Facilitation of Remediation of Petroleum Contaminated Site in Taiwan

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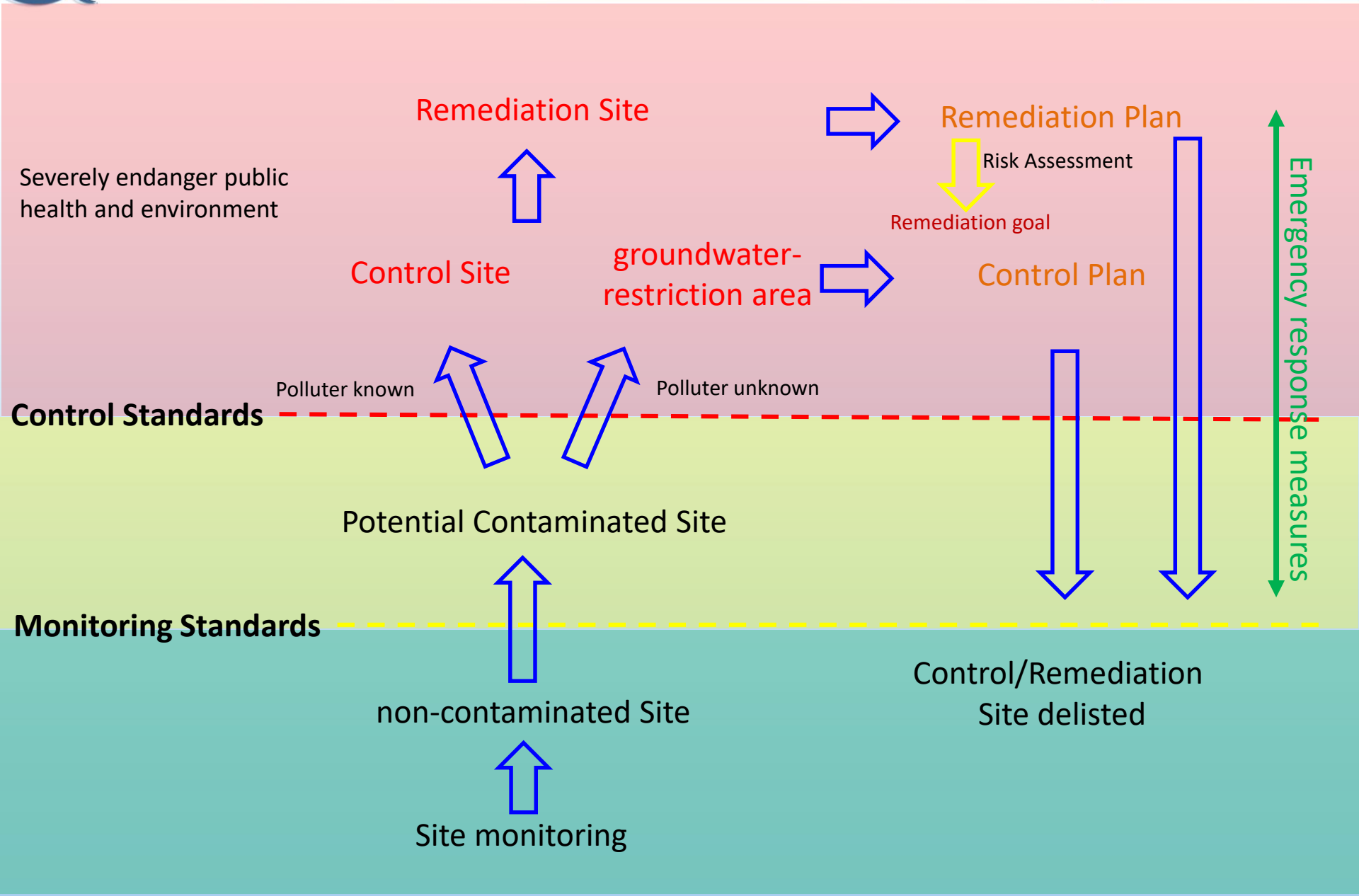
TASGEP (Taiwan Association of Soil and Groundwater Environmental Protection)

Outline

- **Regulation in Taiwan**
- **Status of Petroleum Contamination in Taiwan**
- **Life Cycle Management of Contaminated Site**
- **Case Studies**

Regulation in Taiwan



Challenges and Status of Petroleum Contamination in Taiwan

The proportion of listed VOC/SVOC, TPH, and heavy metal contaminated sites

Proportion of listed sites	Soil Control Sites	Groundwater Control Sites	Soil Remediation Sites	Groundwater Remediation Sites
VOC/SVOC	11 %	79 %	38 %	82 %
TPH	44 %	12 %	34 %	14 %
Heavy Metal	46 %	10 %	28 %	4 %

Data statistics up to 2018

- The main contaminants in soil control sites are HM and TPH
- The main contaminants in soil remediation sites are VOC/SVOC and TPH
- The main contaminants in groundwater contaminated sites is VOC/SVOC

Challenges and Status of Petroleum Contamination in Taiwan

The proportion of listed and delisted TPH contaminated sites

Proportion of listed sites	Soil Control Sites	Groundwater Control Sites	Soil Remediation Sites	Groundwater Remediation Sites
Listed	37 %	71 %	86 %	100 %
Delisted	63 %	29 %	14 %	0 %

The proportion of the duration of delisted TPH contaminated sites

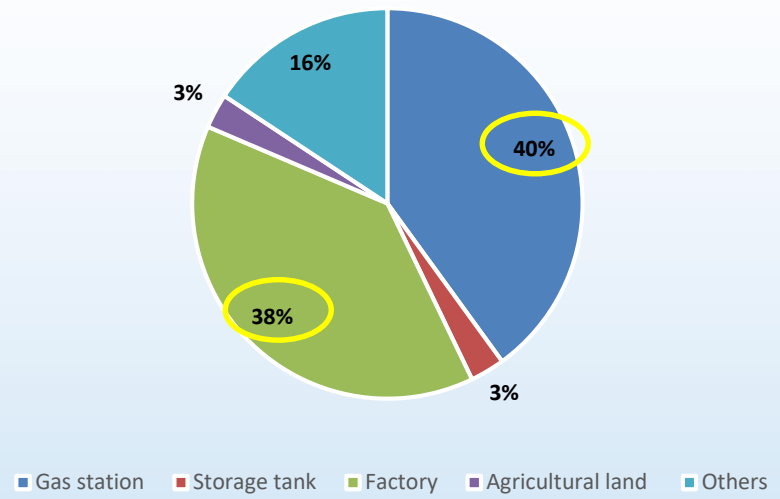
Proportion of listed sites	Soil Control Sites	Groundwater Control Sites	Soil Remediation Sites	Groundwater Remediation Sites
<1 year	11 %	0 %	60 %	0 %
1-3 years	32 %	60 %	20 %	0 %
3-5 years	32 %	40 %	0 %	0 %
>5 years	25 %	0 %	0 %	0 %

Data statistics up to 2018

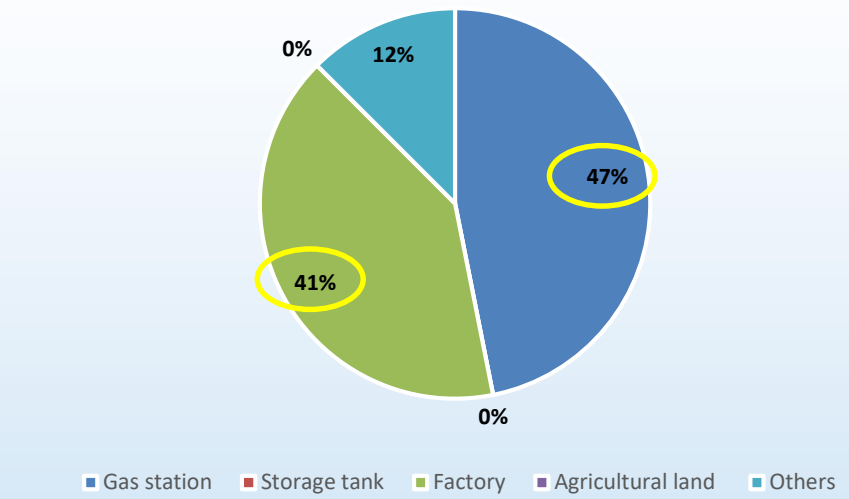
- Remediation Sites are more difficult to be delisted
- The contaminated groundwater sites are more difficult to be delisted
- Most of the TPH contaminated control sites taking 1-5 years to be delisted
- There is no TPH contaminated groundwater remediation site to be delisted, even some listed TPH contaminated sites have remediated for more than ten years.

