The Effects Of Sample Collection Time, Volume, And Probe Construction On Subslab Soil Gas Concentrations

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Study Objectives

- Evaluate the effect of purge volume, sample collection time, and sample volume on subslab soil gas (SSSG) volatile organic compound (VOC) concentrations
- Evaluate the effect of subslab sampling port type on SSSG VOC concentrations
  - Conventional Swagelok tube-, Vapor Pin-, and California-style
- Provide input into future vapor intrusion (VI) guidance on SSSG sample collection

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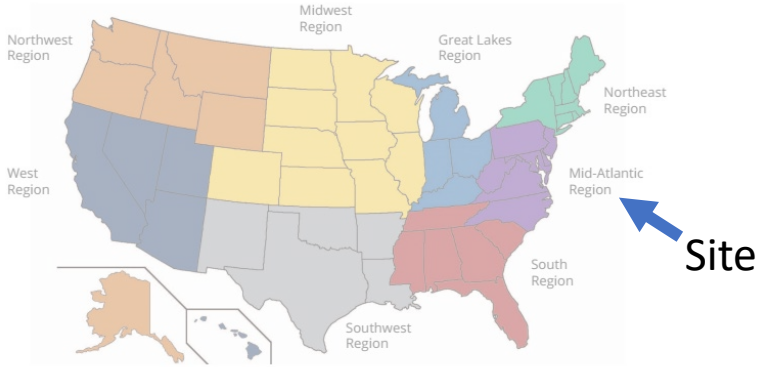
Site Background

- Site located in Mid-Atlantic region
  - Mostly concrete/asphalt-paved industrialized area
  - Chlorinated VOCs (cVOCs) released from damaged industrial wastewater lines
- Medium-to-coarse sands in vadose zone
- Depth to groundwater 3 to 8 feet below ground surface
- Remediation activities:
  - Groundwater extraction and air sparge/soil vapor extraction
  - Discontinued in 2012/13 due to limited effectiveness



Groundwater cVOCs Beneath/ Near Study Building

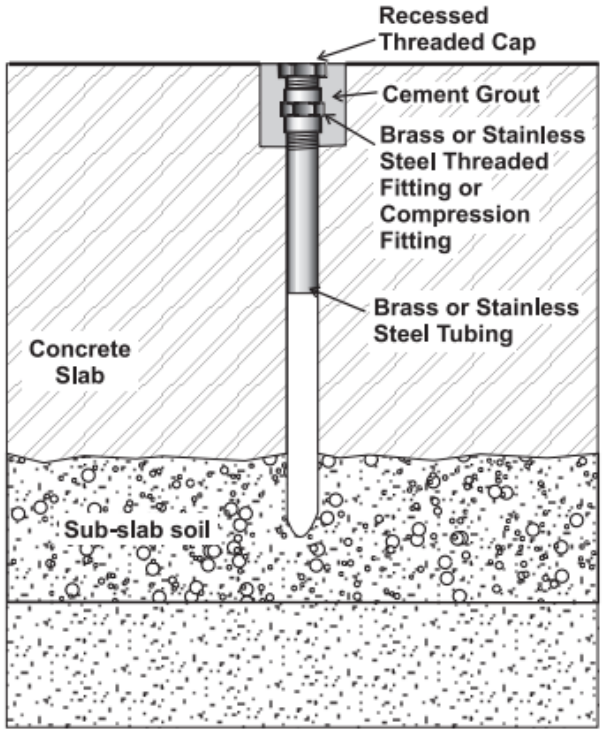
cVOC	Max Concentration (2014-2016) (µg/L)
1,1-dichloroethane (DCE)	650
1,2-dichloroethane	7.4
cis-1,2-DCE	470,000
trans-1,2-DCE	68,00
Trichloroethene (TCE)	900,000
Vinyl chloride	640,000

