



ISCR Remediation on a Shallow and Extremely Variated Geological Conditions – Chlorinated Compounds Contamination in Brazil



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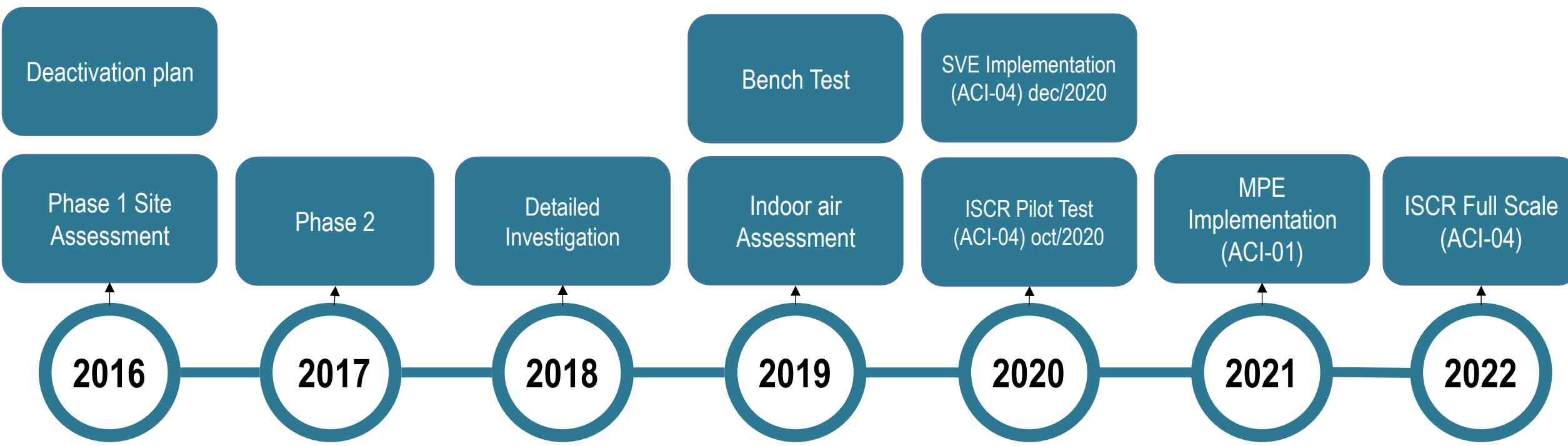
Battelle BioSymposium 2023 – Austin, TX
Sidney Aluani - May 11th - C6

Assessment | Remediation | Audit | Licensing | Consultancy

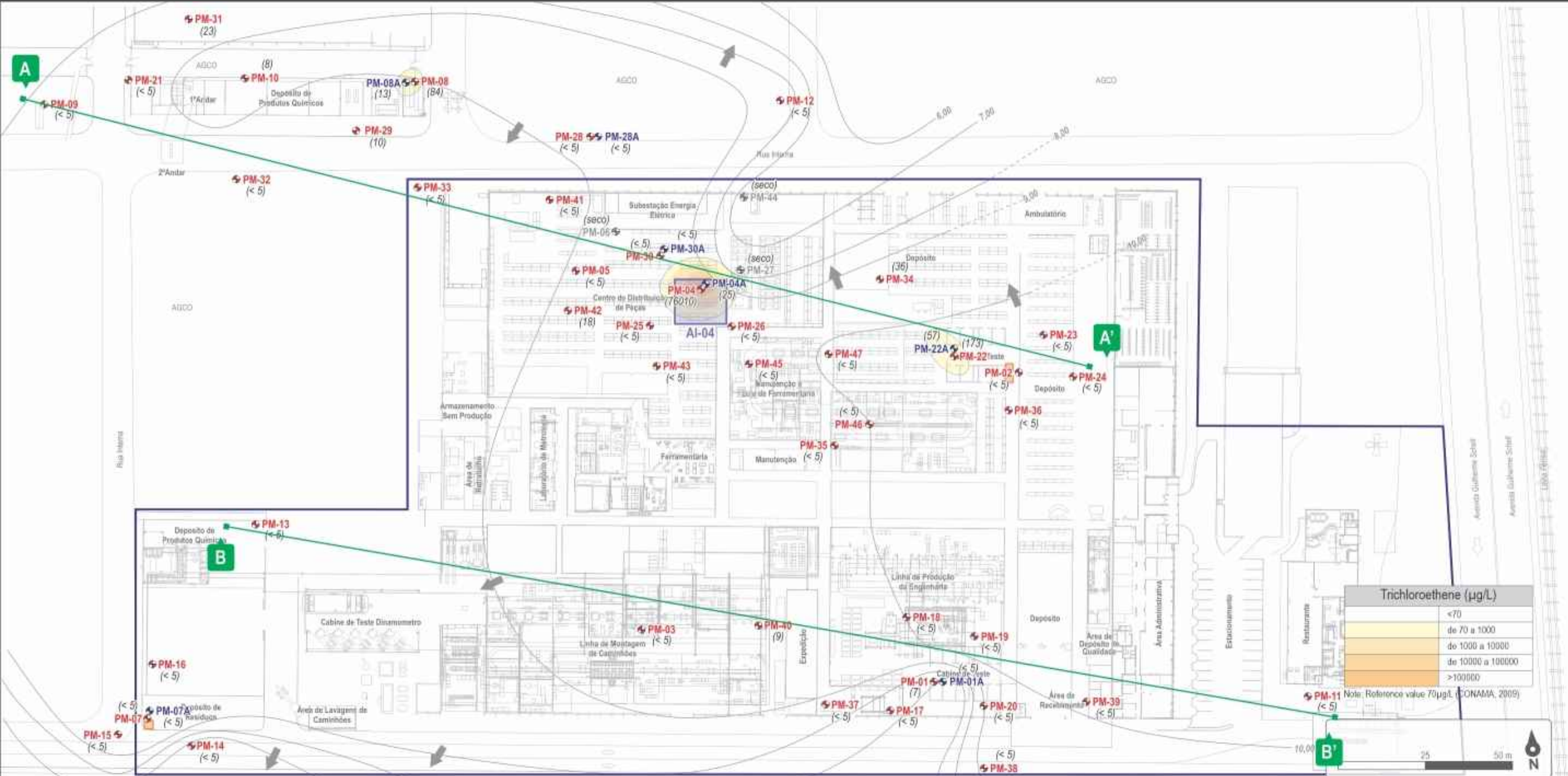
- ✓ Location
- ✓ Geological characterization and Plume delineation
- ✓ Remediation alternatives and challenges
- ✓ Bench Scale Test
- ✓ Pilot test
- ✓ Full scale

