sardinia_2017
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SUSTAINABLE DEVELOPMENT OF EXISTING LANDFILL BY PERFORMING VERTICAL EXPANSION

Presented by:

Ir. Dr. Saravanan Mariappan
Nexus EC Sdn Bhd & Cenviro Sdn Bhd

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INTRODUCTION

Malaysia Scenario



- Malaysia still utilizing landfill as **main waste disposal site** .
- Existing landfills are reaching the life span due to **limited space** and **inadequate land area** for expansion.
- Vertical expansion is an **alternative solution** to extend the local condition of life span and space limitation of landfill.
- **Increase the lifespan** within the existing foot print of the landfill.

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INTRODUCTION

- **New landfills** “**Not at My Back Yard** syndrome
- Option of **Landfill Vertical Expansion** could contribute to:
  - Provide **optimal use of current landfill area**
  - Create **higher air space for waste filling per unit area**
  - **Low construction cost** as compare to developing new landfill.
  - **Less public outcry**
  - **Immediate implementation**
  - **Environmental friendly**

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Overview

- Landfill vertical expansion of landfill can be performed **vertically along with laterally expansion** where old landfill is enclosed by new placement of waste.
- The new expanding landfill could cause:-
  - Additional settlement which could cause **damages to the existing liners** with potential of **slope failure**
  - **Instability of vertical expansion slopes** shall mitigated as any slope failure could cause **environmental damages**
  - **Potential malfunction** of existing landfill leachate collection system and storm water management
  - **Possible interruption** of existing landfill gas and gas release mechanism

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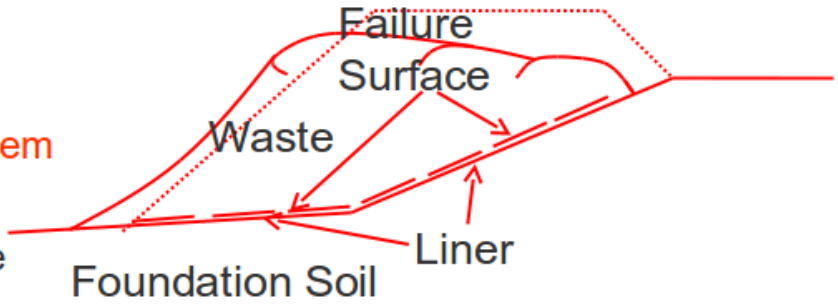
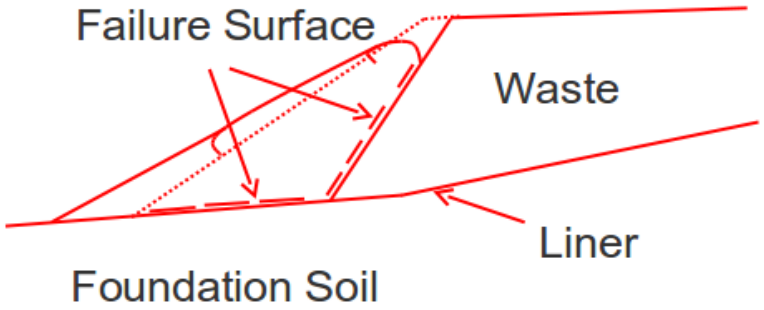
FAILURES AT LANDFILL SITE

Mode Of Common Failures At Landfill Site

- Waste liner and foundation subsoil rotational failure
- Sliding along leachate collection system
- Side slope and base rotational failure
- Rotational failure within waste mass





All of these are classical mode of geotechnical failure depending upon site specific conditions, the placement and geometry of the waste mass