µg/L = microgram(s) per liter

Methodology

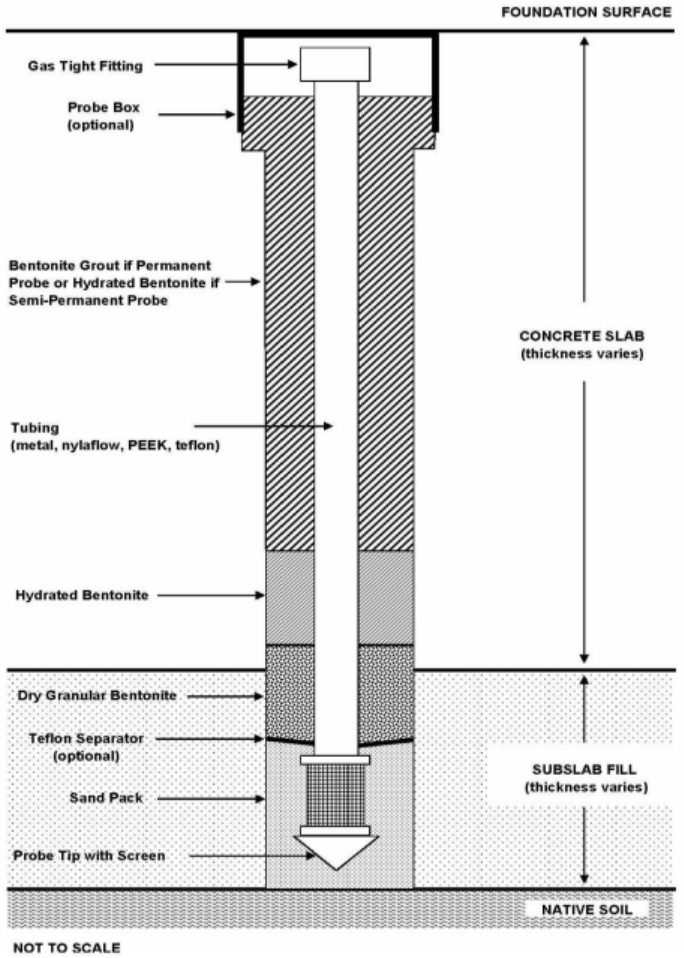
- A hexagon-shaped sampling grid was installed with three styles of SSSG probes and passive and active sorbent samplers
- The hexagon was in an area with elevated subslab cVOC concentrations
  - Concentrations were anticipated to be relatively uniform across sampling grid
- Discrete sampling conducted over 11 months with on-site gas chromatograph-electron capture detector (GC-ECD)
- Time-integrated sampling (e.g., canisters, sorbent tubes) conducted over summer months of 2020 (July through September)

Instrumentation – Subslab Soil Gas Probes



Conventional Swagelok Tube
(Image source: US EPA, 2015)

Vapor Pin
(Image source: Cox-Colvin, 2021)



California-Style
(Image source: CA DTSC, 2015)

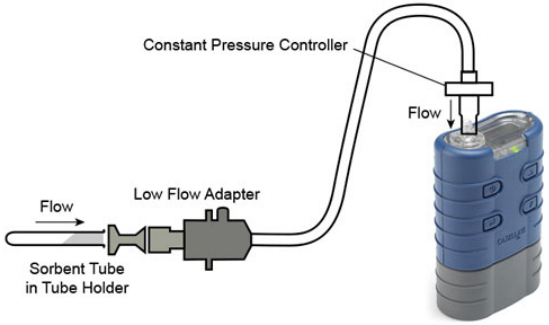
Instrumentation – Sampling

WHOLE AIR
Time-Integrated

Evacuated Canister
Sampling period: 5 minutes to 24 hour

+ Capillary Flow Controller

Evacuated Canister + Capillary Flow Controller
Sampling period: Long-term (weeks)



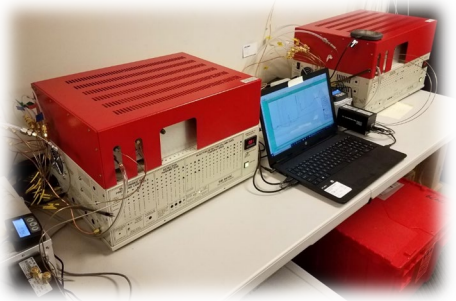
Active Sorbent Tube
Sampling period: Short-term (minutes)
(Image source: Casella)

PASSIVE
Time-Integrated

TO-17 Thermal Desorption Tube with Diffusion Cap
Sampling period: 2, 5, 7, 14 days
(Image source: SKC)

Waterloo Membrane Sampler (WMS)
Sampling period: 2, 5, 7 days
(Image source: SiREM)

