



Combined ERH and ISCR for remediation of chlorinated solvents

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OVERVIEW

- Introduction
- Site Data
- Contract
- Intervention plan (remediation plan)
- Results
- Lessons Learned
- Challenges due to Climate Change



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ConAm is a leading Brazilian environmental engineering company, specializing in consultancy for the revitalization of areas intended for real estate developments in Brazil.

With 20 years of market experience, it has investigated more than 18 million square meters of areas with potential for contamination in São Paulo and several other Brazilian states.

In addition, it specializes in the management of industrial contaminated areas and the licensing of projects in the areas of transport infrastructure, electrical sector, waste, among others.

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www.metalorganis.com.br

Metalorganis develops products for remediation of contaminated groundwater and soil. Focusing on the **Reductive Dechlorination** process, Metalorganis provides products that help customers achieve their objectives and contribute to the rehabilitation of contaminated sites. Our technological research and the products we develop meet the requirements for achieving the standards necessary for an environment without applicable risks to human health.

We have more than 15 years of experience in contaminated sites.



TRSDOXOR is a Joint Venture to provide thermal remediation services in Brazil and South America.

TRSDOXOR has treated over 25 sites in Brazil in the last 10 years.

Site



- Land of real estate interest – Large area in Southern **Brazil**.
- Industrial activities since 1920. More than 100 years of contamination.
- Metallurgy services.
- Elevated concentrations of tetrachloroethene (PCE), trichloroethene (TCE), dichloroethenes (DCEs) and vinyl chloride (CV) in groundwater.
- Evidence of biodegradation.
- Concentrations above applicable targets for risk scenarios associated with inhalation in open and closed environments.
- *Hot spots had aquifer concentrations of ~250,000 ug/L of TCE, ~190,000 ug/L of PCE and ~15.000 ug/L of CV.*

Services Performed



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**Preliminary
Assessment
Confirmatory
investigation**