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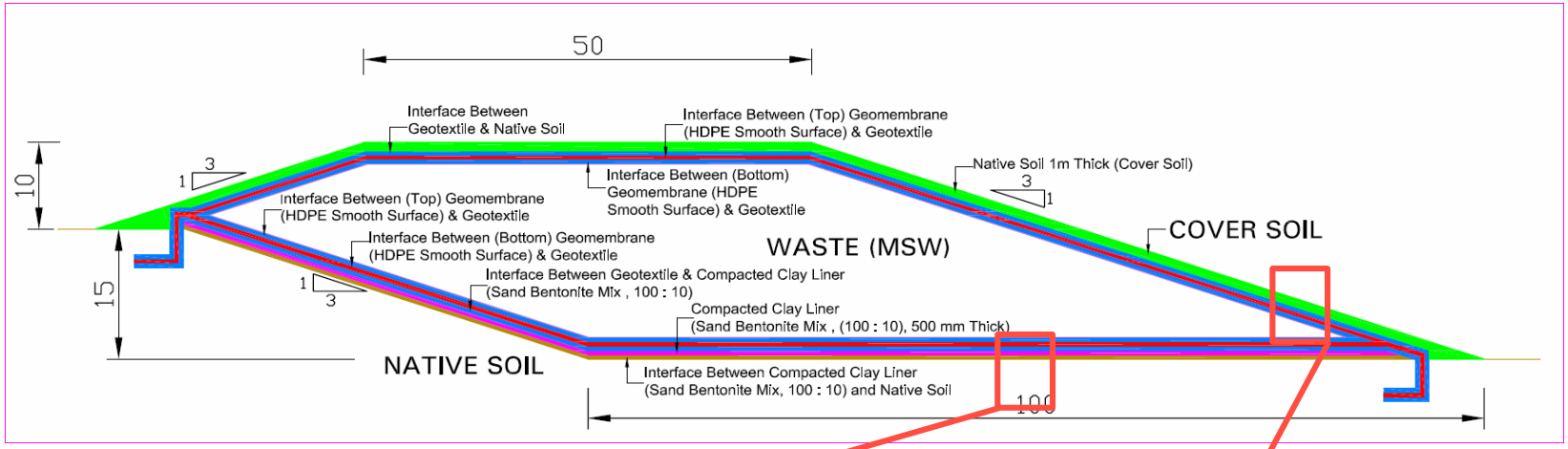
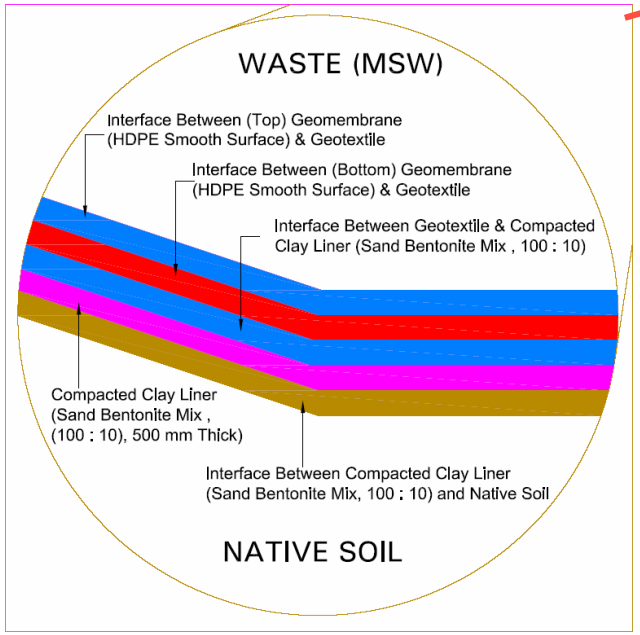
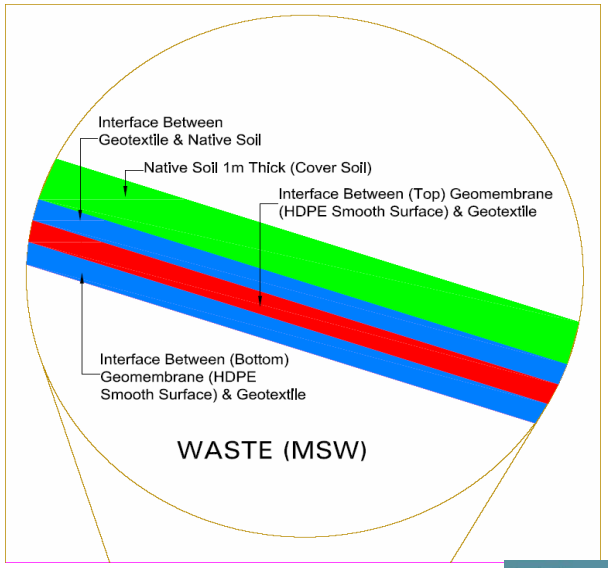
Landfill Liner Interface Failure







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Factors to consider selection for vertical expansion liner

- Vertical expansion liner will be different for **type of waste received** (municipal solid waste, garden waste or hazardous waste)
- Geomembrane is capable to **withstand relatively high in plane tensile strains and stresses** caused by differential settlement.
- Estimation rate of waste placement activities
  - Estimate rate of settlement and **differential settlement of existing and old waste** which influences the stress and strains of vertical liners installation
    - Affect the **integrity of liners components**
    - Eg: **Clay liner will possess very little tensile strength** (tensile strength <1%) which susceptible to cracking as result to differential settlement due to vertical expansion
    - Study the **need to install high strength reinforcement t**o protect the liners

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Condition of existing landfill system

Various structures involved in landfill cell which possibly affected by vertical expansion works:-

- Existing and new liner systems
- Existing and new leachate collection
- Existing and new detention systems
- Existing gas collection system
- Existing waste mass
- Foundation of existing waste mass
- Existing and new final cover systems
- Subsoil and surface water collection systems

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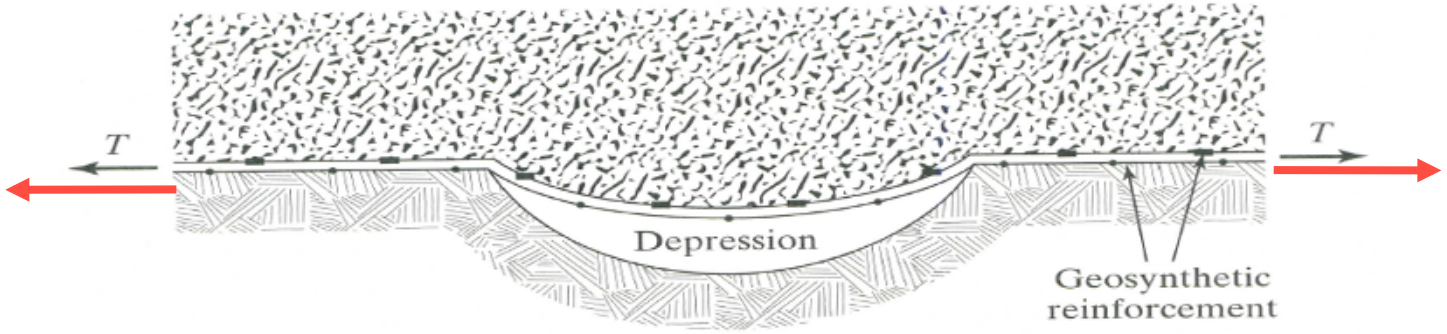
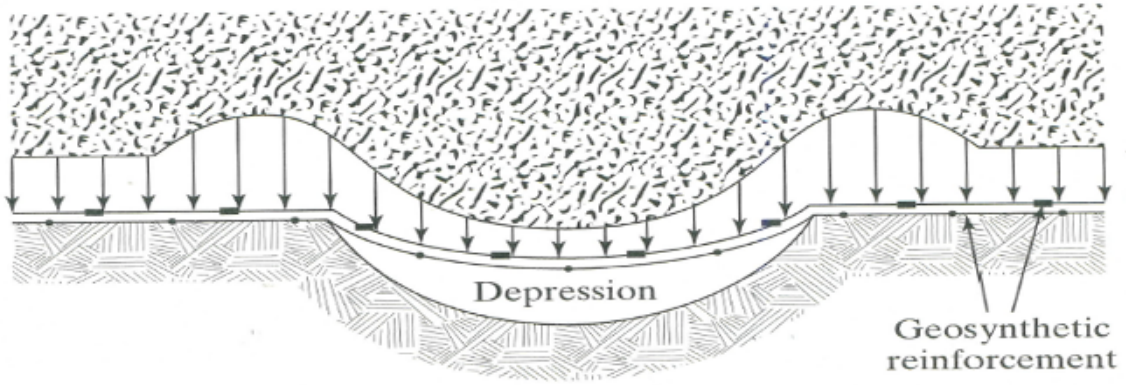
Stress on existing landfill and waste settlement effects



