SOLNA STAD

Identification of new preferential pathways for vapor intrusion of chlorinated solvents found by combining VaporSafe™ and detection dogs

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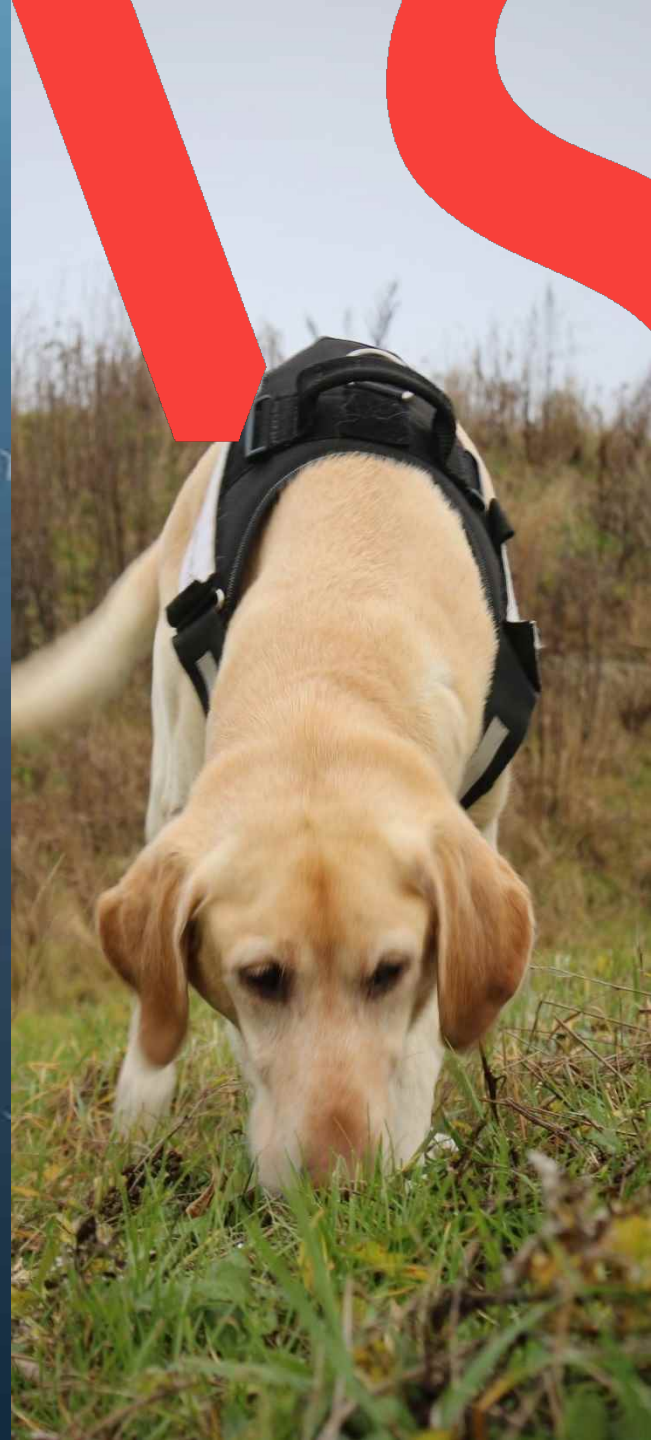


Background

Historical activities

One of Stockholm's largest dry-cleaner

- Operated approx. 1940-1970
- Handled 500-1,000 tons TCE & PCE

After operations ended:

- Buildings were demolished
- Redevelopment with expressway on a viaduct with buildings below