Challenges and Status of Petroleum Contamination in Taiwan

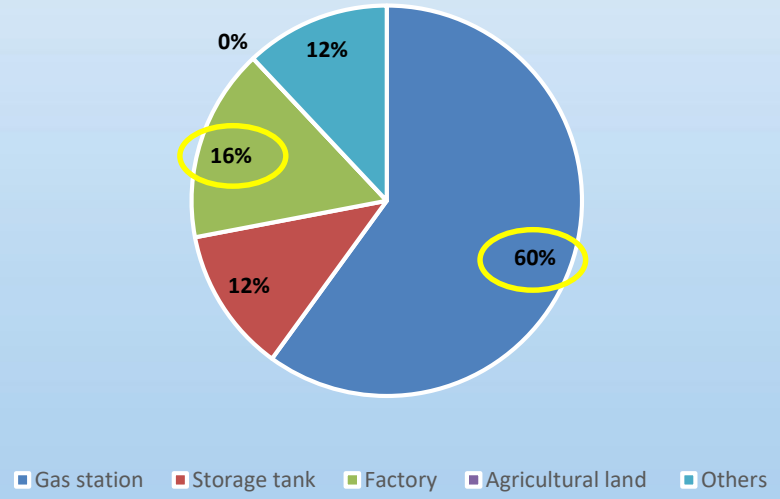
TPH contaminated soil control sites



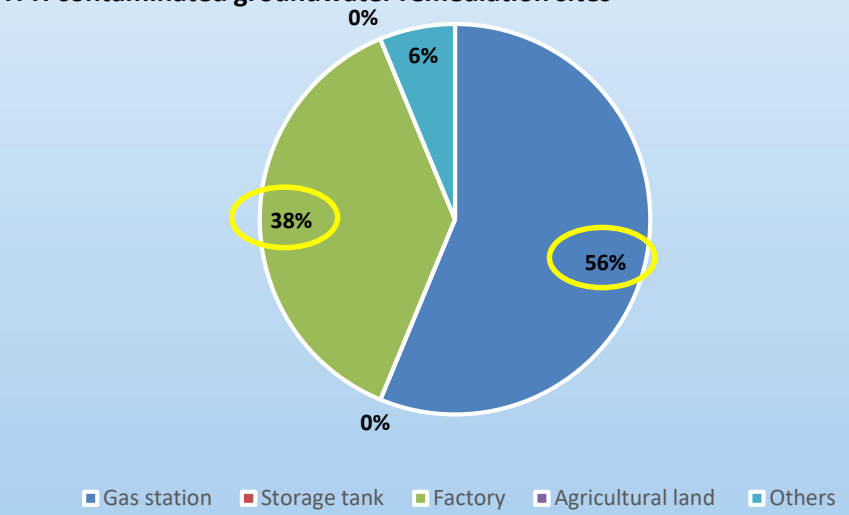
TPH contaminated soil remediation sites



TPH contaminated groundwater control sites

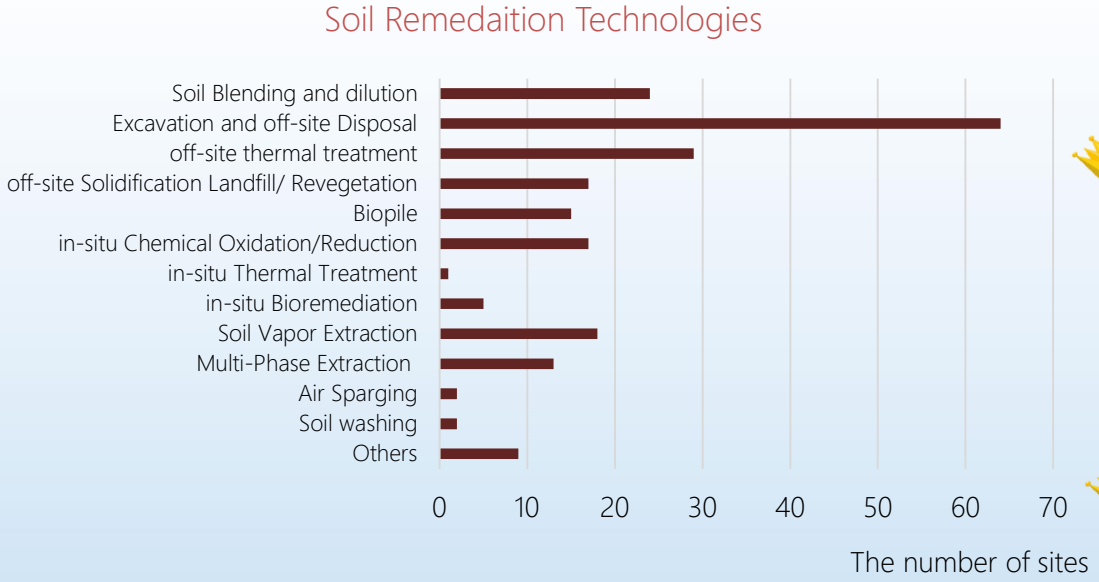


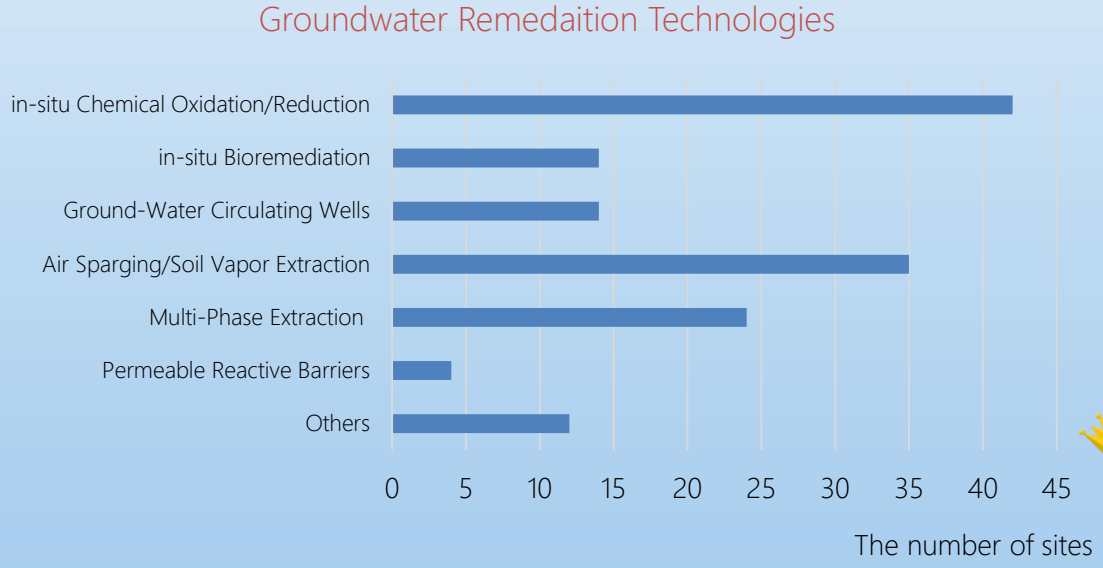
TPH contaminated groundwater remediation sites



- The types of sites of TPH contamination are mainly gas stations and factories
- Petroleum may be considerably used in gas stations and factories

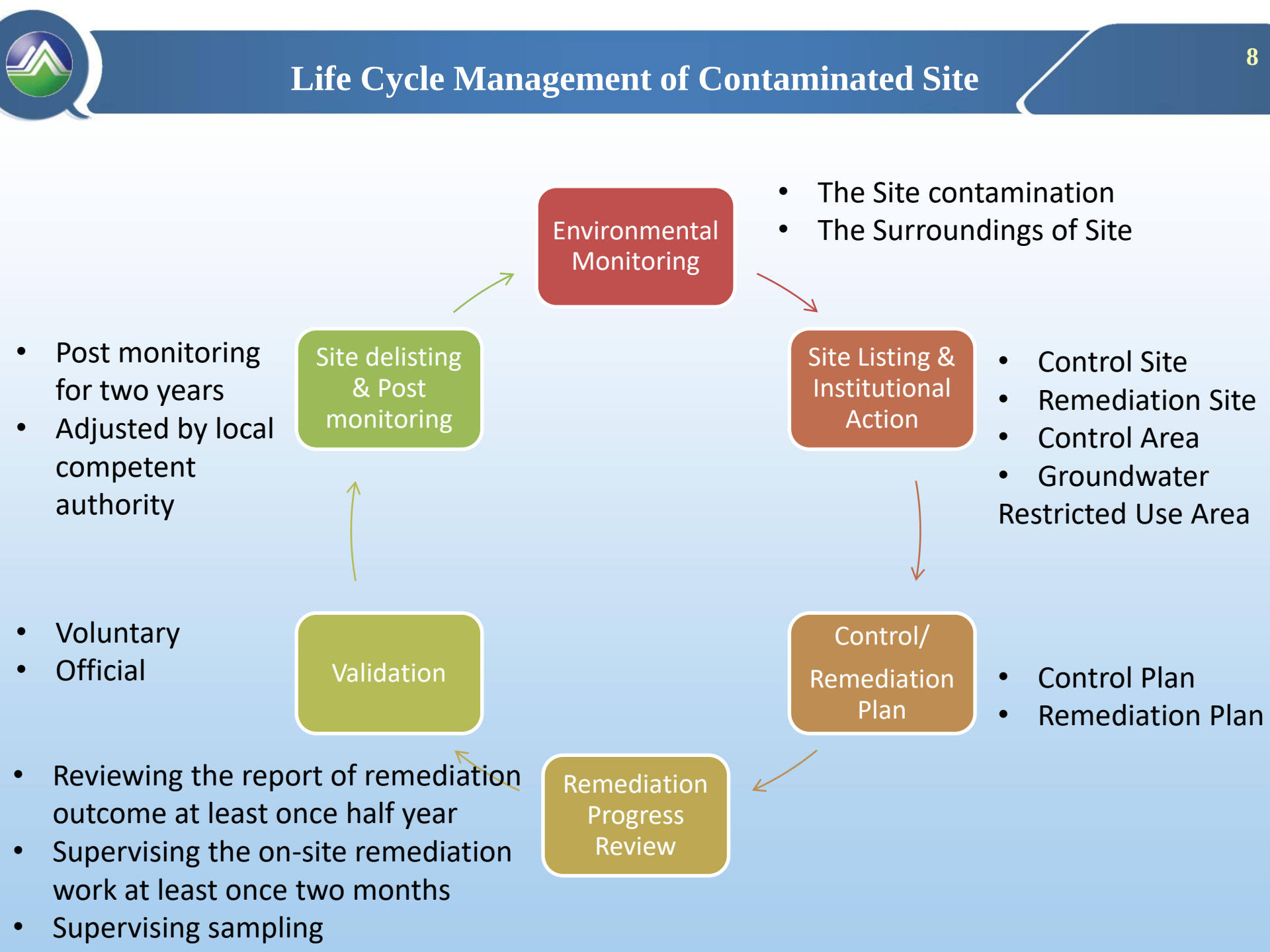
Challenges and Status of Petroleum Contamination in Taiwan





