Potential Habitat Modification of Mangrove Basins

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Sites visited

- Northumberland Drive SEPP14 Wetland
- Angels Beach Dr Chickiba Ck SEPP14 Wetland
- Mangrove basin west of STP also SEPP14

Northumberland Drive

Area highlighted contains

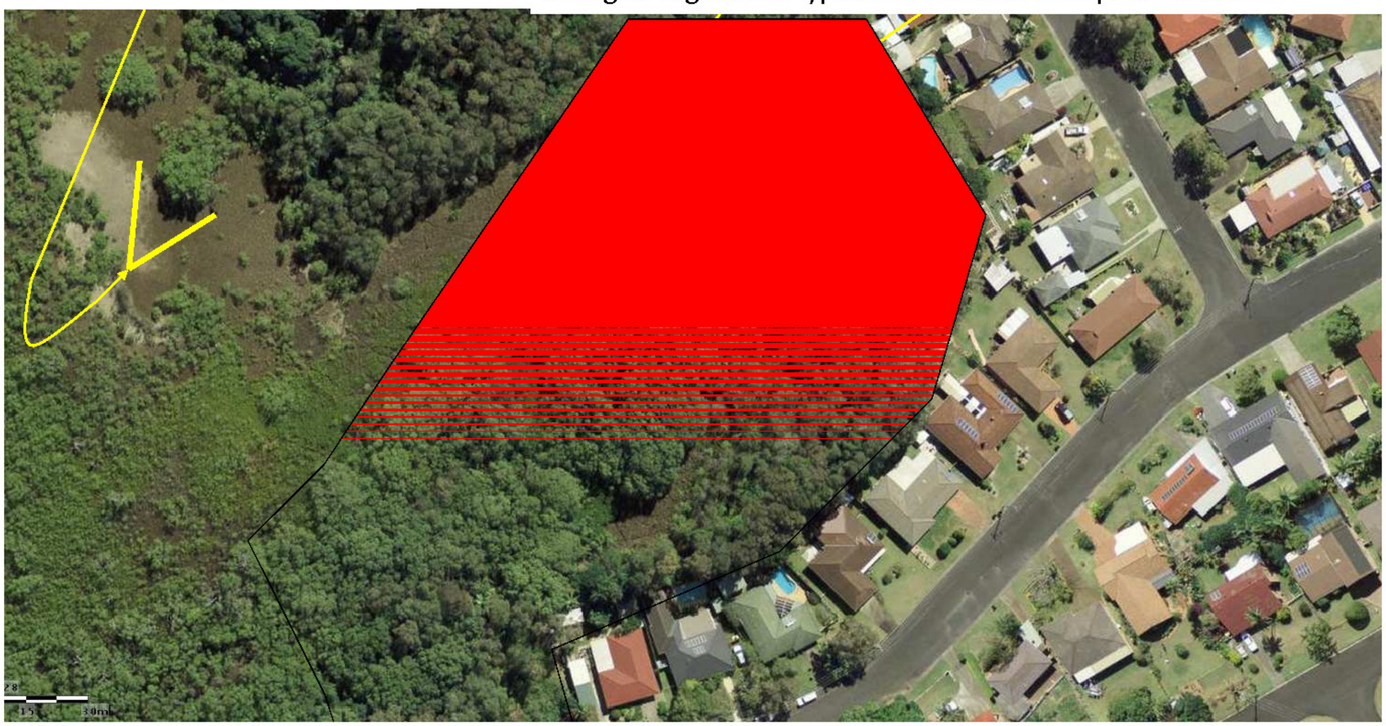
- a number of complicated hydrologic features
- variety of vegetation types
- appears to possess mosquito habitat
- may be due to past modification such as constructed drainage that has now grown over

It may be possible to reduce the *Aedes* mosquito hazard by changing hydrology

It seems unlikely that rainforest freshwater areas in from Craig St (north of outlined section) with *Verralina* nuisance can be improved by us.