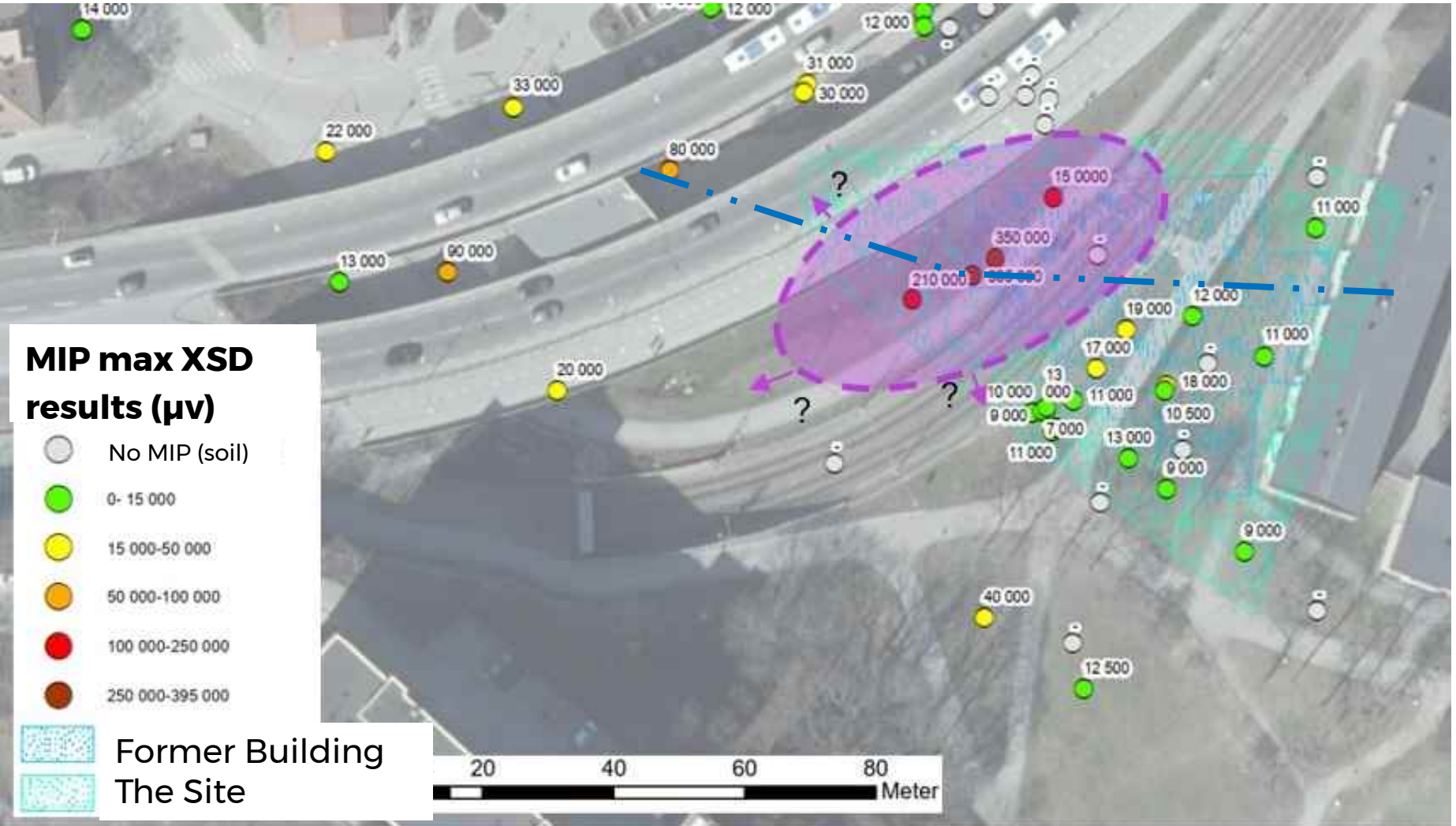
Background

The Site today…

- Various utility lines for sewage, storm water, electricity and telephone etc.
- Tramline
- Expressway on a viaduct with industrial buildings below
- Apartment buildings with radon gas SSD system installed 2012

Very challenging to investigate and to remediate!

Investigations: Source zone

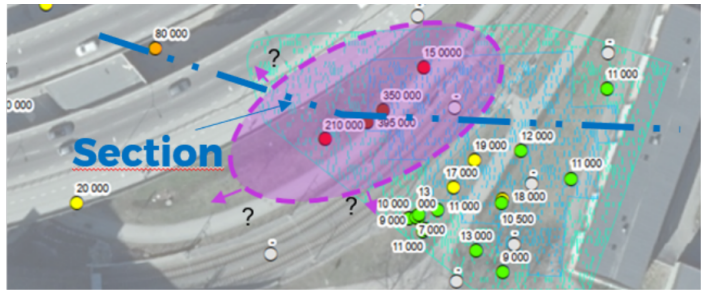


First investigated 2017 & 2019

Now Swedish EPA funded investigations 2020- spring 2022

A **source zone** was identified by MIP and sampling of soil/GW

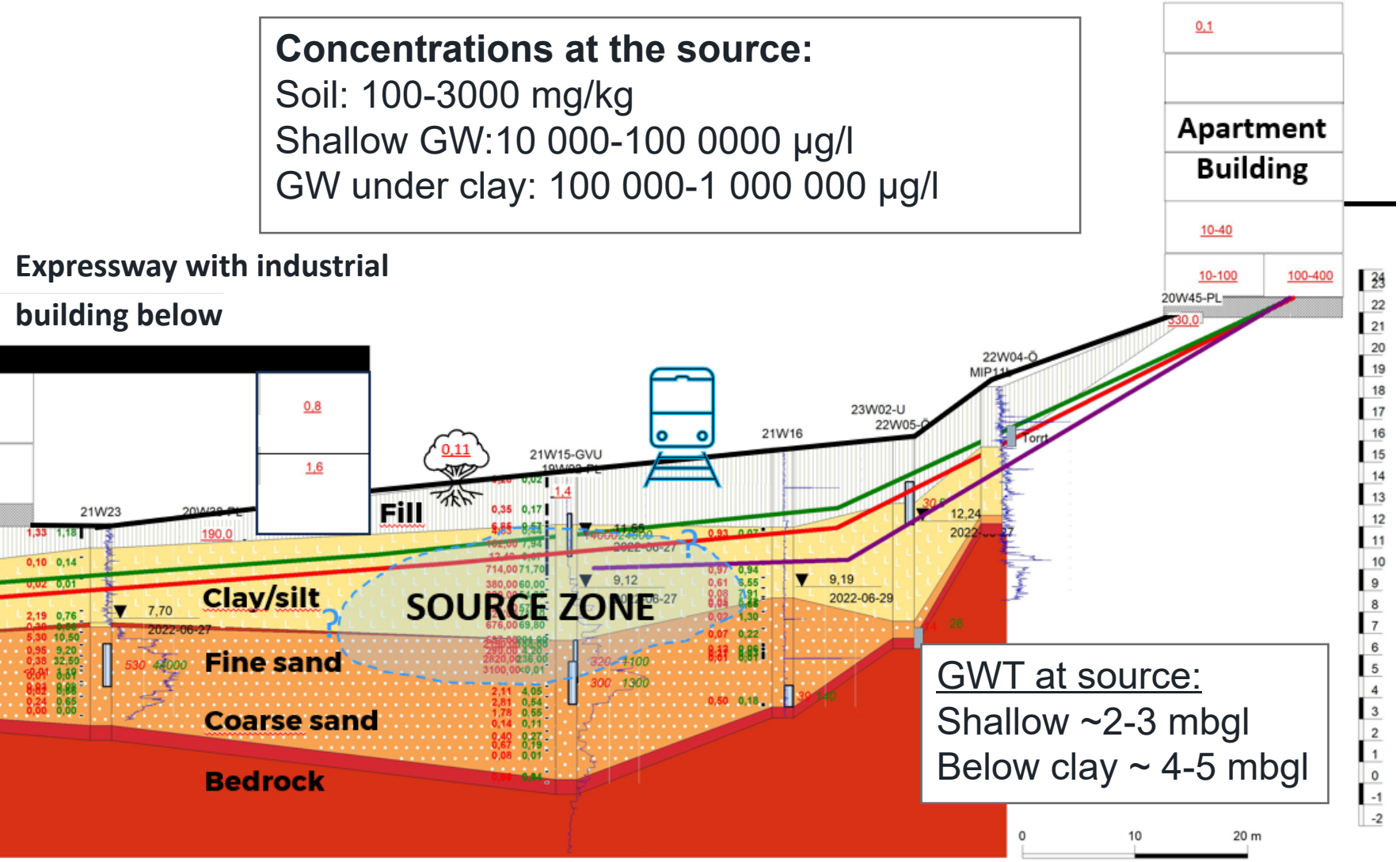
Investigations: Source zone



Concentrations at the source:
Soil: 100-3000 mg/kg
Shallow GW:10 000-100 0000 µg/l
GW under clay: 100 000-1 000 000 µg/l

- 4-10 mbgl, in clay/silt and silty fine sand
- Free phase PCE and possibly also TCE
- 4-7 tons of CAH, primarily 6-10 mbgl