- Contaminated soil sites:
  1. vertical soil mixing
  2. excavation and off-site disposal
  3. off-site thermal treatment
  4. AS/SVE.
- TPH/VOC/SVOC contaminated soil sites:
  1. off-site soil excavation, including excavation and off-site disposal, and off-site thermal treatment
  2. ex-situ bioremediation, including biopile and enhanced bioremediation.
  3. *in-situ* bioremediation and ISCO
- TPH/VOC/SVOC contaminated groundwater sites
  1. ISCO
  2. AS/SVE
  3. Multi-Phase Extraction (MPE)

Life Cycle Management of Contaminated Site



Conclusion/Recommendation

- TPH contamination is mainly from gas stations and factories.
- The remediation sites are more complicated and contaminated groundwater sites take more time to be delisted.
- Off-site soil excavation and disposal is the main approach to be applied in contaminated soil sites because the less remediation time is demanded by local authorities and the sites are valuable.

Conclusion/Recommendation

- TWEPA encourages academic institutes to research and develop the *in-situ* remediation technologies.

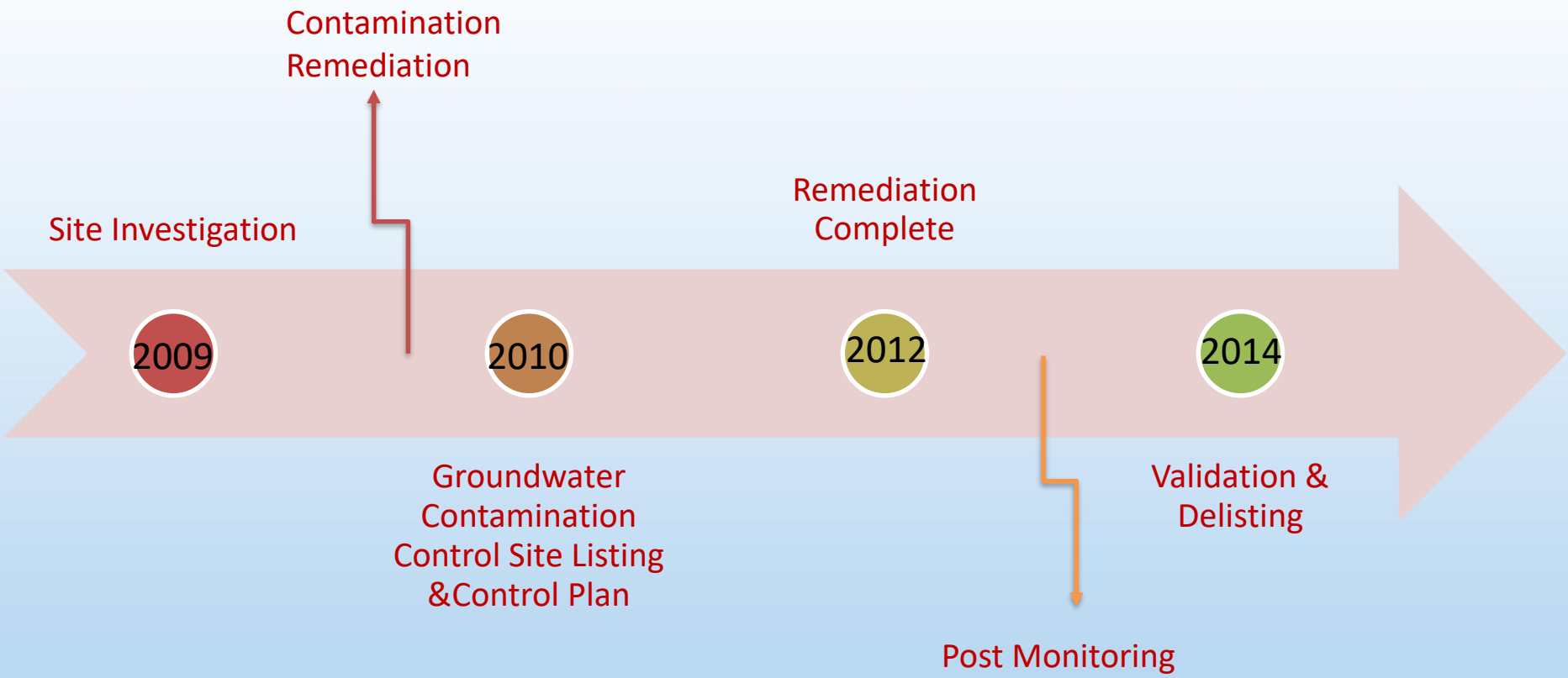
- For controlling the contamination in the site and removing the contaminants, Contaminated Site Life Cycle Management is so significant that the site can be more sustainable and the environment and the public can be protected.

- How to enhance the use and efficiency of *in-situ* remediation technologies to preserve the soil resource is an important issue. This partly depends on the promotion and development of the remediation technologies and is also related to the policy of the government.