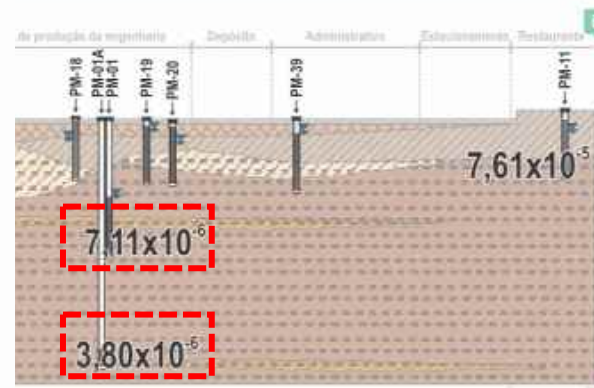
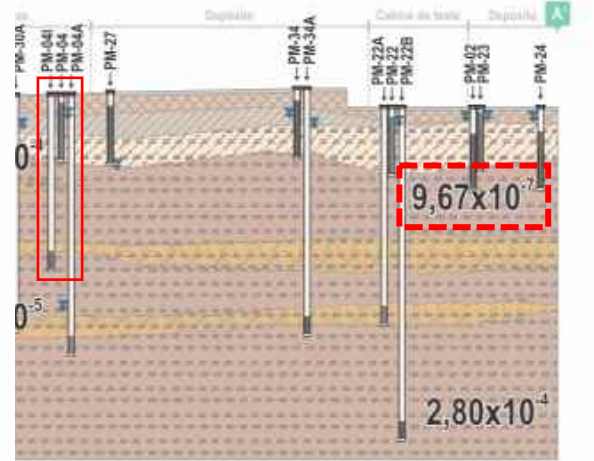
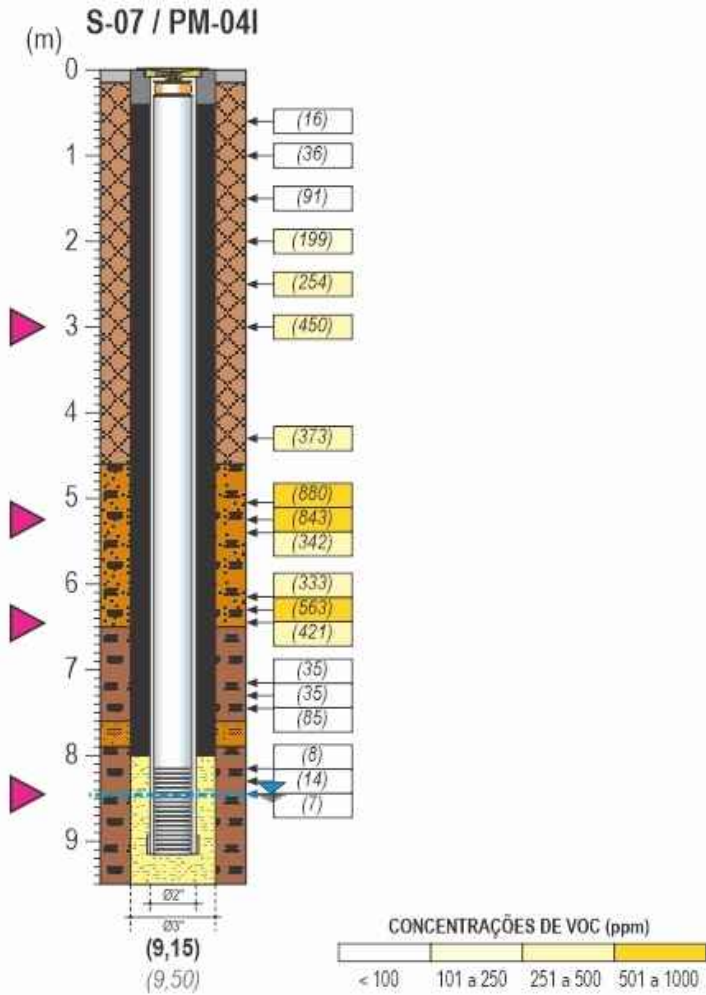
Site Location





Areas of Concern



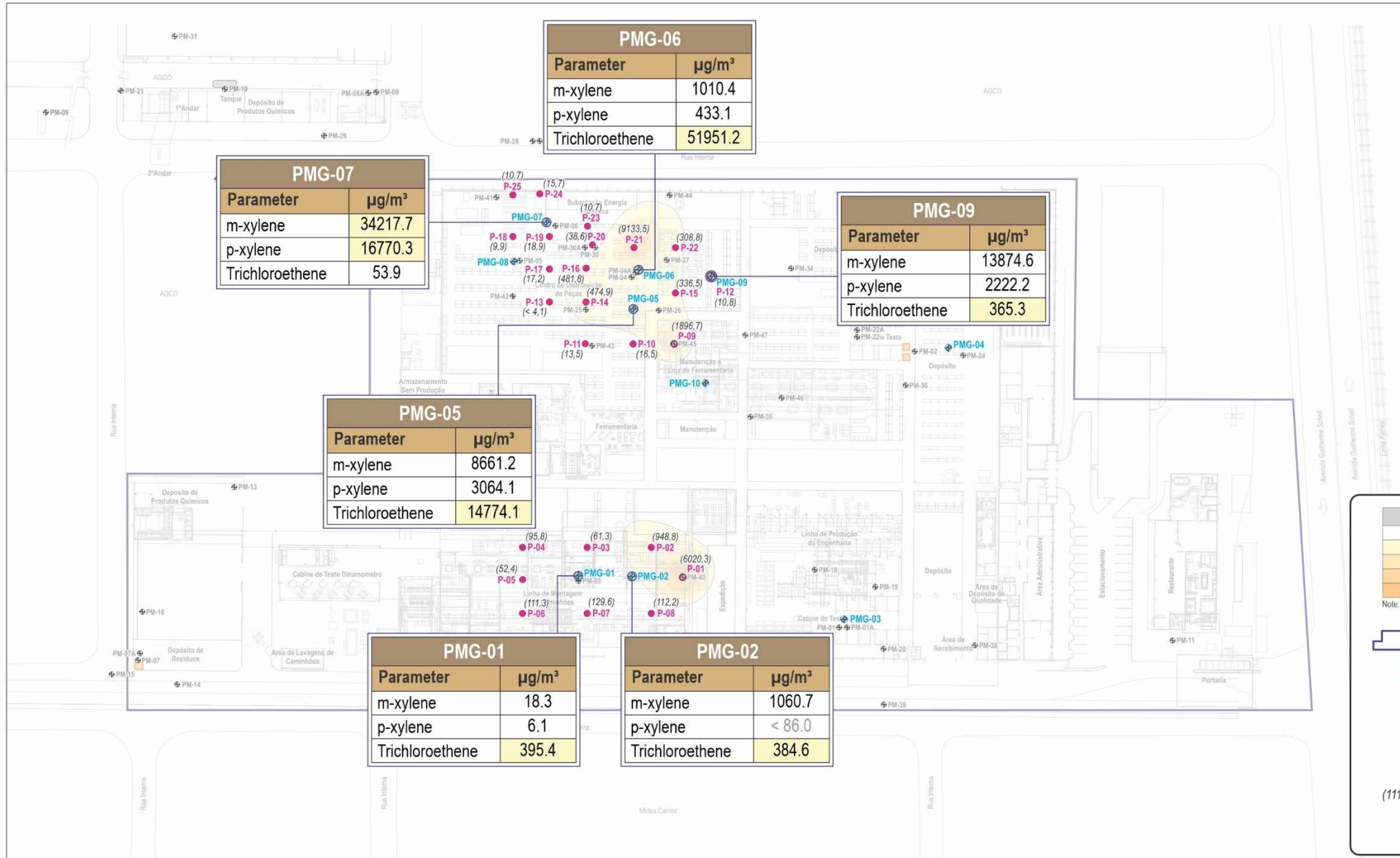


- ✓ Shallow aquifer
- ✓ Lithology mainly clay + silt
- ✓ Limited sandy layers
- ✓ Some wells – no water
- ✓ Low hydraulic gradient + conductivity
- ✓ VOC concentrations through all layers
- ✓ Natural reductive conditions

Fate and Flow Modeling – TCE and VC in Groundwater



Contamination Status – Vapor (may, 2018)



✓ Vapor intrusion potential above acceptable levels

✓ Site being occupied by new company

✓ SVE

Reference Value	
Parameters	µg/m ³
m-xylene	14667 ⁽¹⁾
p-xylene	14667 ⁽¹⁾
Trichloroethene	293 ⁽¹⁾