Saltmarsh with good flushing and limited mosquito hazard

Within the highlighted area hydrology is complicated by remanent drains and ongoing stormwater inputs which appear to have changed vegetation types and increase mosquito hazard.



Angels Beach Drive

Area highlighted contains:
• Accessible hydrologic features;
• Mostly saltmarsh with sedge and mangroves;
• Appears to possess mosquito habitat indicated by suitable depressions with limited flushing;
• Some impact of past vehicle tracks that may now contributes to mosquito problem.

It may be possible to reduce the mosquito hazard by flushing depressions – as in runnelling type approach or filling some areas to limit inundation.

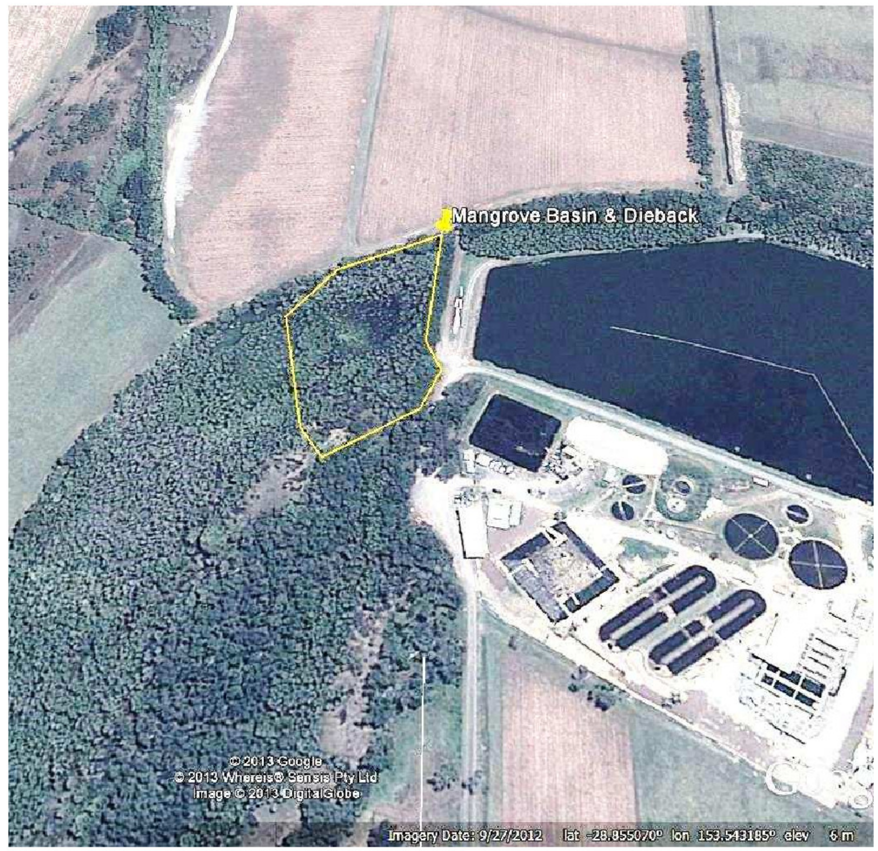
This pool is isolated from all but the highest tides which inundate the pool by moving along the roadside table drain. The limited flushing of the site exacerbates mosquito hazard.

Mangrove Basin & dieback near STP

Area highlighted contains
- a number of vegetation communities including mangroves, 2 saltmarsh forms and casuarina etc.
- The mangrove back basin has experienced dieback and is poorly connected hydrologically
- the site appears to contain a variety of mosquito habitats

It may be possible to reduce the mosquito hazard by changing hydrology

It may also be possible to improve mangrove basin health by reconnecting the basin



Saltmarsh with good flushing and limited mosquito hazard

Within the highlighted area hydrology is complicated by remanent drains and ongoing stormwater inputs which appear to have changed vegetation types and increase mosquito hazard.