a) Arching of fill material and geosynthetic reinforcement tensioning



Vertical stress distribution

b) Effect of fill material arching on vertical stress distribution

After Qian (2002)

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Membrane and piping system

Structure	Design consideration
Liners : **Geomembrane**, Compacted Clay Liner* and **GCL**	• **Tensile strength of new liners** over existing waste • **Stability of new liner system** over existing waste • **Slope changes** for the existing liner system
Pipes: **Leachate**, **riser**, **gas** and **subsoil drainage**	• **Strength and stability** for bucking, crushing and deflection • Slope changes
Drainage layer : **geocomposite** and **aggregate blanket** used in the existing leachate collection and detection system and under drain system	**Drainage capacity** of **aggregate blanket** and **geocomposite** to be reduced due to extra waste fill
Vertical structures in existing landfill: **manholes**, **riser pipes** and **gas extraction pipes**	• **Negative skin friction** due to waste settlement • **Bearing capacity and stability** of the vertical manhole and riser pipe foundations due to negative skin friction force and extra waste fill

Compacted Clay Liner* = not recommended for liner system in vertical expansions

After Qian (2002)

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Overall stability and foundation

Structure	Design consideration
Final cover: Geomembrane, Compacted Clay Liner*, GCL	• Tensile strength on membrane caused by additional waste fill • Stability of new final cover
Lanfill subgrade	• Subgrade changes of the existing landfill caused by additional foundation soil settlement
Landfill and Foundation Stability	• Stability of existing waste during new waste filling on site • Stability of soil foundation due to extra loading • Stability of combination of existing and new landfills in various condition

Compacted Clay Liner* = not recommended for liner system in vertical expansions

After Qian (2002)

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Potential damage to liner facility

Cause of damage	Why it Happened?	Counter measure
Sharp object, foreign bodies	**Excessive stress** due to landfill layer pressure or leachate pressure acting at a point	**Removed sharp objects**, apply a **layer of sand** or protection concrete
Ground settlement	**Uneven settlement of ground** due to landfill layer pressure or leachate pressure cause great strain at local point	**Replace ground** with suitable well compacted earth or rock fill, or **provide high strength reinforcement to control settlement**
Insufficient base support	**Damage to groundwork due to heavy loading** at local point attributed to landfill equipment	**Replace ground** with good material. Apply a **layer of sand or rockfill** and well compact it

Tearing

Damage during installation

Shrinkage

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Potential damage to liner facility

Cause of damage	Why it Happened?	Counter measure
Displacement of **ground foundation**	Upheaval of ground due to displacement caused by earthquake	**Install measures** which are able to **absorb strain** caused by sudden movement in geological condition.
Uplift	**Upheaval** due to **back water pressure**. The force generated can cause **damage to liner facility**.	**Install underground water drainage** facility such as **sand**, **mat**, **culvert**, etc.

Heavy machinery movement

wrinkle

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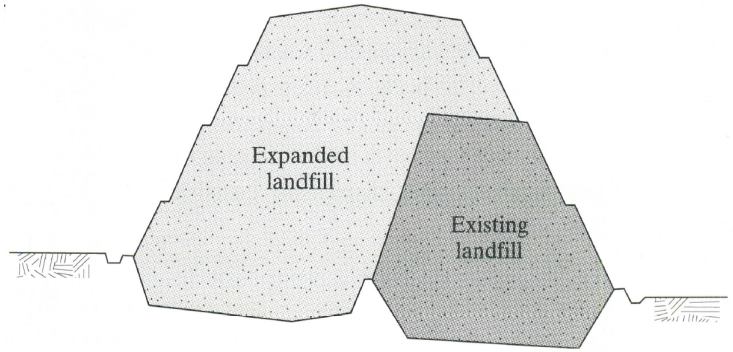
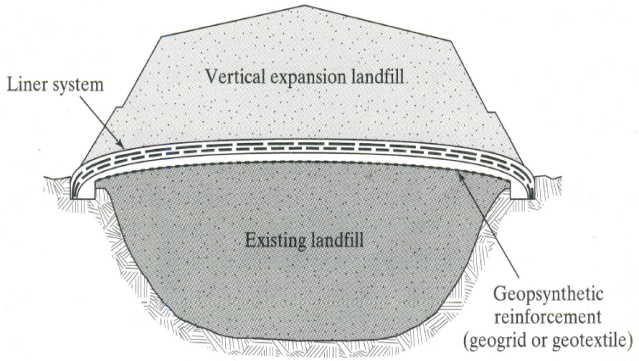
ENGINEERING CHALLENGES



