



Landfill Construction, Operation and Leachate Management for Low-lying Coral Atolls

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Location of three landfills on South Tarawa

All built into tidal sand flats



1. Betio Landfill: historical sea-side tip, enclosed in 1997;
2. Nanikai landfill, purpose built in 2004, operating for 20 years;
3. Bikenibeu landfill, purpose built in 2004, unused for 7 years, opened in 2012.

Betio Landfill in 1990



Area was a tip from the beach into the sea; Betio was the only industrial and commercial centre.

Improvements to Betio Landfill

2003



- Historical tip enclosed by a sea wall in 1997;
- SAPHE project installs fence and leachate pumps in 2003;

Betio landfill Today

- Initial capacity: 54,000m³
- Remaining capacity: ? Maybe two years – 3,000m³?
- Betio will need extending soon, expected to the northwards, alongside existing site, using same access road and gatehouse.

Nankai Landfill

- Opened 2004;
- Two cells, east and west;
- East cell is 18,000m³, West cell is 9000m³
- Total waste to landfill after compaction around 2,000m³ per year;
- The site is overfull by about 1,200m at the latest survey in early April

Bikenibeu Landfill

- Built 2005: remained full of water;
- Opened in 2012 with assistance from MFAT;
- Capacity: 35,000m³
- Current fill rate: around 2,000m³ per year compacted;
- Expected time to fill: 8 years, as long as there are other landfills operating



