

GROUNDWATER AND SEDIMENT ANALYSES OF A MANGROVE SWAMP NEAR BOVONI LANDFILL, ST THOMAS, USVI

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Mangroves and Ecosystem Services

- Mangroves buffer the interaction between terrestrial and oceanic environments
 - protecting land and human development from storm surges (Zhang et al. 2012; Kathiresan and Rajendran 2005; Mazda et al. 1997)
 - trapping terrestrial pollutants (Tam and Wong 1999; Clark et al. 1998; Harbison 1986).

Mangroves in St Thomas, USVI



- Largest intact stand of mangroves on St. Thomas is between Bovoni Landfill and Mangrove Lagoon, a protected marine reserve.
- Pait et al. (2014) found heavy metal concentrations (Cr, Cu, Pb, Hg and Zn) in Mangrove Lagoon sediments
 - Bovoni Landfill possible source?

Mangroves in St Thomas



- No published papers on the mangroves themselves
- Little known about impacts from the landfill
- The EPA observed violations of waste management at Bovoni Landfill:
 - improper disposal of medical and septic waste, used oil, lead-acid batteries, and migration of leachate into the adjacent mangroves (Complaint at 16, USA v. The Government of the Virgin Islands et al. 2006)).



Mangroves in St Thomas

2002



2014



- The Nature Conservancy (TNC) expressed concern about the health of these mangroves (Anne-Marie Hoffman, pers. comm.).
- Natural or man-made causes? What influences mangrove health?

Seasonal Variation in Standing Water



A



B



C



D

Dry Season
December – July*

Wet Season
July – November*

Photos A, C, and D were taken by JAK, photo B was taken by KW

- Standing water levels in the mangroves varies throughout the year.
 - No strict wet and dry season in the Virgin Islands, it is generally drier from December to July (Crossmand and Palada 2003).
- How does this variability affect the mangrove swamp?

Research Questions

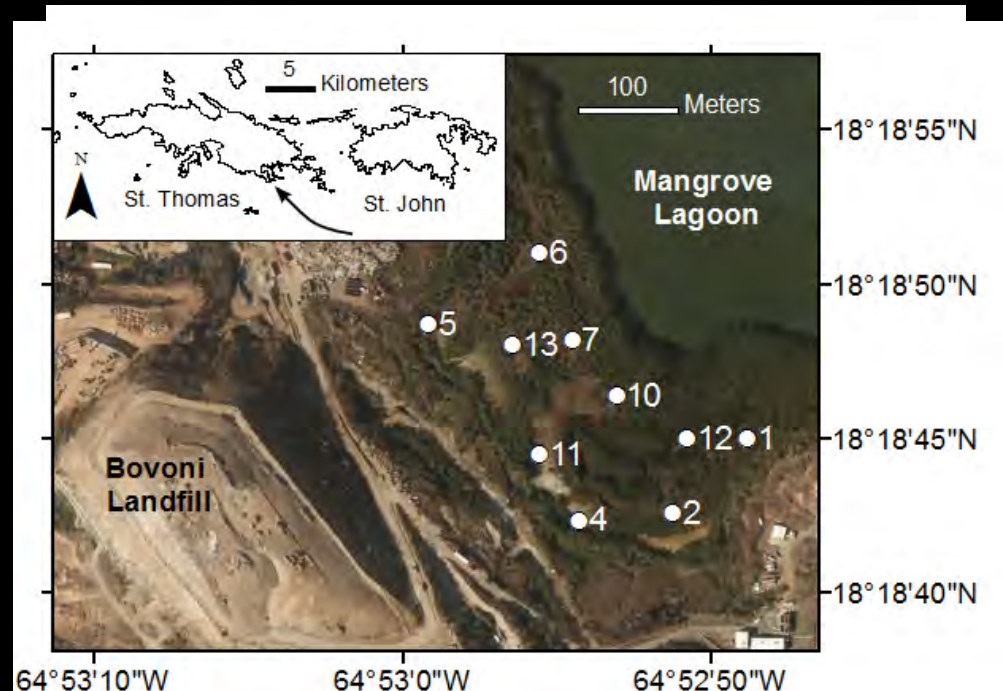
- Does groundwater flow from the landfill toward Mangrove Lagoon?
- Does groundwater flow change throughout the year?
- Are heavy metals found in groundwater and sediments?
- What are implications for management decisions?