Vertical and Lateral Expansion of Landfill



Piggyback Vertical Expansion of Landfill

Technical design requirement to optimize air space volume additional 50-70 % with 15 - 25 years of extended life span

- **Tangible air space** could be created by construction of perimeter retaining wall with slope stability – **slope failure potential analysis**
- **Settlement** – **differential settlement**
- **Pipe strength** – **design** of **leachate collection pipe**
- **New network** of **storm water management** – to be integrated with new leachate collection
- **New leachate collection** and **management system**

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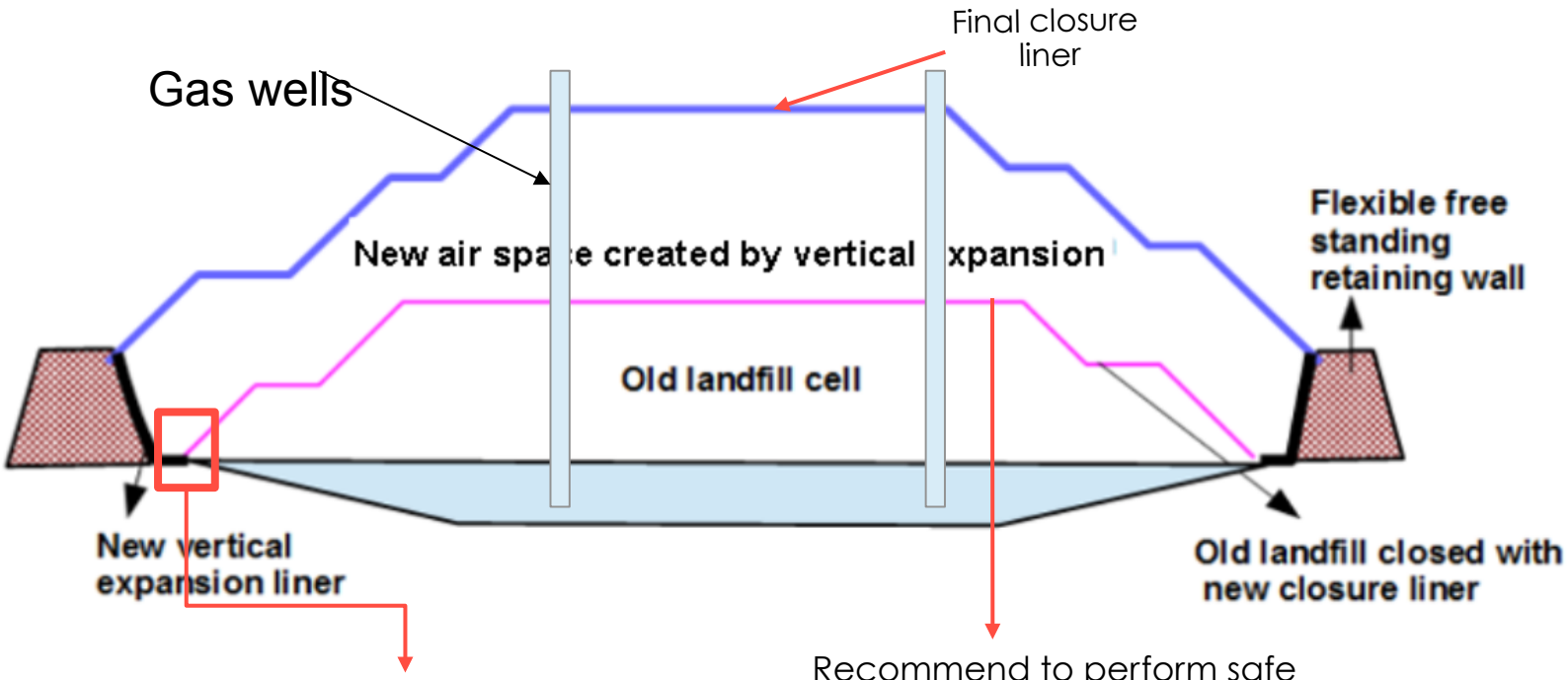
Typical of landfill vertical expansion



Join closure and base liner of old landfill with new liner for vertical expansion