Outcome

1. Preparation of reports similar to Bosun Bld site investigated in the Tweed;
2. Contribute to the development of EIS requirements for assessment of site for recommended works;
3. Contribution being sought $15,000.

Proposal

1. Obtain LIDAR or elevation data (~1m resolution) and develop detailed topographic map
2. Conduct hydrologic survey and construct detailed tidal connectivity model (in-situ loggers)
3. Develop wetland – mosquito model
4. Evaluate potential habitat modification
5. Report findings including suggested actions

Proposed Management of the Mangrove Wetland at Bosun Blvd

Jon Knight, Pat Dale, Pat Dwyer April 2013

Summary

A survey of tidal connectivity into the Bosun Blvd mangrove basin site had the objective of identifying potential solutions to a mosquito production hazard existing at the site. The hazard exists because mosquitoes breed in a mangrove basin that was created when a levee was constructed across the creek for power line construction. A number of houses back onto the basin.

Aim: to determine options for:

1) re-connecting the basin (and pools there in) by modifying the level of the levee
2) enhancing tidal connectivity to:
    a. manage mosquito production
    b. maintain / conserve system health

Approach:

1) assess current tidal hydrodynamics
2) model the effect of lowering the levee to various depths including -10, -20, -30 & -35cm; levels derived from the assessment.

Results: We assessed four channel depth options.

Option 1. –10cm : Limited impact on the current system, mosquito production likely but reduced.

Option 2. –20cm : Enhanced tidal connectivity; Gap duration between tidal events would be too short for mosquito production, but pool persists for sufficient time to support larval development. This option would support larvivorous fish but pools may dry out between tidal connections on occasions; flushing from the basin pools may contribute to control of mosquitoes.

Option 3. –30cm: Mosquito production unlikely because the period between tidal connections is too short to enable larval development; access for predatory larvivorous fish would be enhanced; flushing from the basin pools would contribute to control of mosquitoes – if there was a breeding event.

Option 4. -35cm: as for Option 3 with the addition that this option would also account for circumstances where rainfall / runoff accumulated in otherwise empty pools.

In addition to modifying tidal connectivity by constructing a channel across the levee, the extent to which mosquito production would be achieved also depends on the extent to which the basin pools are connected to the channel. We recommend that the depression areas/pools are also interconnected to ensure that there is even dewatering from all depressions in the basin.

Some questions and issues to be considered:

Do we want water to be retained and if yes, for how long?

Do we want the basin to dry out, and if yes, for how long?

Do we want to construct a channel, or embed a poly pipe, or remove the levee entirely?

Construction: Following from the work at the Mahers Lane mangrove study site, the Idea is to cut a channel through the levee then, on a subsequent flooding tide, use observed water flow through the levee to guide any further excavation in the basin pools to ensure flushing.

Spoil: From a regulatory perspective the preferred method is to remove spoil from the site: access at Bosun Blvd is quite good.

Report

Preamble

The following information is the result of detailed mapping of water levels and residence time in response to tidal patterns within the Bosun Blvd site. This can inform planning for any modification.

The key issues for discussion include (but are not limited to):

Defining the aims/ balancing priorities e.g:

- Conserving resident **fish**
- Facilitating visiting **fish** access
- Reducing **mosquito** larval survival. This may be by reducing:
  - oviposition sites (no suitable substrate);
  - egg conditioning potential (little time for drying);
  - larval survival (water around for < 5days in summer)
- Conserving **environmental** values

Achieving these aims should alleviate odour issues for the local community

The information allows us to see how much modification (depth of channel) would be needed in order to alter water depth in the basin and to determine the time it would take for water to be lost (by evapotranspiration and infiltration) following the completion of the tidal ebb. These are key factors in assessing and achieving the aims noted above. These key factors are discussed below.