**Bikenibeu Landfill 2010:
Full of water once built;
Used as Fish Farm for
several years**



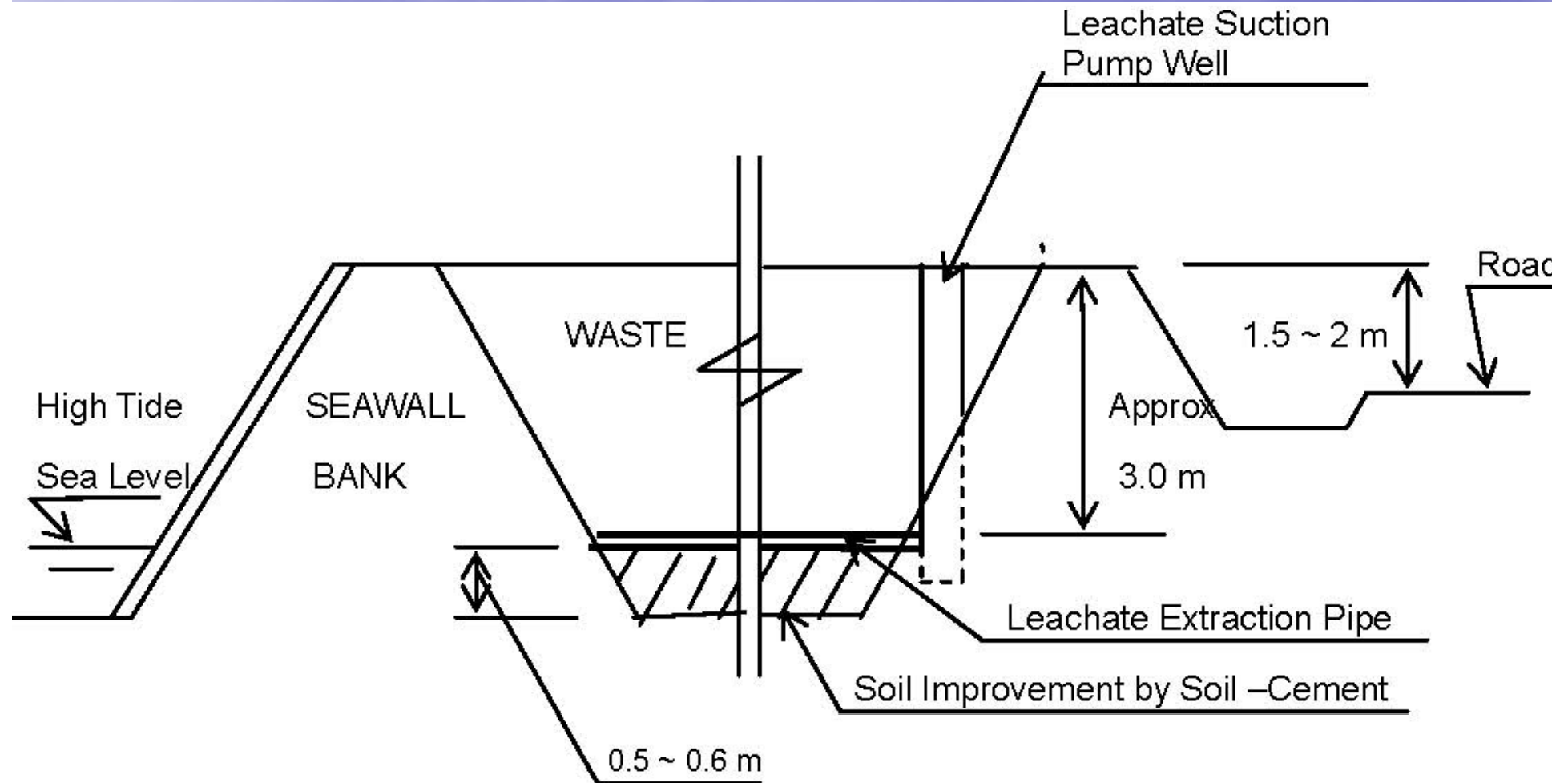
Water Table in the Landfill



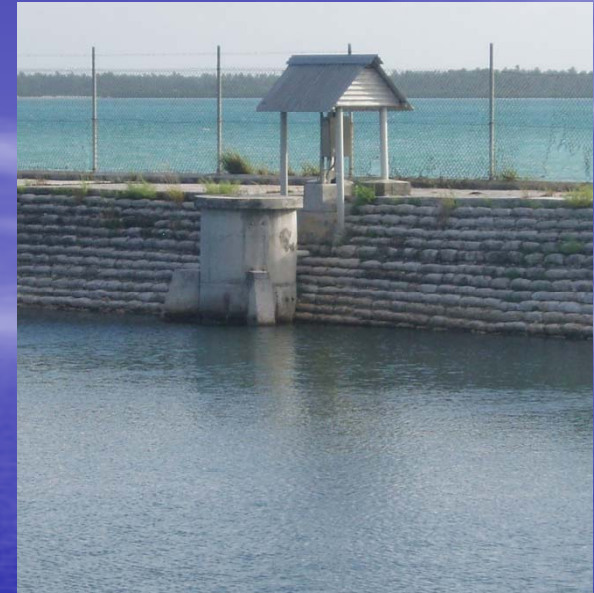
Construction Technique



Construction Schematic

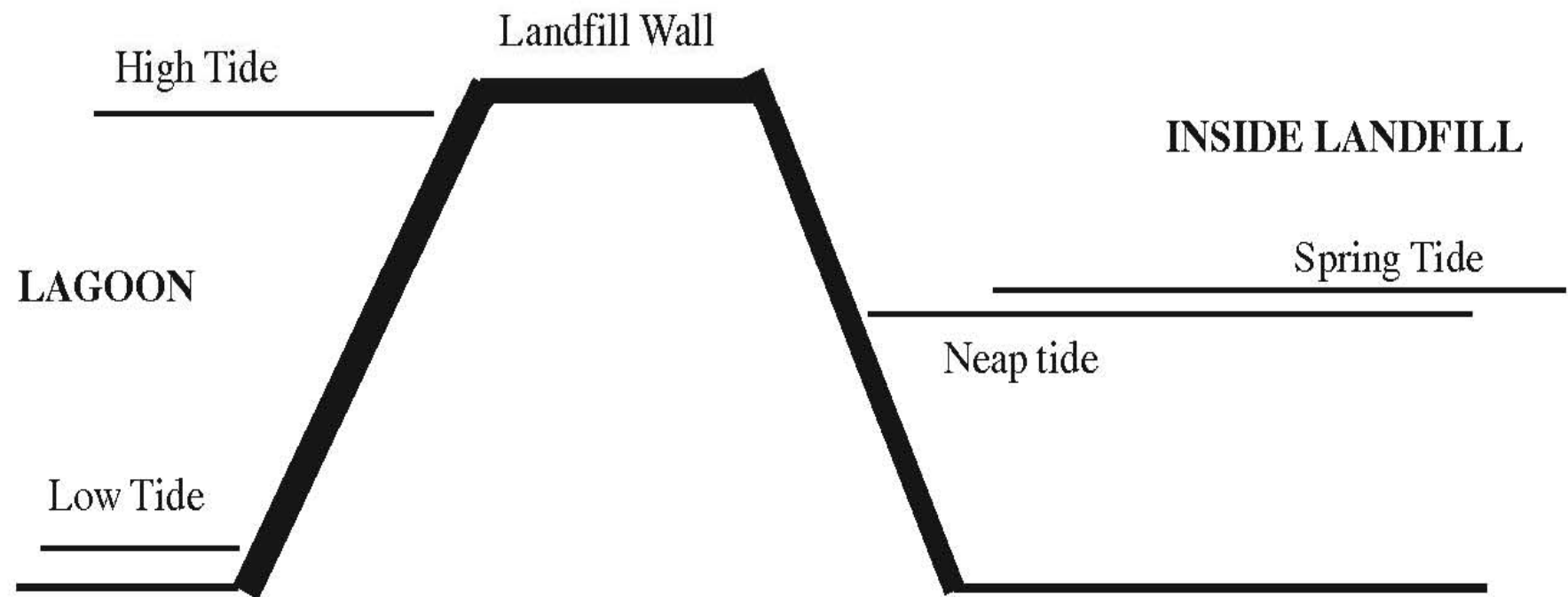


Installed Leachate Systems:



Each landfill had a sump and 2 kW pump with float switch, pumping leachate out of the landfill into the local sewer which in turn pumped untreated leachate onto the ocean-side reef. All quickly failed.