Recommend to perform safe closure for old landfill

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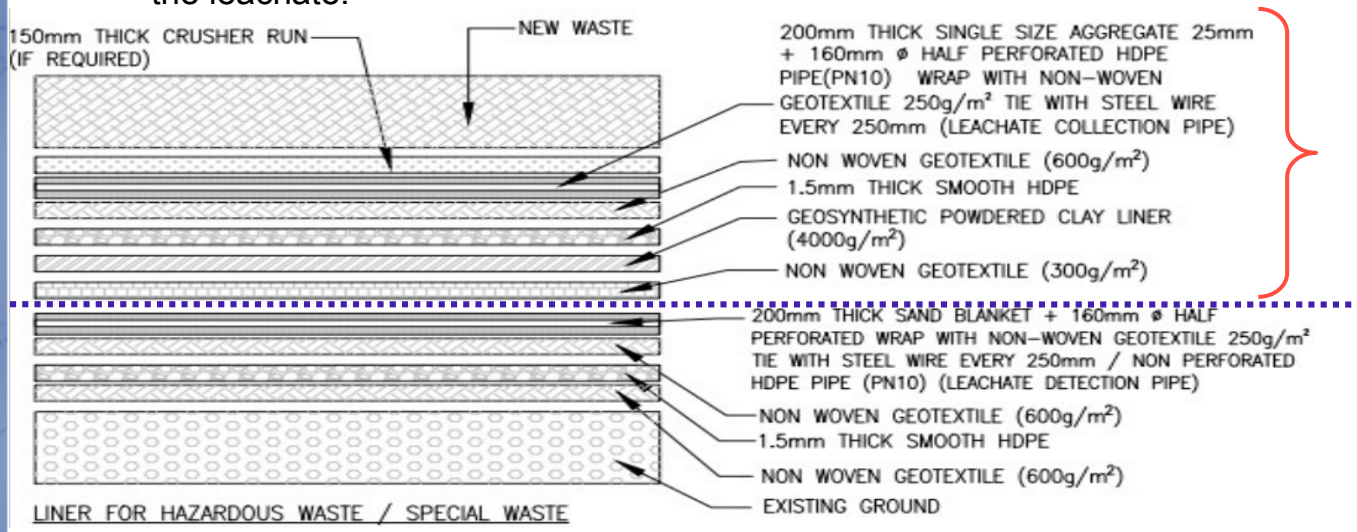
ENGINEERING CHALLENGES

Lining system

- **Suitable liner system** required to **prevent liquids movement** (leachate) and **hazardous material** from landfill into underground water.
- Liners act to **assist management** of **landfill gases.**
- **Double lined system** with **leachate detection system** is provided for **hazardous landfill**.
- This barrier (double liner system) to **detect the leakage** if primary liner fails to contain the leachate.



ENGINEERING CHALLENGES

Maximizing the Air Space of Vertical Expansion

- The cost benefit of vertical expansion required minimum 1.5 to 2.0 times airspace used by old landfill.
- In order to create huge air space, it requires to build high retaining wall that met various stringent criteria as;
  - High resistance against **corrosion**
  - Robust leachate and waste **containment capability**
  - **Stable wall** exceeding 18 ~ 24m height
  - The **wall required to be stand alone**
  - Flexible wall and able to **tolerate differential settlement**
  - Wall able to **tolerate anticipated large ground settlement** and provide stable leachate containment
  - **Cost effective** and maximize the utilization of **in situ materials**
  - Green finishing and **environmental friendly**

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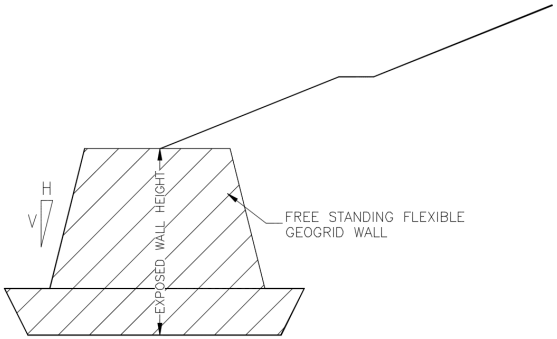
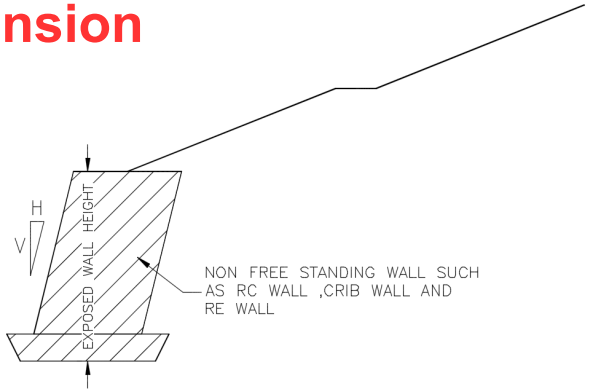
Maximizing the Air Space of Vertical Expansion