Expressway with industrial building below



GWT at source:
Shallow ~2-3 mbgl
Below clay ~ 4-5 mbgl

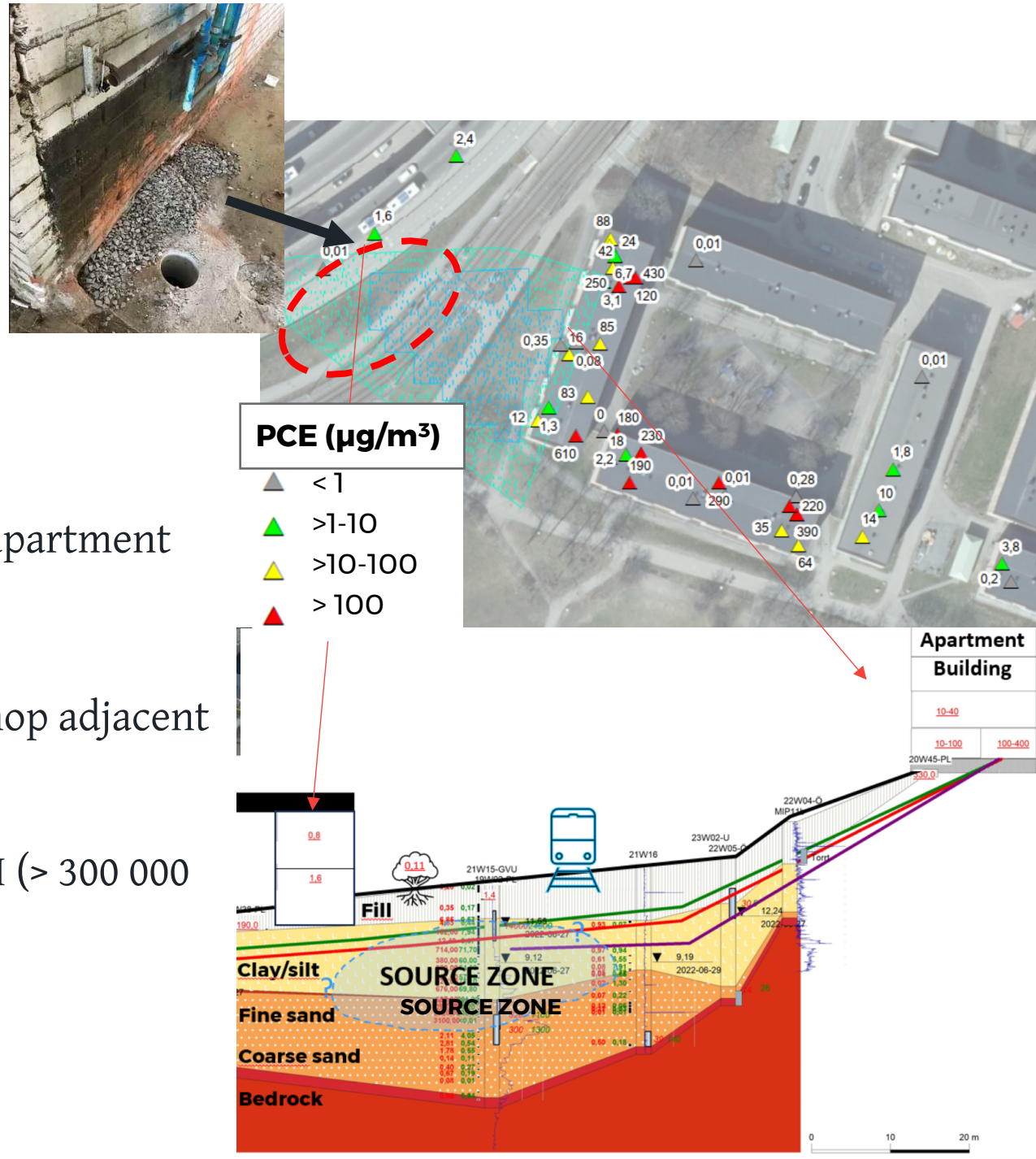
Units for PCE /TCE conc. in section:
Soil: mg/kg
Groundwater: µg/l
Soil gas/indoor air: µg/m³
Treecores: mg-h/kg

Contamination

Investigations: Indoor air

Vapor intrusion the primary risk driver:

- High PCE in indoor air in basement in apartment building (100-400 µg/m³)
- Low PCE in indoor air in vacant workshop adjacent to source (1-3 µg/m³)
  - Surprisingly high attenuation of VI (> 300 000 times)



Background

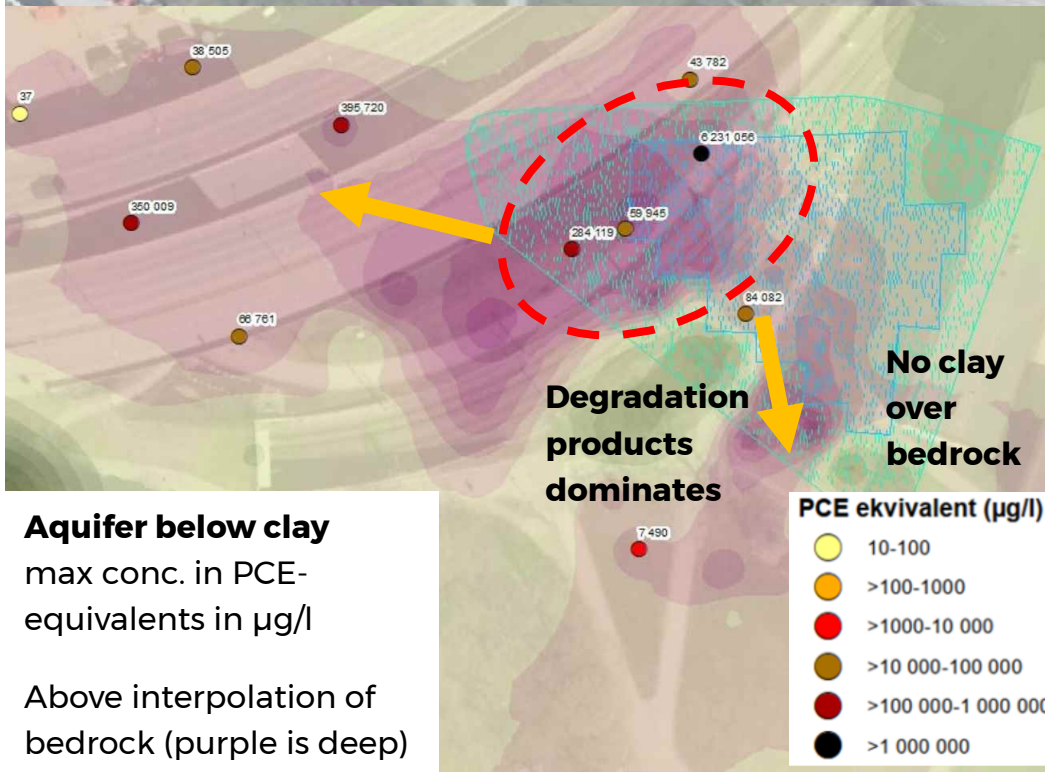
Investigations: Plume in GW

<u>Localised shallow groundwater</u>:

- Low conc. in gw (and soil) near the apartment building (< 70 µg PCE-eqv/l)
- High conc. under the vacant workshop

<u>Aquifer below clay:</u>

- Plume in two directions with high conc.
- However, no deep aquifer near the apartment building



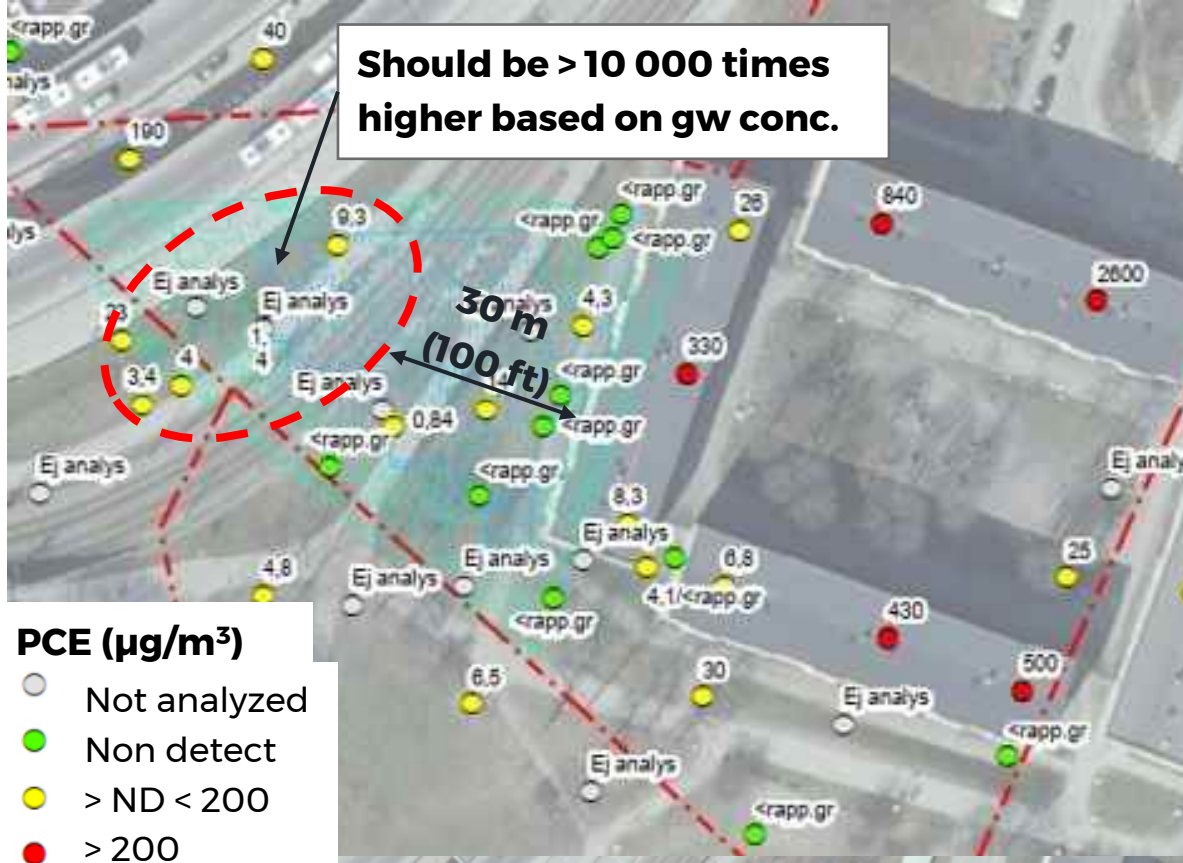
Background

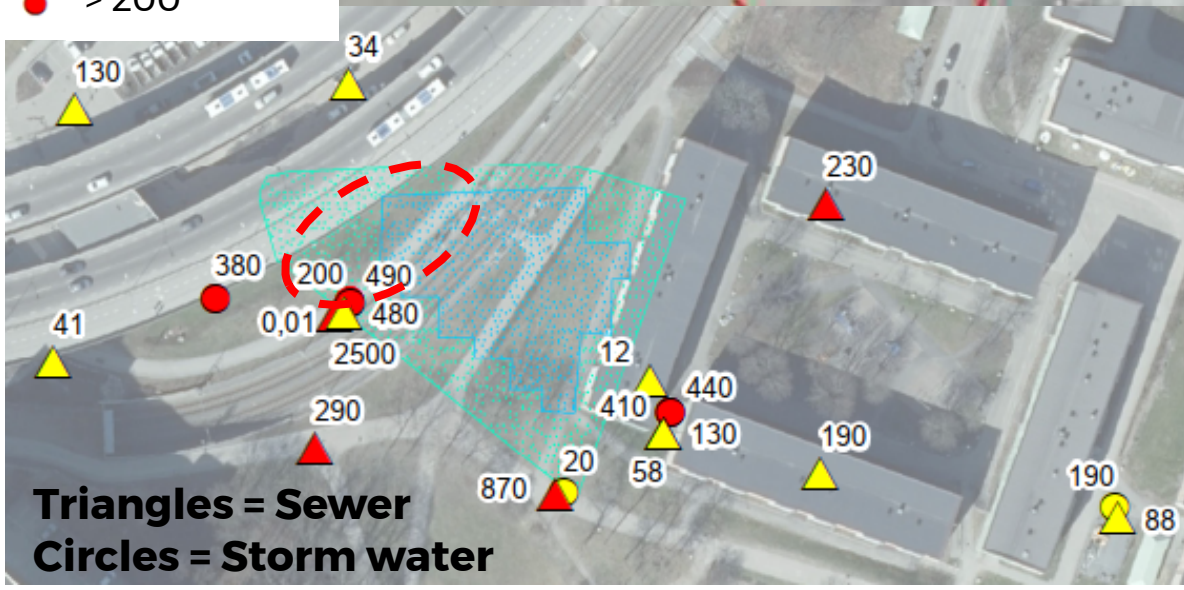
Investigations: Soil gas & gas in sewer & storm water lines

- Low conc. in soil gas over source zone (10-100 µg/m³), but high sub-slab conc. (300-3 000 µg/m³)
- High conc. in gas in sewer and stormwater lines (100-1000 µg/m³)

What causes the high conc. in indoor air?

Does the radon gas system affect the VI?