Water Levels in the Landfill



The Problem: where does the water in the landfills come from?

- Water in landfill is above low tide and below high tide;
- During a 10-month drought water level appeared to be stationary;
- Water level did not *appear* to move during a 12-hour tide cycle;
- Local well water is well known to observably move during a daily tide cycle;

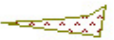




Methodology

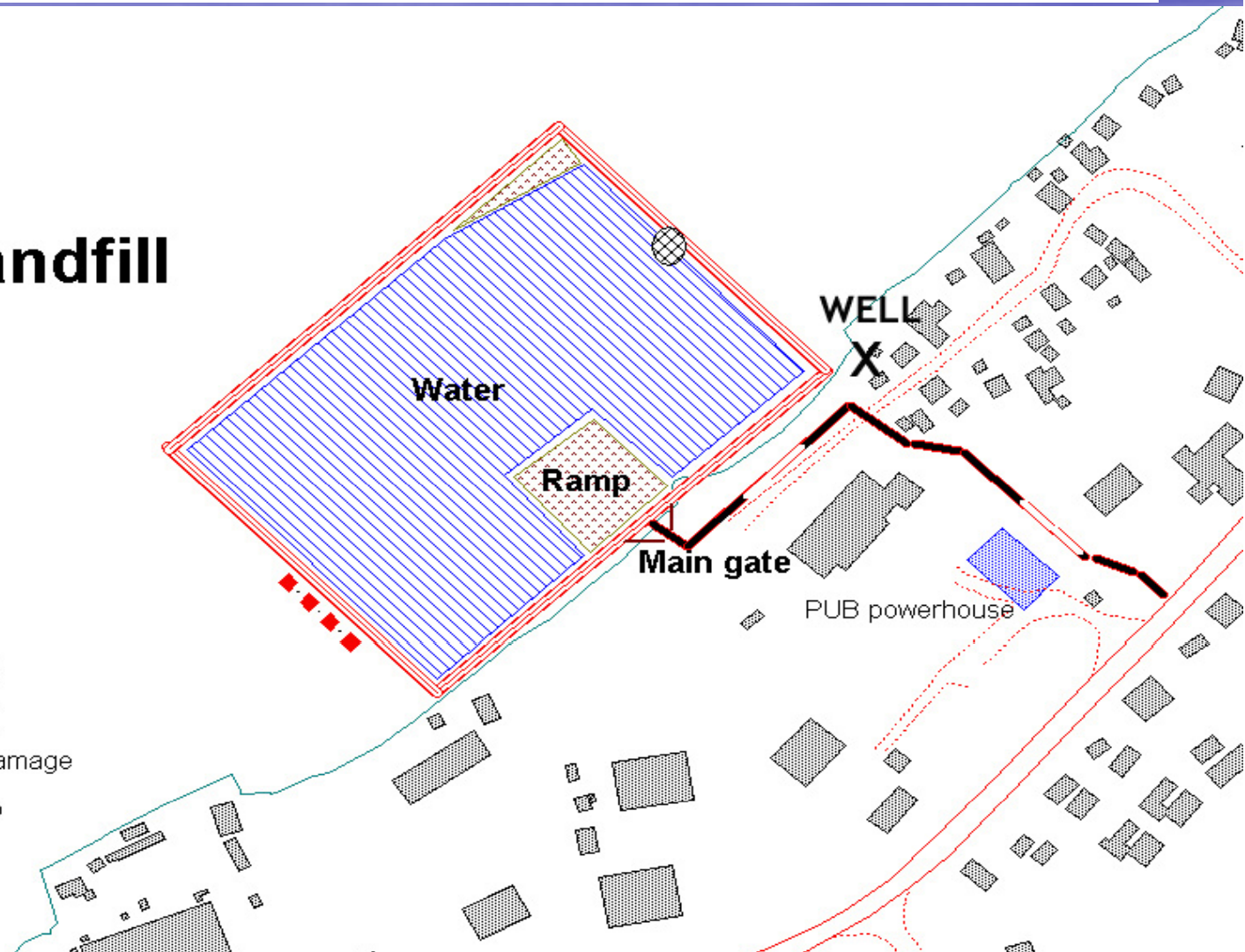
- Measure the water movement in Bikenibeu landfill, with data loggers, across a longer tidal cycle;
- Measure closest well water level concurrently;
- Match this information with the Tide Gauge at Betio, and rainfall;
- Conduct a series of water tests to determine if leachate is polluting local sea water at all three landfills;
- Study the construction of the landfills;
- Develop a hypothesis of what is happening.