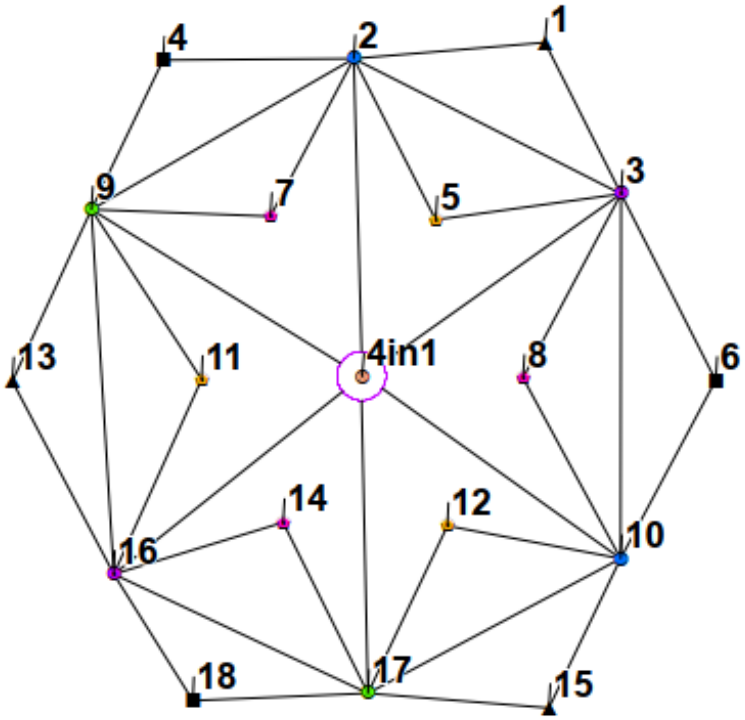
WHOLE AIR
Discrete



GC-ECD
Sample collected every few hours

Sampling Grid: Construction, Sample Collection Type and Frequency

Icon	Location #	Probe Construction	Sample Collection Method	Sample Integration Time or Frequency
▲	1, 13, 15	Vapor Pin	Capillary controlled evacuated canister	Two consecutive 14-day periods
●	2, 10	CA-style	GC-ECD (discrete) Sorbent tube: Active, syringe-pulled TO-17	GC-ECD: Daily Sorbent tube: Four events (~1 min)
●	3, 16	Conventional		
●	9, 17	Vapor Pin		
■	4, 6, 18	2.5 cm (1 in) diameter open boring	Sorbent tube with passive diffusion cap	Two events (14 days each)
⬟	7, 8, 14			Six events (2x 2 days, 2x 5 days, 2x 7 days)
⬟	5, 11, 12		WMS passive sampler	
●	Center (HVS)	10 cm (4 in) diameter open boring	Sorbent tube with passive diffusion cap	



Sampling Grid: Construction, Sample Collection Type and Frequency

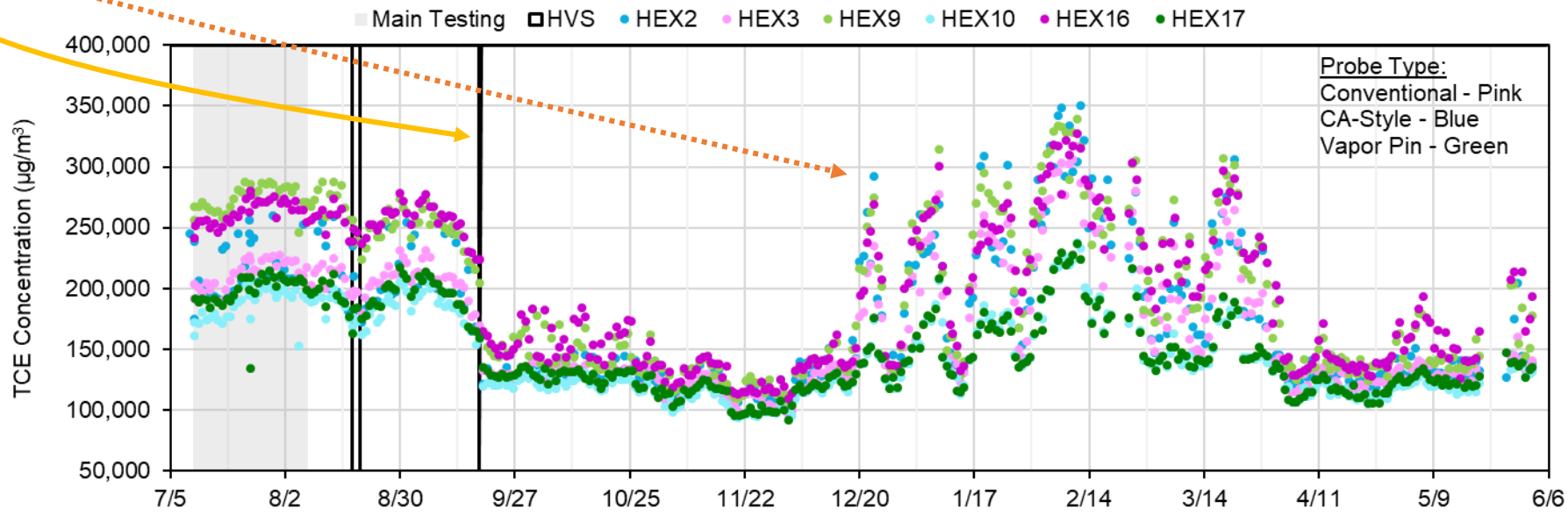
Icon	Location #	Probe Construction	Sample Collection Method	Sample Integration Time or Frequency	Volume purged or Collected and Flow Rate
▲	1, 13, 15	Vapor Pin	Capillary controlled evacuated canister	Two consecutive 14-day periods	~2 L @ ~0.11 mL/min
●	2, 10	CA-style	GC-ECD (discrete) Sorbent tube: Active, syringe-pulled TO-17	GC-ECD: Daily Sorbent tube: Four events (~1 min)	GC-ECD: 30-300 mL @ 60 mL/min Sorbent tube: ~50 mL @ <200 mL/min
●	3, 16	Conventional			
●	9, 17	Vapor Pin			
■	4, 6, 18	2.5 cm (1 in) diameter open boring	Sorbent tube with passive diffusion cap	Two events (14 days each)	~1 L @ 0.05 mL/min[a, b]
⬟	7, 8, 14			Six events (2x 2 days, 2x 5 days, 2x 7 days)	~1 L @ 0.05 mL/min[a, b]
⬟	5, 11, 12		WMS passive sampler		~7.5-26 L @ 0.26 mL/min[a, c]
●	Center (HVS)	10 cm (4 in) diameter open boring	Sorbent tube with passive diffusion cap		~6,200-27,600 L @ ~67-300 L/min (2.4-10.6 scfm)