Note: USEPA - 2018/2
(1) Non-Carcinogenic

Trichloroethene (µg/L)	
<70	
from 70 to 1000	
from 1000 to 10000	
from 10000 to 100000	
>100000	

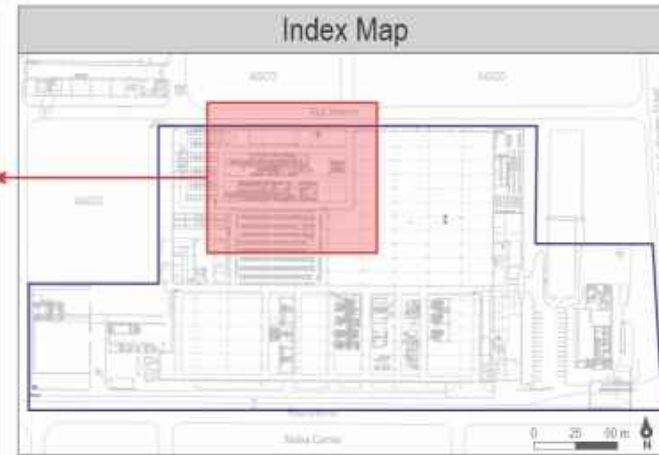
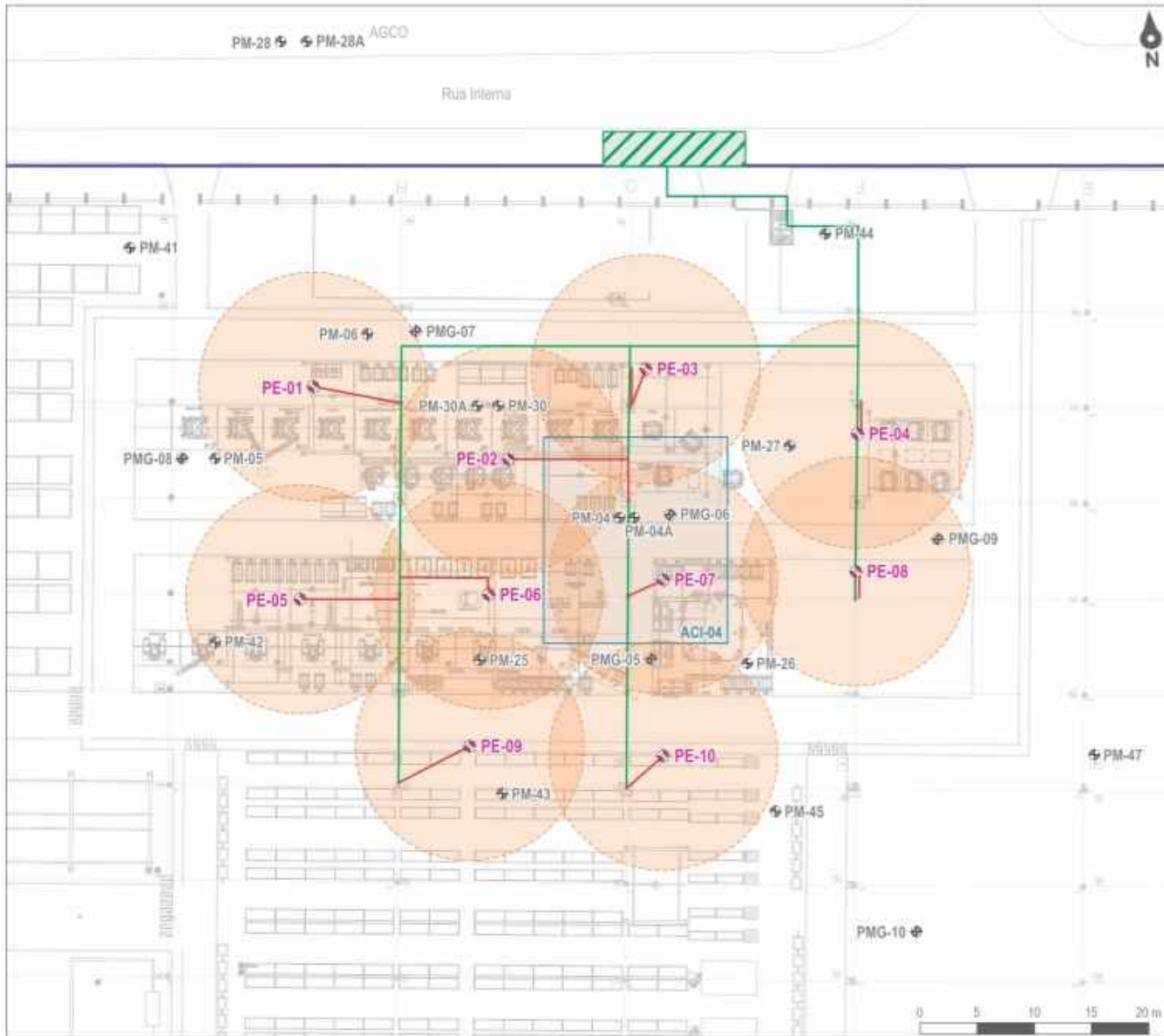
Note: Reference value 70µg/L (CONAMA, 2009)

- Property Limit
- Industrial effluent box
- Monitoring wells
- Subfloor Vapor Monitoring Wells
- Location of passive samplers (WMS)

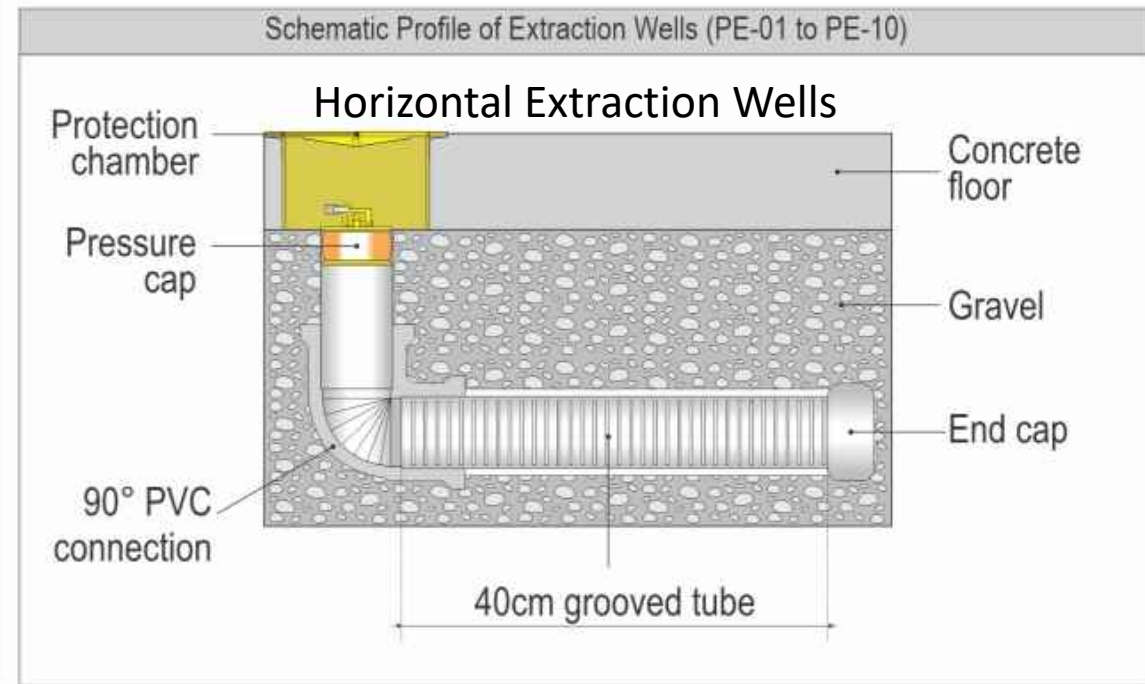
(111.3) Concentrations of Trichloroethene (µg / m³)