Case Study

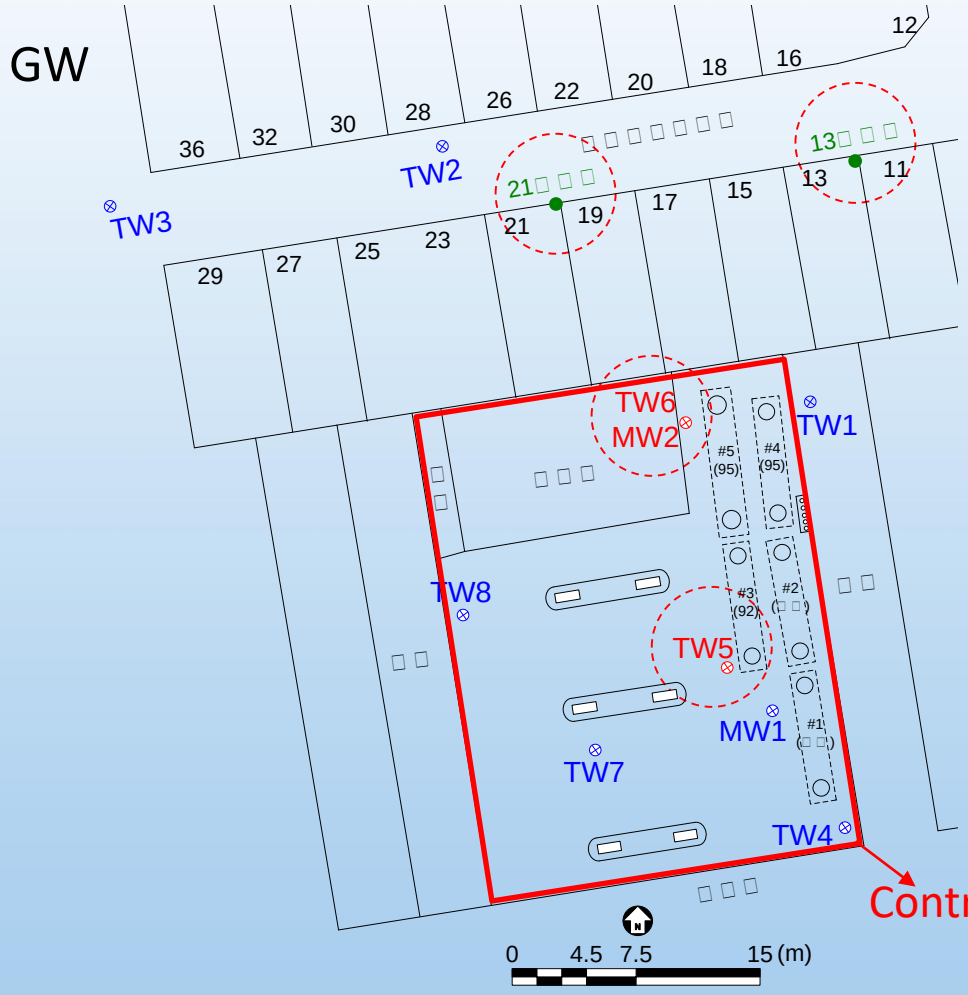
Guo-ling Gas Station

Guo-Ling Gas Station



Guo-Ling Gas Station

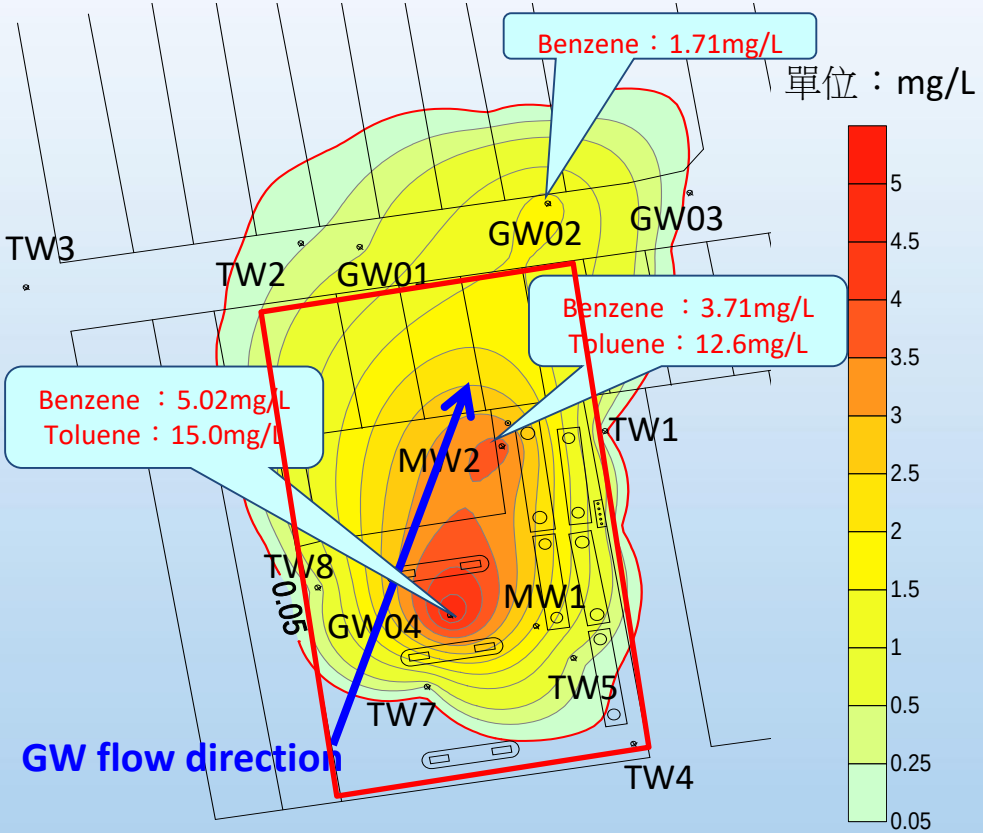
Site Investigation (EPB)



Number	Items (mg/L)		
	Benzene	Toluene	Naphthalene
21	5.74	21.5	0.719
13	0.214	0.631	0.281
TW1	0.0222	0.0220	ND
TW2	0.0297	ND	0.00113
TW3	ND	ND	ND
TW4	ND	ND	ND
TW5	1.44	6.42	0.187
TW6	2.40	10.0	0.340
TW7	0.00258	0.0110	0.00134
TW8	0.0127	0.0138	0.00338
MW1	0.00372	0.0138	0.00267
MW2 (TW6)	2.30	8.84	0.248
GW Control Standards	0.05	10	0.40