Number of events: an event a string of contiguous tides where a gap between adjacent tides is < 3 days. If the conditions are appropriate the commencement of a tidal connection event can trigger mosquitoes to hatch – instigating a mosquito hazard event.

Number of tides in an event: The number of tides in an event is important for visiting fish and general mangrove health as individual tides provide the mechanism for fish access and water exchange.

Gap duration between tidal events: The length of the gap between tidal connections is important for the mosquito's lifecycle development. It controls larval success (minimum 5 days for larval development) and availability of exposed substrate for egg laying (oviposition).

Time taken for the basin pool to dry: This is the rate of water loss from pools due to combined evapotranspiration and infiltration.

The combination of gap duration and the pool drying rate are important for two mosquito lifecycle reasons:

1. A period of three days for eggs to condition or re-condition. Conditioning must happen before eggs can hatch. Note that *Aedes vigilax* eggs can hatch at any of up to ~20 wetting phases provided they recondition (dry) before the next wetting-up phase.
2. A period of ~11 days is required from hatching, larval development, and development into adults and lay eggs and for these newly laid eggs to condition prior to being ready to hatch.

The flushing of the basin pool areas is also important for mangrove health.

Approach

Three pressure transducers were deployed between Nov 14 2012 and April 11 2013. This includes the summer which is the main mosquito season. The loggers were deployed on the substrate in the deepest pool, on the power line levee that crosses the creek and forms the mangrove basin and at the mouth of the creek. The loggers recorded water depth at intervals of 5 minutes. The loggers were non-vented and were corrected for atmospheric pressure post-retrieval using ambient air pressure data recorded concurrently at the site. Temperature was also recorded (not analysed). Tidal observation data for the nearest local tide gauge at Barneys Pt were acquired from Manly Hydraulics Laboratory (MHL) and used to correlate tides at the site. Barneys Pt data were transformed to the Australian Height Datum using a -0.883m offset as published by MHL.

Analysis of water level data

Comparison of water level traces: logger data and Barneys Pt data were superimposed for visual inspection. Estimation of the Barneys Pt tide level at which ingress into the basin pool was achieved was by visual inspection of tide traces. Two levels were identified: the first was the tide level that resulted in a **fully connected basin** and corresponded to full pools in the basin; the second was the tide level at which **water crossed the levee** and entered the basin, but this did not fill the pools.

Loss of water after completion of the ebb was derived by fitting a linear line of best fit to the basin pool trace for the period 21/11 – 1/12, deemed to be typical of periods between tidal connections. We attributed water loss from the basin pool following the completed ebb tide to be due to combined evapotranspiration and infiltration.

Attenuation of the tidal flood compared with levels at Barneys Pt were derived for each location (creek mouth, levee and in the basin pool) by regressing the maximum daily levels during the period 12/12 – 18/12/2012. This was deemed to be a typical tidal event.

Tidal events were defined as the collection of contiguous high-tides where fewer than 3 days separated adjacent high-tides at or above a designated height. The **number of high tides** in an event comprised all contiguous high-tides separated by fewer than three days. The **duration of gaps** between tidal events was the period from the last tide in one event and the first high-tide in a subsequent event.

General observations

Water-depth trace comparisons:

a) Barneys Pt – Creek Entrance: The creek entrance high-tide peaks about 30 minutes before Barneys Pt. The creek entrance connects with tides above MSL or ~0m AHD.
b) Barneys Pt tides and the creek entrance are in sync given the 30 min offset – as expected.

c) Rainfall has a direct impact on water levels in the basin pool – ratio of rainfall / runoff to water depth change in basin has not been determined but indications are ~1:5.

The impact of rainfall/runoff is best illustrated for the period 7-12 Dec 2012 on Fig 1 where water levels in the basin pool (thick black trace line) show a small increase of ~120mm corresponding with 20mm and 30mm of rainfall on consecutive days. Responding to rainfall when the basin pools are empty is the main justification for developing option 4 over option 3 as above.