**Detailed
Investigation**

**High Resolution
Investigation with
MIP**

**Human Health
Risk Assessment**

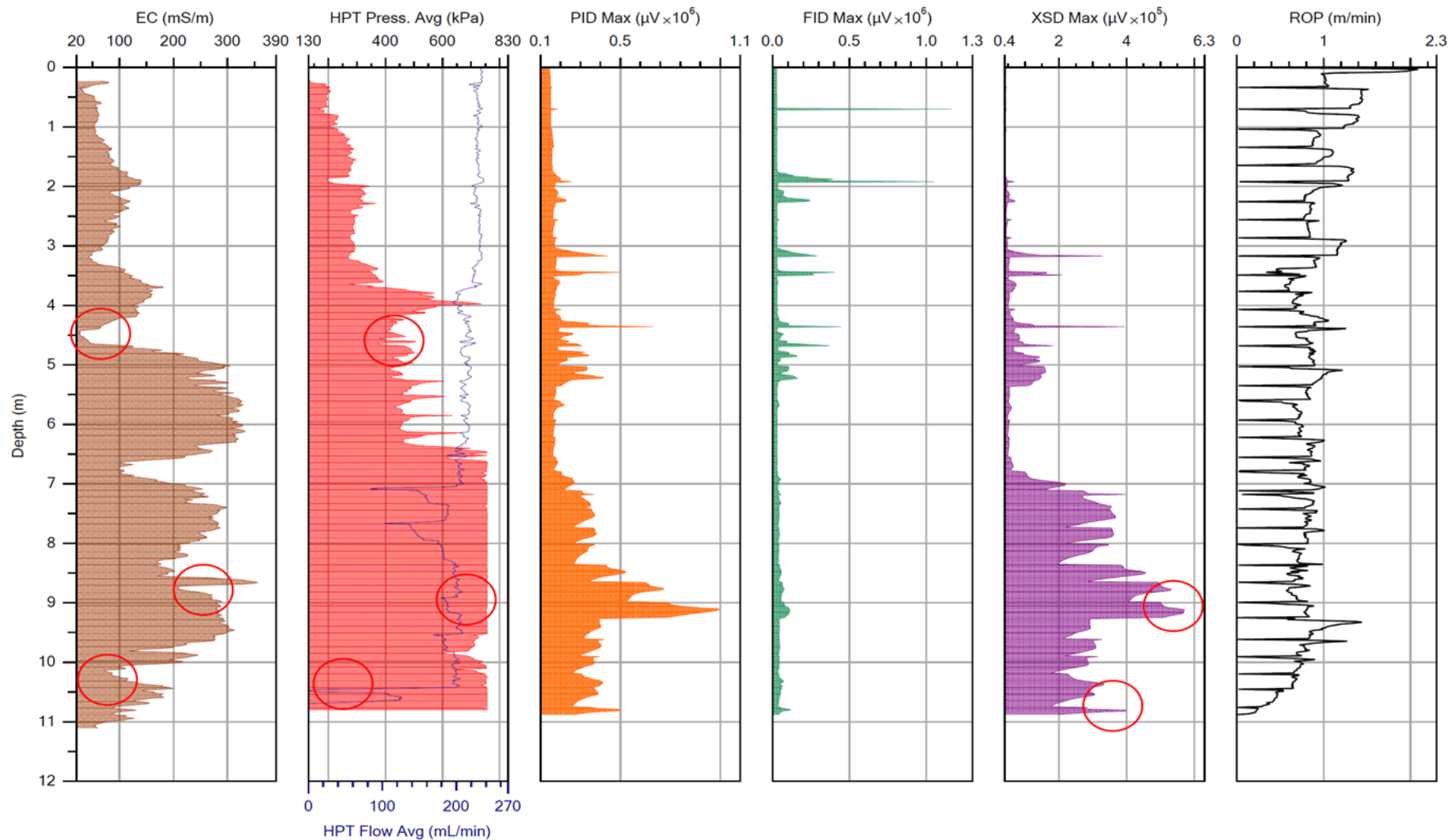
**Investigation for
Remediation**

Intervention Plan

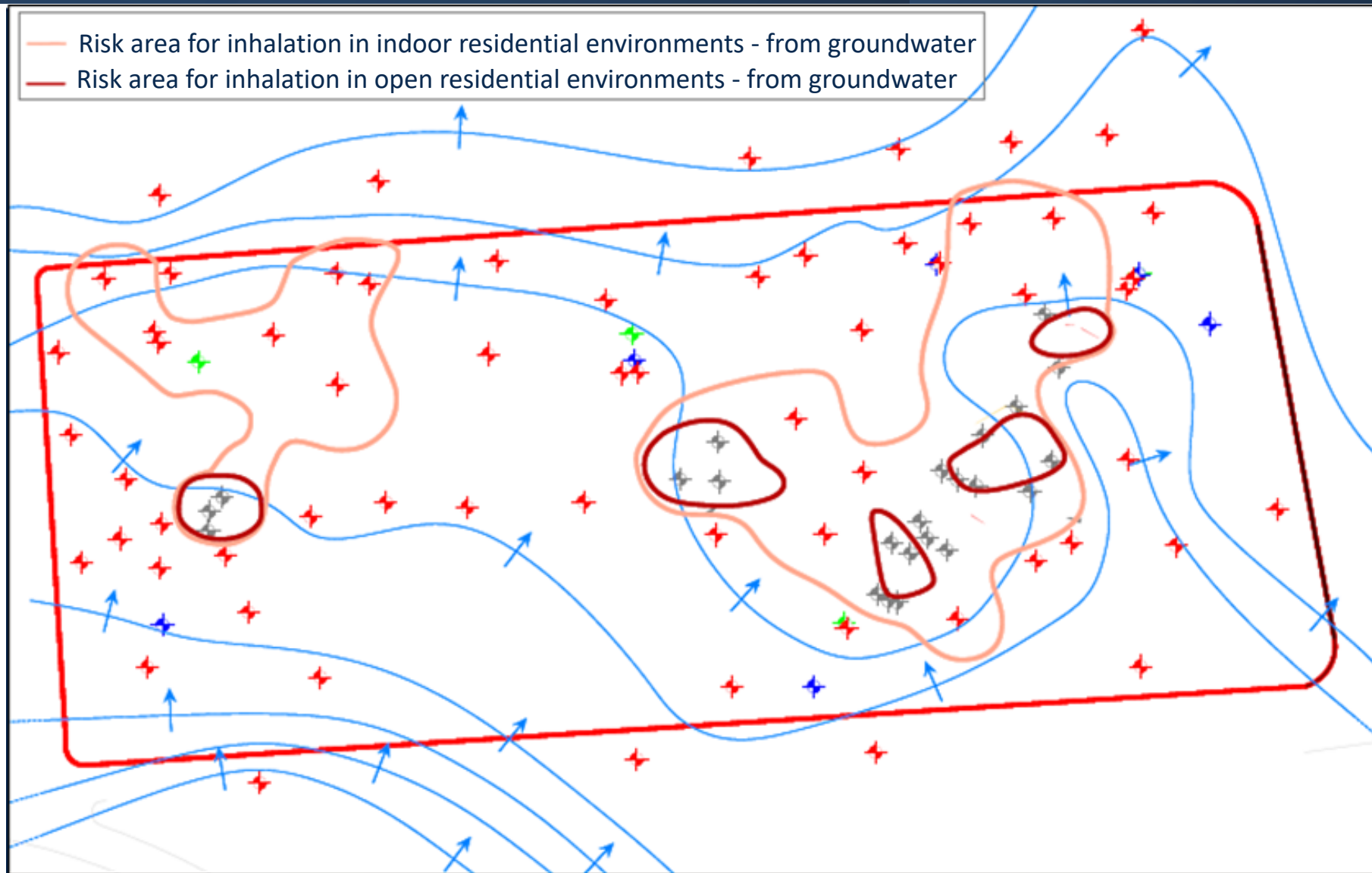
Remediation

High Resolution Investigation - MIP

MIP showed that remediation would need to act down to 12m:



Risk map



INTERVENTION PLAN



Variables to consider

Technical complexity:

- High concentrations of chlorinated solvents in groundwater
- Inhalation risks in open environments.
- Plumes on the edges of the land, towards residential surroundings.
- Geological limitations (bedrock at ~12m deep).
- **Restrictions on power supply.**
- Need to adapt remediation to the client's available budget.
- Client wanted guarantee.
- Limitations of remediation techniques.
- Risks associated with remediation techniques.



Viability study considered many option but ended up focusing in to two technology:

ISCR and Thermal

ISCR



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- In situ chemical reduction with the active reduction of contaminants through dechlorination, together with the biological action of compound degradation.
- Application of a mixture amendments containing zero-valent iron (ZVI), reactive, as a food source for dehalogenation bacteria, in order to provide biostimulation of the environment together with chemical reduction.
- It generates an extremely reducing environment in which it quickly degrades compounds that are difficult to degrade in a short space of time, such as, for example, volatile organic solvents
- The application region also act as a permeable reactive barrier to the flow of contaminants.
- It can be applied by pits, trenches or direct push.