Guo-Ling Gas Station

Site Investigation

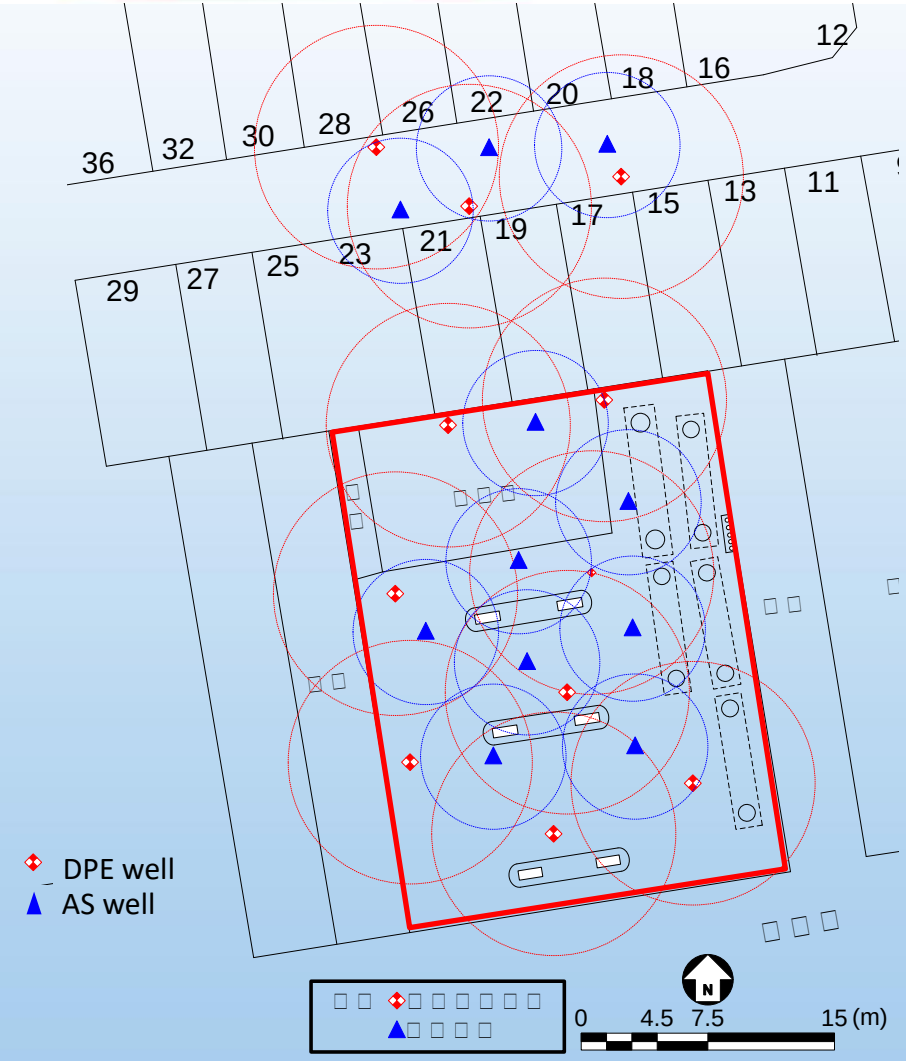


Benzene Contour

- Benzene: 5.02 mg/L
- Contaminated area: 1410 m^2

Guo-Ling Gas Station

Remediation

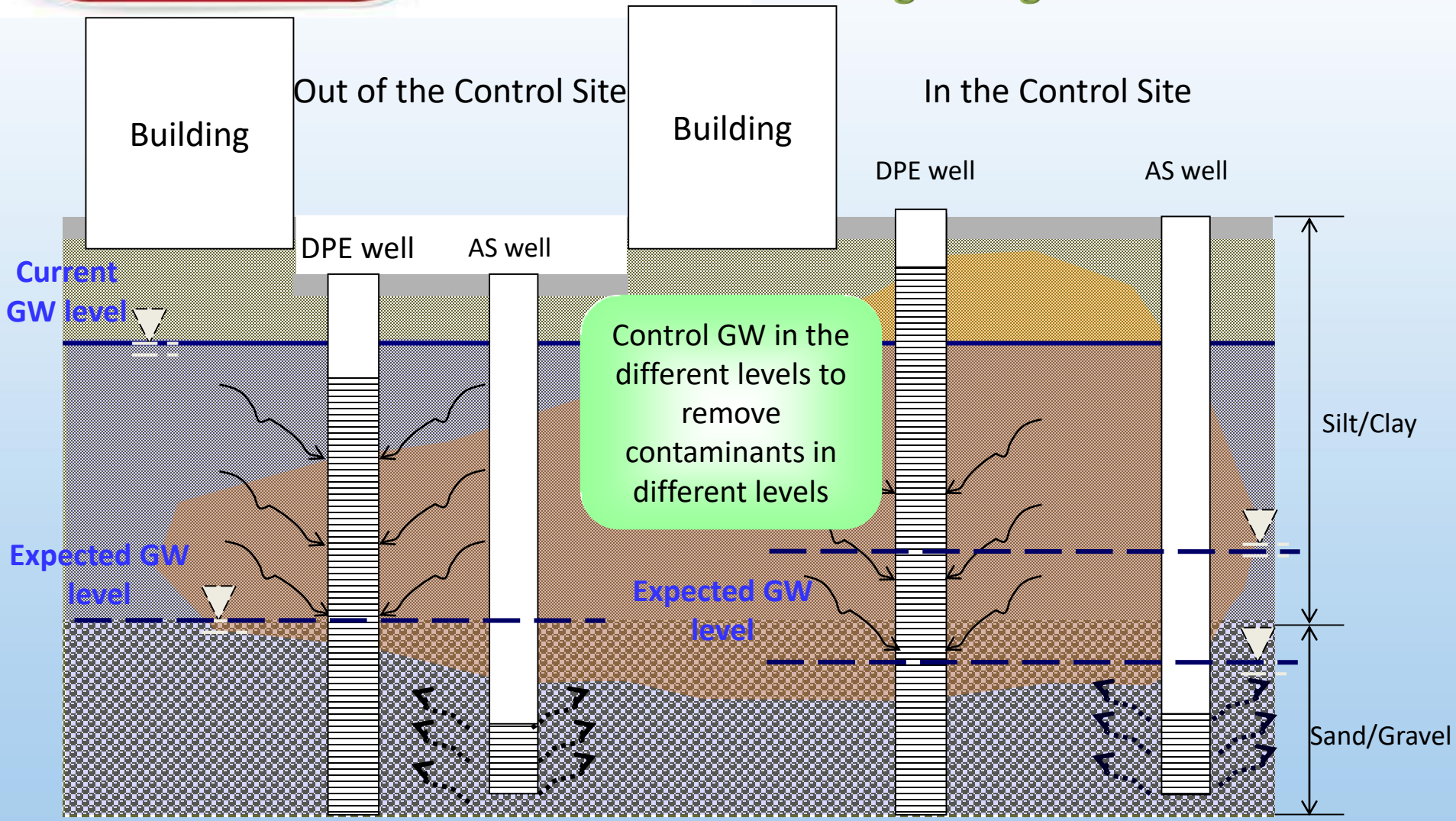


- To avoid contaminant diffusion
- To remove contaminated groundwater
- To enhance biodegradation