0 25 50 m

Soil Vapor Extraction (SVE)



- Property Limit
- Contaminated area (ACI)
- ACI-04 Former Degreasing Machine
 - Subslab vapor monitoring wells
 - Groundwater monitoring wells
 - Extraction wells
 - 10 m radius
 - Overhead extraction lines
 - Underground extraction lines
 - Container



Decision Matrix	ERD	EVO	ISCO	ISCR
Reductive underground environment	✓	✓	✗	✓
Organic substrates	✓	✓	✗	✓
By products formation	✗	✗	✗	✗
Risk for the underground structures	✓	✓	✗	✓
Cost and time effective	✗	✗	✓	✓
Need for multiple applications	✗	✓	✗	✓
IBAMA license	✗	✗	✓	✓
Rebound	✗	✗	✗	✓
H&S	✓	✓	✗	✓

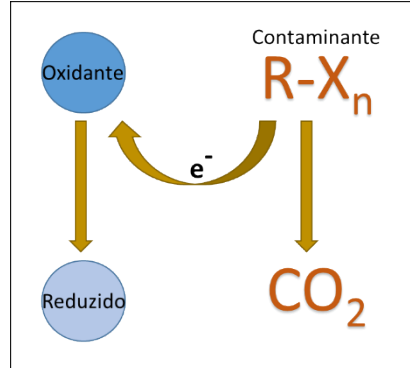
Bench Scale Test: ISCR x ISCO



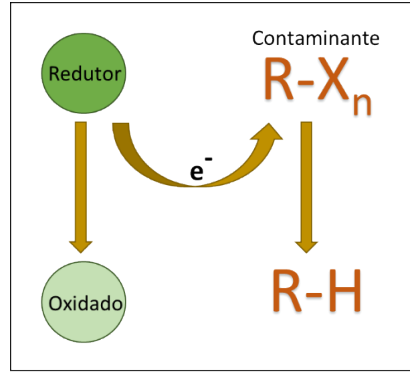
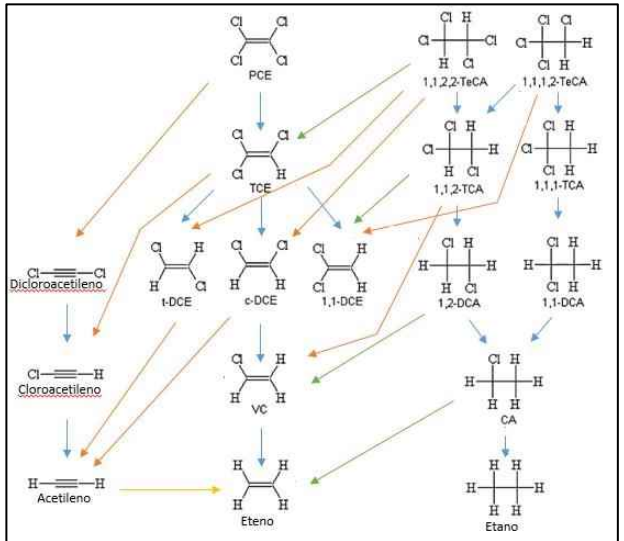
Binding Energy by Binding Type		
Bonding	Typical Compounds	Binding Energy (eV)
Carbon-Carbon (simple)	Chlorinated Ethanes, Long Chain Hydrocarbons	2.5
Carbon-Carbon (one and a half)	Aromatics (BTEX)	2.0
Carbon-Carbon (double)	Chlorinated ethenes	1.5
Carbon-Hydrogen	Alkanes (TPH)	1.0

ISCO

Oxidation Potential of the Main Agents	
Oxidant	Potential (V)
Fluorine (F ₂)	2.87
Hydroxyl radical (OH•)	2.80
Persulfate radical (SO ₄ •)	2.60
Ferrate (Fe ⁶⁺)	2.20
Ozone (O ₃)	2.08
Persulfate (S₂O₈²⁻)	2.01
Hydrogen peroxide (H ₂ O ₂)	1.78
Permanganate (MnO ₄ ⁻)	1.68
Chlorine (Cl ₂)	1.49