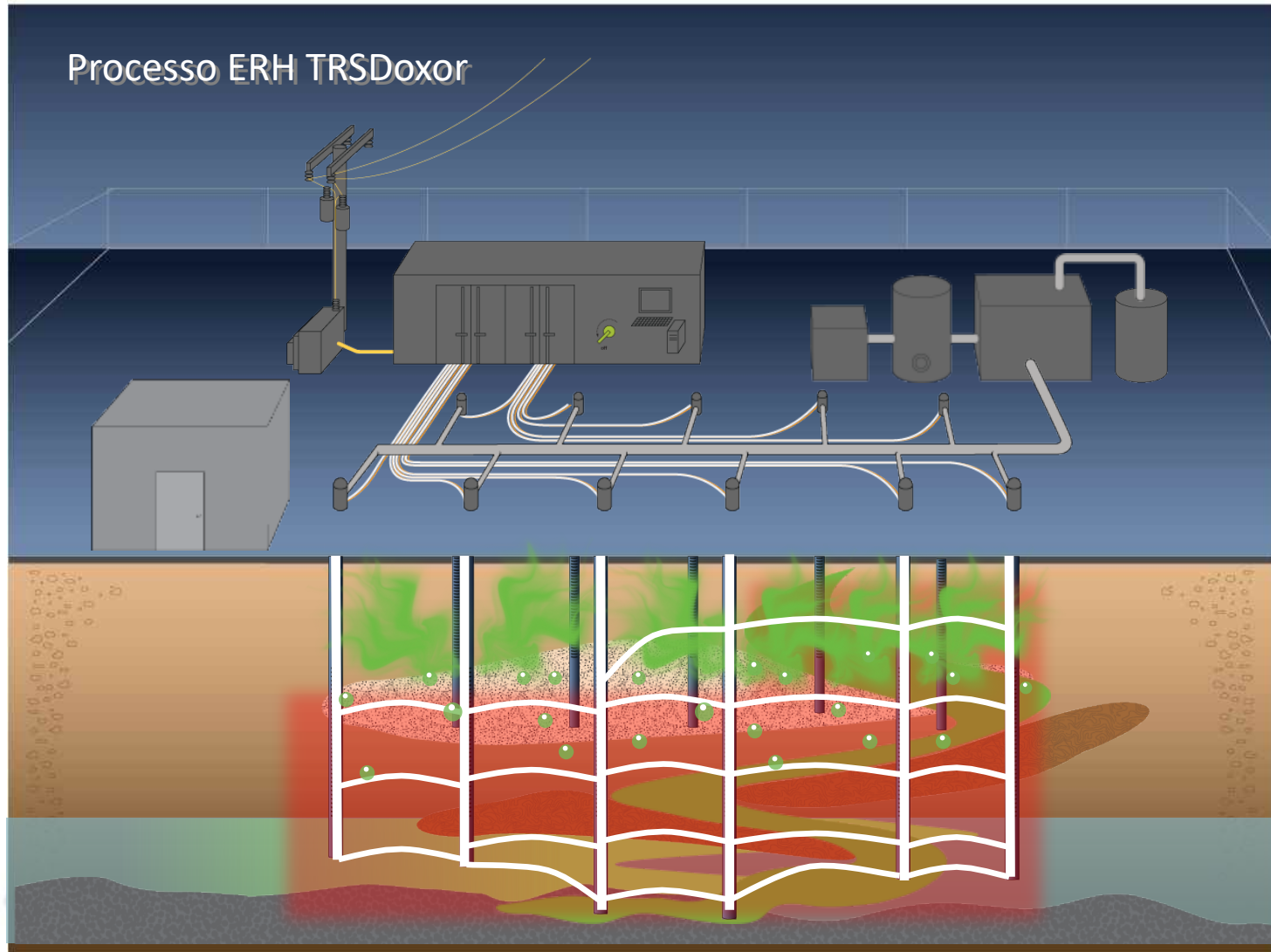
Remediation product MO-40

Reductive Dechlorination

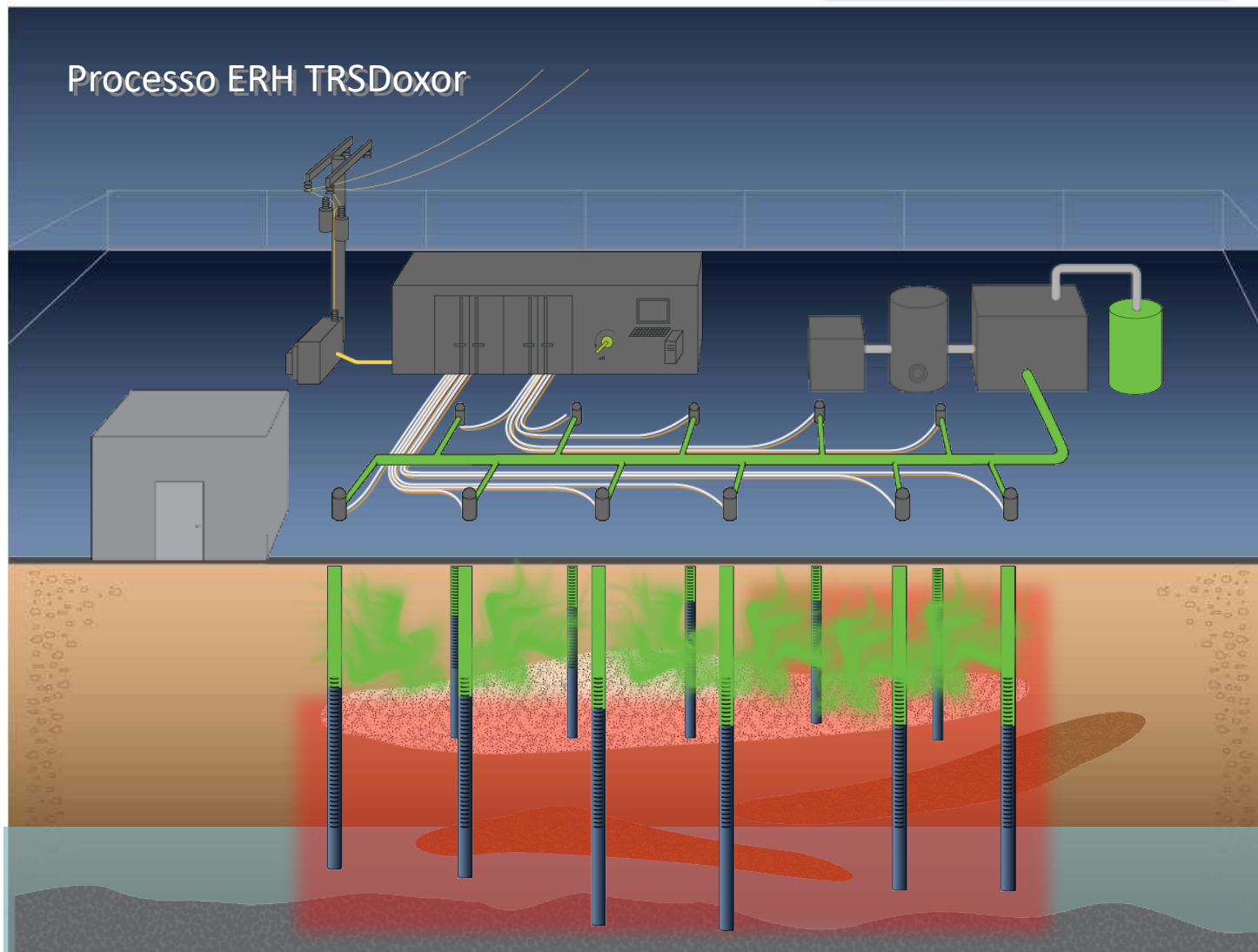
- Zero valent iron, around 40% by mass.
- Remediation product duly registered with IBAMA - Brazilian Institute of Environment and Renewable Natural Resources, in compliance with Brazilian legislation.
- Good results when applied to the target contaminants
- Powder product, injectable after mixing with water allows direct application through trenches/pits. It acts directly into the contaminated groundwater and also works as a permeable reactive barrier in the application regions.
- Granulometry – particles ranging between 5 and 100 micrometers, facilitating their migration in the porous medium;
- Self-sufficient – includes all the necessary additives in its registered formulation, without the need to add any other products to adjust the environment.