Water level Measuring at Bikenibeu

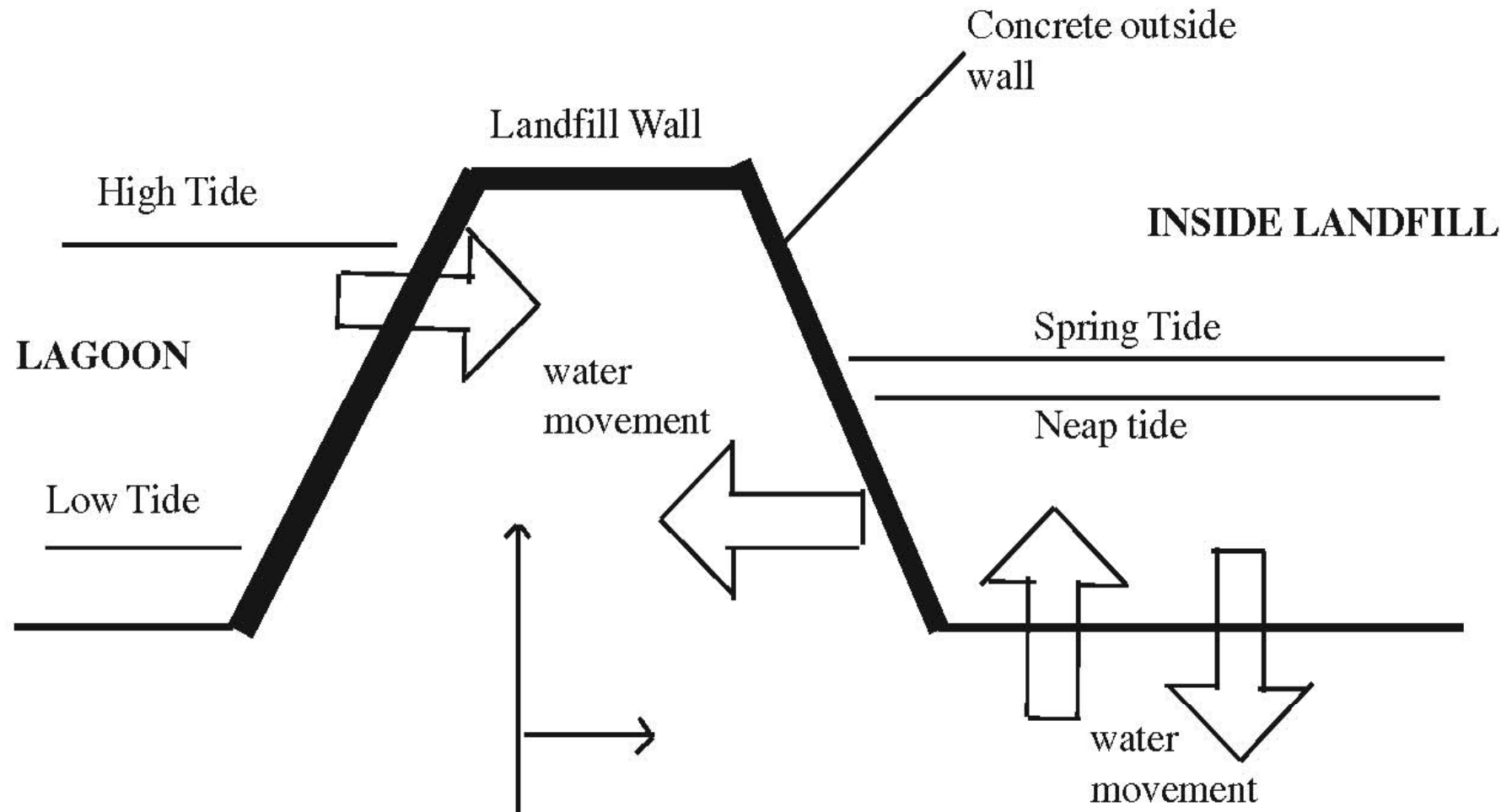
Bikenibeu Landfill

Legend

-  Filled areas
-  Access road
-  Landfill wall
-  Light wall damage
-  SAPHE pump