ISCR

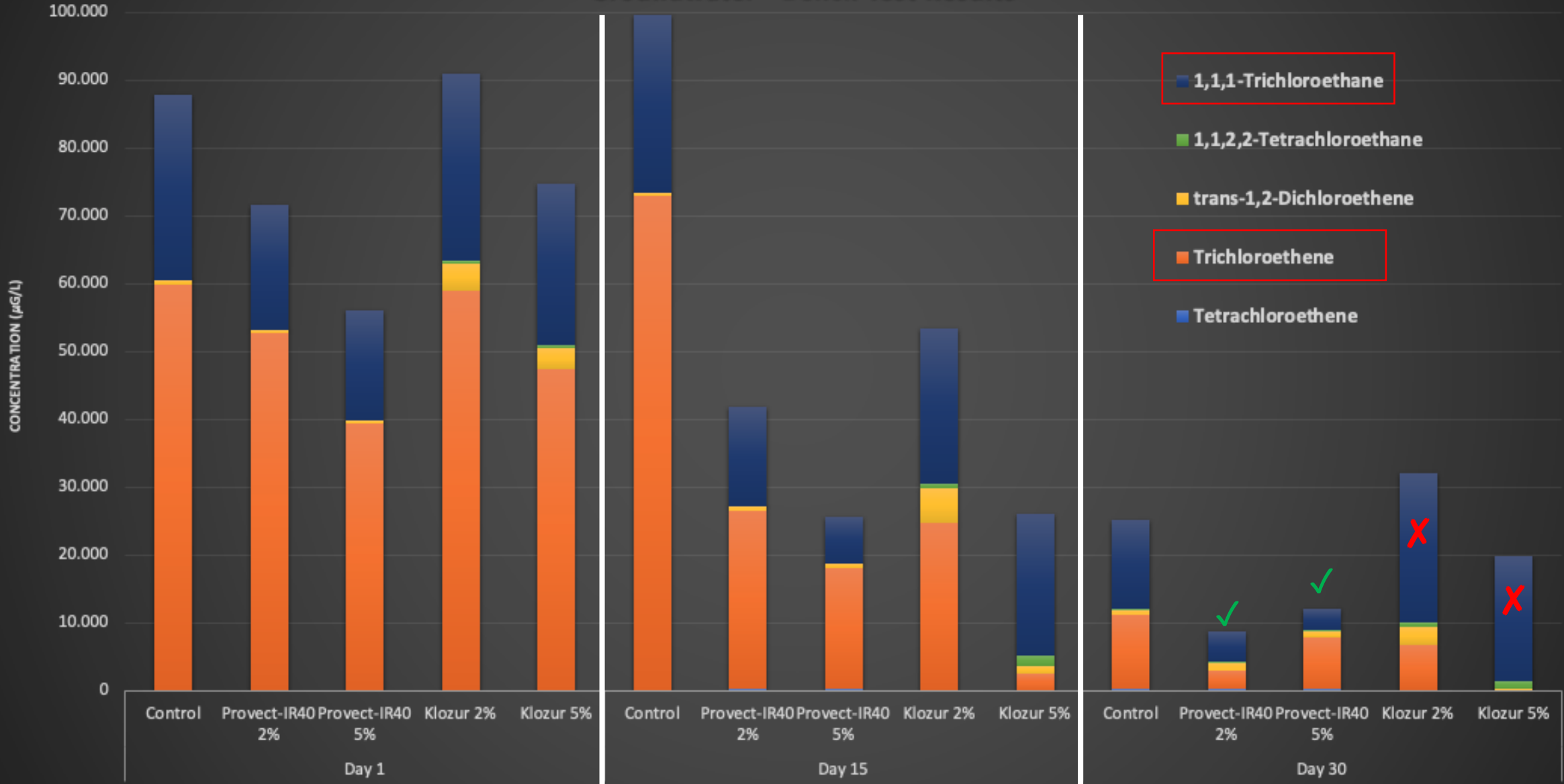


		Microcosms					
Amendment	Replica	Reaction time (days)					
		1	15	30	45	60	
Control	-	C-1	x	x	x	x	x
		C-2	x	x	x	x	x
		C-3	x	x	x	x	x
ISCR	Provect-IR40 2% (mass)	R2-1	x	x	x	x	x
		R2-2	x	x	x	x	x
		R2-3	x	x	x	x	x
	Provect-IR40 5% (mass)	R5-1	x	x	x	x	x
		R5-2	x	x	x	x	x
		R5-3	x	x	x	x	x
ISCO	Klozur SP 2% (massa)	O2-1	x	x	x	x	x
		O2-2	x	x	x	x	x
		O2-3	x	x	x	x	x
	Klozur SP 5% (massa)	O5-1	x	x	x	x	x
		O5-2	x	x	x	x	x
		O5-3	x	x	x	x	x

Bench Scale Test: ISCR x ISCO | Groundwater Results

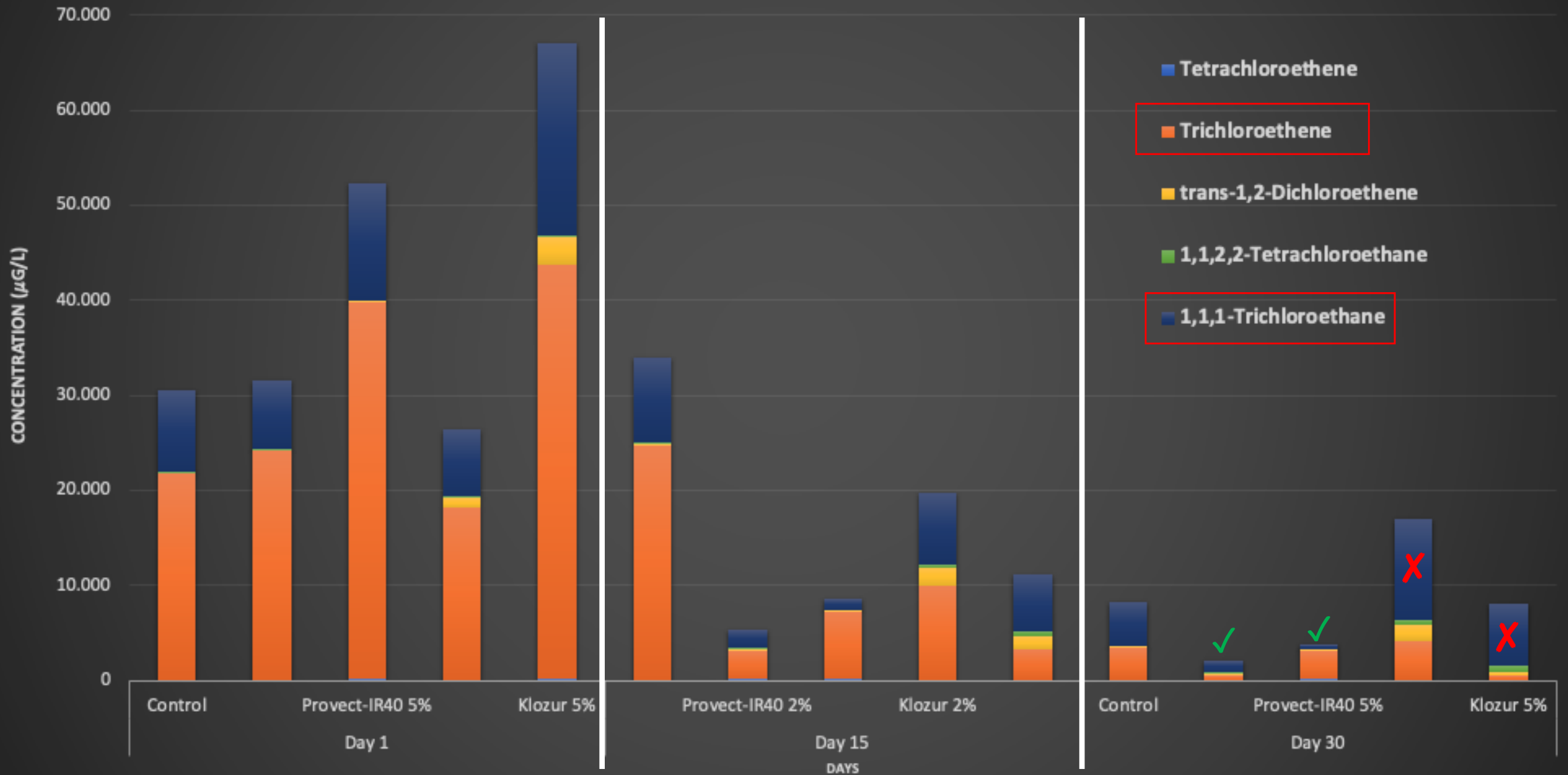


Groundwater - Bench Test Results



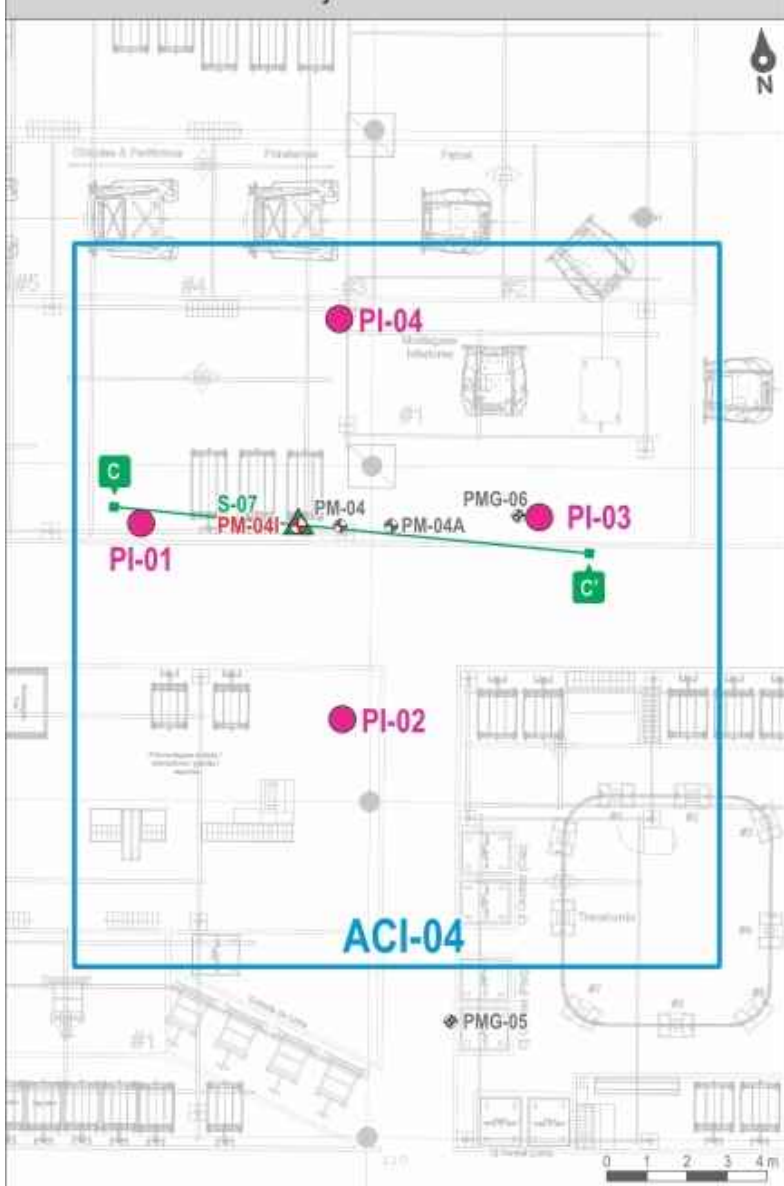
Bench Scale Test: ISCR x ISCO | Soil Results