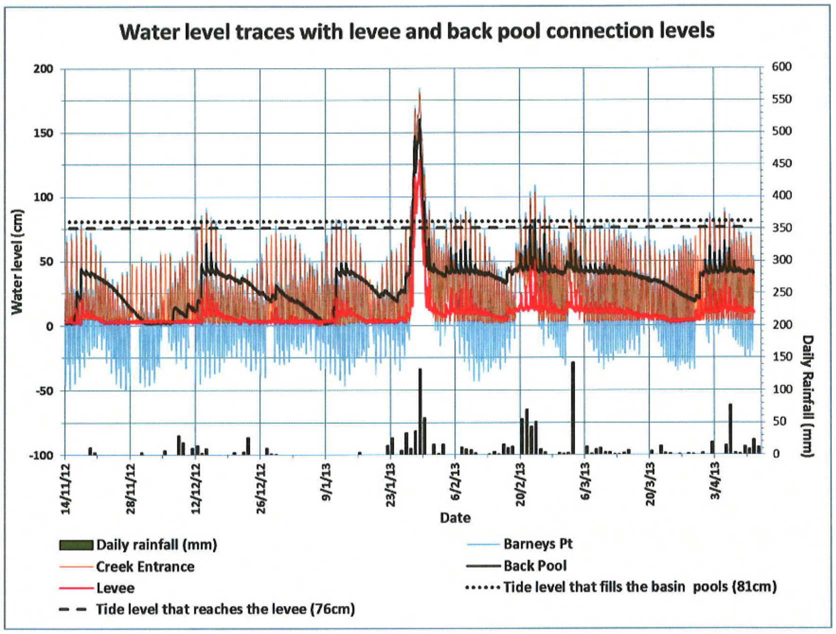


Fig 1: Water depth traces from the Bosun Blvd site (Nov 14 2012 and April 11 2013) superimposed over the tide trace from Barneys Pt MHL station. Tidal connection levels (basin pools and levee) are shown relative to Barneys Pt tide levels where the Barneys Pt water level data has been transformed to the Australian height Datum. The three site data sets are as recorded. The loggers were placed on the substrate. Rainfall data is from Tweed Heads Golf course BOM site (www.BOM.gov.au).

Individual site traces

a) **Basin pool** depth logger located in the base of the deepest depression. The level of water retained in the basin pool after tidal ebb across the levee was 40cm.
b) **Levee** depth logger located in low part of the levee north of the rocks. The level of water across the levee is generally controlled by tide height, however about 5-10cm of water remains after the tidal ebb for 3-4 days and decreases at about 3 cm/day. This may be

because there is a slight depression where the logger was deployed or the logger was not deployed exactly on the levee.

c) Creek entrance depth logger located in the opening of the creek. The creek entrance is a mirror of the system (as expected). The CE connects about 30 minute before Barneys Pt and as a comparable tidal pattern but is truncated at lower tides. The gauge, by chance, was positioned at an elevation of approximately 0m AHD.

