



行政院環境保護署

Environmental Protection Administration
Executive Yuan, R.O.C.

Development of Green and Sustainable Remediation in Taiwan

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Outline of Presentation

1. Policies for Contaminated Soil and Groundwater in Taiwan
2. Strategies for Green and Sustainable Remediation
3. Pilot Case Studies
4. Future Work for Green and Sustainable Remediation in Taiwan



Policies for Contaminated Soil and Groundwater in Taiwan

- ❖ “Soil and Groundwater Pollution Remediation Act” was enforced in January 2000 and revised in February 2010
 - ◆ Manages contaminated soil, groundwater and sediments
 - Soil Control Standards
 - Groundwater Control Standards
 - Sediment Quality Control standards
 - ◆ Control site and remediation site
 - ◆ Risk assessment and risk communication
 - ◆ Remediation fund



Current Contaminated Sites Nationwide

Type	Completed		In progress	
	Number	Area (ha)	Number	Area (ha)
Farmland	1,757	410	391	77
Gas Stations	57	12	96	19
Storage Tanks	7	40	8	171
Industrial Sites	85	96	135	751
Illegal Dump Sites	10	5	19	14
Others	15	8	66	120
Subtotal	1,931	571	715	1,152

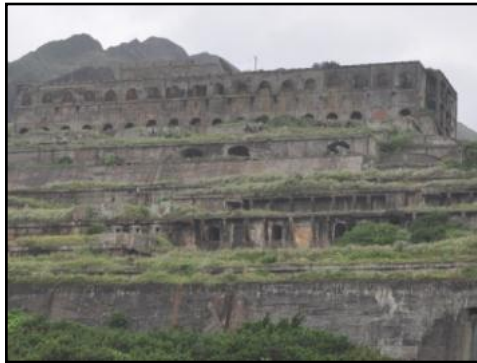


Challenges in Taiwan

❖ Green and sustainable clean-up strategies are needed

Mega sites and Industrial sites

1. Heavily contaminated
2. Community issue
3. Need for a balanced solution



Farmland pollution

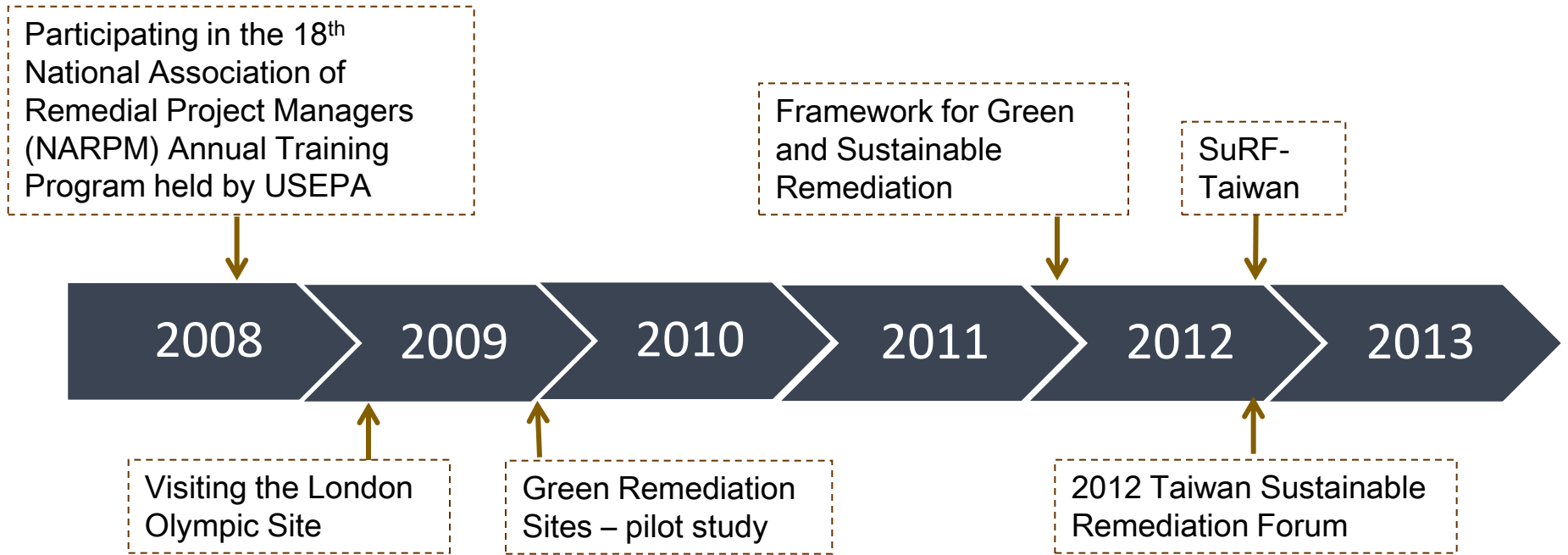
1. The world food crisis
2. Crops and plants selection
3. Renewable energy