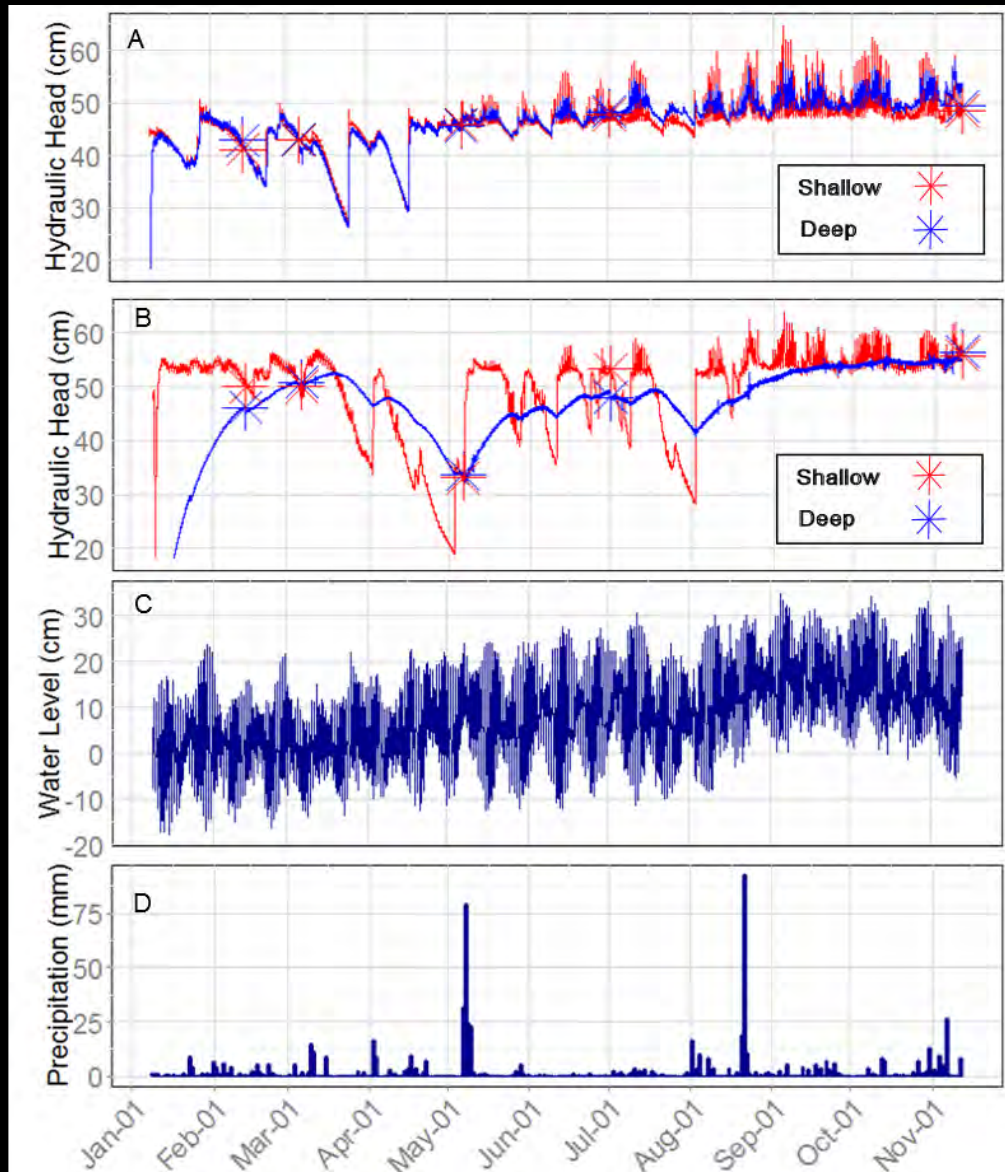
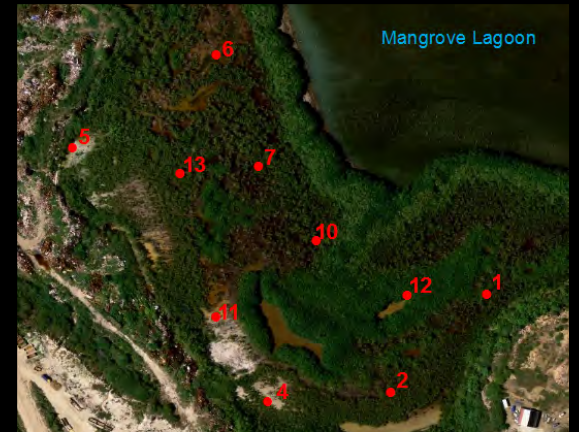
JAK