[a] Volume is equivalent to the sample volume, but is actually the uptake rate multiplied by the sample duration
[b] flow rate same for all compounds
[c] flow rate for TCE provided

HVS = high volume sampling
mL/min = milliliter(s) per minute
scfm = standard cubic feet per minute

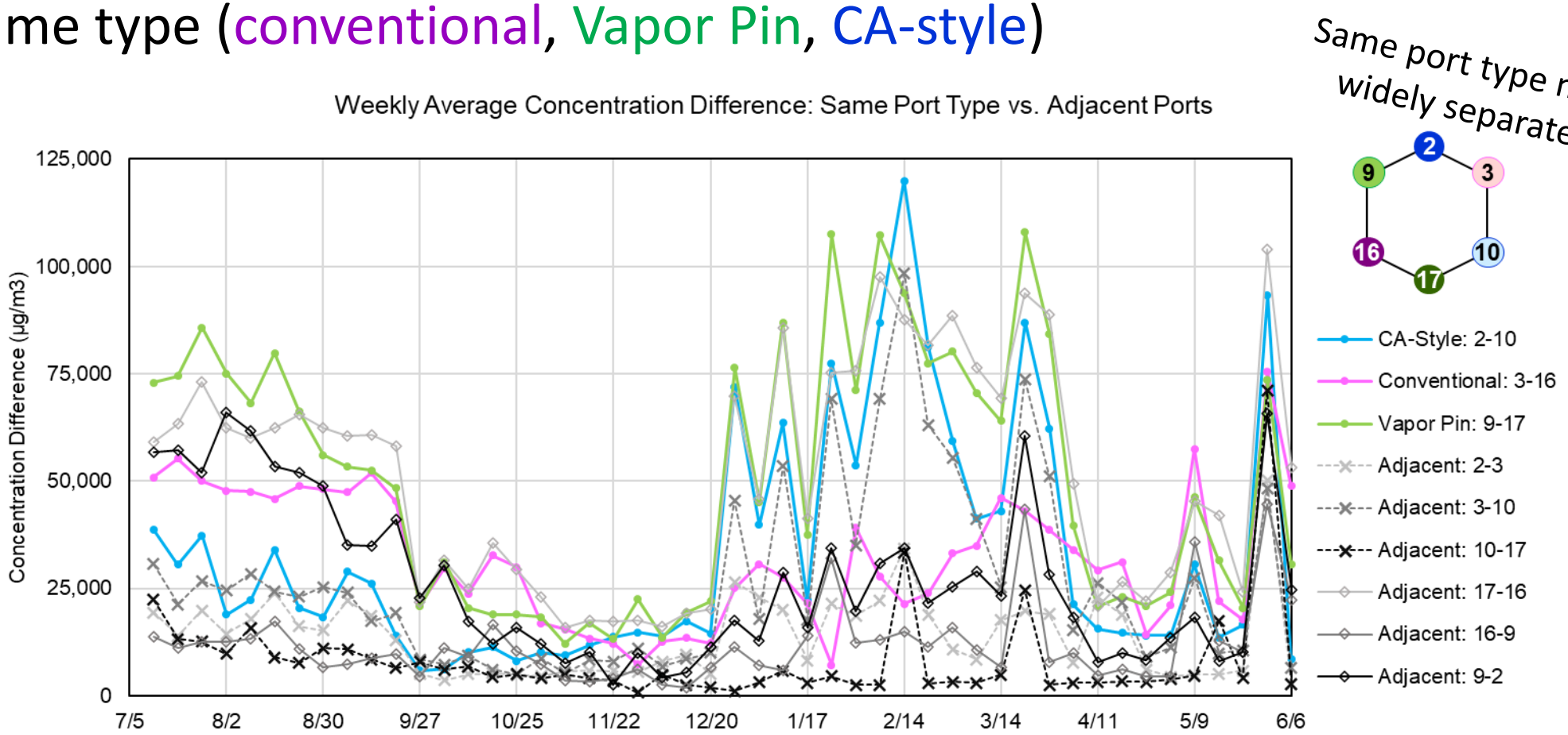
Results – SSSG Probe Construction

- Little temporal variability in GC-ECD results over 11-month sampling period.
  - High volume sampling (HVS, >20,000 L) event (9/18/20) lowered TCE concentrations and had a mixing effect, which lasted for several months