Approaches

Solution: Investigation of VI preferential pathways

Combination of:

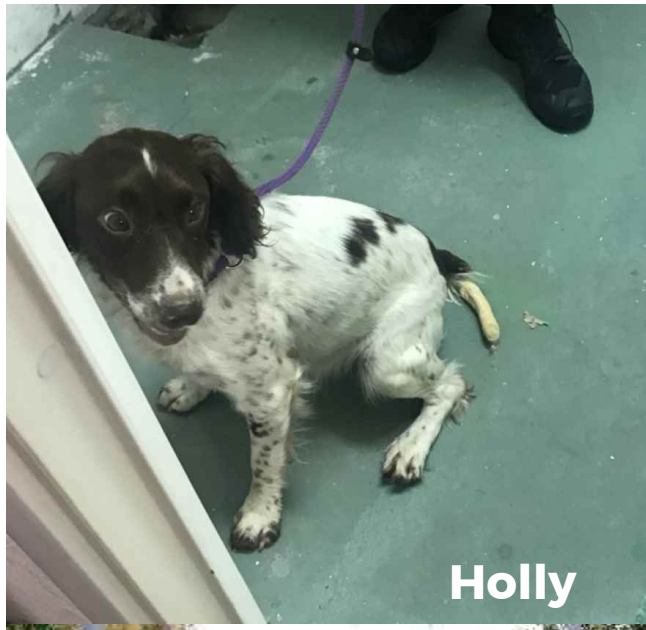
- Detection dogs, WSP Denmark first globally in 2019!
- VaporSafe™, continuous and discrete sampling of air and soil gas
- Verifying traditional air/gas investigations:
  - Indoor air, soil gas and gas in mains

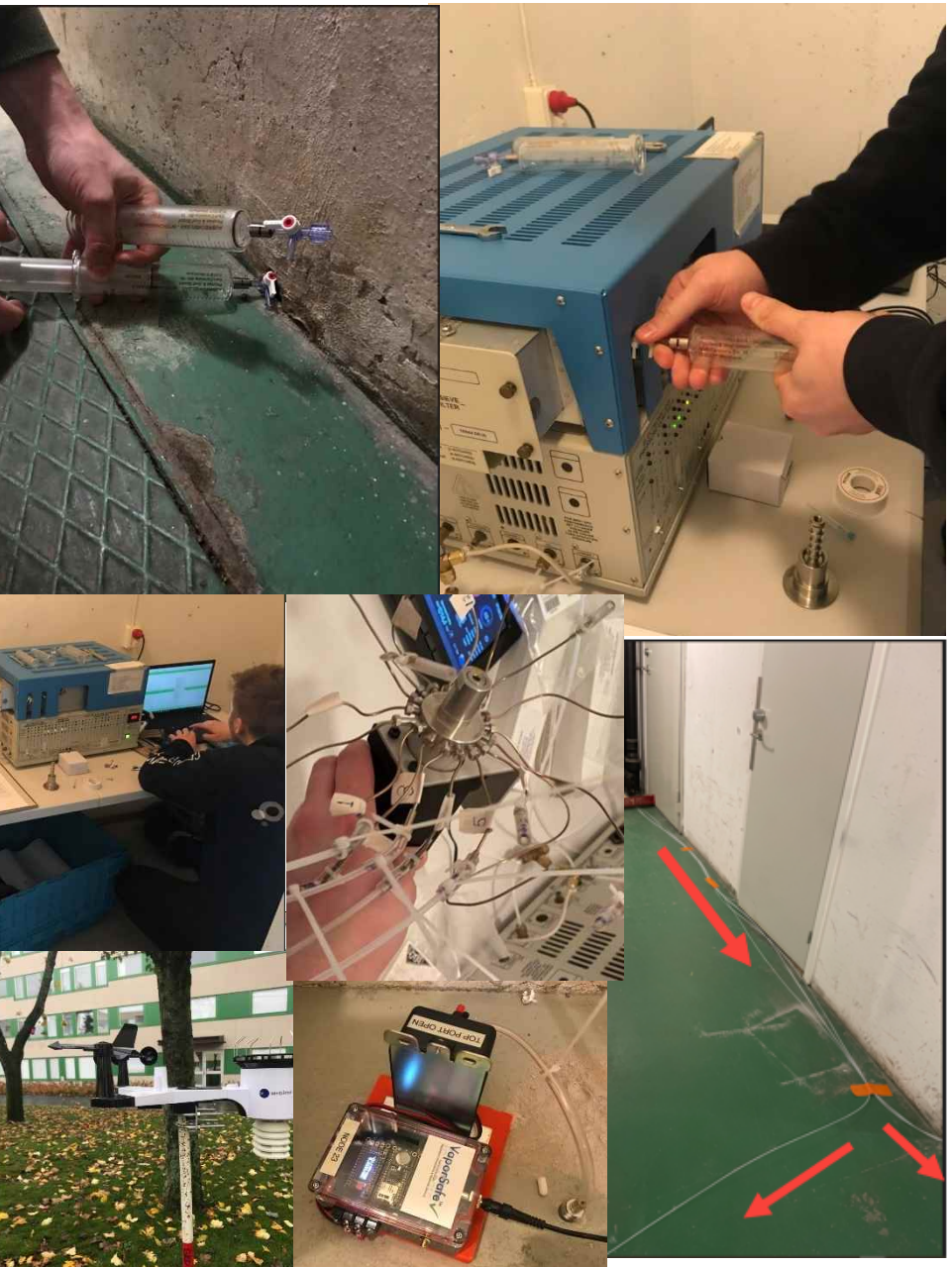

The WSP dog Louie, first in the world!

Approaches

Nordic Detection Dogs

- Trained and certified for detecting PCE/TCE
  - Certifying agency: SLU (Swedish University of Agricultural Sciences)
- Screening method to discover VI entry points
- Mark where they smell the contaminant, i.e., can't detect far below GWT
- Covered all 4 apartment buildings in 1 day
  - 2 basements per building and some apartments