Guo-Ling Gas Station

Remediation

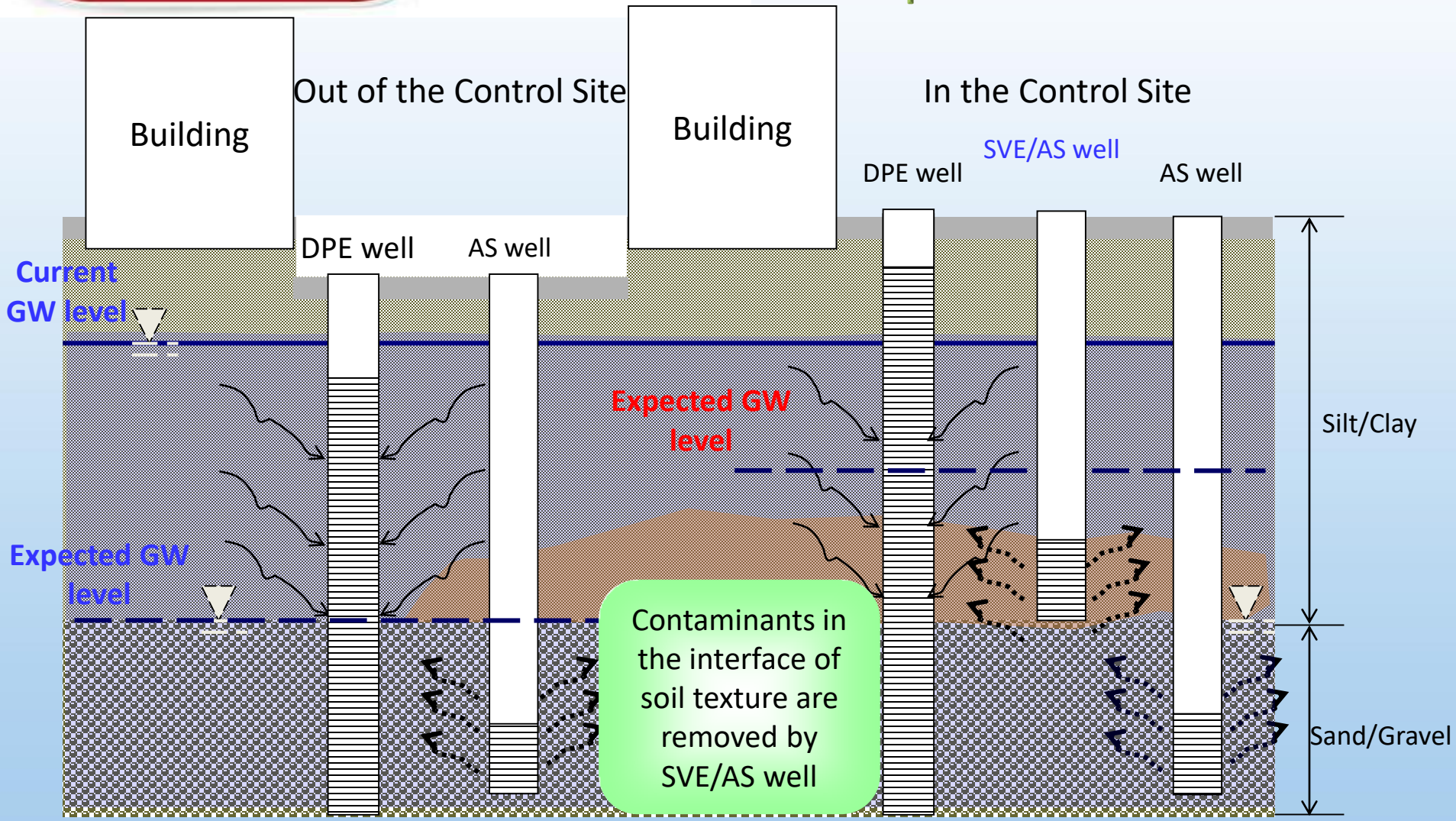
In the beginning of the remediation



Guo-Ling Gas Station

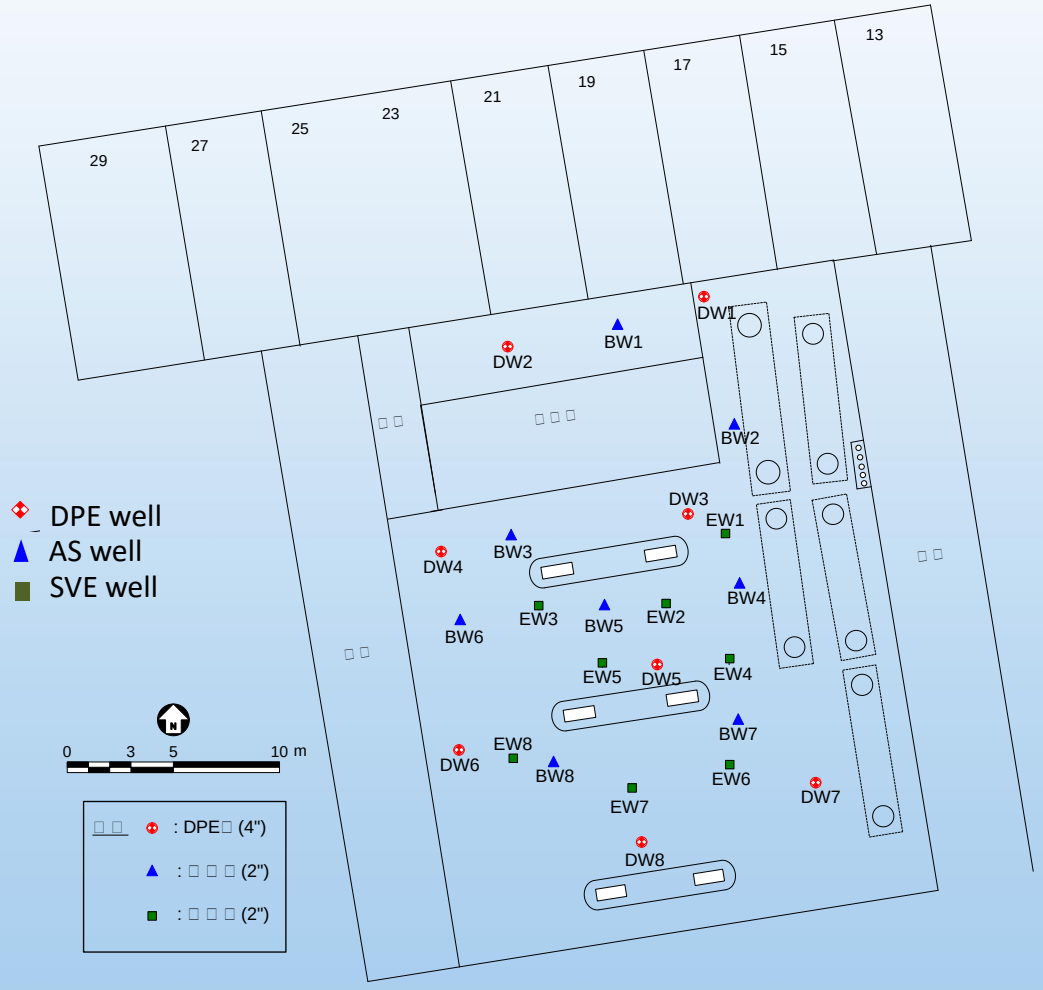
Remediation

The later period of the remediation



Guo-Ling Gas Station

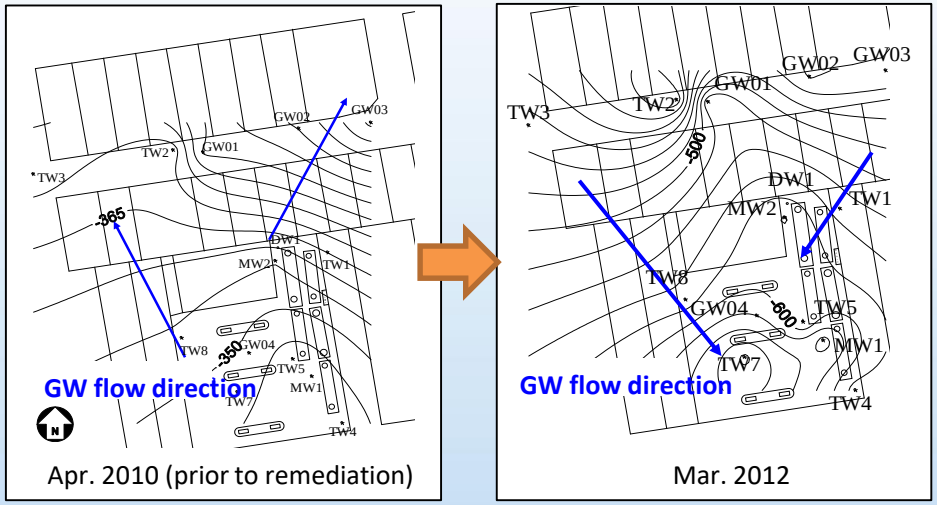
Remediation



- 8 DPE wells, 8 AS wells and 8 SVE wells were installed in 2010

Guo-Ling Gas Station

Remediation



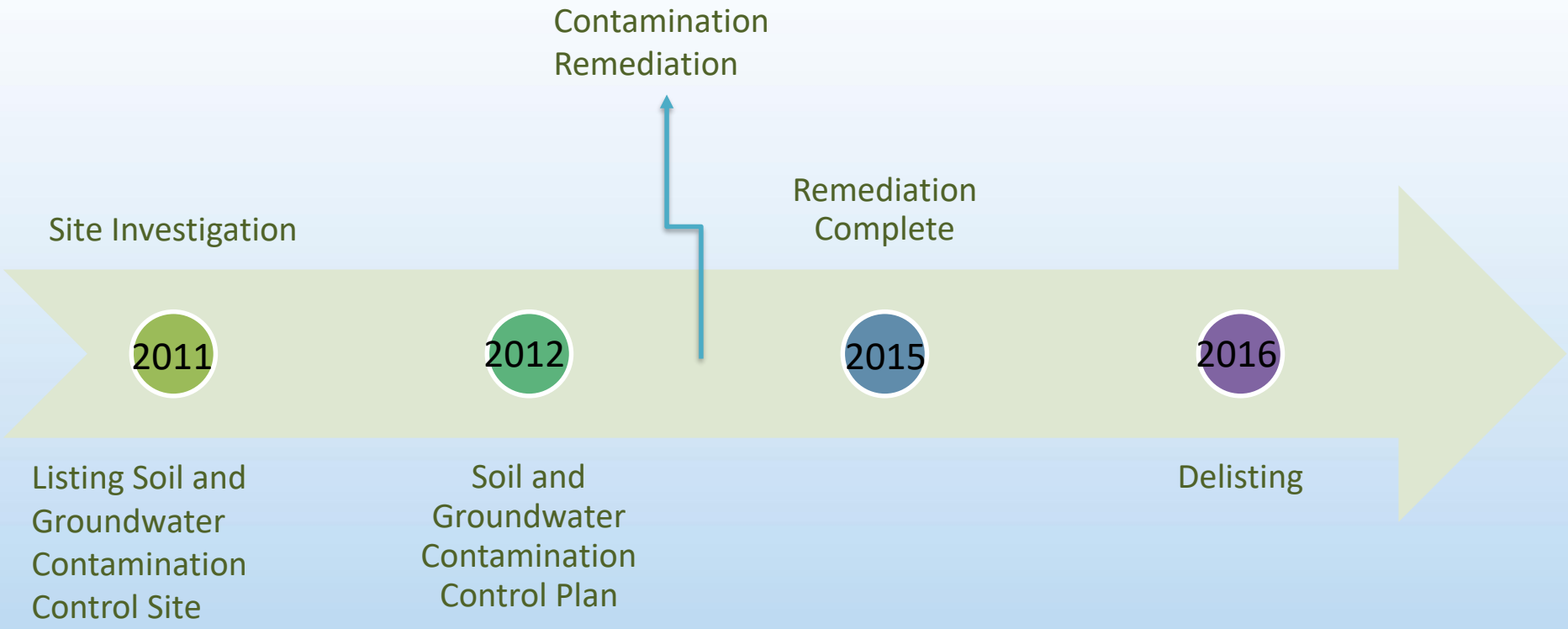
Apr. 2010 (prior to remediation)

Mar. 2012

- Contaminants can be controlled in the site
- 2 years later, the concentrations of contaminants were below Control Standards