Thermal – ERH Electrical Resistance Heating

Processo ERH TRSDoxor



Processo ERH TRSDoxor



Applicable scenarios for remediation

SCENARIO 1- APPLICATION OF REDUCTIVE DECHLORINATION THROUGHOUT THE RISK AREA, INCLUDING APPLICATION IN THE DEEP AQUIFER.



SCENARIO 2- APPLICATION OF THERMAL REMEDIATION THROUGHOUT THE RISK AREA, INCLUDING HEATING IN THE DEEP AQUIFER.



SCENARIO 3 - APPLICATION OF REDUCTIVE DECHLORINATION THROUGHOUT THE RISK AREA (SHALLOW AQUIFER) AND APPLICATION OF THERMAL REMEDIATION IN SHALLOW PORTIONS AND IN THE DEEP AQUIFER

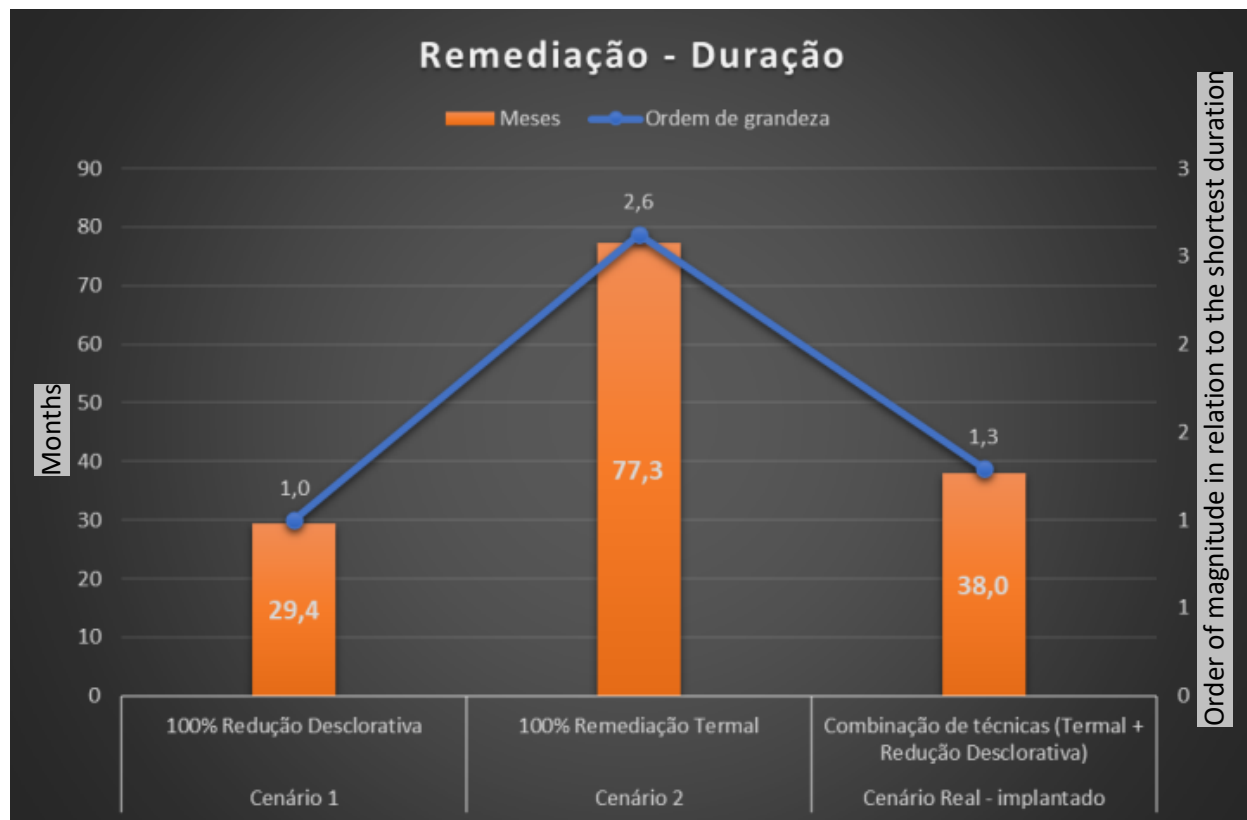


Applicable scenarios for remediation



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Estimated time periods for remediation



REDUCTIVE
DECHLORINATION)

THERMAL

COMBINATION OF
TECHNIQUES
(THERMAL +
REDUCTIVE
DECHLORINATION)