Free Standing Wall Flexible Geogrid Wall with two tiers



Non Free Standing Wall, such as RC Wall, Crib Wall, RE Wall and Geogrid Wall

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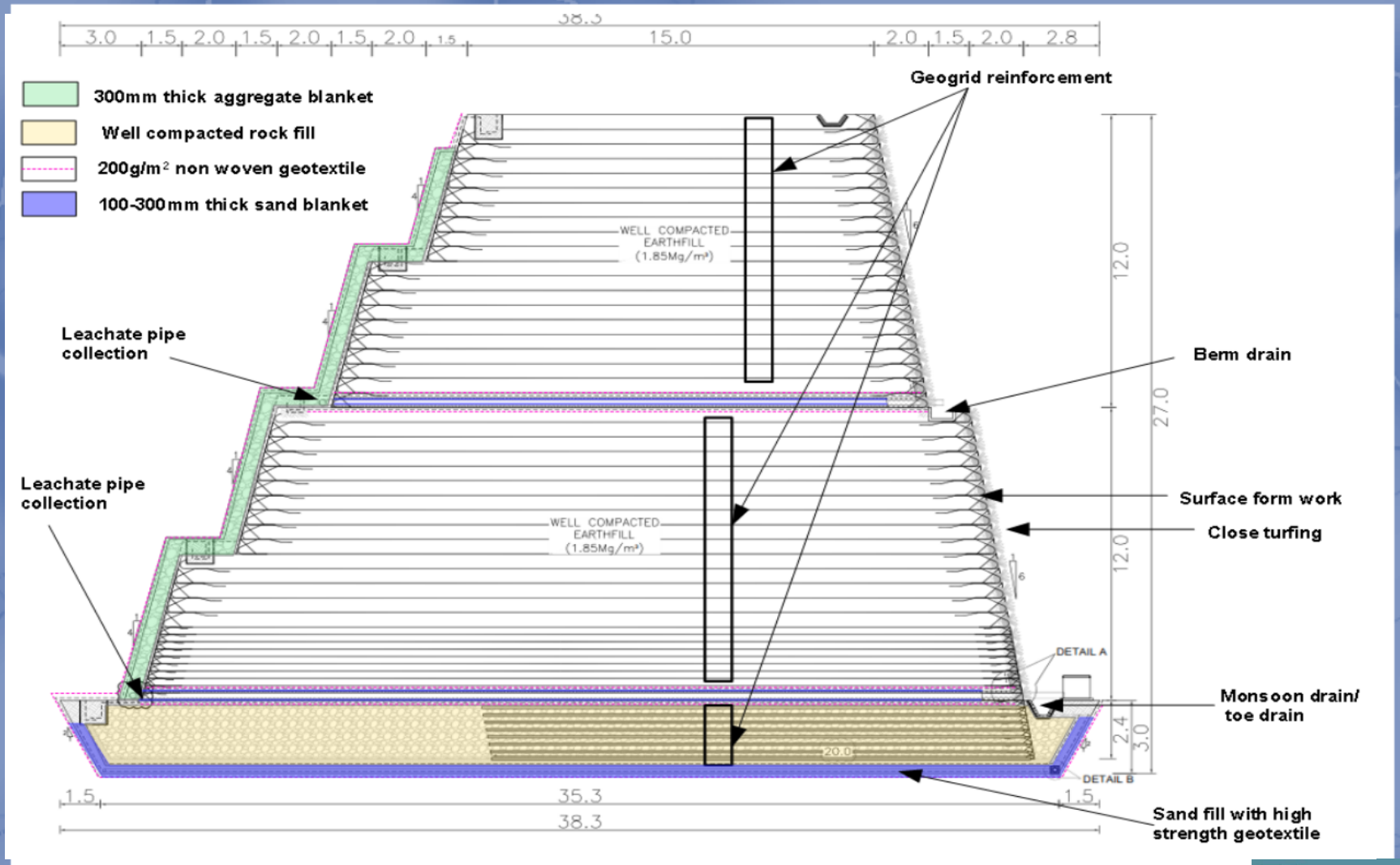
Maximizing the Air Space of Vertical Expansion



Typical detail free standing wall

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Ongoing Vertical Expansion of Landfill within Active Landfill

Parallel works:-

- **Closure** of old landfill
- Creation of **new cells to receive waste**
- **Perform construction** of vertical expansion of new landfill
- Active **storm water and leachate management**
- **Continuous waste filling activities**