Methods – An Integrated Approach

- Groundwater wells
 - Vertical and horizontal flow, influences on groundwater levels
 - Groundwater chemistry
- Sediment cores
 - Stratigraphy, dry bulk density, percent water content, percent organic content, shear strength
 - Heavy metal presence in sediment particles

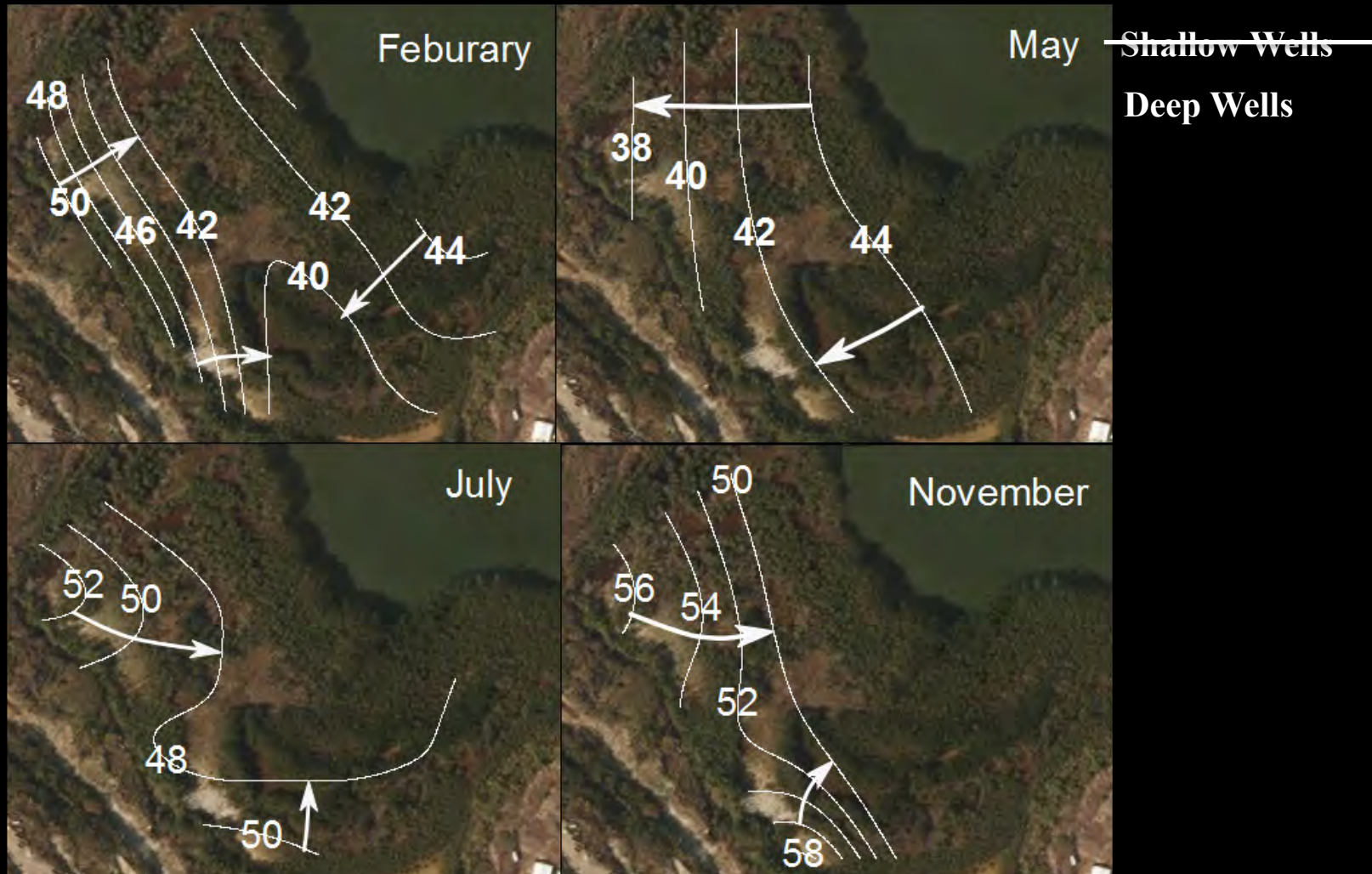


Precipitation and Sea-Level Influences



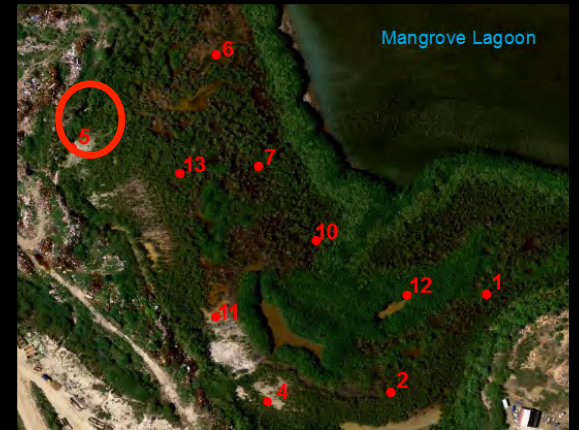
- Rainfall more influential in the upland area.
- Tides more influential near the lagoon
- Daily tidal signal after rise in mean sea-level and two large rain events

Groundwater Contour Maps



- Groundwater flow direction changed seasonally