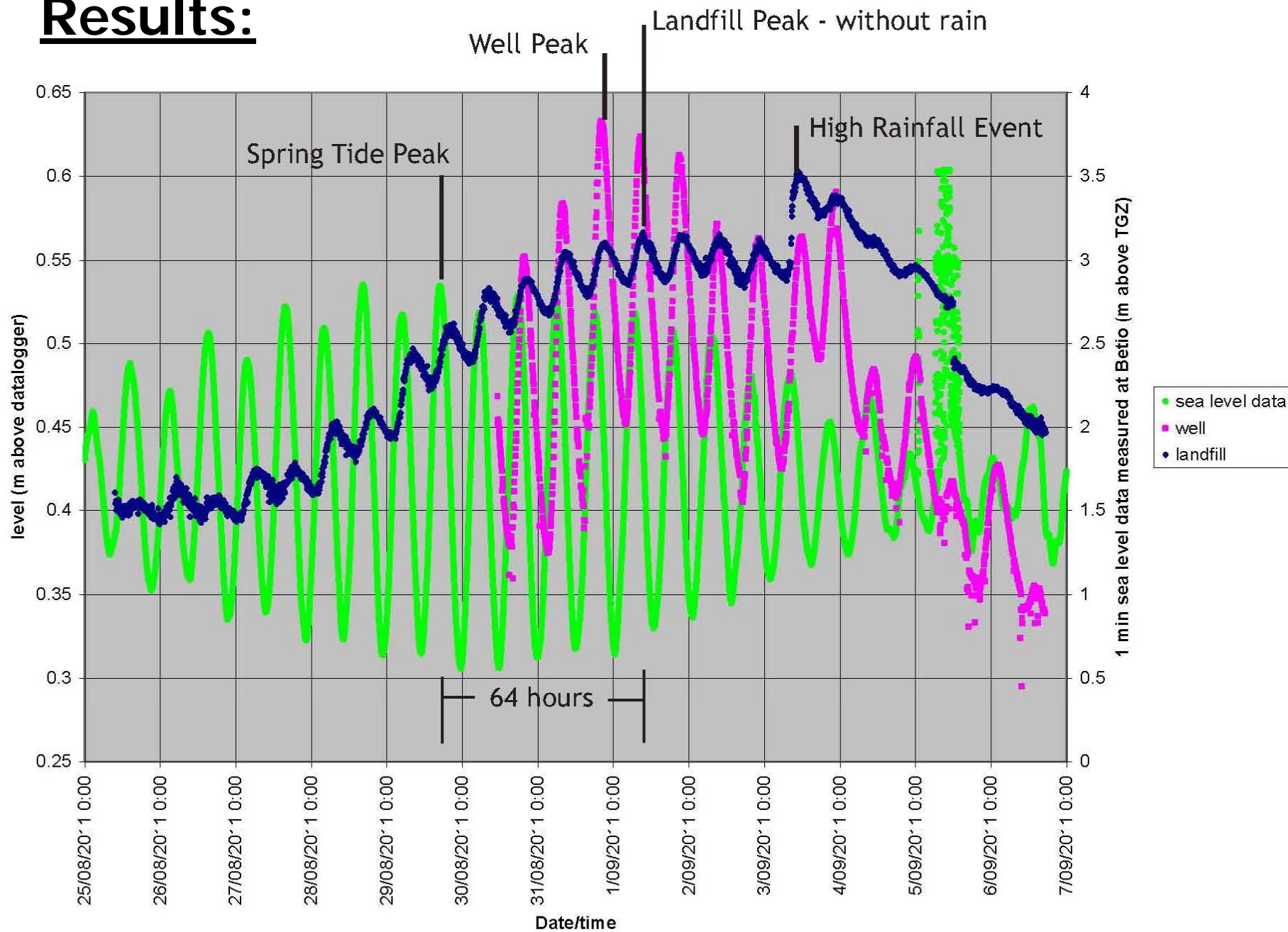


Water movement through the landfill wall



Sand (Calcium Carbonate) inside the wall and the floor of the landfill

Results:



Key Points:

- a) **Water levels in the landfill vary by about 20 – 40mm (3/4 – 1.5 inches) - without rainfall added - with time taken for maxima and minima change about 6 hours (similar to the tide);**
- b) **Water levels in the well vary by about 200 – 240mm (normally about 200mm) over a similar 6 hr period between maxima and minima;**
- c) **The ratio varies, but is around five to eight times the movement of the well water compared to the landfill water level;**
- d) **The tidal range is of the order of 2 – 2.5m, roughly 100 times the movement of the landfill water, and 10 times the well water movement**
- e) **The peak water levels in both landfill and ground (discounting rainfall) are several days after the peak tide, an unexpected result, but clearly shown from both data loggers.**
- f) **Water levels in both landfill and well are affected by rainfall i.e. the pattern diverges from the modulated tidal changes, for example after the rainfall on 3rd and 6th September.**

Water Test Results

- All three landfills' waters tested six-monthly for two years, inside and outside;
- Bikenibeu was tested before any waste put inside, and then after coming into use;
- Detailed testing in an NZ laboratory for typical range of landfill leachate chemicals;
- Nanikai shows no significant pollution; even Betio with an older, crude – but thicker – sand wall is relatively good;
- Water testing was from late 2011 until late 2013, and then again 2022 and 2024.

Calcium Carbonate for Leachate Treatment

- At 25°C nitrate removal rates are much higher – over 90%
- Lower hydraulic gradient across the filter increases filtering capacity
- The Calcium Carbonate does slowly go into solution, so would possibly need replenishing over time.

Discussion

- The dataset is very short, ideally would be at least one whole lunar cycle;
- The authors are not water specialists, but have consulted closely with those who are;
- Water is moving across the landfill wall in both directions driven by a hydraulic gradient;
- The landfill wall dampens out the tidal hydraulic gradient to a significantly greater extent than the land dampens the well movement;
- Leachate cannot be pumped out of the landfill, as the sea will come in as fast as you can pump it out.