Jia-Xing Gas Station

Jia-Xing Gas Station

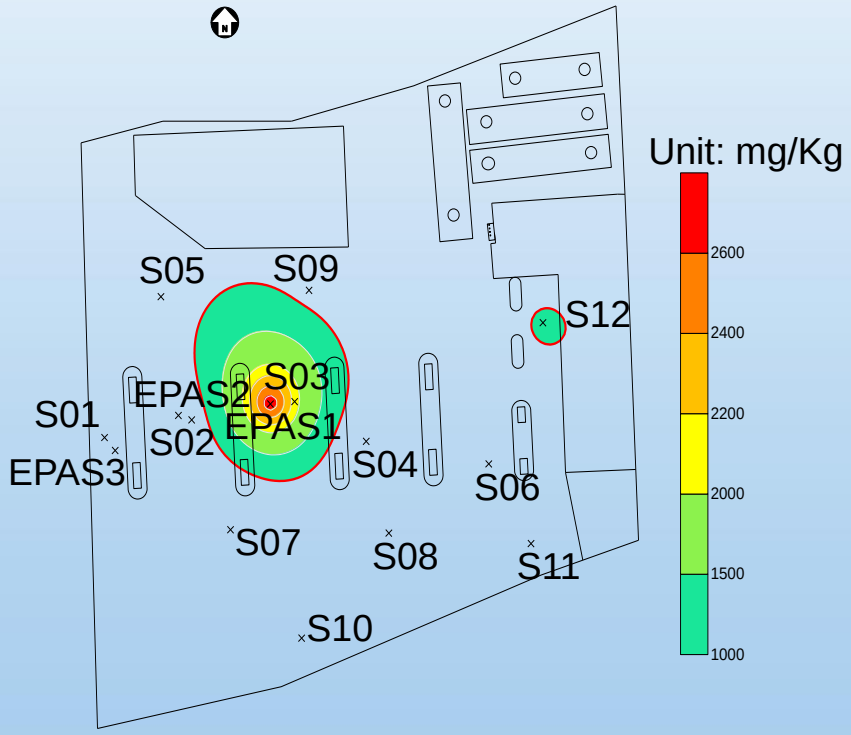


Jia-Xing Gas Station

Site Investigation

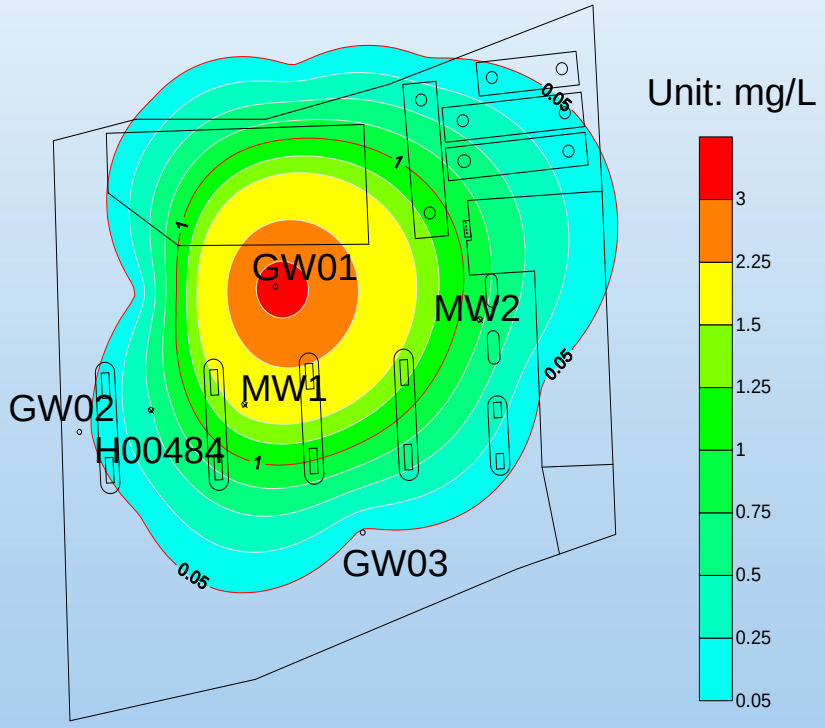
TPH contamination in soil

- Soil-TPH: 2600 mg/kg
- Contaminated Soil area: 138 m^2



Benzene contamination in groundwater

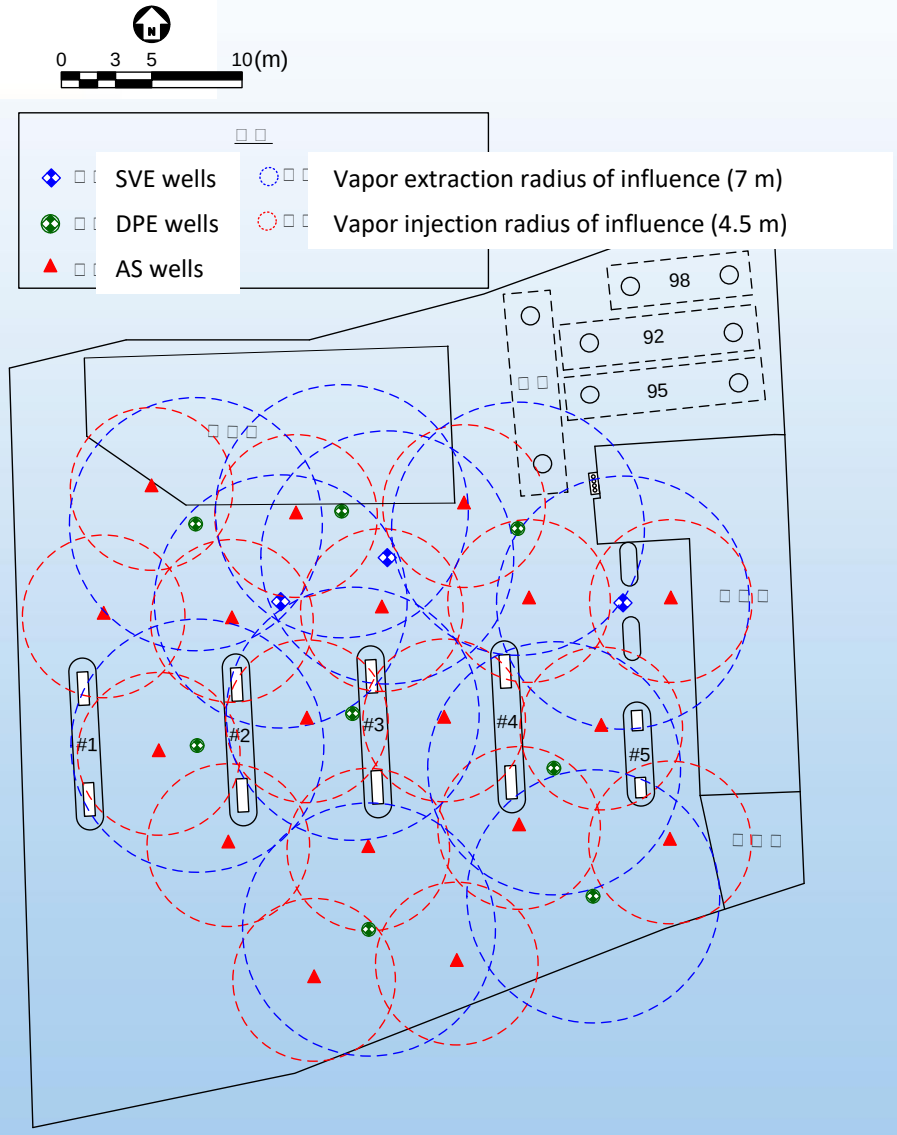
- Groundwater-Benzene: 5.02 mg/L
- Contaminated Groundwater area: 1028 m^2



Jia-Xing Gas Station

Remediation

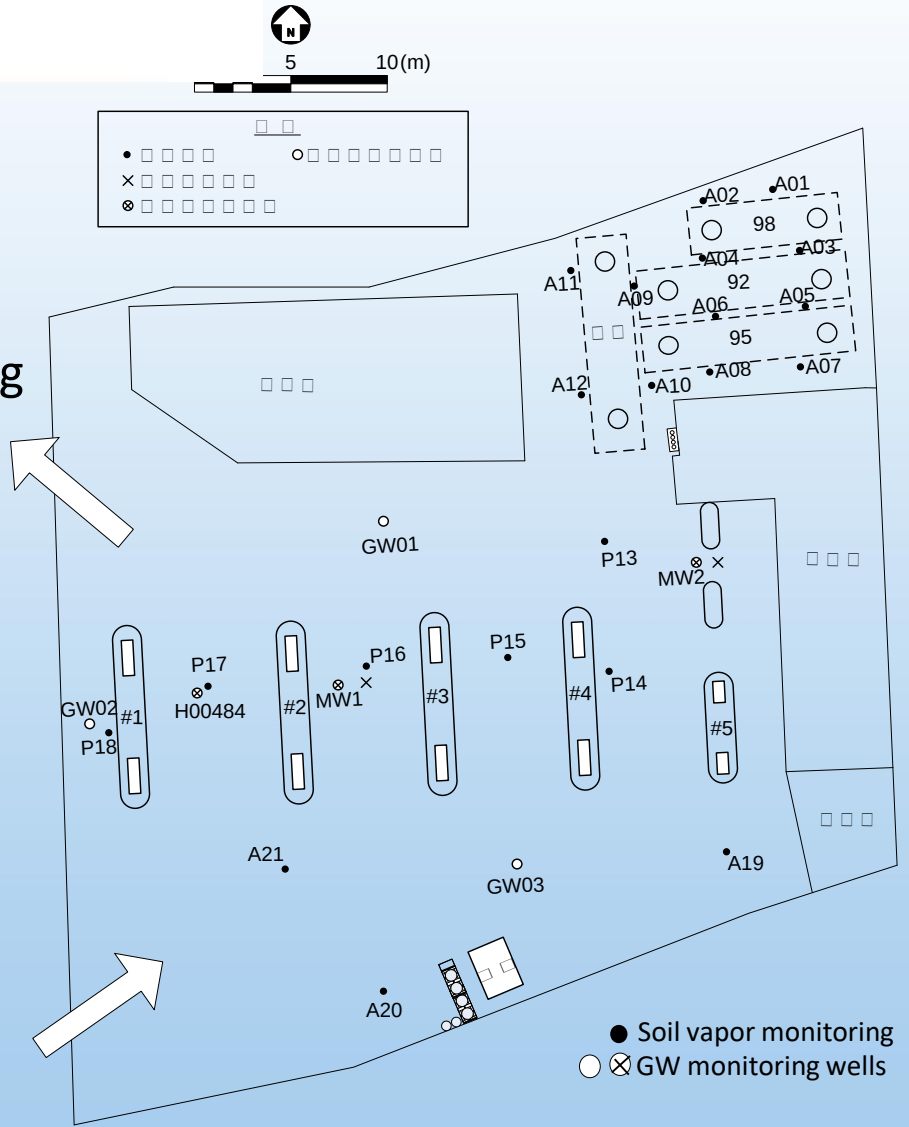
- 8 DPE wells, 3 SVE wells, 18 AS wells and 3 soil monitoring wells