Illegal dumping sites

1. No responsible party
2. Partial or thorough remediation



Green and Sustainable Remediation in Taiwan



Important initiatives for GSR in Taiwan



2012 Taiwan Sustainable Remediation Forum



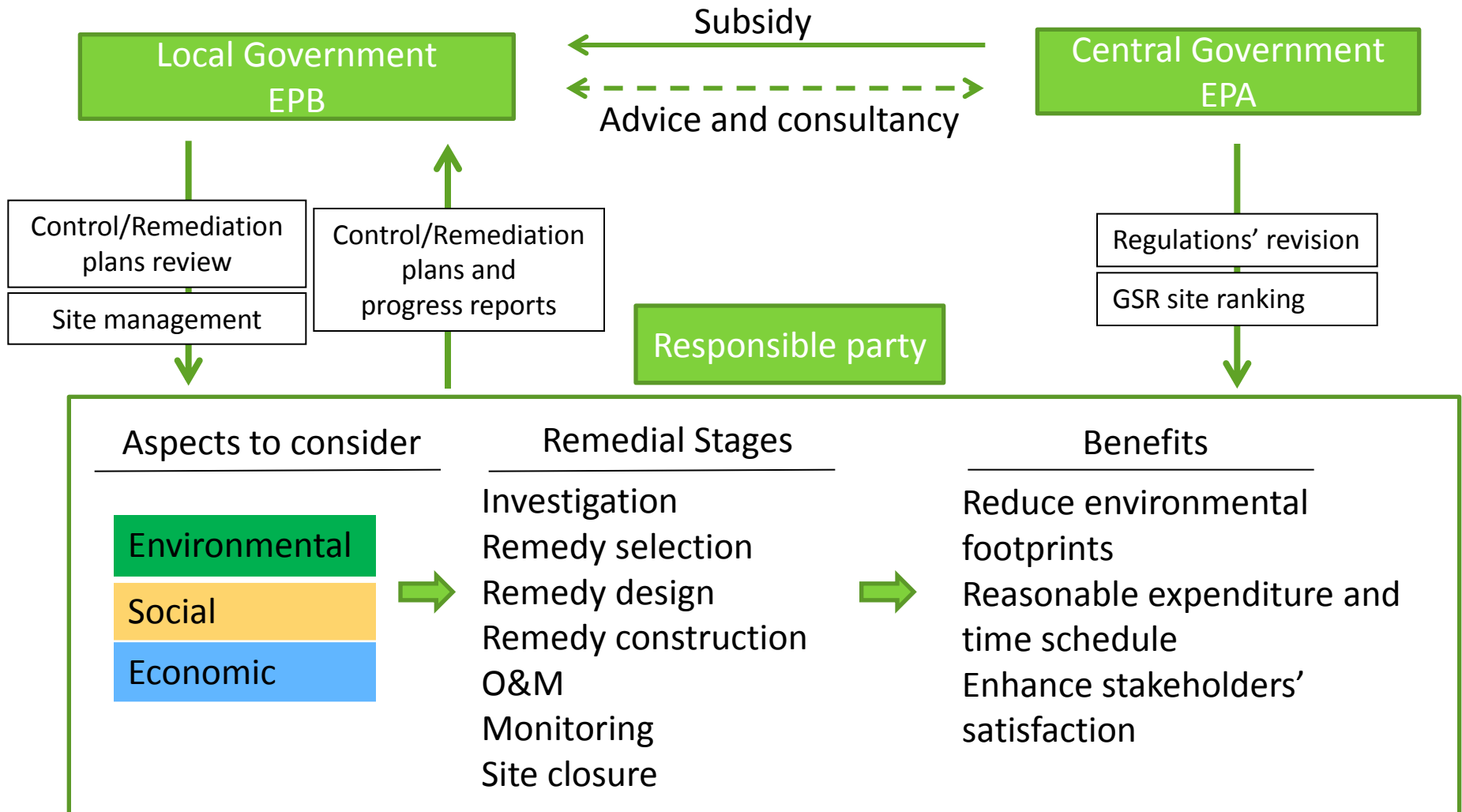
2012 Taiwan Sustainable Remediation Forum