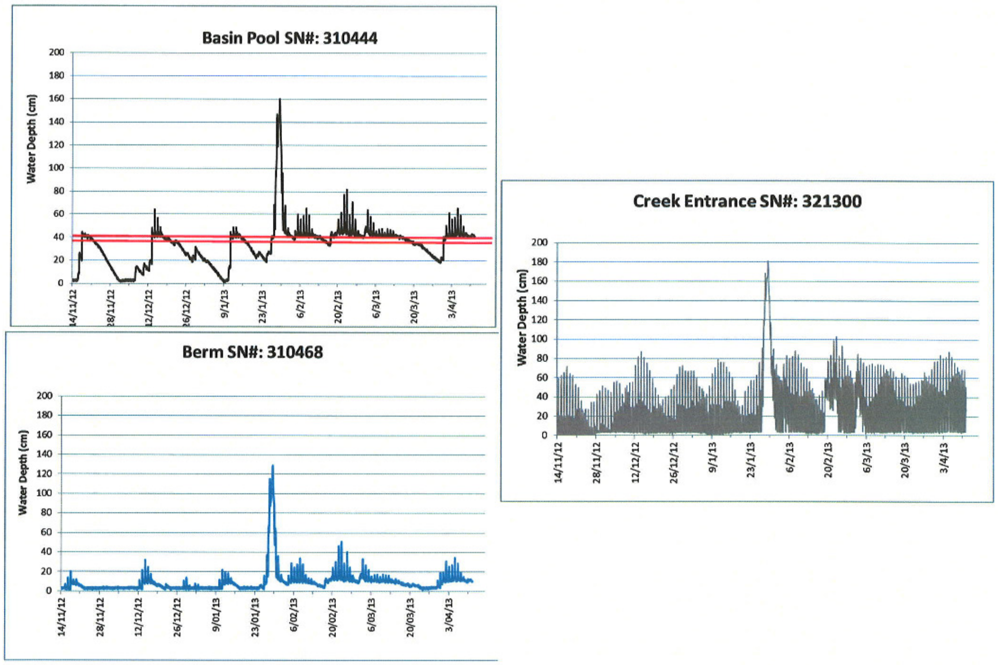


Fig 2: Individual water level traces. The red lines in the basin pool plot are the fully connected level (upper) and partially connected level (lower).

Water loss between tidal connections

Water level decreases as a result of evapotranspiration and infiltration from the basin pool. In the absence of recharge the water level decreases at ~3.8cm/day. The period displayed (23rd Nov – 1st Dec 2012) was comparable to other similar sections of the basin pool trace.

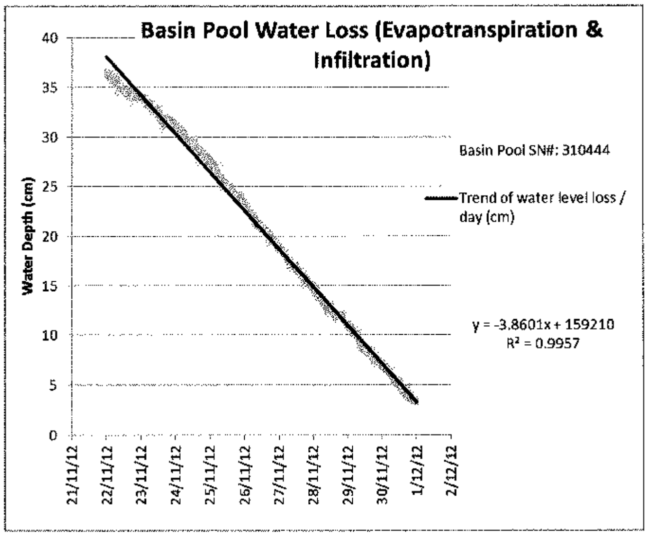


Fig 3: Water loss rates due to evapotranspiration and infiltration from the basin pool.

Tidal attenuation

Attenuation of the tide trace compared with Barney's Pt. All three sites show a loss of energy when compared with the Barney's Pt observation data. The data were derived from high-tide levels on each of 12-18th Dec 2013. The slope of the trend lines shown in Fig 4 (or x-co-efficient from each equation shown in Fig 4) indicates the attenuation rate as a loss in water level compared with Barneys Pt levels and included:

a) Creek Entrance 97.3%. A loss of 2.7% could be within the error of the data.
b) Levee 85.8% or a loss of 14.2%.
c) Basin Pool 75.7% or a loss of 24.3%

Note that the tide levels shown are for the part of the high-tide that connects with the sites at Bosun Blvd.