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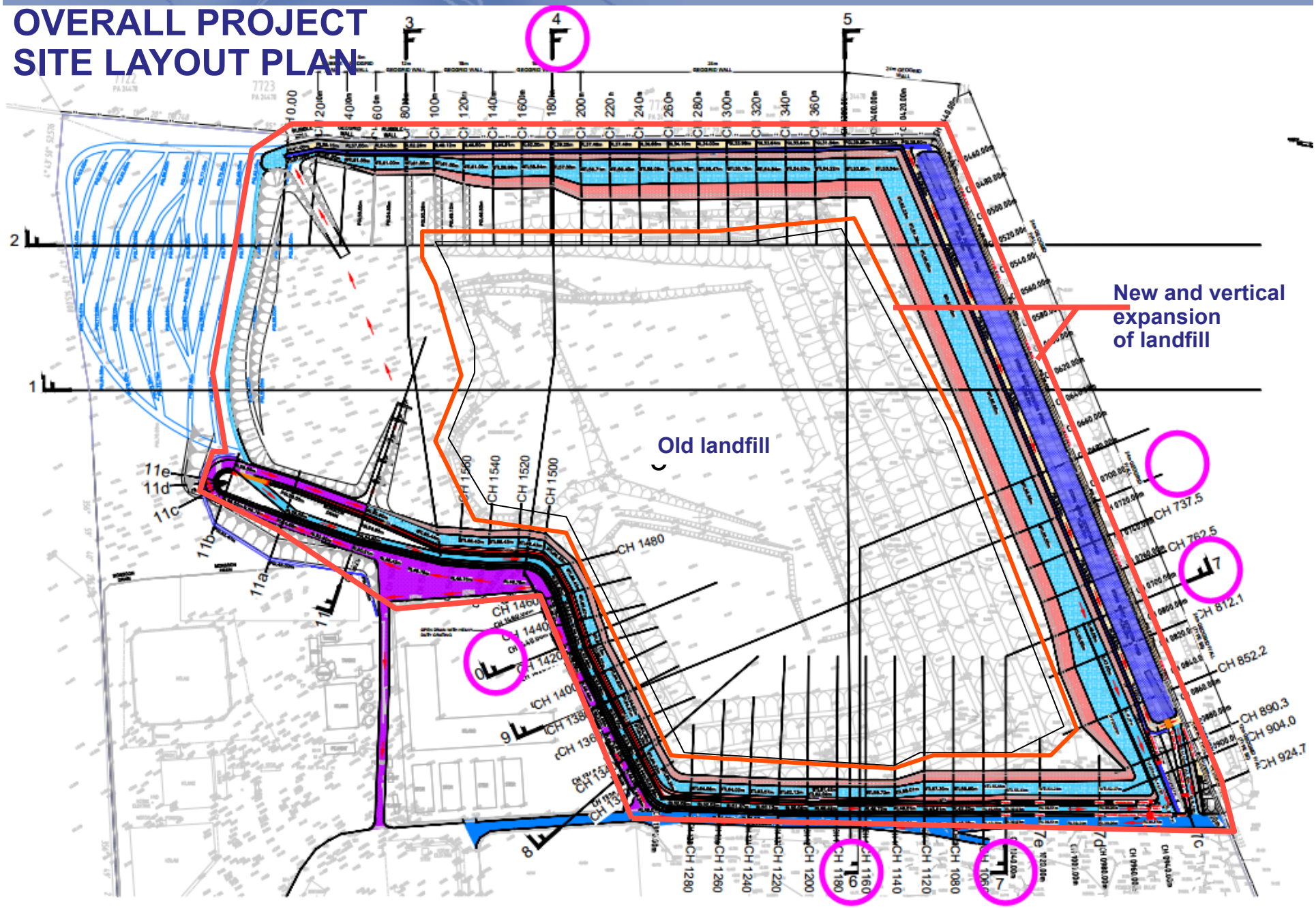
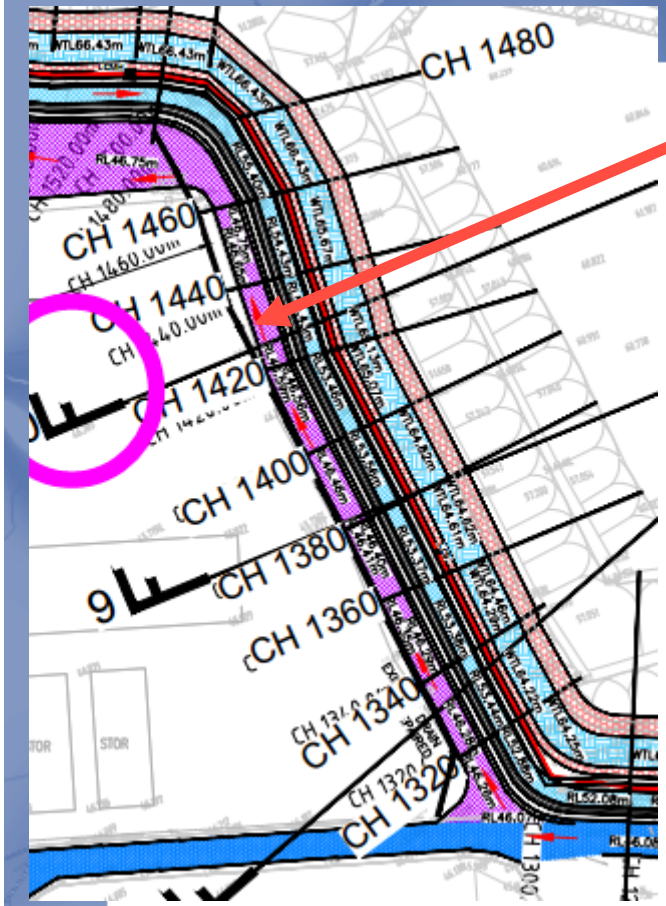
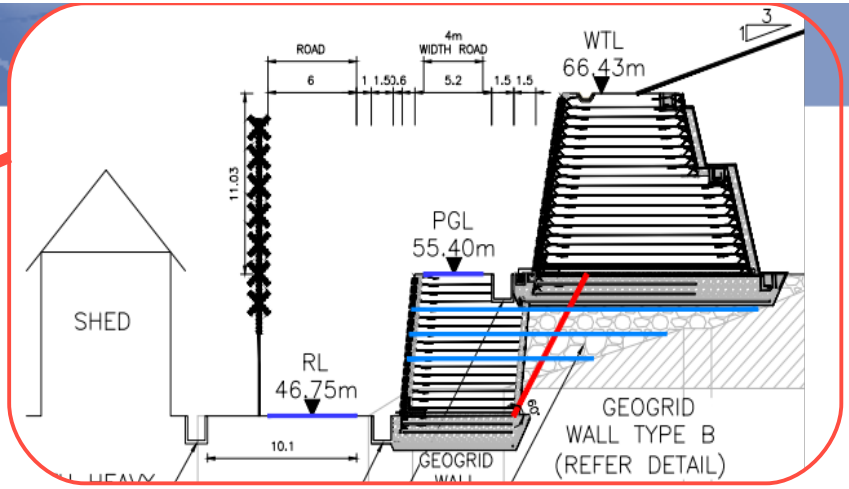
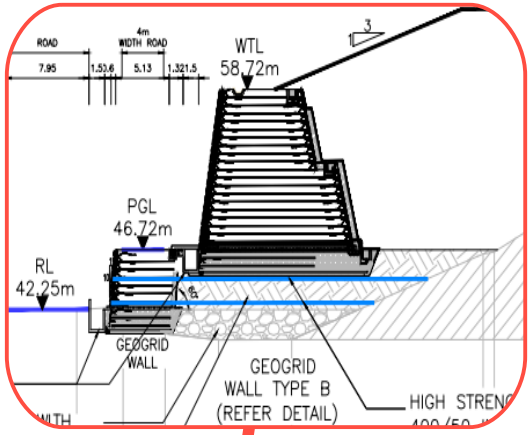
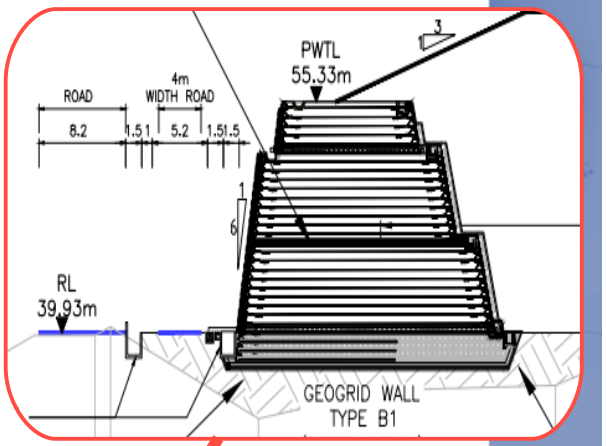
OVERALL PROJECT SITE LAYOUT PLAN