- During the dry season, groundwater flows into the mangroves
- During the wet season, groundwater flows into the lagoon

Heavy Metals in Groundwater



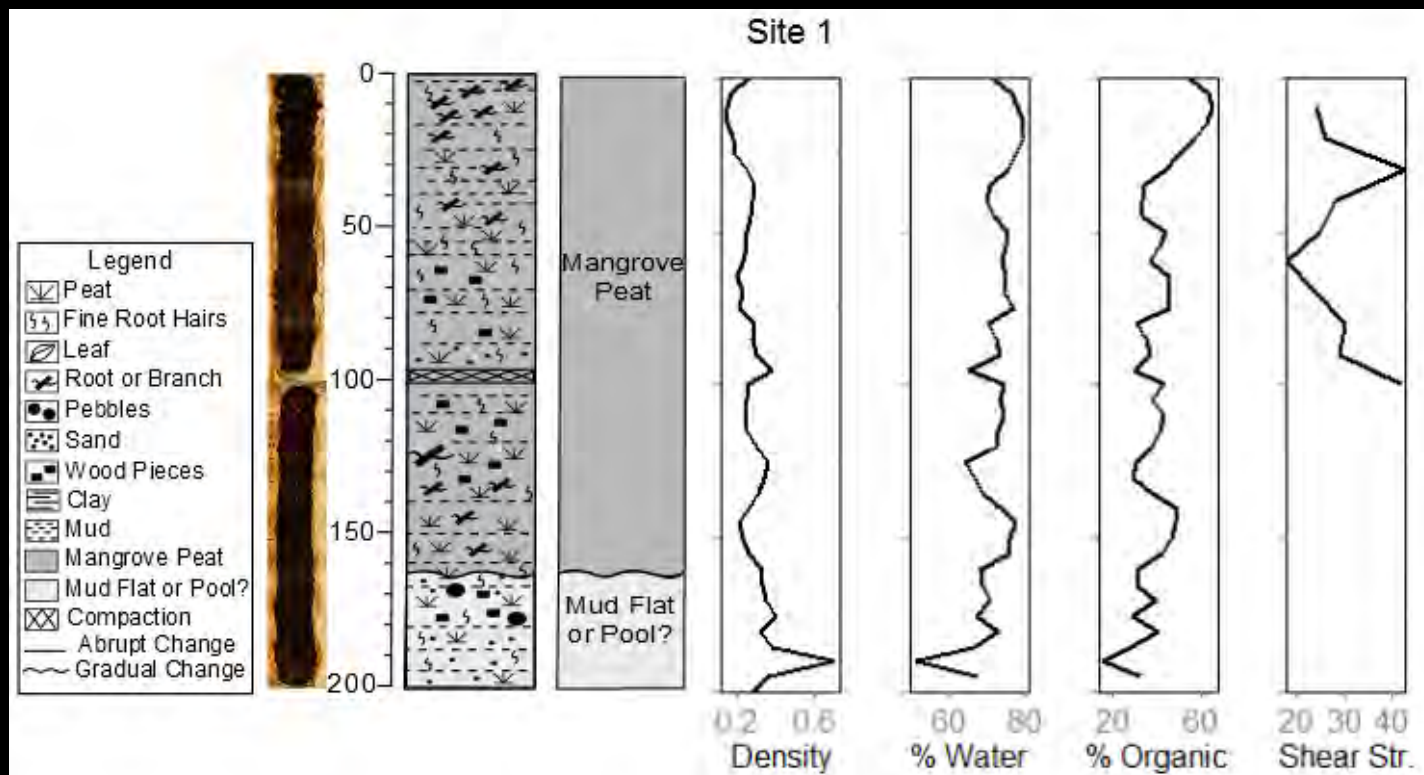
	TDN	Cr	Ni	Sn	Zn
Sample ID	mg/L	µg/L	µg/L	µg/L	µg/L
Reporting Limit	0.1	20	40	100	40
Site 1 Shallow	6.21	35.5	--	--	--
Site 1 Deep	4.45	39.2	--	--	--
Site 2 Shallow	14.1	47.1	--	--	--
Site 2 Deep	4.71	41.7	--	--	--
Site 4 Shallow	4.94	23.4	--	--	--
Site 4 Deep	5.14	30.9	--	--	--
Site 5 Surface	20.9	37.3	130	--	67.7
Site 5 Shallow	--	33.5	82.2	--	--
Site 5 Deep	15.0	51.7	--	--	--
Site 11 Shallow	15.2	47.1	--	--	--
Site 11 Deep	9.75	35.4	--	--	--
Surface Ditch	120	74.5	99	105	--