  - TCE concentrations fluctuated from each other starting around 12/20/20
    - Appears to correlate with differential temperature (article in review)
    - Major construction activities north of the sampling area also occurred during that time



Results – SSSG Probe Construction

- Relatively small differences in TCE concentration with SSSG probe type
- Better concentration agreement between adjacent probes than probes of the same type (conventional, Vapor Pin, CA-style)



Same port type more widely separated

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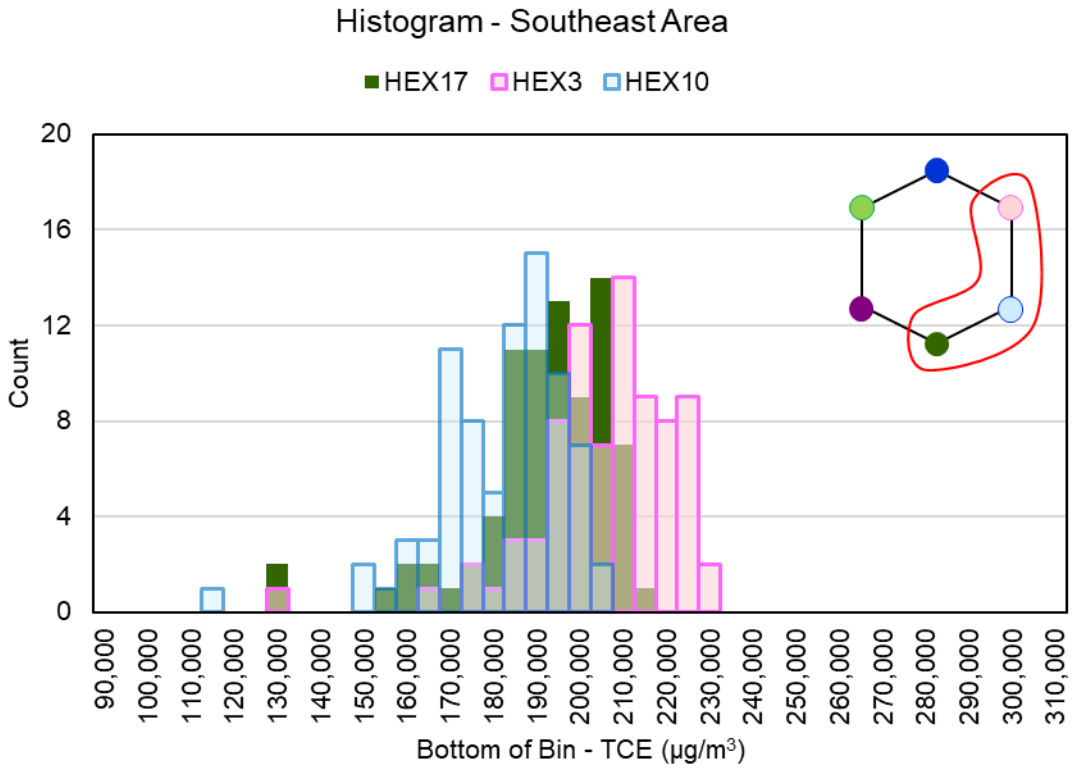