Soil - Bench Test Results

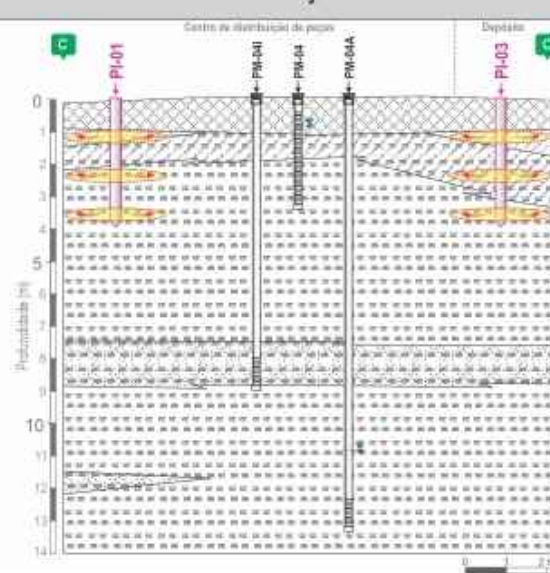


ISCR Pilot Test – Shallow level Injection

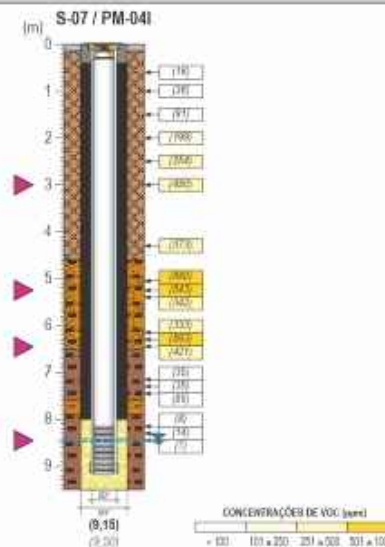
Location of Injection Points on ACI-04



Schematic Section of Injection Points in ACI-04



Constructive Profile of the Monitoring Well



Index Map



- Property Limit
- Contaminated area under intervention (ACI)
- ACI-04 Old Degreasing Machine**
 - Subslab vapor monitoring wells
 - Existing water monitoring wells
 - Monitoring well installed and used in the pilot test
 - Drillings:
 - Injection Points of the Pilot Test in the ACI-04
- Landfill:** surface layer of stones followed by silty clay (20% sand) dark reddish brown/light red silt
- Quaternary Sediments**
 - Dark gray to ocher clayey sandy sediment, plastic texture
- Neogene and Paleogene Sediments**
 - Compact clayey silt sediment (5% sand), gray and ocher in color, with concretions
 - Very compact clayey silt sediment (without sand) of reddish brown to light red color
 - Clay silty sediment (10% sand) of reddish color
- VOC concentration (ppm)
- Water level (m)
- Soil sample collection for chemical analysis
- Injection points - section
- Schematic representation of injection zones

ISCR Pilot Test – Shallow level Injection



ISCR Pilot Test – Shallow level Injection



ISCR Pilot Test – Shallow level Injection

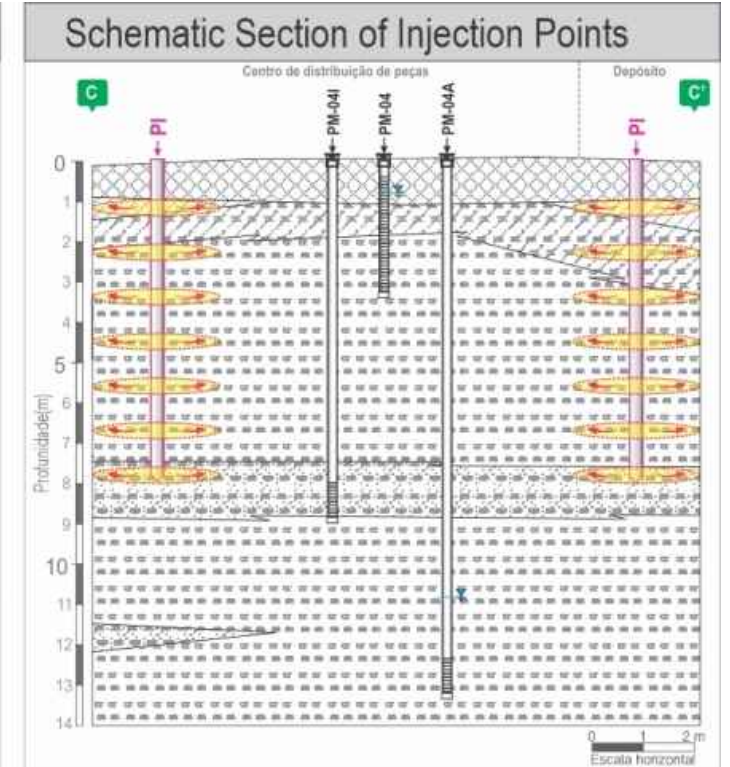
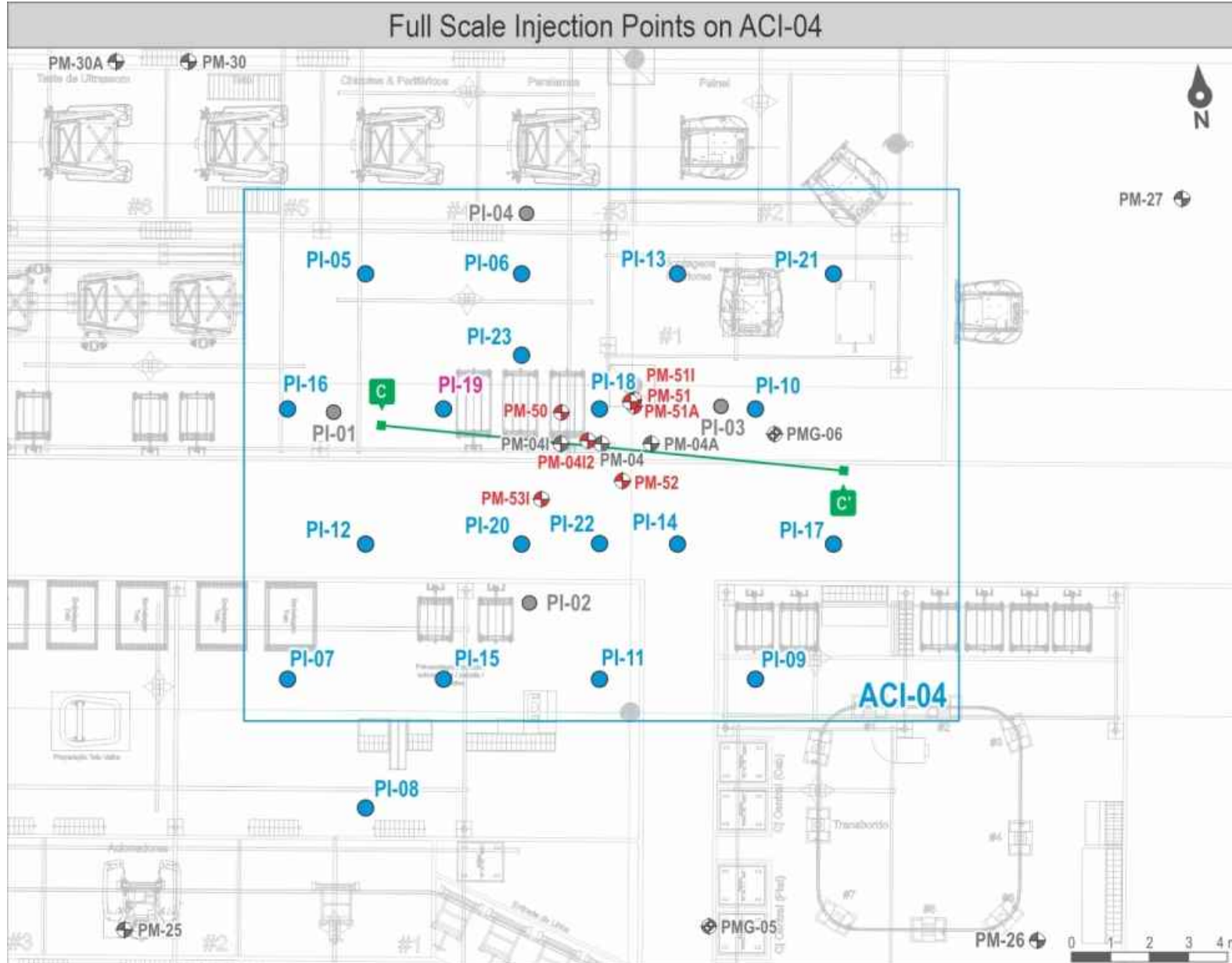