Taiwan EPA's Framework of GSR

❖ Top-Down Approach





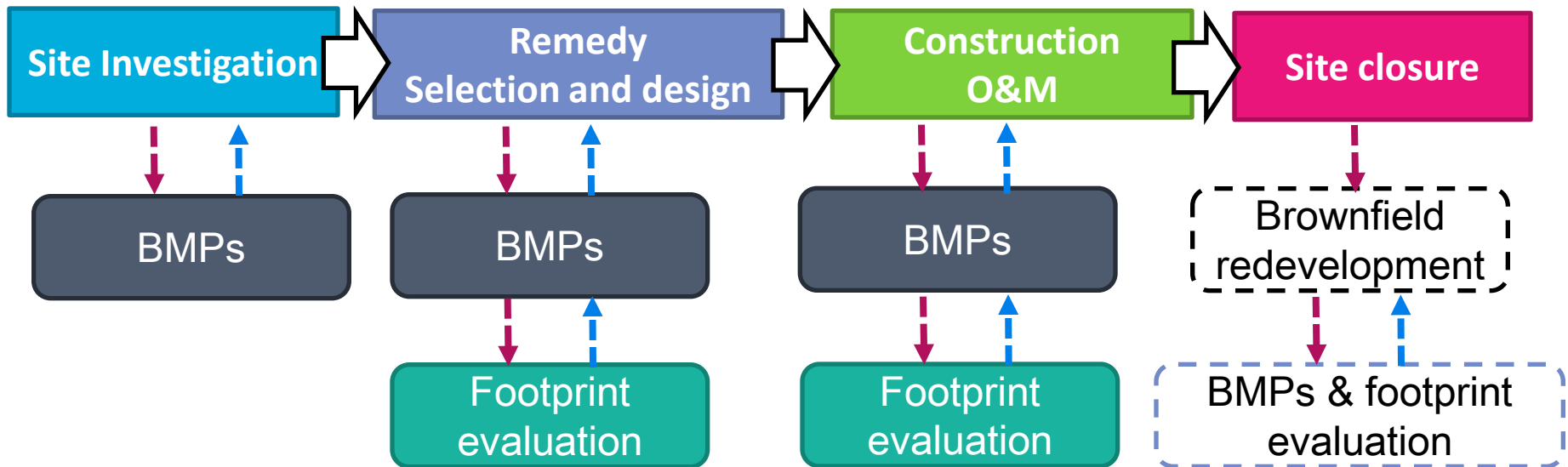
Strategies for promoting GSR

- ❖ **GSR toolkits**
 - ◆ Environmental footprint evaluation
 - ◆ BMPs recommendation
- ❖ **Case study**
 - ◆ Pilot test cases
 - ◆ Full scale case study
- ❖ **GSR guideline**
 - ◆ Social and economic experts involved
- ❖ **Regulations' revision**
- ❖ **Communication / Education**
 - ◆ Education for general public
 - ◆ Training for contractors and government officials



Draft processes for applying GSR

- ❖ BMPs can be applied to all phases of a remediation program
- ❖ The environmental footprint evaluation results support the decision making process and the adoption of BMPs





