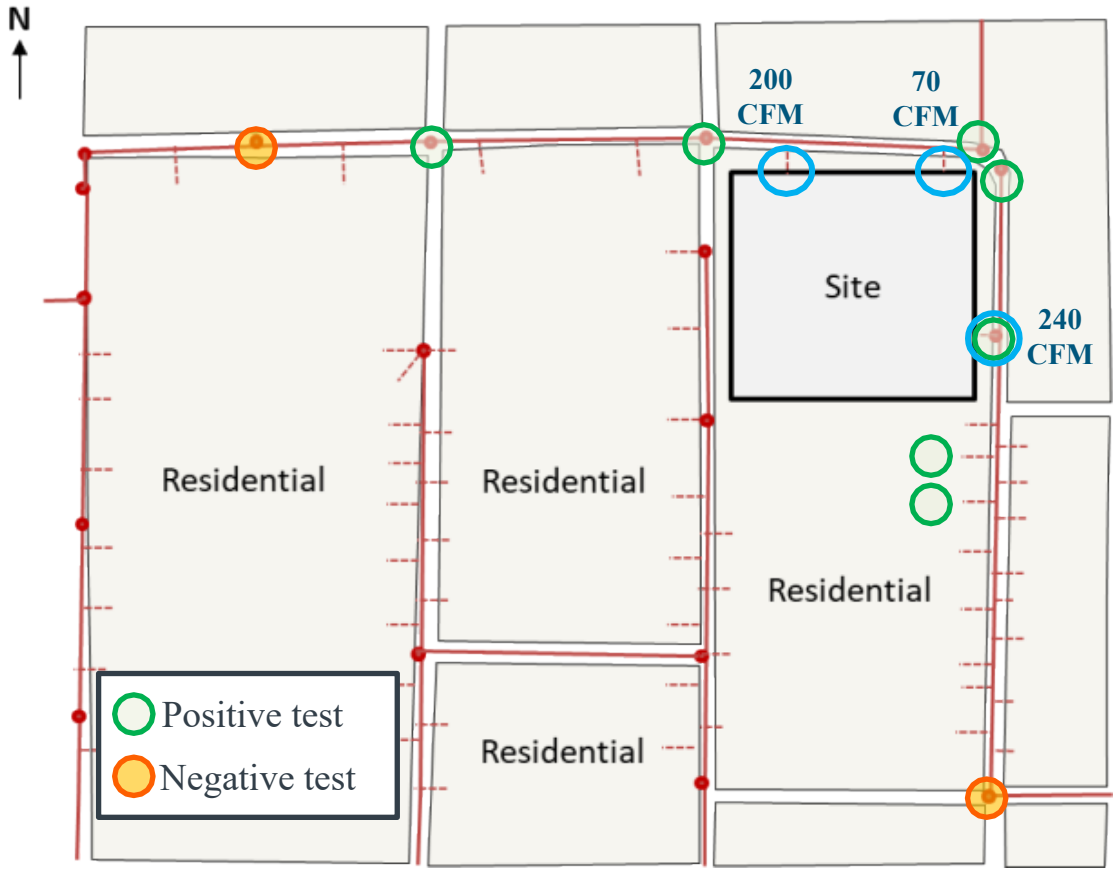
Sewer Venting System

2 Sewer Cleanout Extraction Points

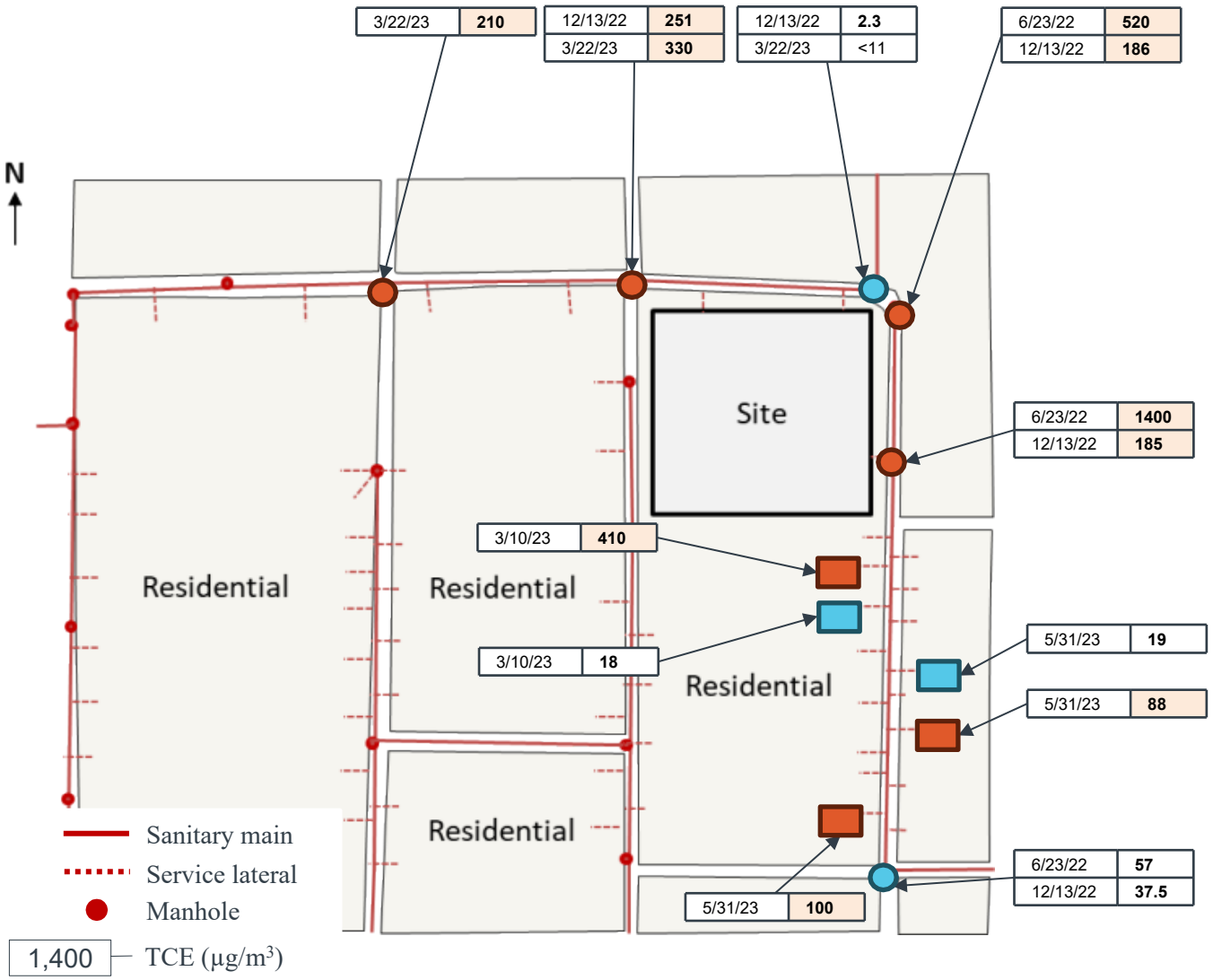


1 Manhole Extraction Point (trenched)