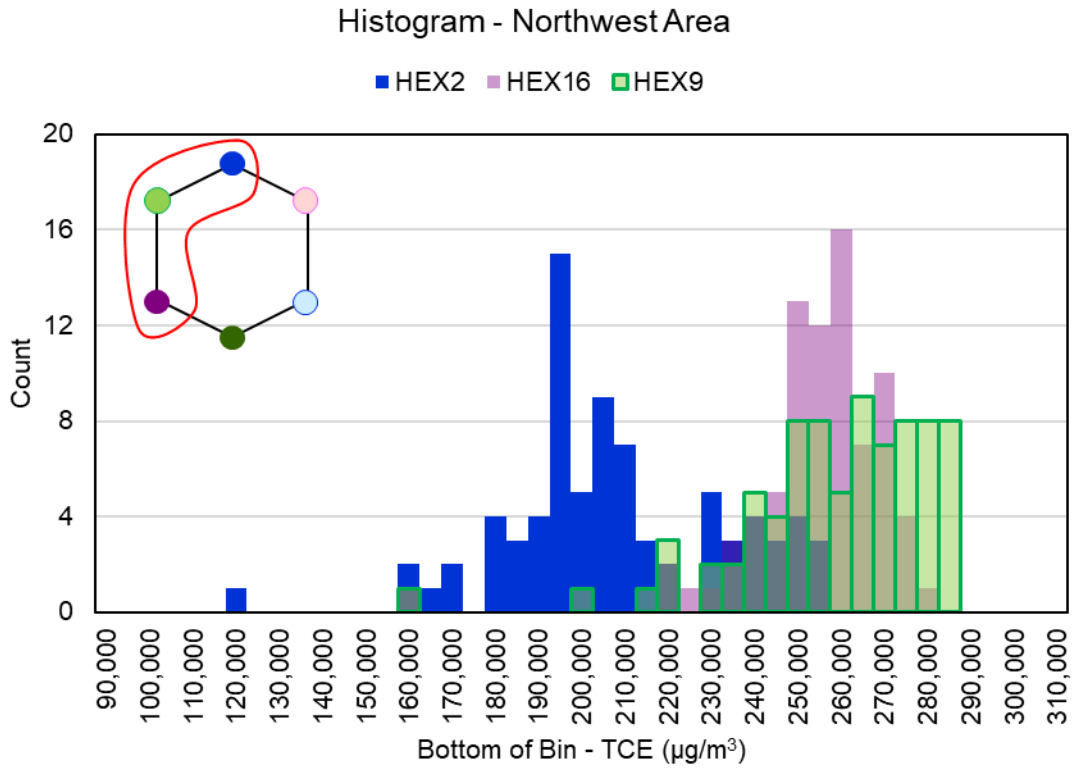

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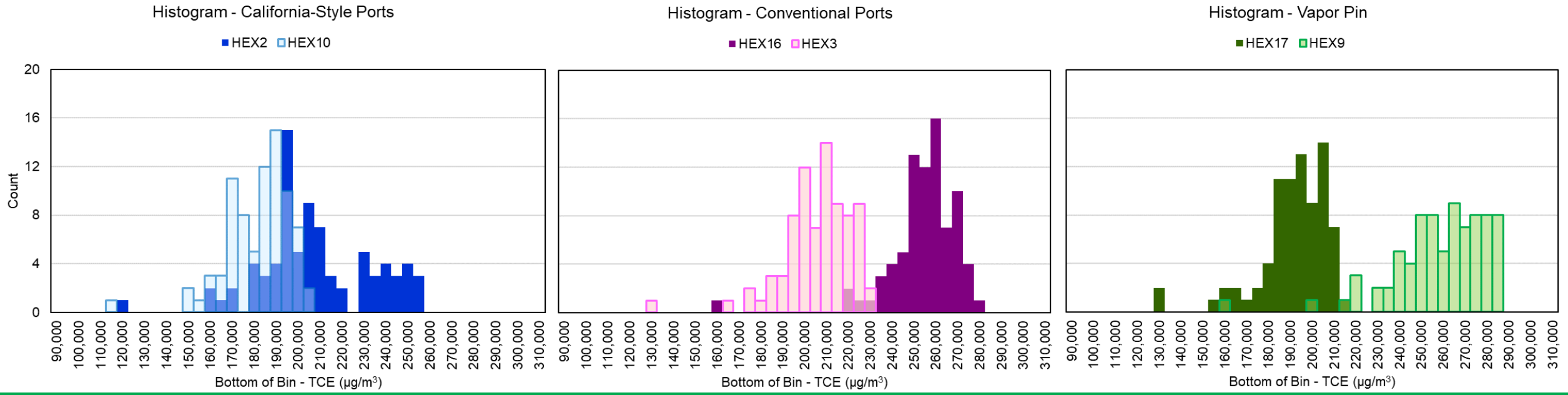
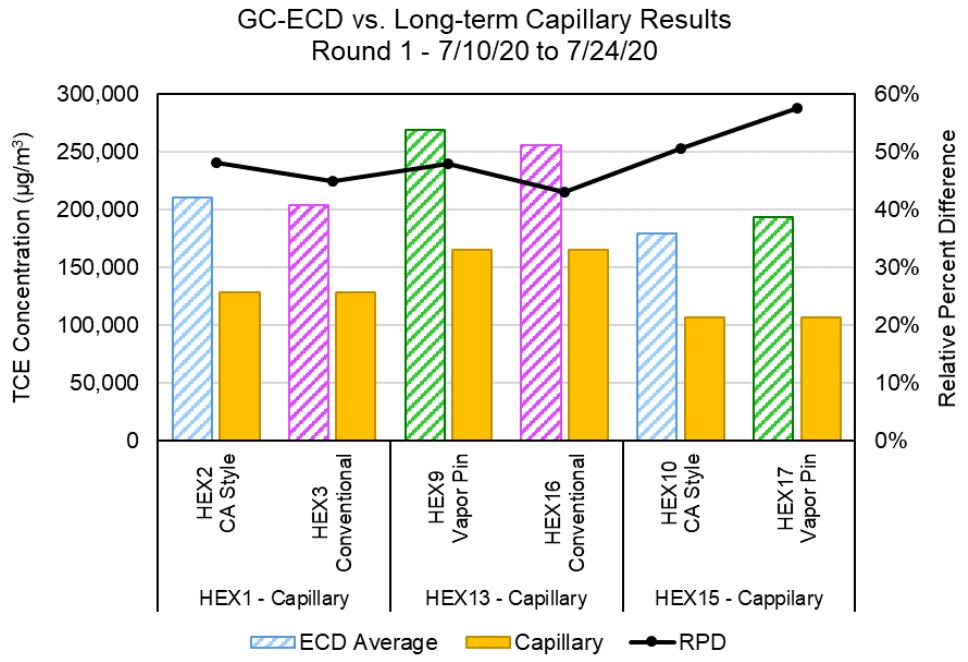
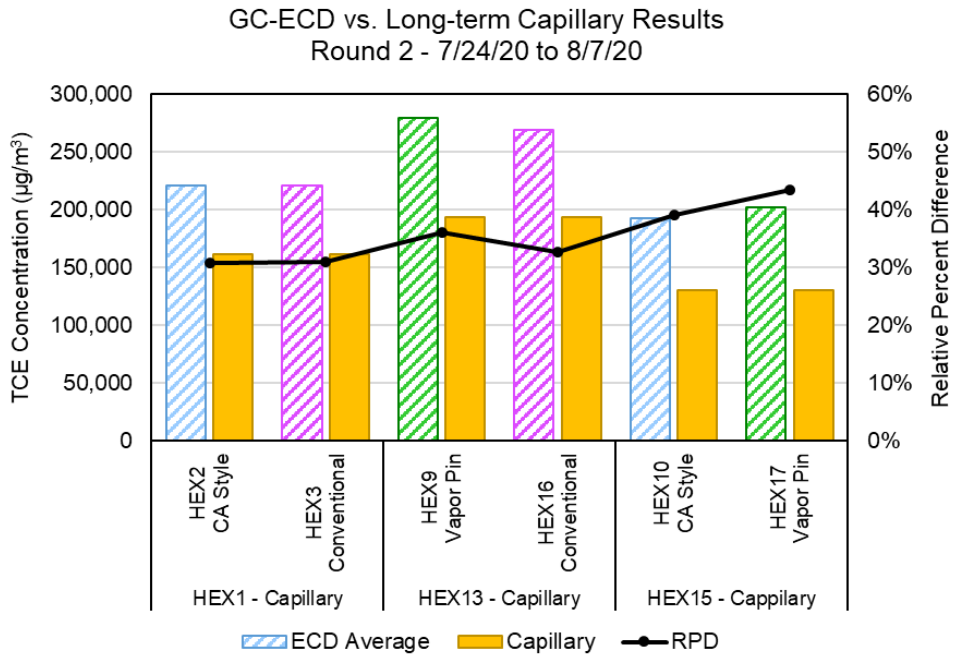
- Better concentration agreement between adjacent probes than probes of the same type (conventional, Vapor Pin, CA-style)
  - Based on histograms, CA-style probes had better agreement than conventional- and Vapor Pin-style
  - Less variability in CA-style probe may be because of probe construction