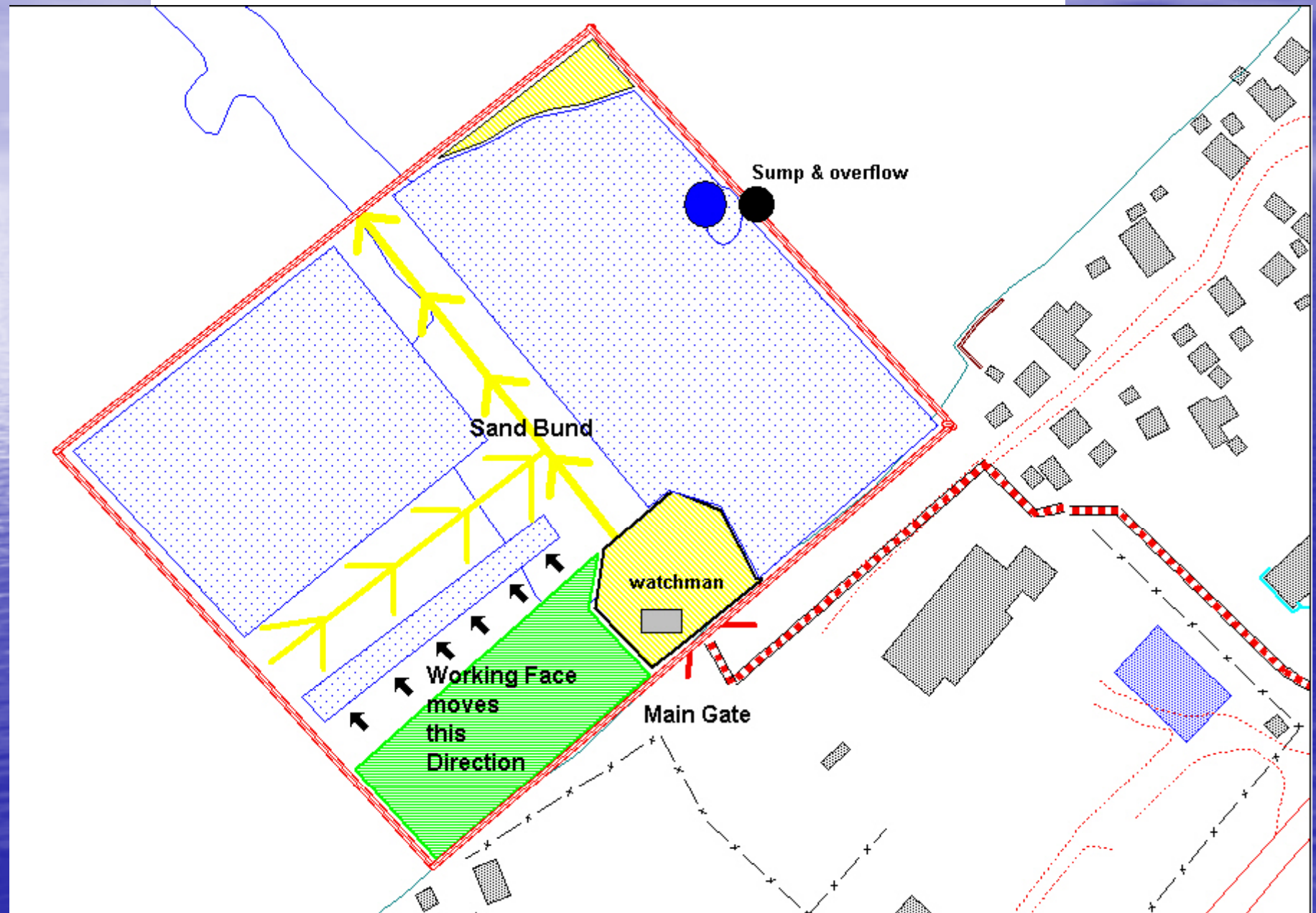
Hypothesis

- The sand-filled landfill walls are acting as a filter;
- Coral Sand – Calcium Carbonate – is chemically treating the leachate;
- It is essential to allow water to move across the wall for landfill operation;
- Landfill wall design and construction must take this into account in this environment;
- Traditional leachate management system of sumps and pumps is no use, will be expensive and cause external pollution.

Conclusions From Study

- Having the three landfills in different states has provided an excellent opportunity to conduct a trial;
- Understanding how the water is moving is also essential for ongoing day-to-day landfill operation and management, especially during periods of high rain fall;

Landfill operations











Nanikai Landfill Remediation

- In April 2011 access to landfill no longer possible as waste spilling out of gates;
- From June to September 2011 the east cell was cleared and all waste dumped into west cell;
- Landfill has reached capacity by early 2023

Nanikai Landfill c.2007



Nanikai Landfill East Side 2011



Where can ISLANDS help us?

- Landfill wall design to build new landfills;
- Design of an engineered new skin for the existing landfill walls at the three landfills
- Also support for the new Materials Recovery Facility (MRF) built on Betio landfill;
- Support to the ELV system



**Proposed
Landfill
Extension**

BETIO SHIPYARD

**Existing
Gateway**

Small boat harbour

Access Road

**Kiribati
Oil
Company
Tank
Farm**

**Current Landfill
Area**

Port Authority Are

Customs House

Possible Nanikai Landfill Extension