Jia-Xing Gas Station

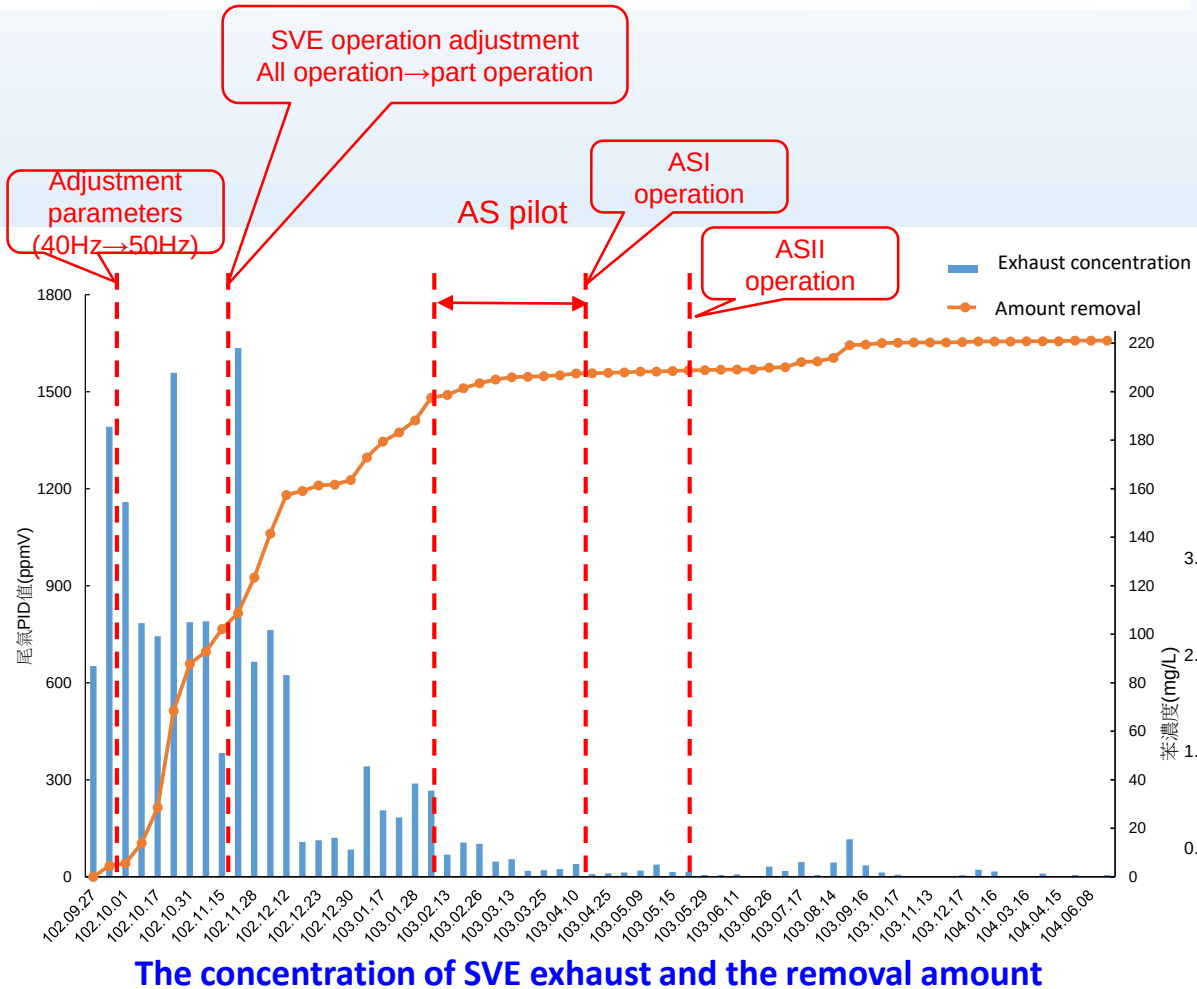
Monitoring

- Soil vapor monitoring
- Soil monitoring
- Headspace of groundwater monitoring
- Groundwater monitoring



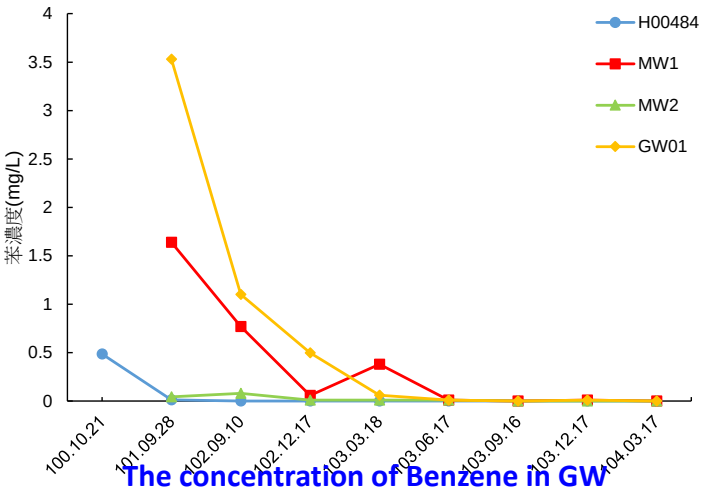
Jia-Xing Gas Station

Outcome of remediation



The concentration of SVE exhaust and the removal amount

- Operation Time: 8785 hrs
- The contaminants removal amount : 221 kg
- 2 years later, the remediation was completed

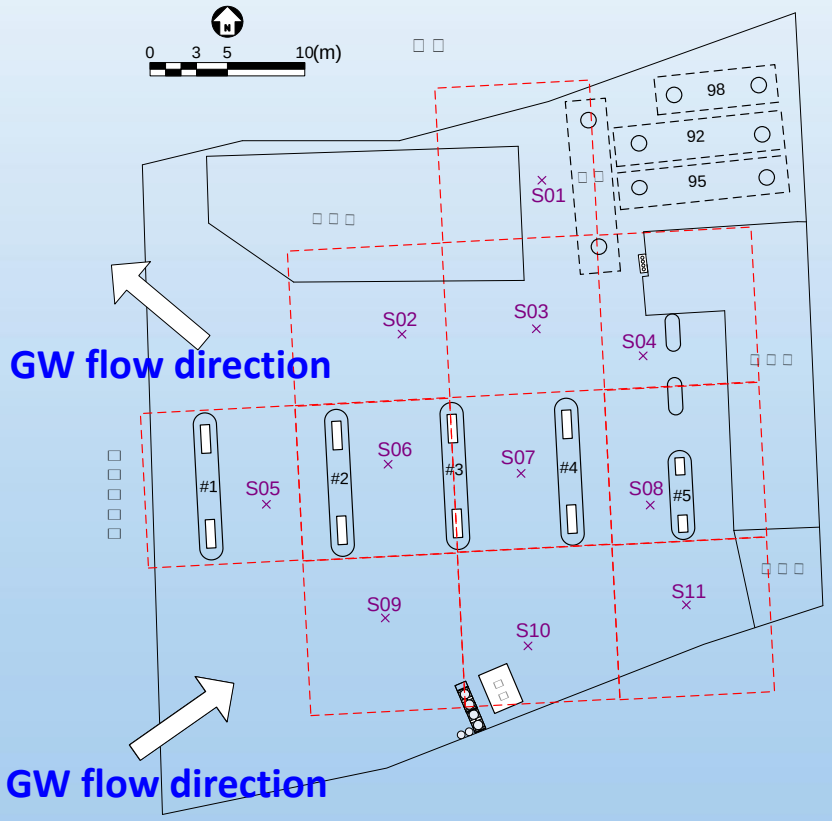


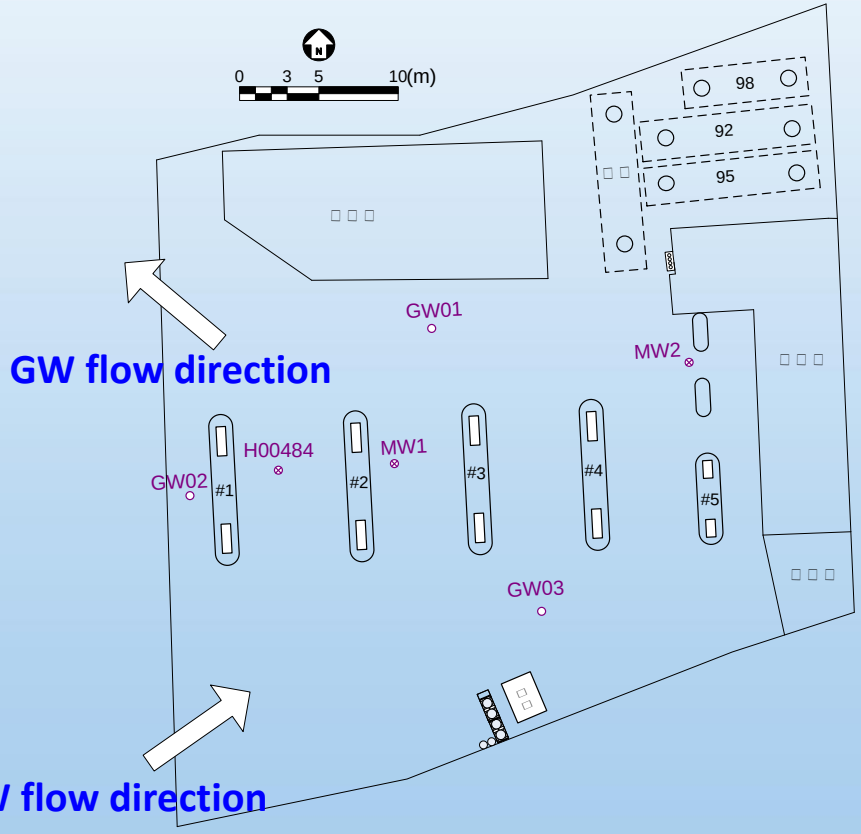
The concentration of Benzene in GW

Jia-Xing Gas Station

Validation

- 11 soil samples (by dividing into 11 areas)
- 6 groundwater samples (original groundwater wells)





Thank You