Approaches

VaporSafe™

Real time results with highly sensitive GC

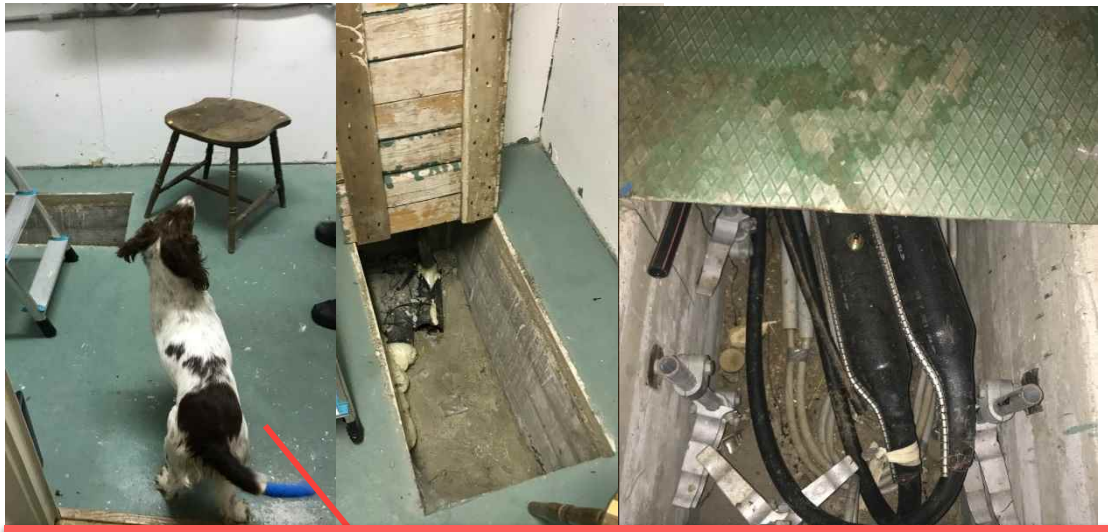
Logging of conc., pressures, weather data etc.

120 discrete samples to refine CSM and narrow down locations for continuous sampling

2 rounds of continuous sampling (12 & 16 h) on the lower basement of the west building

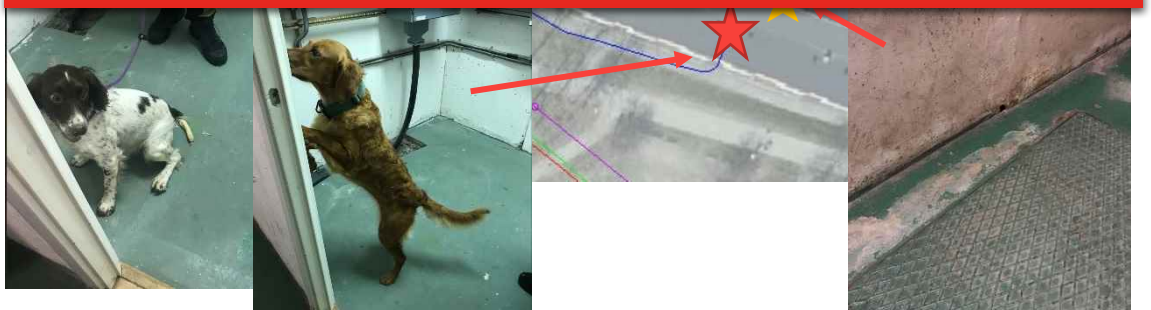
- Normal conditions (active radon gas system)
- Inactive radon gas system
- Reactivated radon gas system

One week incl. establishment (4 days on site)



Identified focus areas for VaporSafe™:
→ Lower basements and especially technical spaces in the west and south building

New insight: More than pipes can act as preferential pathways for VI!

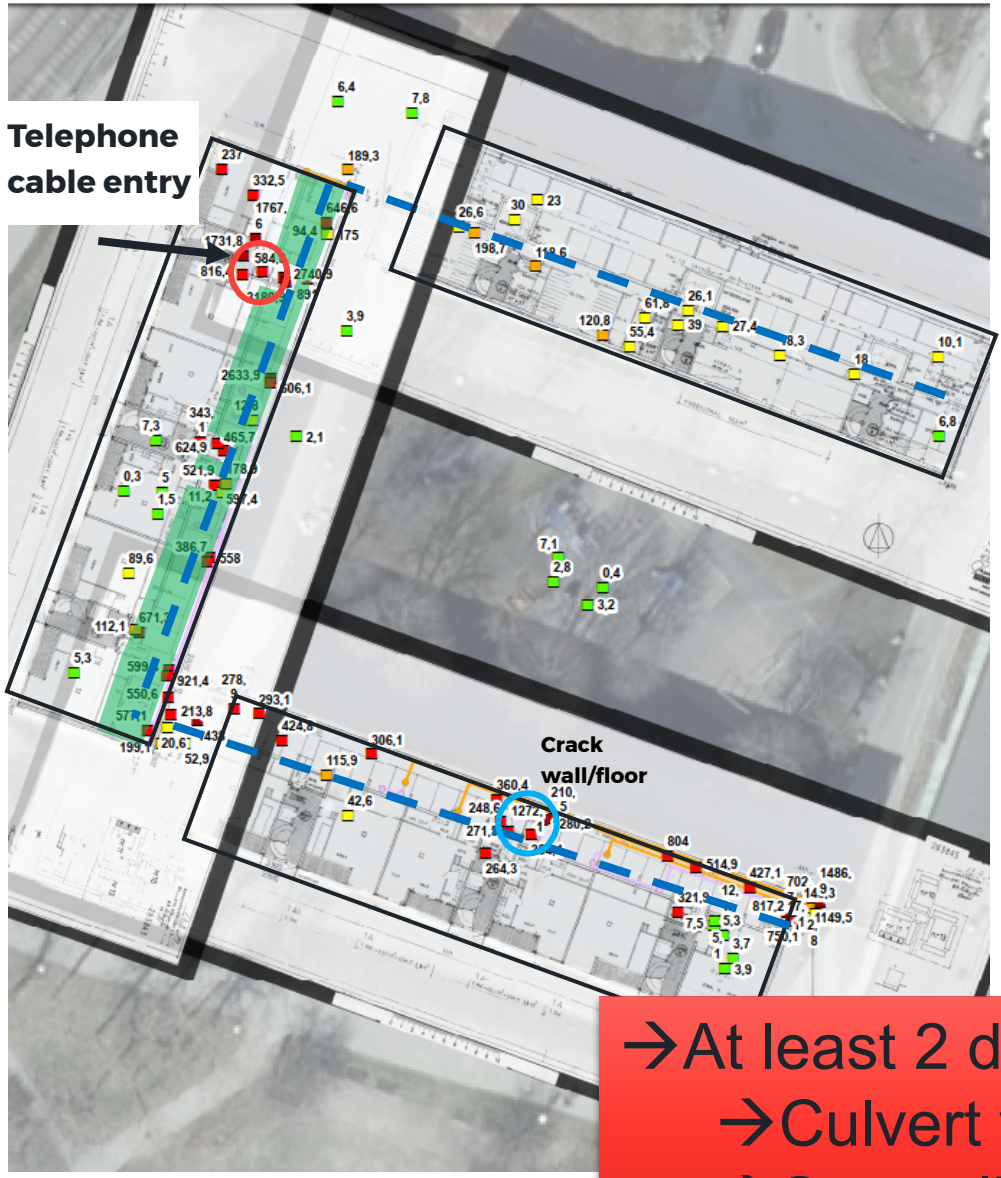


Results: Detection dogs

Marked only in the **West** and **South** Building:

- High interest in room with **incoming telephone cables**
  - Deep culvert crosses the source
- Marked where **electricity cables enters** buildings
- Interested in **hatches over sewer line(s)**
- Interested in **crack between floor/wall**

No marks/interest in the north and east building



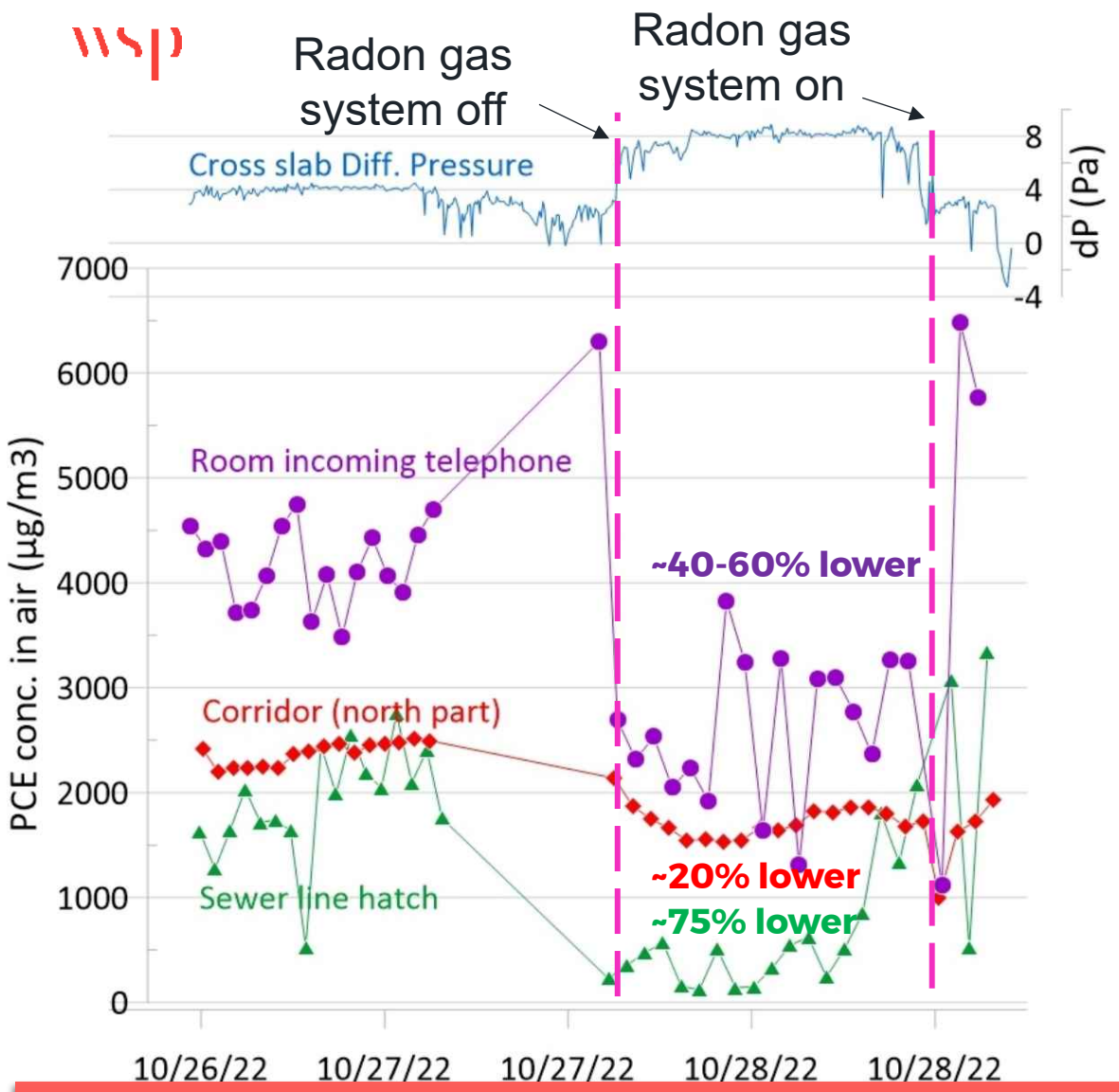
Results: VaporSafe™ – Discrete sampling

Verified and refined the results from the Detection Dogs:

- Very high PCE where telephone cables enters and in corridor outside (1000-3000 µg/m³)
- High PCE and degradation products at the crack between floor/walls (1500 µg/m³)
- High PCE and degradation products in sewer line that connects the buildings (500-1000 µg/m³)

Relatively low PCE sub-slab (200-600 µg/m³)

→At least 2 different VI preferential pathways:
→Culvert with telephone cables
→Sewer line



→The radon gas system increases the VI!
→Later impact in sewer line v/s at telephone cables

Results: VaporSafe™ – Continous sampling

Radon gas system ON:

- Positive differential pressure (dP) cross slab!?

Shutdown of the radon gas system :