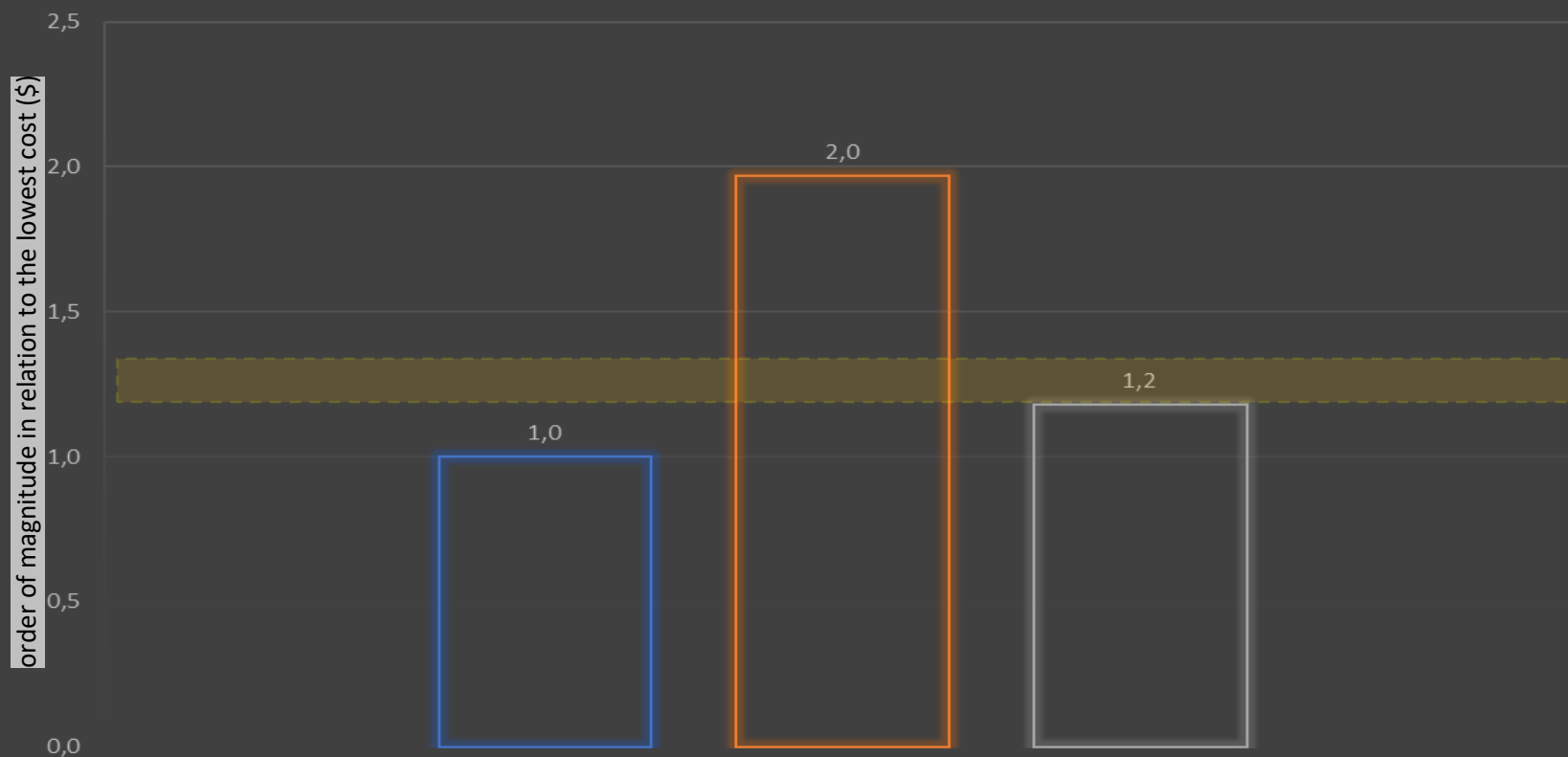
Client budget

Remediation - costs

■ Cenário 1 - 100% Redução Desclorativa

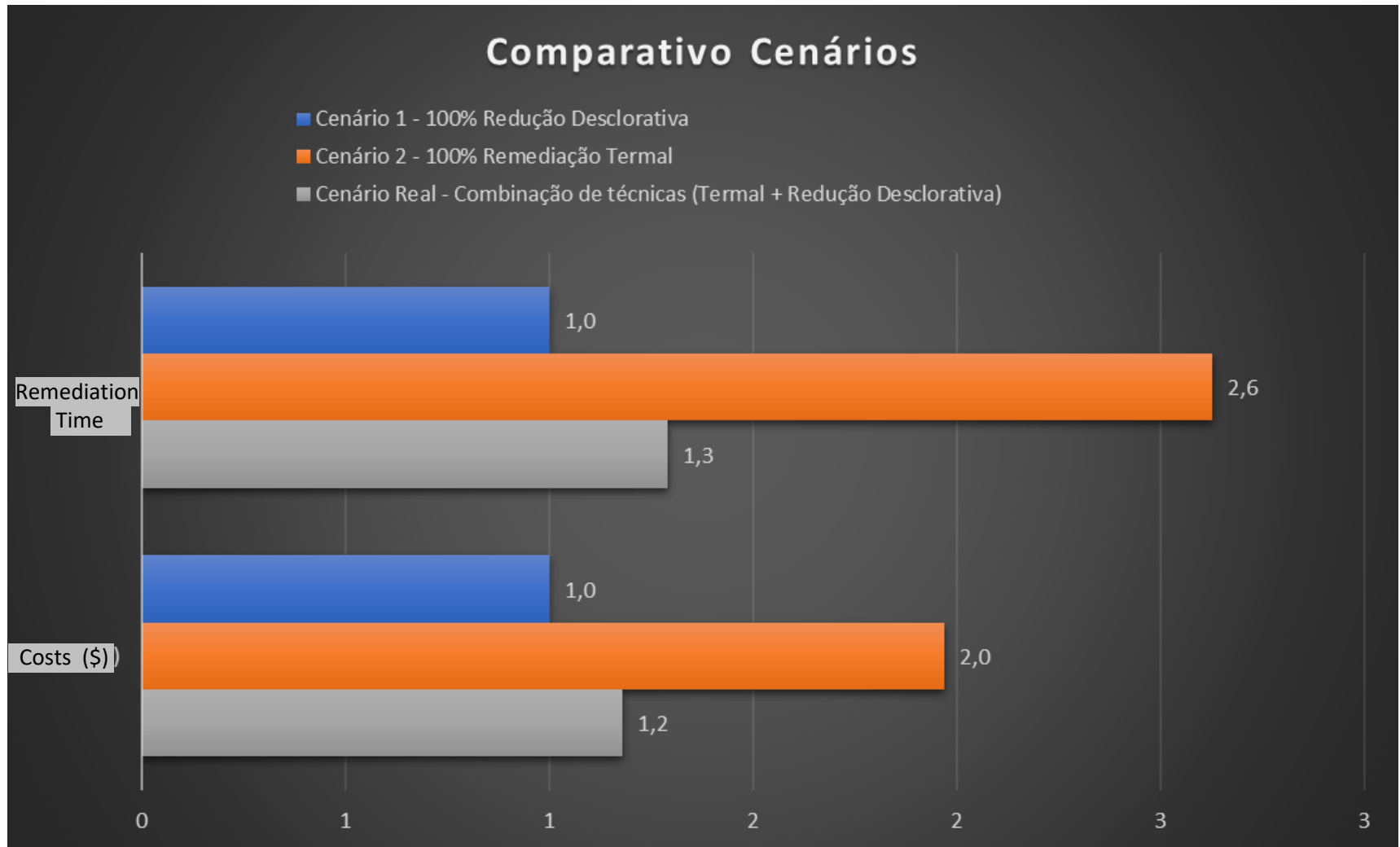
■ Cenário 2 - 100% Remediação Termal

Budget do cliente disponível para o Projeto

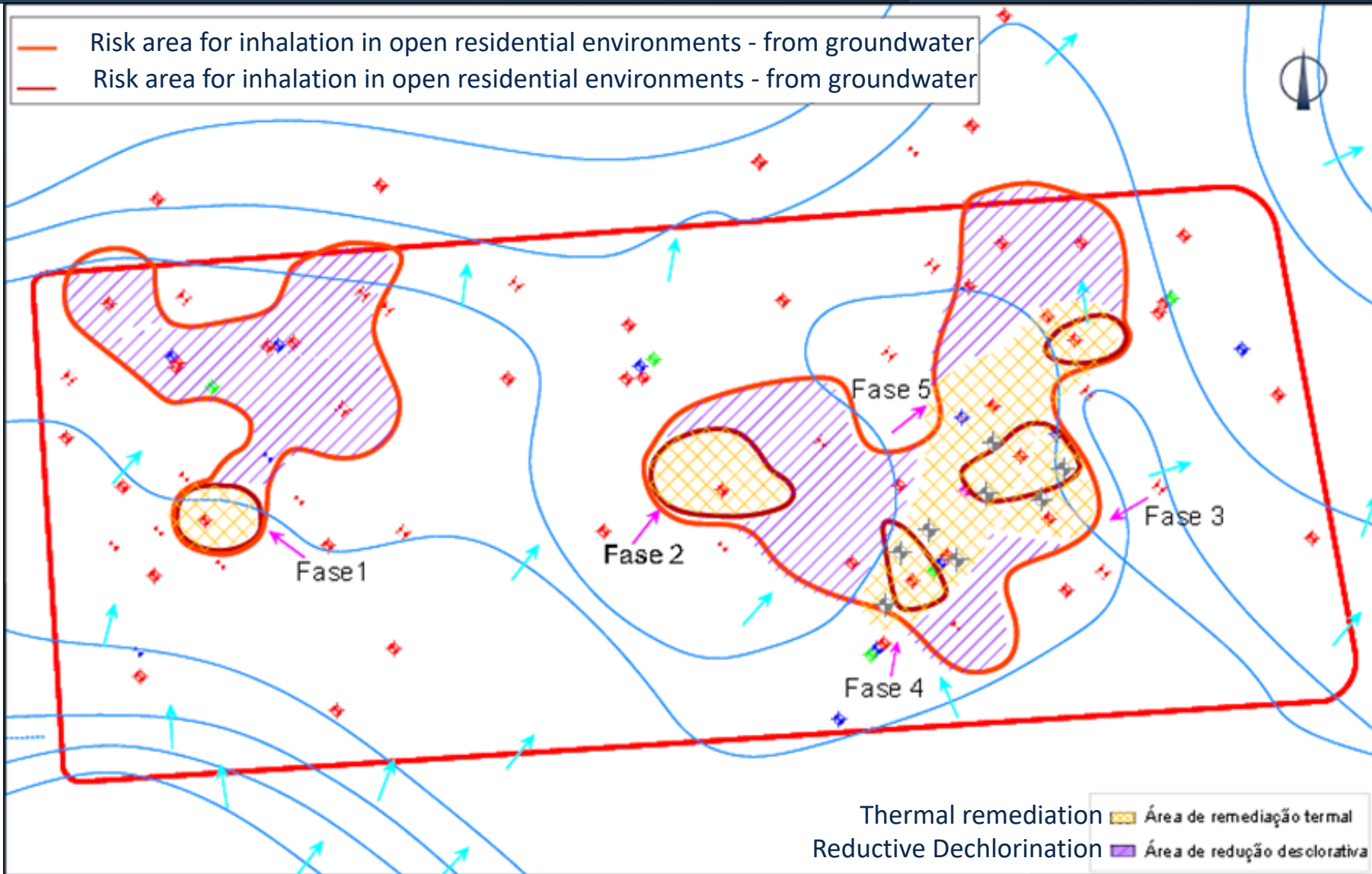


Applicable scenarios for remediation

How much more expensive??? How much faster??? Guarantee???



Intervention map



Technical details

- Application of ISCR focused on concentrations of organochlorines up to a limit of around 10.000 ug/L down to 4,5m deep.
- ISCR done before thermal, guaranteeing achievement of the applicable goals and the urgent protection of the boundaries of the site, avoiding risks to neighbors.
- ERH done at that source zones down to 12m deep
- Periodic resampling scheduled considering the possibility of rebound or recontamination downstream of hot spots that would take longer time to start heating (final thermal phases).



Application of remediation product

- Deposit of the reducing product **MO-40** before mixing in the pits/trenches



Application of remediation product

- Mixing water, soil and reducing product inside the pit.

Thermal remediation



- Equipment

- Installations in the heating region.