Major considerations of GSR

Environmental	Social	Economic
Energy requirements	Human health safety	Direct economic effect
Air emissions	Social justice and acceptance	Indirect economic effect
Water consumption impacts		
Land and ecosystem impact		
Material usage and waste		



15 measures



8 measures



9 measures



BMP check list for GSR

表 3.1.1-1 綠色及永續導向型整治定性評估表單

面向	核心項目	原則	是否適用	最佳管理作業 (BMPs)	是否達成(Y/N)			紀錄文件
					整治工法選擇/設計	設備建置	操作維護	
Core Items		Measures	Applicability					
環境面	減少能耗	提高能源使用效率			Remedial stages			Documentation
		使用再生能源						
		採行節能措施						
	降低大氣排放	減少空氣污染物排放						
		降低溫室氣體排放						
		防止關切污染物大氣排放或逸散						
	最小化水資源使用影響	減少水資源消耗與廢水						
		廢水回收再利用						
		防止對地表及地下水體造成衝擊						



Social justice and acceptance consideration

- ❖ Public meetings
- ❖ Survey and Questionnaire
 - ◆ Understand the needs of stakeholders
 - ◆ Ascertain local community's satisfaction with the remedial activities



Environmental footprint evaluation

1 場址評估工具

1. 工作資訊輸入 **Site info** **評估工具使用簡介**

工作編號 使用者自行輸入