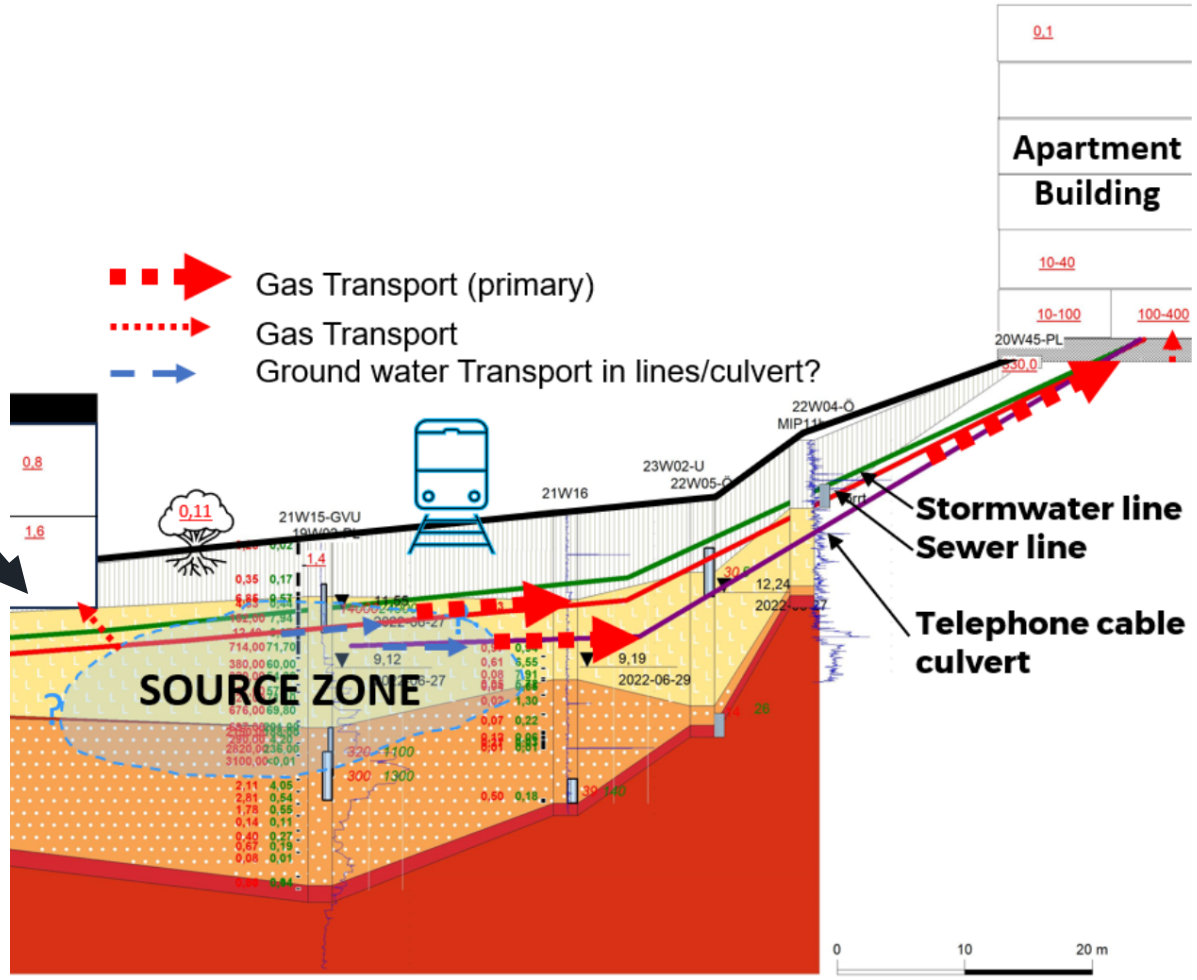
- 2-3 times higher dP cross slab, than with system on
- Air: PCE decrease 20-75%!
- Sub-slab: PCE decreased 2-3 times

Reactivation of radon gas system:

- The dP goes back down instantly
- PCE goes down and then fast up in telephone room, later at sewer line and other places

Conclusions

Impact of the radon gas system



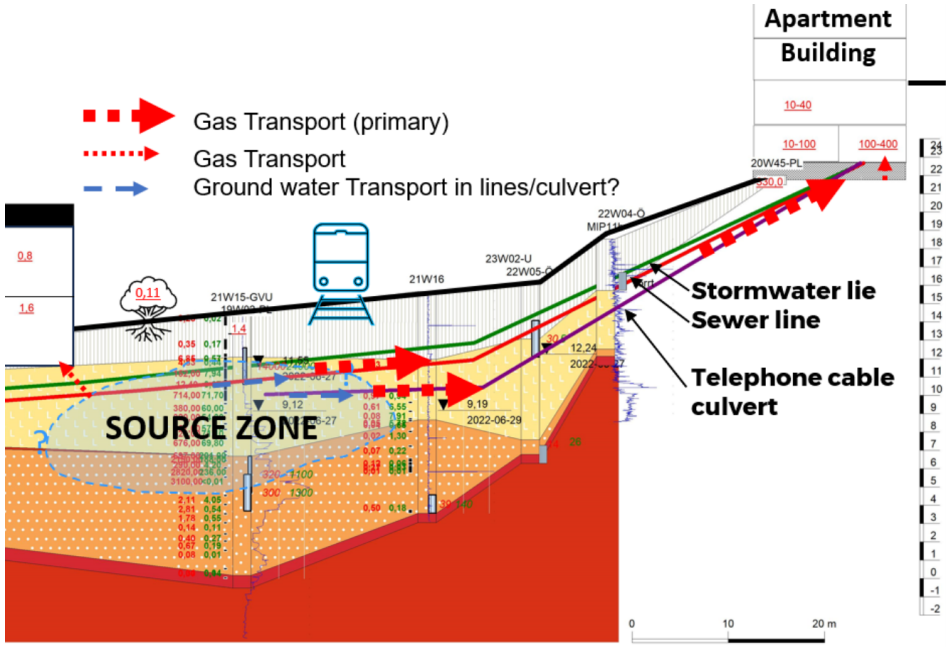
The soil gas plume over the source is drawn by the radon system to the apartment building via lines/ culvert!

3-13 kg CAH/year is spread to the air by the radon gas system!

- Source of background conc. in outdoor air in the area (< 0,9 µg/m³)?

Mitigation of VI to apartment building could lead to increased VI in the industrial building

Investigation conclusions



- A soil gas plume can be drawn from the original location by a radon gas system etc.
  - A low permeable soil source might not reach steady state after weeks/months of shutdown of such a system
- Only the shallow part of the source contribute to VI (only ~15-17% of ~ 4-7 tons CAH)
- Remediation that address VI feasible by injection-based technologies

Investigation conclusions

- **Combining of VaporSafe™ and Detection Dogs lead to:**
  - Cost savings, the detection dogs could scan areas at least 5-10 times faster than VaporSafe™
  - Possible to do extensive mapping of all 4 apartment buildings within a couple of weeks
  - Discovered unexpected new VI preferential pathways

Conclusions

Take home message regarding Detection Dogs

+ Quick & cheap way to scan a large area regarding VI

+ Low demand of planning/preparation and set-up time

+ Showed new pathways

Challenges:

- Marking of entry point is challenging for the dogs when high conc. in the room

- Unclear detection limit

Conclusions

Take home message regarding VaporSafe™

+ Possible to quickly collect and evaluate a vast amount of accurate data

+ Can see in real-time how concentrations vary and what affects the concentrations

+ Good tool in existing building when VI is the risk driver

Challenges:

- Quite expensive

- The field lab is not very portable, needs well thought out and secure space
    - Continuous sampling points must be connected by tube to the field lab
    - Need of table, oxygen tube etc.

- The establishment takes time

Thank you

Further questions? Contact: lena.torin@wsp.com

Acknowledgements:

Nordic Detection Dogs: Susanne Kummel, Tomas Gustafsson and Lotta Nilsdotter and the dogs Holly and Pippi

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NORDIC DETECTION DOGS | NDD

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