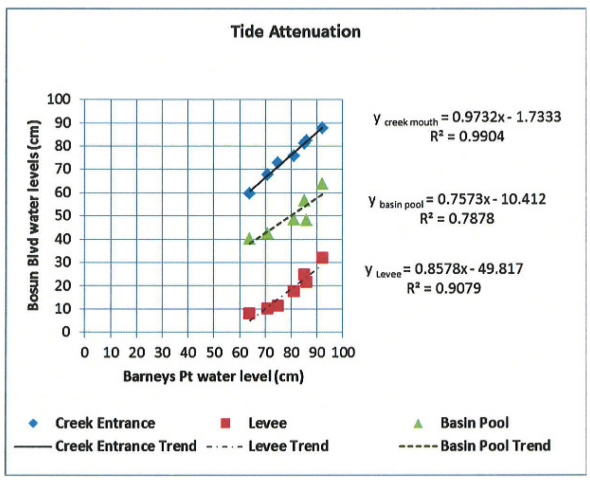


Fig 4: Attenuation calculation plots derived from traces for 12-18 Dec 2013.

Tidal Connection Structure and channel depth options

Key tidal connection statistics including number of connection events, number of high-tides per event and the number of days during the gap between tidal events were derived from the Barneys Pt tide data during the survey period (14/11/2012-11/4/2013) for existing levels (basin pool 81cm and levee 76cm; Table 1) and proposed channel depth options (-10, -20, -30 & -35cm; Table 2).

Calculation of the relevant tide level adjustment at Barneys Pt to reflect the proposed channel depth adjustment requires an adjustment of level from the levee to the level at Barneys Pt. To do this we divided the channel depth by the levee attenuation factor (0.857) and subtracted the result from the Barneys Pt level corresponding with the full basin pool level (81cm). For example using the 10cm deep channel option, the comparable level adjustment at Barneys Pt is 10/0.857 = 11.8 → 81 – 11.6 = 69.4 rounded to 70cm as shown in Table 2. The resultant water levels corrected Barneys Pt water levels were used to calculate tidal connection data (# events, # tides, gap duration) for each option, used to identify possible impacts of channel construction option.

Table 1: Summary of tidal connection key factors for the basin pool and levee locations based on Barneys Pt tide data for the period 14/11/2012-11/4/2013.

Site	Key Factors						Comment
	Tide Height Level Barneys Pt	Basin Pool Depth	Average No. Events	Average No. Tides/Event	Average Gap Duration	Time taken for basin pool to dry (after ebb) @ 3.8cm/day	
Basin Pool	81cm	40cm	8	4	16.6 days	10-12 days	Existing level that fully connects the Basin pool
Levee	76cm	34cm	9	5.6	11.4 days	9 days	Existing level that connects to the levee but does not fill the basin pool

The potential impact of the four channel depth options (-10, -20 -30 & -35cm) that correspond to creating four pool depth scenarios (30, 20, 10 & 5cm, respectively) is summarised in Table 2. Note that constructing a shallow channel (-10cm) leads to deeper residual depth in the basin pool which would consequently retain water for longer than would occur with a deeper channel (e.g., -30cm). This is because there would still be an impounding effect of the levee. For options 3 and 4 the frequency of tidal connections are almost continuously daily with averages of 45 and 65 tides in the few events. The benefit of option 4 over 3 is that option 4 is more likely to drain rainfall/runoff from the site reducing the potential for an odour issue to develop.

Table 2: Summary of key factors for each channel depth option based on data between Nov 14 2012 and April 11 2013.

Construction Options	Key Factors					
	Tide Height (at Barneys Pt) (cm)	Residual Basin Pool Depth	Average No. Events	Average No. Tides	Average Gap Duration (days)	Time taken for basin pool to dry (after ebb) @ 3.8cm/day
1. Channel depth 10cm	70cm	30cm	7	11	12.8	8 days
2. Channel depth 20cm	58cm	20cm	7	15.6	7.7	5 days
3. Channel depth 30cm	47cm	10cm	4	45	7.5	3 days
4. Channel depth 35cm	41cm	5cm	3	65	3.5	1-2days

Fig 5 illustrates the intersection of Barneys Pt tides and the proposed channel depth options. The deeper the channel the more frequently tides connect into the mangrove basin, increasing flushing with in the basin area. Also, the length of the gap when no tides connect to the basin decreases with greater channel depth.