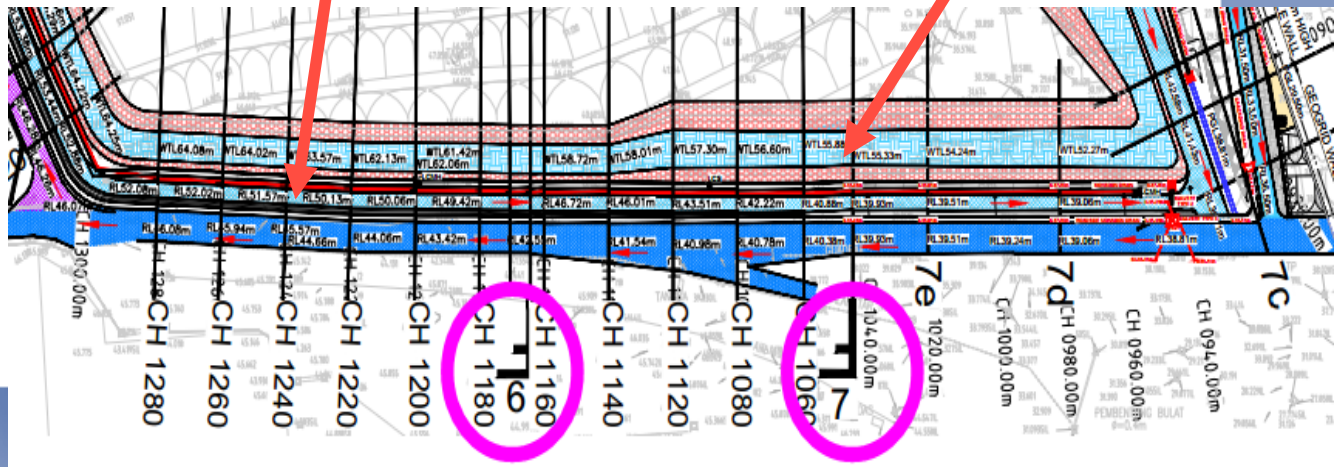










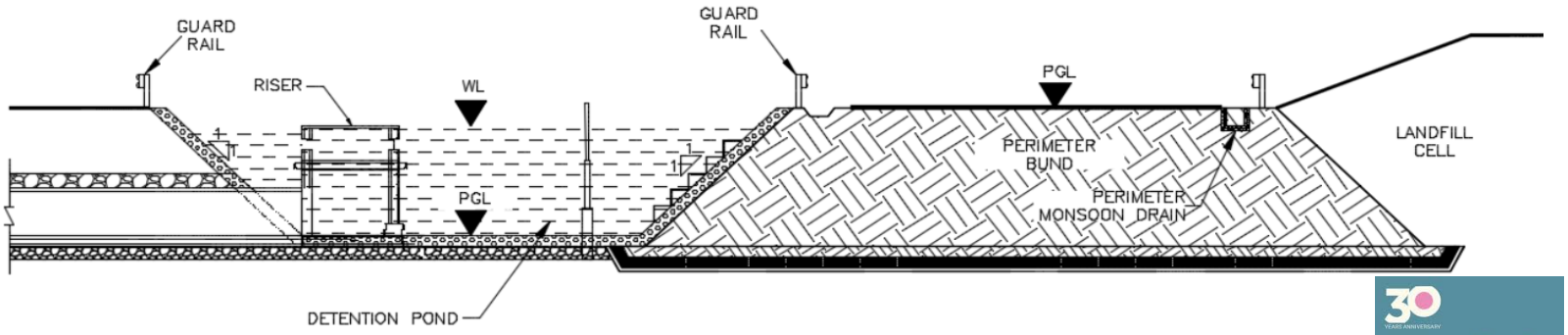


FREE STANDING GEOGRID WALL TYPICAL CROSS SECTION

STORM WATER MANAGEMENT

- The rain water shall be **separated from waste**.
- **Existing landfill** is recommended **to be contained** within **perimeter containment** bund to **prevent leachate runoff** from the cell.
- **External storm water monsoon drain** required to be installed to **separate rain water** or **surface water** from **leachate**.
- **Cell closure** is required to be **systematically design** to ensure all **surface runoff** are well **intercepted and channeled** to the the **external storm water monsoon drain**.

Detention pond CH 700



Typical details of perimeter bund and detention pond

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CONCLUSIONS

- **Adoption of high flexible free standing wall** for landfill vertical expansion works, it is possible by obtaining;
- **Large air space** to extend the life span of landfill
- Able to provide or construct **stable landfill slope**, (gentle final slope cover on top of the geogrid wall).
- The **flexible wall** can also be constructed on poor ground condition **without the need for heavy foundation system**.
- Able to manage the **leachate collection** and **storm water management system** effectively

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CONCLUSIONS

- Extremely **cost effective solution** compare to the development of new landfills
- The concept can also be used for development of new landfill to obtain **higher air space within a small footprint**.
- Construction can be performed with **locally available material**.
- Vertical expansion of landfill could **reduce landfill operational cost and overall new development cost and also carbon footprint reduction for landfill developments.**

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THANK YOU