 場址名稱 使用者可下拉選擇
 場址地點 系統自行計算
 整治預算成本

2. 污染場址選擇

土壤整治 **地下水整治**

場址資訊輸入 **整治工法資訊輸入** **永續指標輸出**

Soil/Groundwater remediation

2 土壤整治

Remedy's selection

土壤場址資訊輸入 **2. 整治工法選擇**

受污染的土壤面積 平方公尺
 受污染土壤深度(側向)(距離地面) 公尺
 受污染土壤深度(底部)(距離地面) 公尺
 地下水深度(距離地面) 公尺

土壤種類
 污染物最大濃度 mg/kg
 污染物一般濃度 mg/kg
 污染物質量 kg
 受污染的土壤總積 立方公尺

Contamination type, area, depth

土壤整治

離地處理 **現地處理**

開挖處理 土壤氣體抽除 (SVE)
 污染土方外運 植生復育
 土壤清洗
 土耕法
 離場熱處理
 土方回填

土壤整治結果

3 土壤清洗處理

原場址受污染的土壤體積 立方公尺

施工人員所需人次 人次
 施工人員所需平均距離(單程) 公里
 車輛油耗 3.97 車輛消耗1公升所行駛里程
 汽油消耗量 公升

1. 篩分

用水量 立方公尺
 乾式篩分機功率 5.2 kw
 機具使用時數 小時
 耗電量 kwh
 濕式篩分機功率 5.2 kw
 機具使用時數 小時
 耗電量 kwh

受污染土方減少量 立方公尺
 篩分總耗電量 kwh

Detailed information

4 土壤清洗處理 計算結果

Results

總用水量 公升
 總耗電量 千瓦小時
 化學藥劑總使用價錢 元
 受污染土方減少量 立方公尺
 污泥回收處理費 元
 總汽油消耗量 公升

環境足跡計算結果					能量計算		風險計算	
二氧化碳排放		NO _x *	SO _x	PM ₁₀	總能源消耗量		安全 / 意外風險	
CO ₂ (公噸)	每公升污染物處理產生多少二氧化碳	(公噸)	(公噸)	(公噸)	兆焦耳	千瓦小時	損失時間	傷害風險
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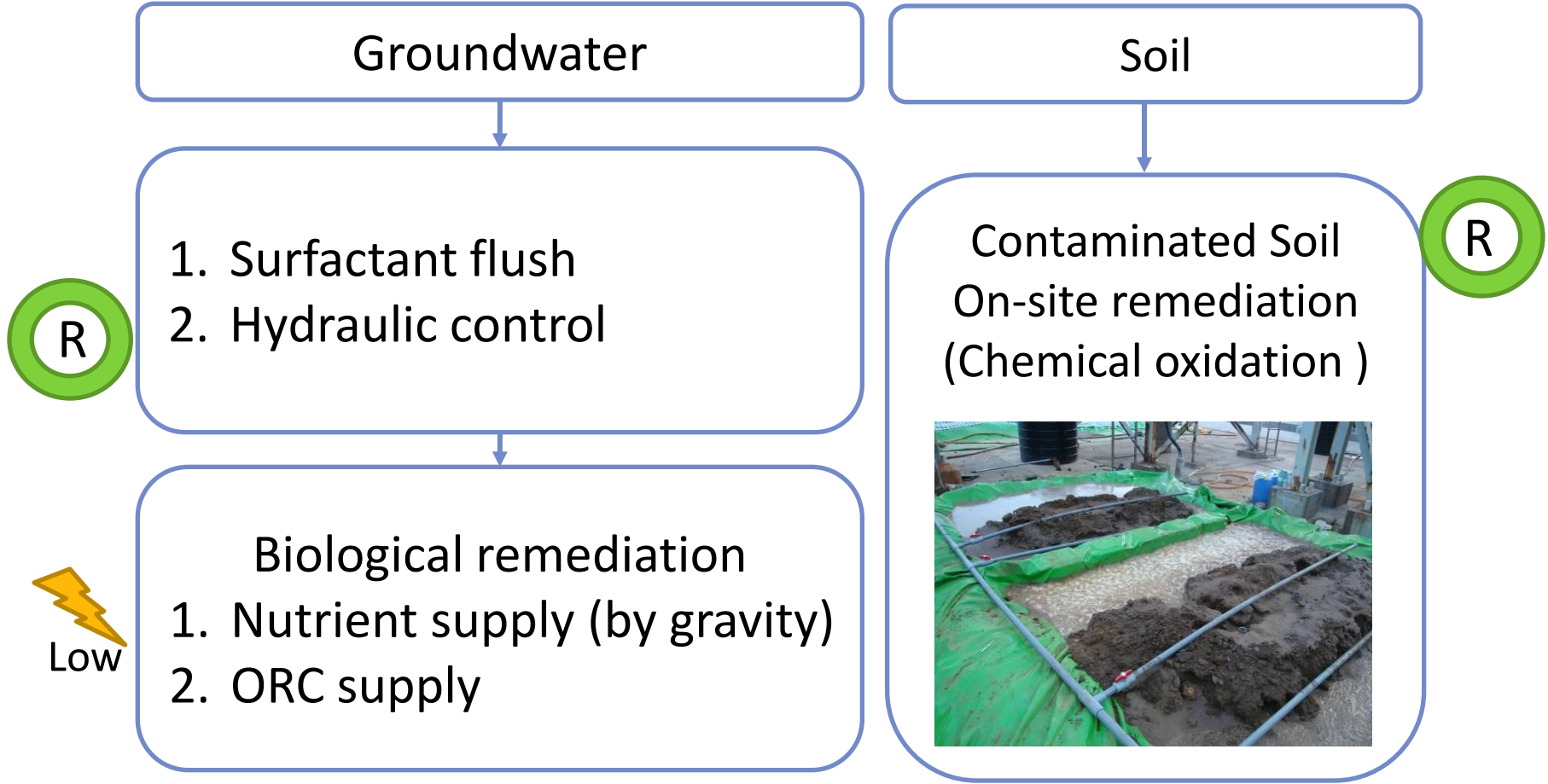
Pilot study - Jianshan Power Plant