Results – Time-Integrated Active Sampling

- GC-ECD TCE concentrations consistently higher than evacuated canisters with capillary flow controllers (14-day samples)
  - Relative percent difference between GC-ECD and capillary samples was 31-58%, consistent with expectations for interlaboratory and intermethod comparisons
- GC-ECD TCE concentrations generally higher than active sorbent samples





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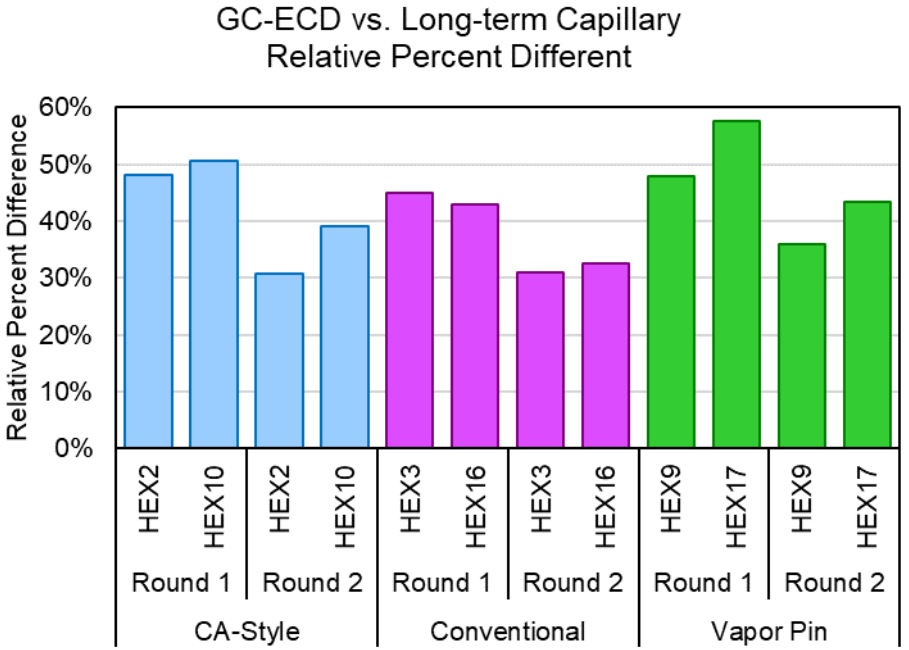

Results – Time-Integrated Passive Sampling

- Two- and 5-day passive sorbent tubes (sorbent tube with passive diffusion cap and WMS) and 7-day sorbent tube with passive diffusion cap within a factor of 2 (50-200%) compared to GC-ECD
- Sorbent tube with passive diffusion cap concentrations generally greater than GC-ECD
  - Some 14-day samples had lower concentrations compared to GC-ECD (12 and 26%), suggesting sampler had reached saturation
- WMS sampler concentrations generally less than GC-ECD
  - Results diverged more from GC-ECD at 7-day samples, suggesting sampler had reached saturation
- No consistent difference observed with borehole diameter (1 and 4 inches)

Conclusions and Recommendations

- SSSG probe type resulted in small differences in TCE concentrations when compared to adjacent sampling locations with different probe types
- The use of the capillary controller attached to an evacuated canister allowed for the extension of the sampling period from typical 8- or 24-hours periods to a 2-week period
- Thermal desorption sorbent tubes with low uptake diffusion caps were within a factor of two for 2-, 5-, and 7-day sampling durations
- WMS samplers were within a factor of two for 2- and 5-day sampling durations
- Sorbent saturation may have been reached at 14 days (thermal desorption tubes) and 7 days (WMS) at the site (TCE concentrations >100,000 µg/m^3)

Conclusions and Recommendations

- No systematic differences in TCE concentrations observed with SSSG probe type (conventional, Vapor Pin, or CA-style)
  - Results should be applicable to sites with lower concentrations of TCE, or other VOCs, that are closer to action levels because the physical similarities and differences in probe construction should produce similar effects regardless of concentration range
- The use of a field GC-ECD, either of the passive samples, or evacuated canister with capillary flow controller over short durations would likely lead to similar site management decisions

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