- Surface and shallow groundwater is a more important conduit
- Only one round of water chemistry tests was performed and not all sites were tested.

Sediment Cores

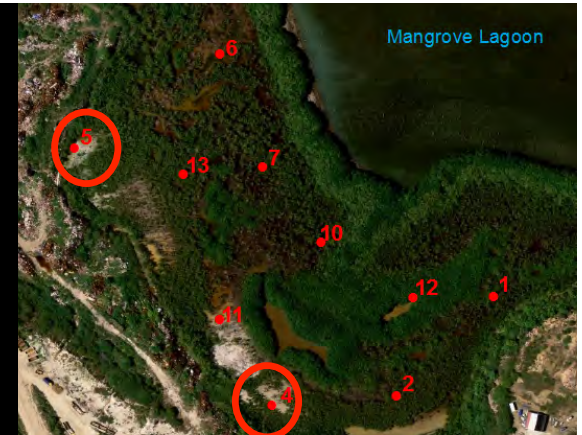


- Environmental interpretations (mangrove peat and mud flat or pool) were based on stratigraphy.
- Dry bulk density (g/cm^3), percent water content, percent organic content, and shear strength (kPa) were compared between these interpretations



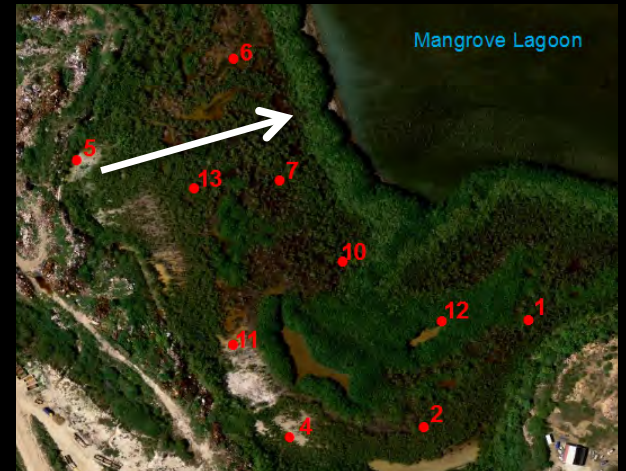
Heavy Metals Found in Sediment Particles

- At least two samples from each site were tested (more from sites 4 and 5)
- Titanium and Bismuth were found in samples from site 4
- Titanium, Bismuth, Iron, Tin, and Zinc were found in samples from site 5.
- Stratigraphy from sediment cores help explain the distribution of metals in the area