- ❖ Site area : 11.8 hectares
- ❖ Contaminants : TPH
 - ◆ 29,7000mg/kg






Pilot study - Jianshan Power Plant



 Renewable energy apply

 Low energy demand strategy

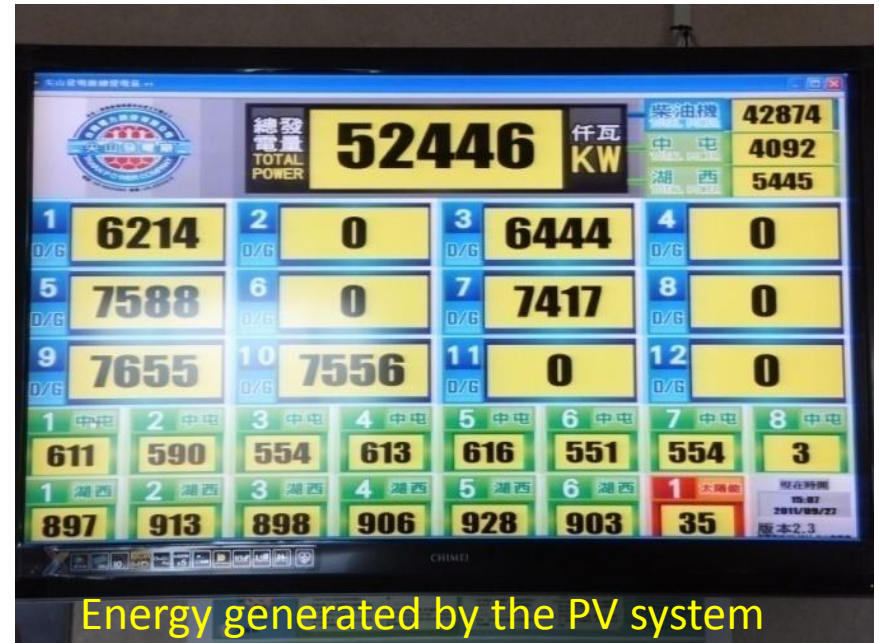


Pilot study - Jianshan Power Plant

❖ GSR approaches

- ◆ PV system for the remediation
- ◆ Sustainable usage of the PV system

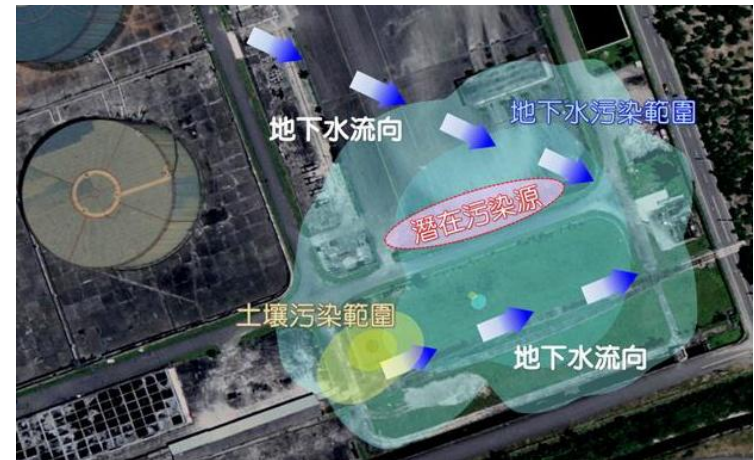
Solar panels at the Jianshan Power Plant





Pilot study - Peipu oil storage tank

- ❖ Site area : 71.8 hectares
- ❖ Contaminants
 - ◆ Soil : TPH
 - ◆ Groundwater : Benzene
- ❖ Concentration
 - ◆ TPH : 1,190~3,470mg/kg
 - ◆ Benzene : 0.1~6.6 mg/L



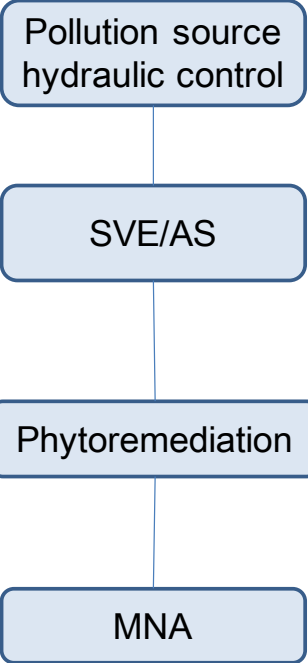
- ➡ Groundwater flow
- Plume
- Soil contaminated zone