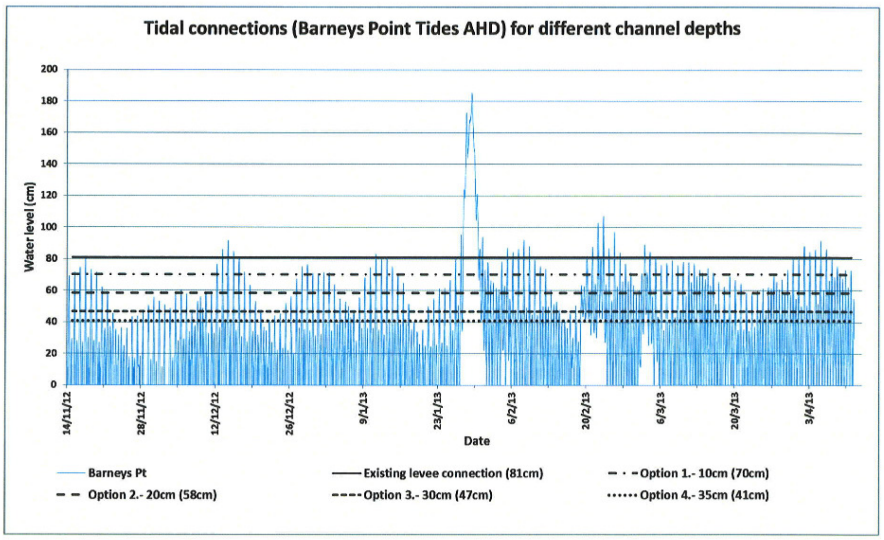


Fig 5: Intersection of channel depth options overlaid on Barneys Pt tide trace (MHL data) where the tide data were converted to the Australian Height Datum. Low-tide data below zero m AHD are not displayed for clarity reasons.

Patterns in number of events, number of tides and gap duration (with trend line) for different high-tide heights (as in Table 1 & 2) are illustrated in Fig 6. A trend line has been fitted to the gap duration data to enable deriving gap duration from tide height.

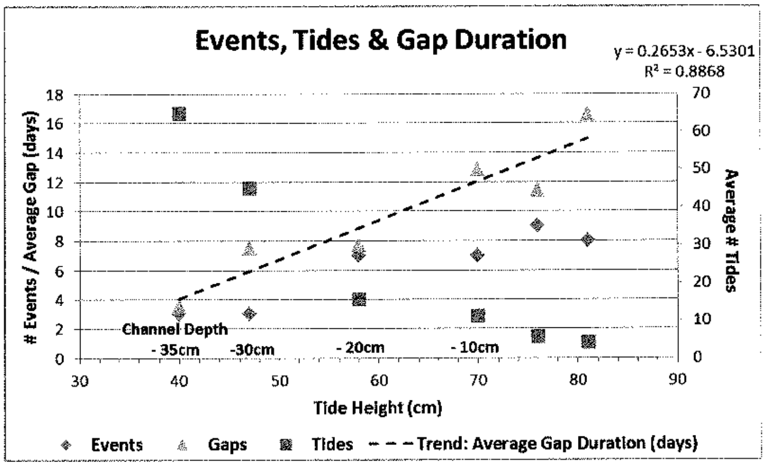


Fig 6 : Comparison of tidal connection factors (events, tides and gaps) for each of the four channel depth options (-10, -20, -30 & -35cm as labelled) and levee and basin pool levels (tide height at 76 and 81 cm respectively). Events: contiguous tides where gaps between consecutive tides were < 3 days). Tides: average number of tides in each event. Gaps: average duration of the gap between tidal events.