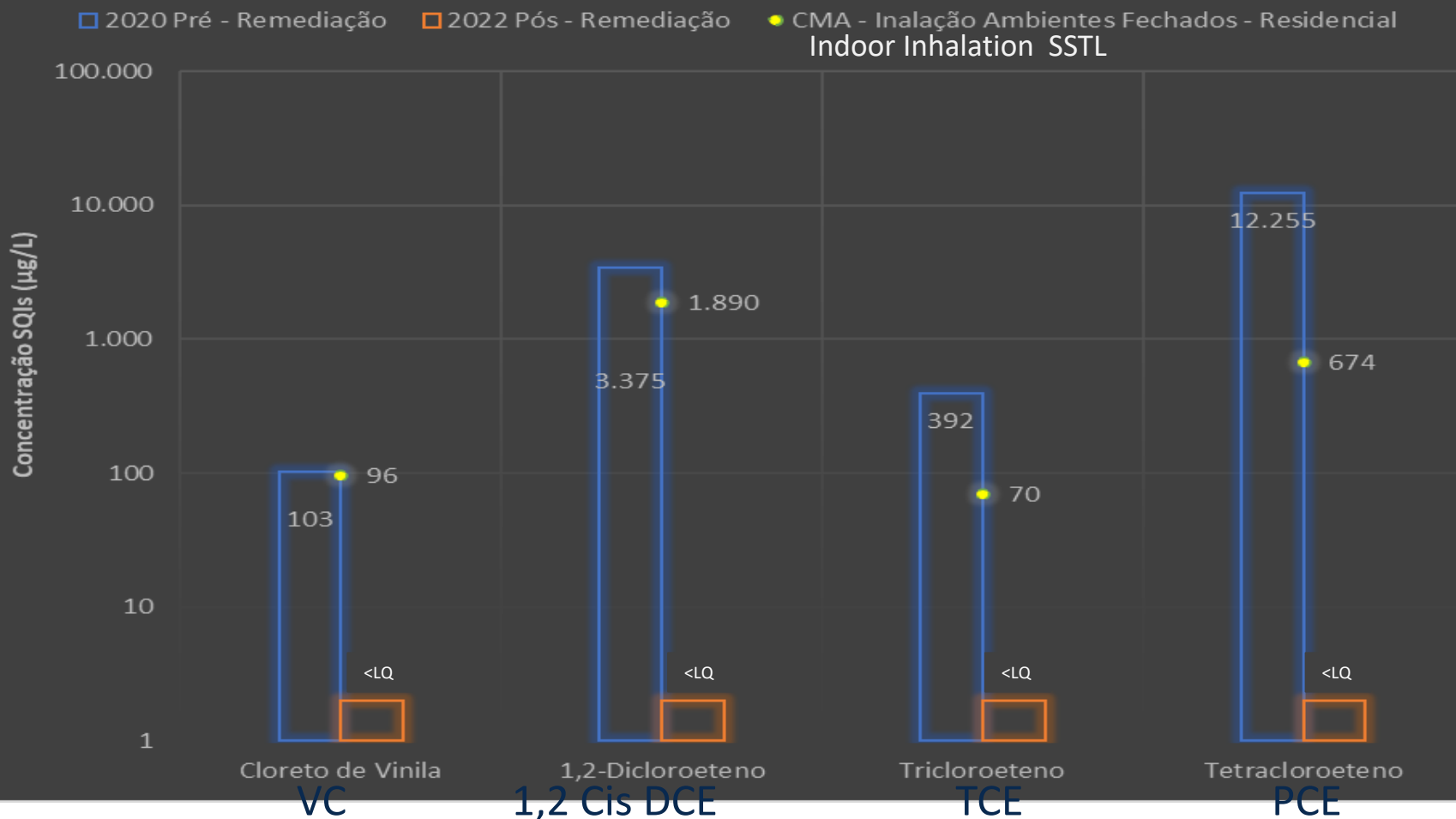
Reductive Dechlorination Results



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Fases 1 and 2

Evolução concentração SQIs- Redução Descolorativa

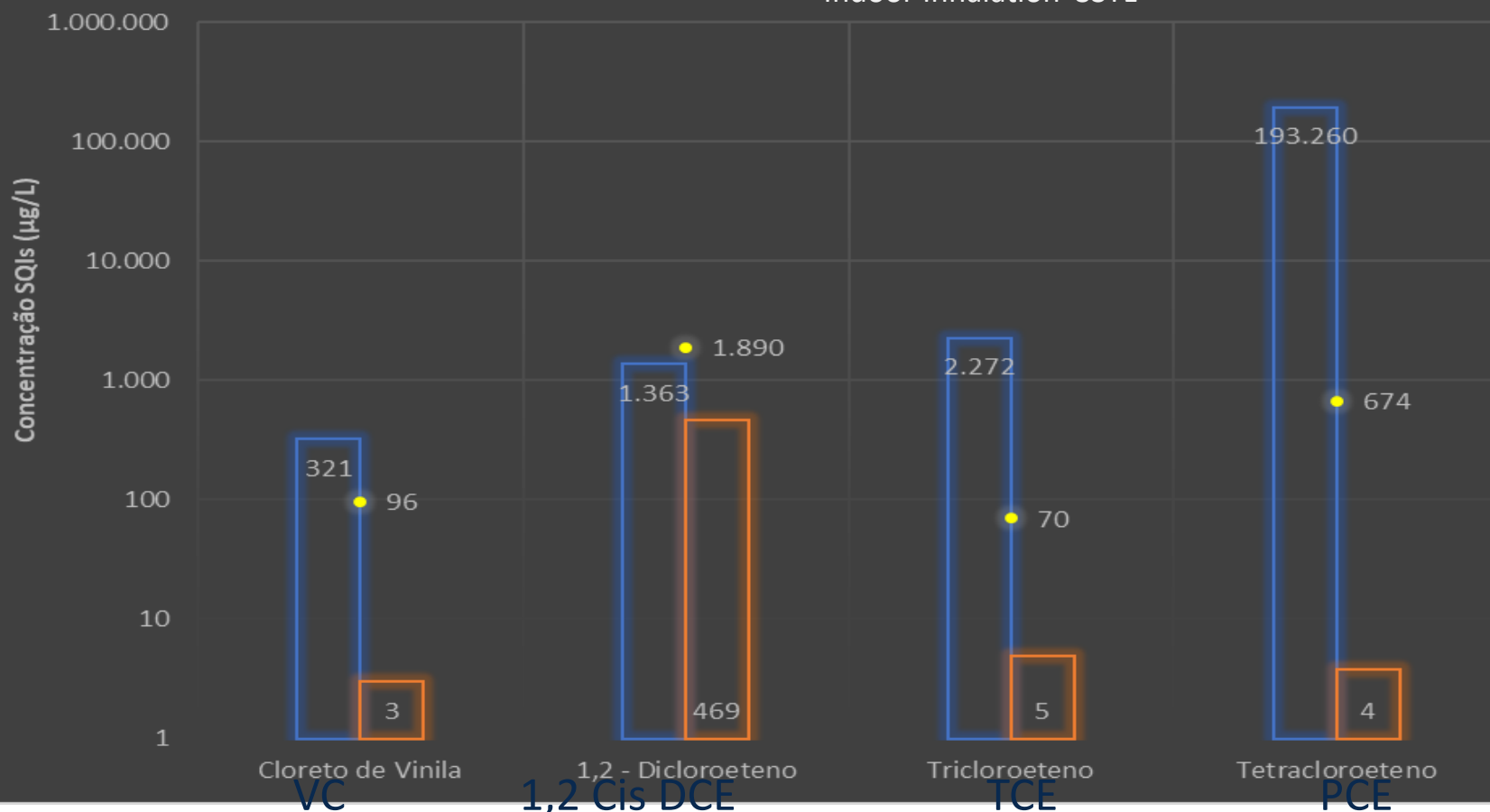


Thermal Remediation Results

Fases 1 and 2

Evolução concentração SQIs- Remediação Termal

■ 2020 - Pré Remediação
 ■ 2022 Pós - Remediação
 ● CMA - Inalação Ambientes Fechados - Residencial
 Indoor Inhalation SSTL

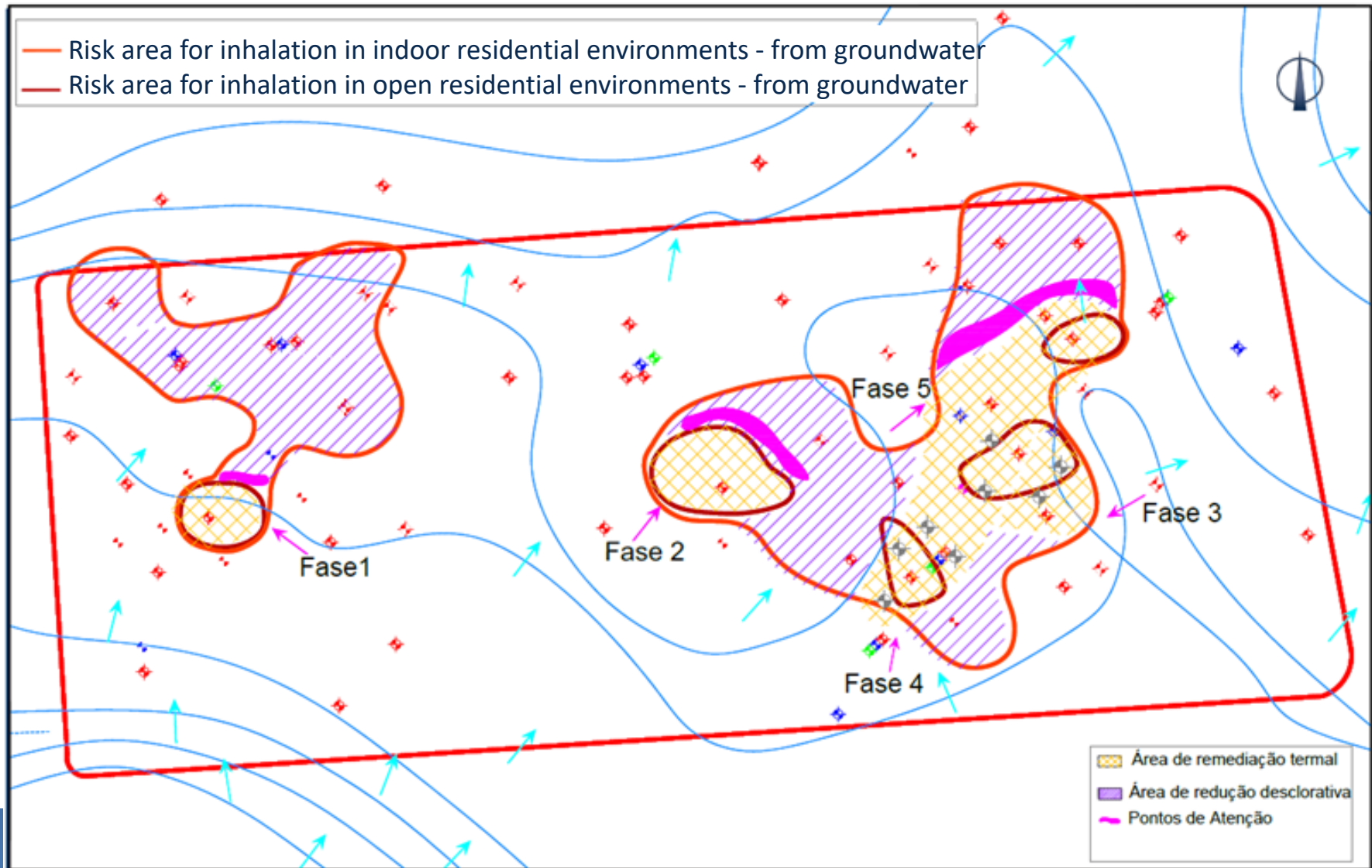


Borders between different remediation techniques

• **ATTENTION**



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- Results suggest that the pit regions just downstream of the heating areas showed improvements in the reductive dechlorination process due to the increase in temperatures and their influence on the activity of dehalogenating bacteria.

Future work

- In border regions between the two techniques, there was a huge increase in electrical conductivity, from ~ 800 $\mu\text{S}/\text{cm}$ up to 5.000 $\mu\text{S}/\text{cm}$ which required upgrades in the Thermal Remediation Equipment



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Effects of Climate Change in the Remediation Work



Antes e depois do Guaíba

Imagem: European Union, Copernicus Sentinel-2 imagery

Effects of Climate Change on the Remediation Work



Aeroporto Salgado Filho, em Porto Alegre, antes e depois da enchente do dia 3 de maio — Foto: Laboratório Lapis, da Universidade Federal de Alagoas

Effects of Climate Change on the Remediation Work





Thermal remediation facilities

- Redesign the electrodes and Vapor recovery wells
- covering for thermal insulation.



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THANK YOU!! OBRIGADO!!

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