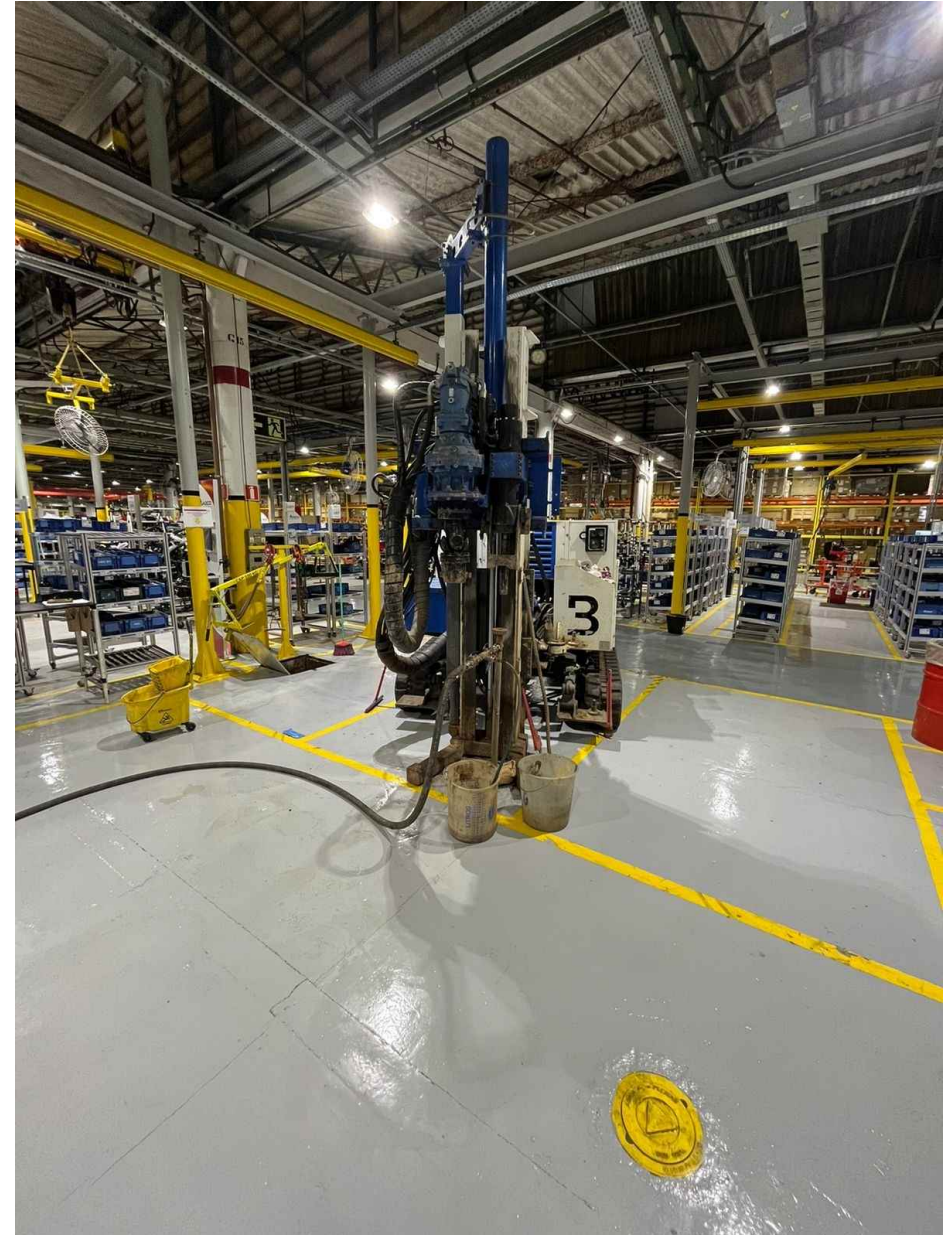
ISCR Pilot Test – Results



Results of the Pilot Test Performance			
Parameters (µg/L)	MW-04		
	oct.-20 (baseline)	dec.-20	may-21
VOC			
PCE	150.00	6.00	9.00
TCE	74,970.00	657.00	439.00
TCA	36,610.00	65,160.00	9,011.00
DCE	66,190.00	369,430.00	218,450.00
VC	98.00	5,792.00	17,436.00
Biogeochemical			
pH	7.49	5.50	5.80
ORP	-85.10	-124.00	-70.50
Total Alkalinity	235,000.00	388,000.00	830,000.00
TOC	42,500.00	2,842,700.00	1,096,400.00
Chloride	142,000.00	2,840,000.00	894,000.00
Ethane	50.00	88.00	113.20
Ethene	142.00	187.00	459.50
Fe II	6,540.00	661,000.00	529,000.00
Methane	97.00	135.00	159.00
Nitrate	490.00	<7,500	5,250.00
Sulfate	37,500.00	89,000.00	<5,000