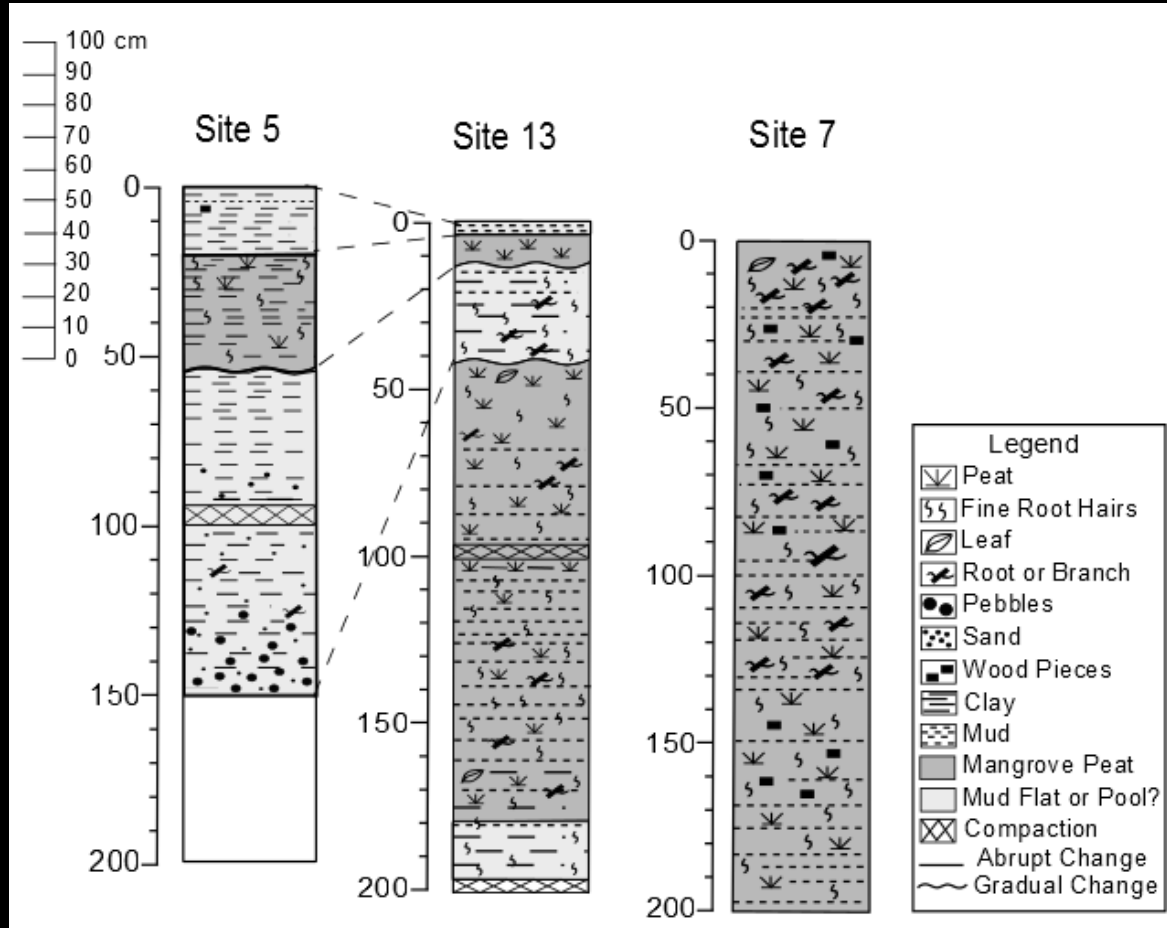


Site	Depth	Site	Depth
1	1	5	87
1	43	5	112
1	168	5	132
2	0	6	23
2	162	6	52
4	2	7	2
4	7	7	32
4	12	10	23
4	22	10	147
4	42	11	3
5	3	11	63
5	7	11	123
5	12	13	12
5	19	13	131