Pilot study - Peipu oil storage tank

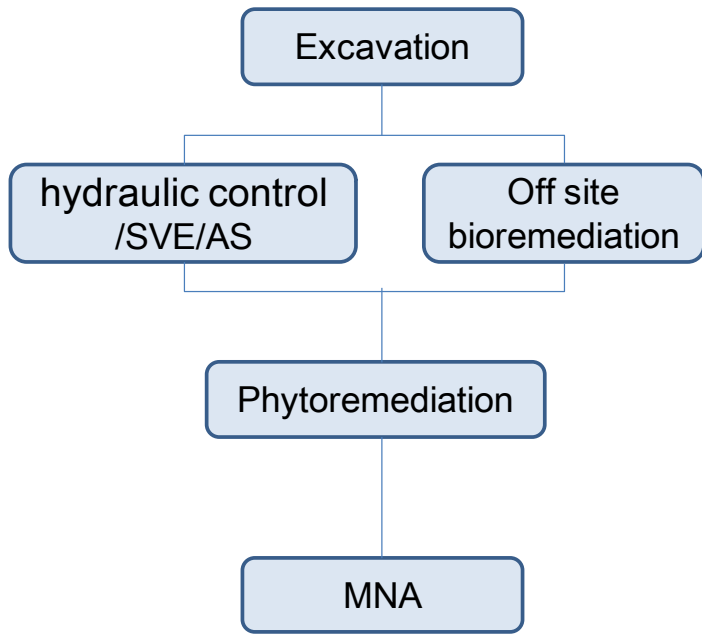


Alternative A



Estimate CO₂ emission
192,432 kg

Alternative B

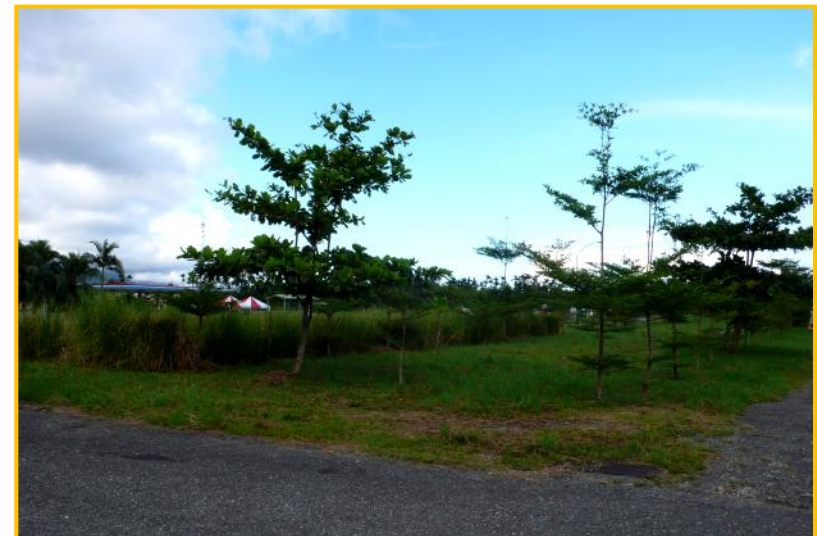


Estimate CO₂ emission
578,182 kg



Pilot study - Peipu oil storage tank

- ❖ Source Zone
 - ◆ Hydraulic control
 - ◆ SVE/AS
- ❖ Less contaminated zone
 - ◆ Phytoremediation
 - Vetiver grass
 - Madagascar almond





Pilot study - Peipu oil storage tank

❖ GSR approaches

◆ SVE system optimization

- Reduced energy consumption
- 204,000 kg CO₂ reduction

◆ Phytoremediation

○ Vetiver grass

- Engineering controlled
- Low ecological effect
- Amount of CO₂ absorbed is estimated to be 2,855 kg by 2012



Future Work

❖ 2013 - 2014

- ◆ Green and sustainable remediation guidelines
 - ◆ Publication of the environmental footprint evaluation and BMPs toolkits
 - ◆ Guidance and consultation for selected sites
- ❖ Continue to promote GSR
 - ❖ Increase SuRF-Taiwan members and influence
 - ❖ Share GSR experience with Asian countries



Thank you for your attention

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