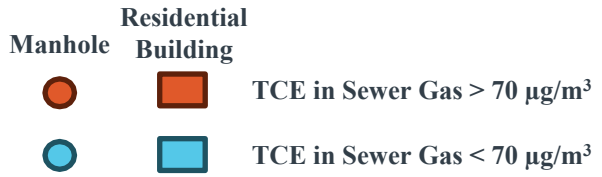
Sewer Venting System Performance



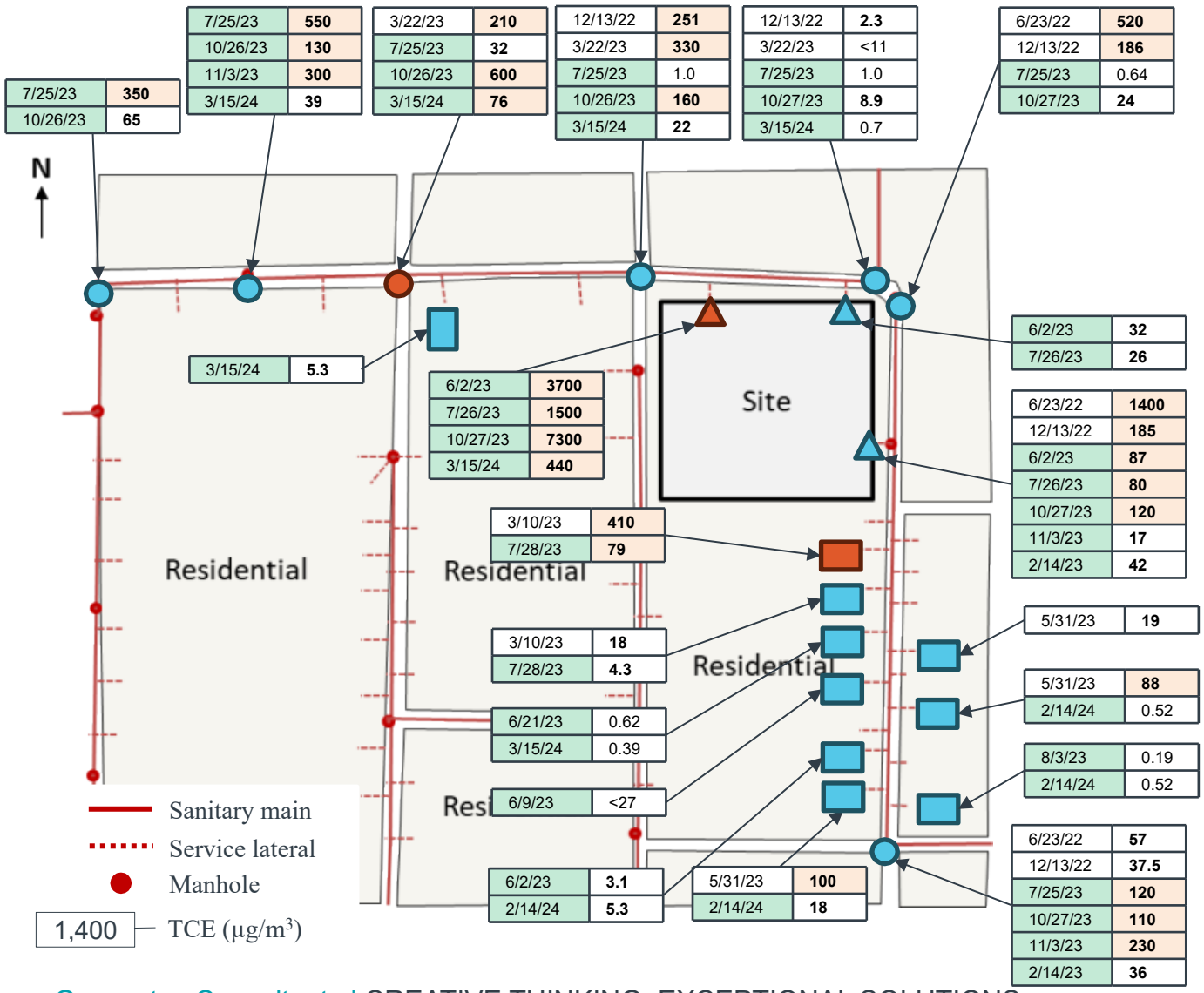
Sewer Venting System Performance



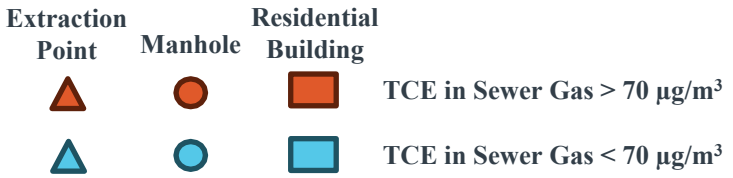
- Pre-Venting System Installation Sewer Gas Results
  - Multiple locations with concentrations greater than the residential sanitary sewer gas screening level (70 µg/m³)