Sediment Cores – Cross-sections

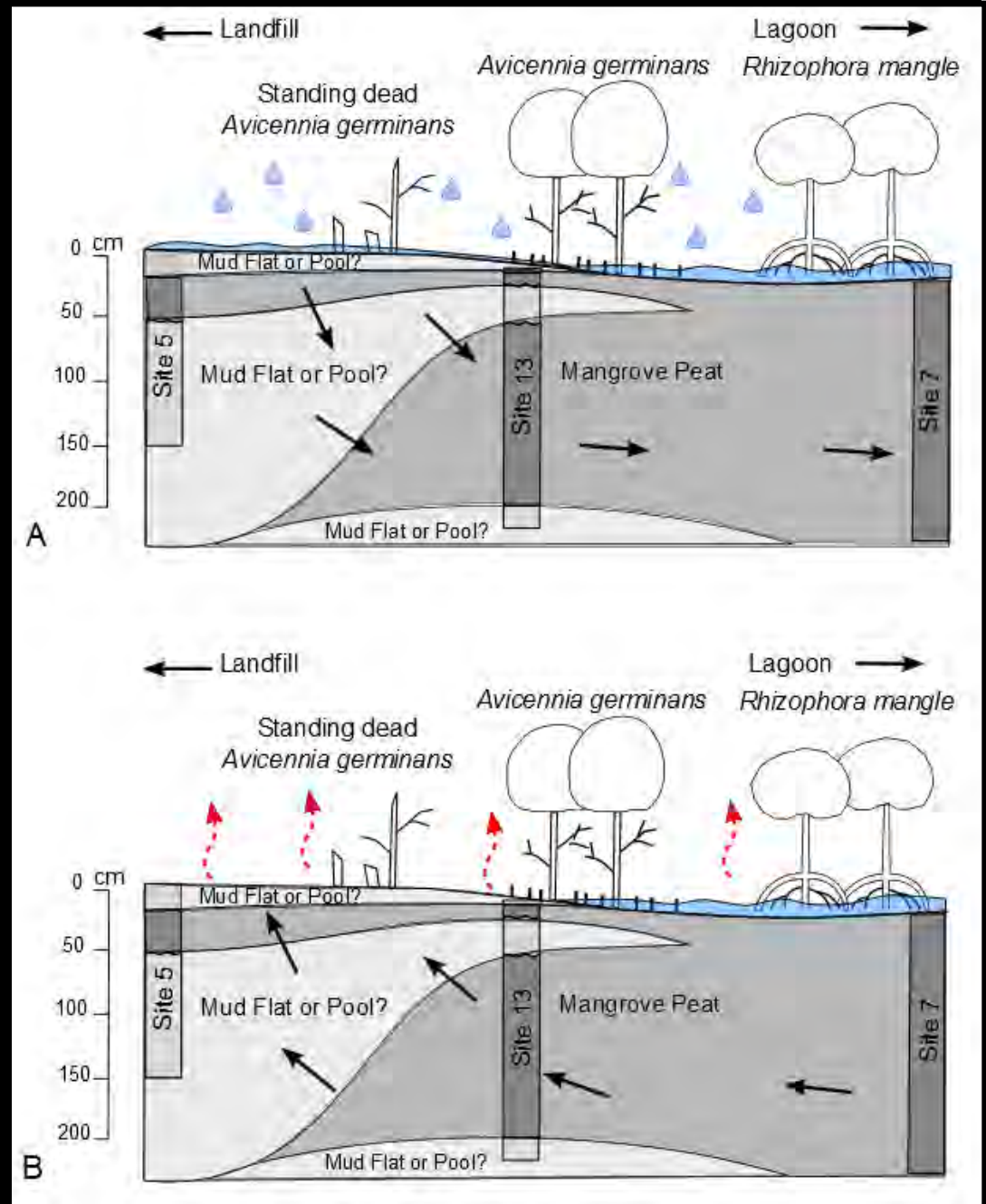


- Clay rich sediments closer to the landfill are likely slowing groundwater flow and trapping particles containing heavy metals



Conclusions

- Groundwater flow direction changed based on precipitation and sea-level
- Chemical constituents from terrestrial sources would be transported into the Mangrove Lagoon during the wet season
- Groundwater was more responsive to precipitation than tides near the landfill, vice versa



Changes in the hydrologic regime or increased sediment input could be causing patches of dead mangroves

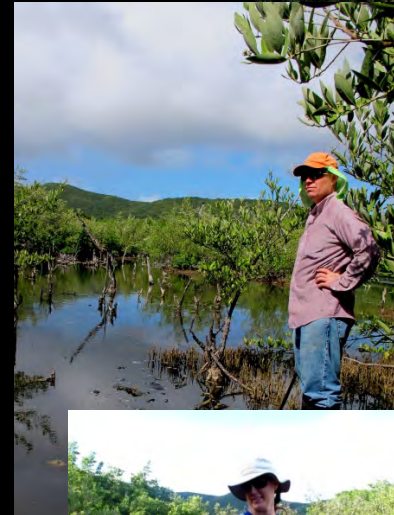


Conclusions

- Diurnal tide signals were only present when groundwater levels were above a certain point (~45 cm)
 - presence of some sort of barrier?
- Metals are entering the mangroves via physical transport in the sediment and via chemical transport in the surface water and groundwater
- The mangroves swamp is trapping heavy metals, protecting the lagoon from terrestrial-based pollutants

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aine

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