Full Scale | Injection Points Location and Injection Layers





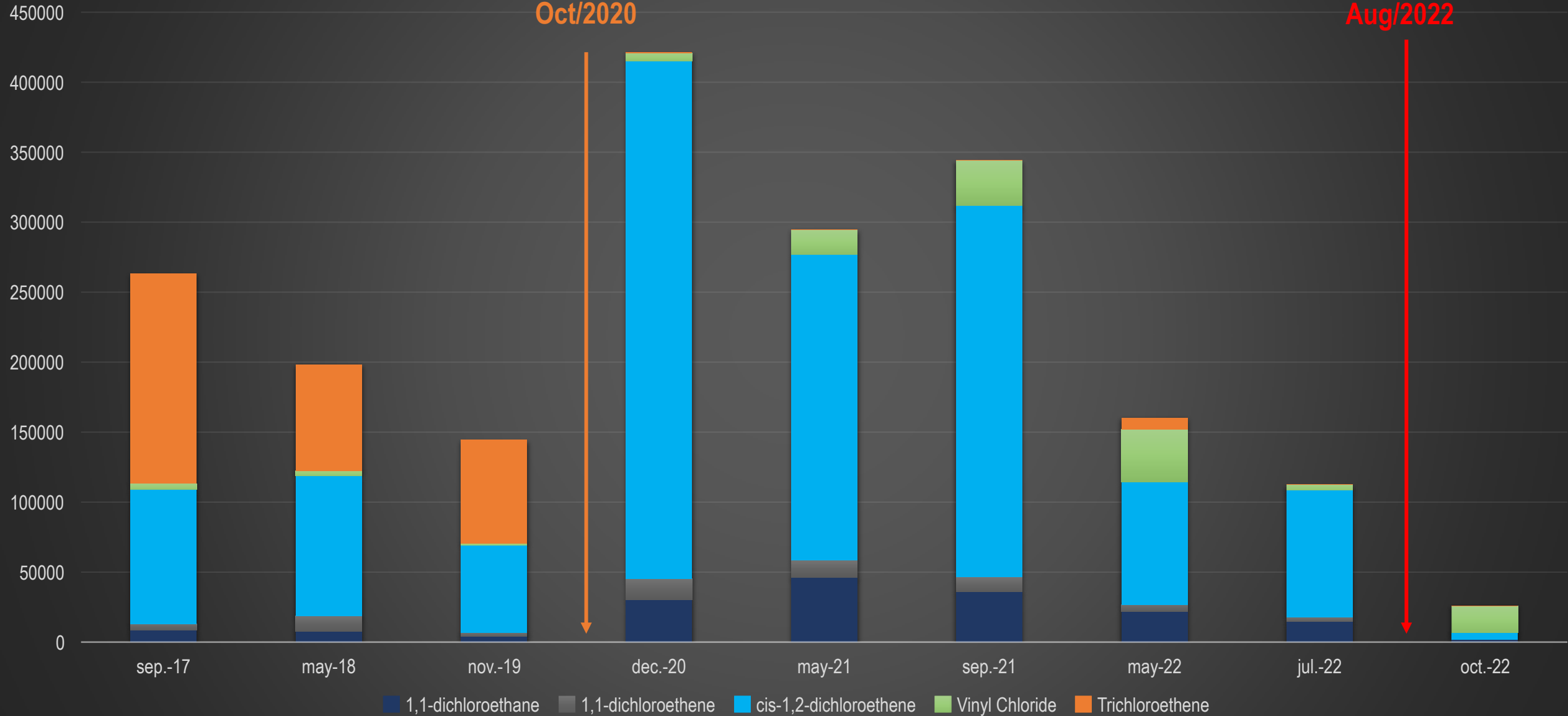
Current Scenario | Groundwater Results



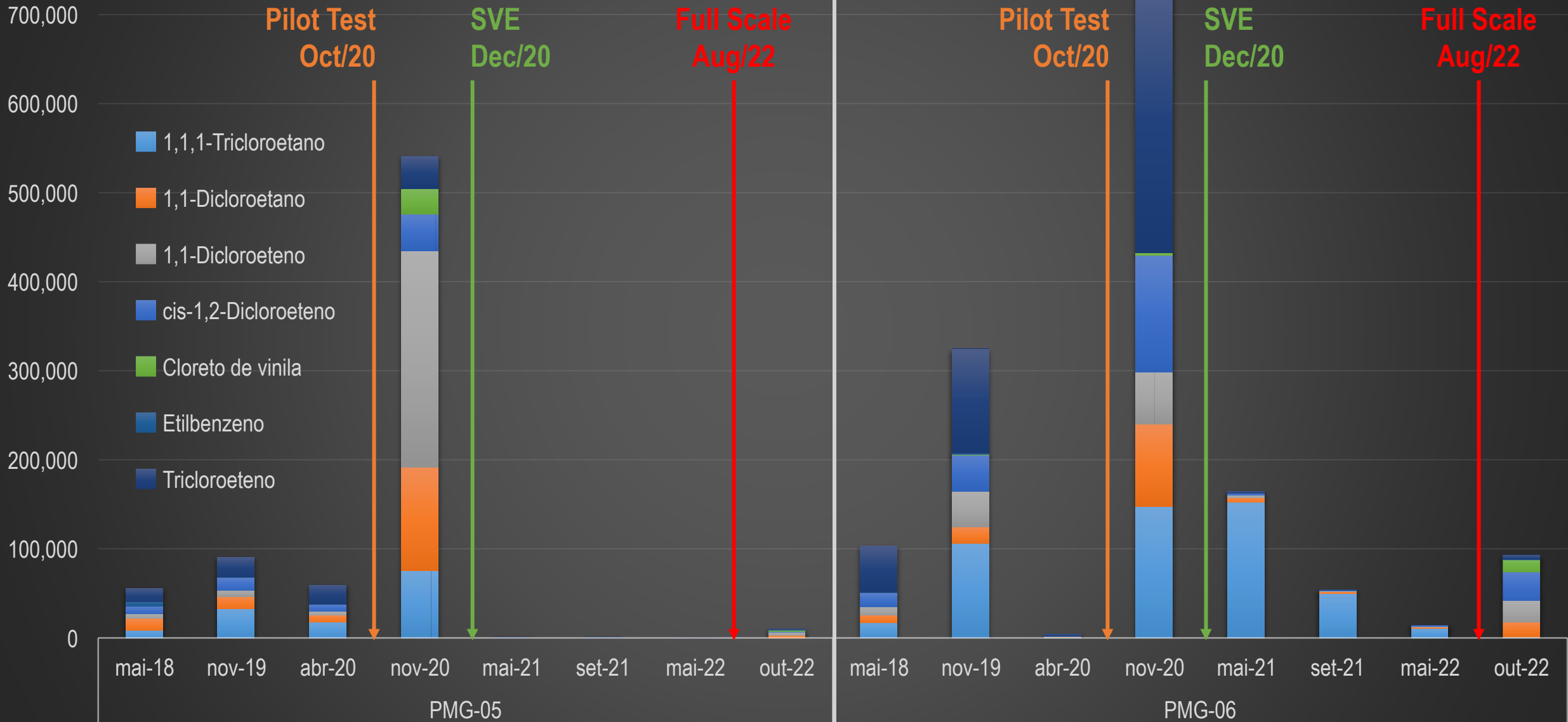
MW-04

Pilot Test
Oct/2020

Full Scale
Aug/2022



Vapor in Subslabs Points



- ✓ Compact clay + silt thick horizontal continuous layer \neq natural barrier for contaminants
- ✓ Bench scale test confirmed to be important even on obvious situations – allowed to confirm the performance of all COC in soil and GW
- ✓ The results so far are proving that the ISCR reactive zone is being effective in local complex lithology
- ✓ Potential vapor intrusion during remediation controlled by SVE is mandatory



Thank You!

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