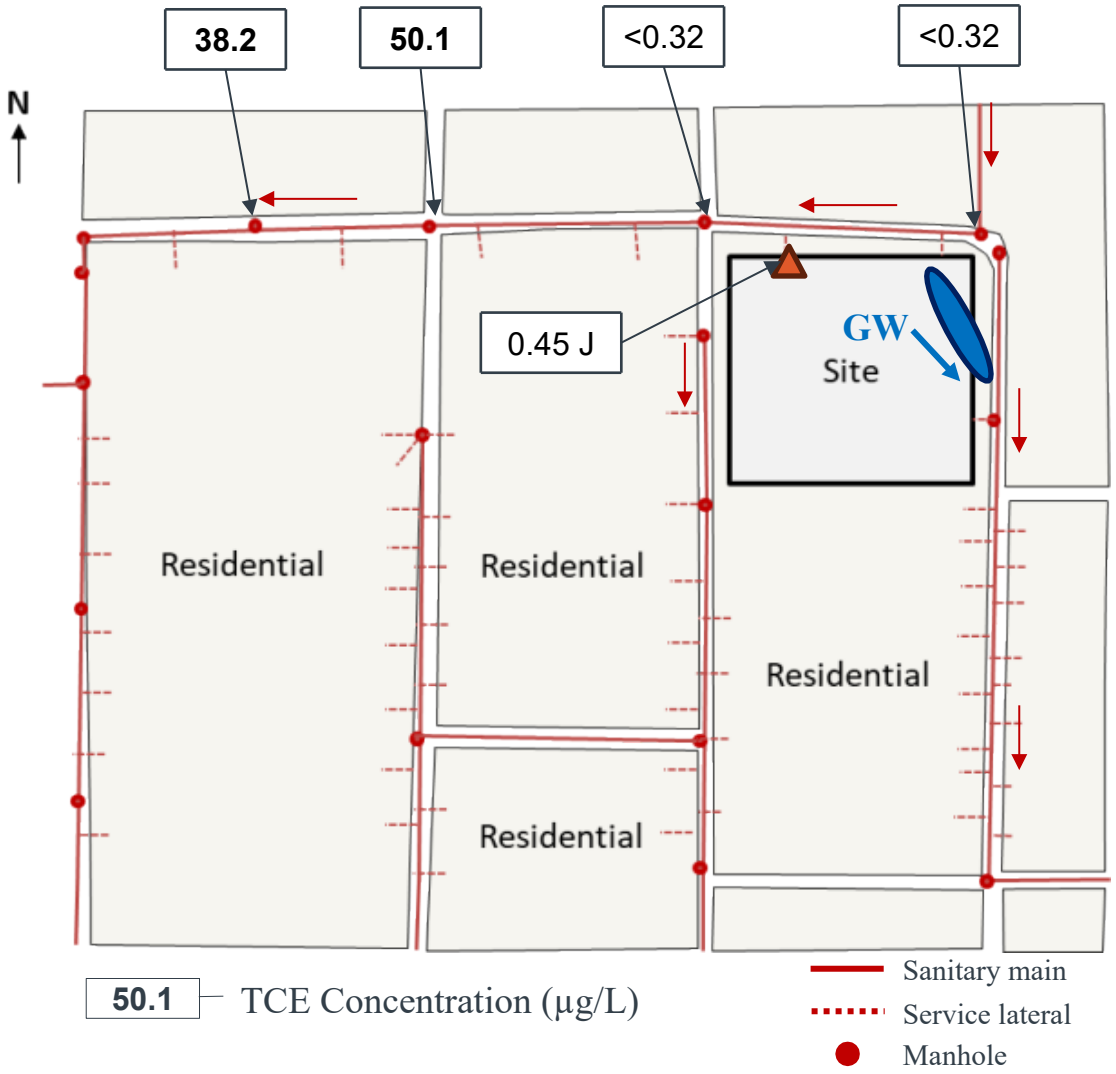
Sewer Venting System Performance



- Sewer venting system installed in June 2023
  - Multiple rounds of sampling performed between June 2023 and March 2024
- Overall, venting system reduced sewer gas concentrations by an order of magnitude

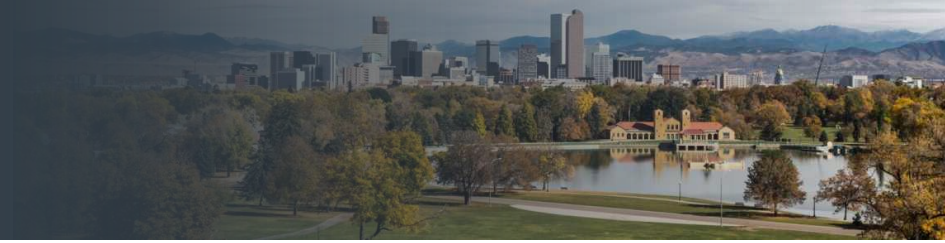


Sewer Effluent (Wastewater) Results



- Ongoing investigations to locate source of vapors in the northern sewer
  - Northwest sewer cleanout
  - TCE in the sewer main up to 50 µg/L
  - Ongoing investigations to evaluate the effect of groundwater levels on sewer vapor concentrations

Conclusions



- Migration through sewers and other preferential pathways is an important consideration when developing a VI Conceptual Site Model
  - Investigation and mitigation methods differ from conventional VI
  - Disregarding this pathway could lead to improper characterization, and inadequate or unnecessary mitigation.
- Passive samplers can be used for sewer gas and indoor air sampling to address temporal variability
- Active sewer venting systems are readily implementable and can be effective in mitigating the sewer VI pathway