Wilsons Beach
Erosion Management Strategy

Options Assessment Report

Whitsunday Regional Council

International Coastal Management PTY LTD **(ICM)**
OFFICE 50 / G Arm, SYC Marina. Main Beach. Qld. 4217. Australia
POST PO Box 306. Main Beach LPO. Main Beach. Qld. 4217. Australia
TELEPHONE +61 7 5564 0564 FAX +61 7 5532 9147
WEBSITE www.coastalmanagement.com.au

Document Control Sheet

Prepared by:	Marty Mulcahy
Title:	Coastal Engineer
Company:	International Coastal Management
Approved for release:	Angus Jackson
Title:	Executive Coastal Engineer
Company:	International Coastal Management
Final Review:	Bobbie Corbett
Title:	Senior Coastal Engineer
Company:	International Coastal Management

Version History

Version No.	Date	Changed by	Nature of Amendment
DRAFT	22/4/2015		
Rev1	19/05/2015	MM	Revisions from client

Contents

1. Locality

Wilsons Beach is located in the Whitsunday Region approximately 20km east of the town of Proserpine at the mouth of the Proserpine River in Repulse Bay (Figure 1). The beach is south facing and is located on the northern side of the Proserpine River entrance (Figure 2).

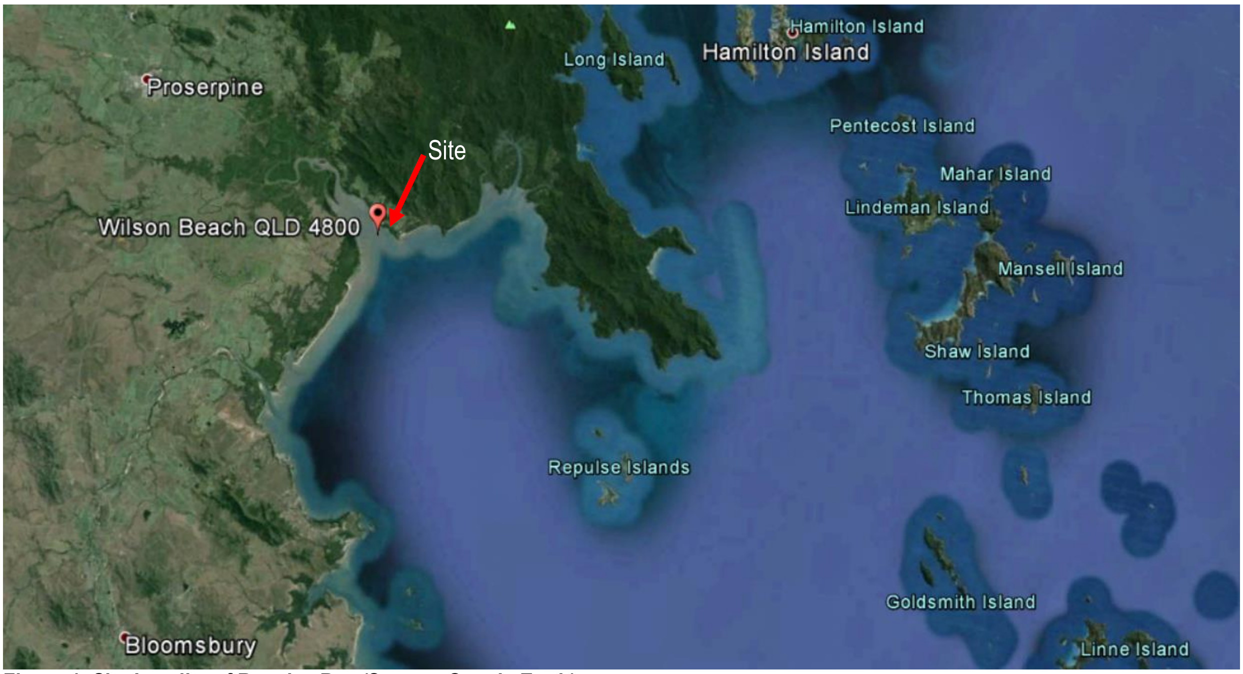

Figure 1: Site Locality of Repulse Bay (Source: Google Earth)

Figure 2: Aerial of Wilsons Beach (Source: Google Earth, 2013)

2. Background

Whitsunday Regional Council (WRC) has advised that from January to April 2014, tides and wave action associated with Cyclones Dylan (30th and 31st of January), Hadi (10th to 11th of March) and Ita (9-11th of April) had various impacts on the Wilson's Beach foreshore including:

- Damage to the rock seawall
- Loss of up to 5m of the dune / foreshore reserve at Wilson's Beach [as reported by local residents]

The Whitsunday Regional Council has received numerous complaints from the residents at Wilson's Beach regarding the erosion. On the 26th of May a public meeting was held at Wilson's Beach to discuss the erosion issues. On the 9th of July the Whitsunday Regional Council passed the following motion:

"That Council resolves to:

- *select the Wilson's Beach coastal erosion site as a pilot project location to gauge the effectiveness of using beach scraping as a method in responding to coastal dune damage, and, apply to the Queensland state government for the relative permits to conduct sand scraping at Wilson's Beach of up to 200m3, and,*
- *engage a suitably qualified coastal engineer to assess the coastal erosion hazard at Wilson's Beach and identify the most appropriate coastal protection method, and,*
- *subject to the advice gained by the coastal engineer engage a suitably qualified engineer to develop detailed plans for the recommended coastal protection measures for Wilson's Beach, and,*
- *seek quotes for the construction of the recommended coastal protection measures for Wilson's Beach and report back to the Council prior to the implementation of the proposed works."*

Subsequently, sand scraping of about 200m^3 has been undertaken by the Whitsunday Regional Council (WRC) with a permit from the State Government to restore safe pedestrian access and visual amenity to the beach, while also providing a storm buffer for future erosion event(s).

3. Scope of Works

This report addresses the erosion experienced along the section of Wilson's Beach shown in Figure 3 and includes:

- Preliminary assessment of the erosion issues at Wilson's Beach.
- Evaluate the mitigation options.
- Recommendation of a preferred option and comment on the suitability of a rock revetment wall.

Figure 3: Location of the existing rock wall (red line) and investigation area (blue line) [Source: WRC]

4. Prevailing Conditions and Erosion Issues

Limited investigations have been undertaken regarding coastal processes of the region, however there have been some investigations regarding storm conditions and the recent Development Application (Ref WRC DA 2014) for the sand scraping provides background data for Wilsons Beach.

4.1. Offshore Wave Conditions

The coastline is largely protected from large ocean swell by the Great Barrier Reef, however Wilsons Beach can be exposed to waves with a significant fetch from the SE quarter (Figure 4). It is calculated (using ACES software) that wind-generated waves for a 50 year ARI event over this fetch could generate offshore waves at Wilson Beach with significant wave heights (Hs) of 3.3m and periods (Tp) of 7 seconds.

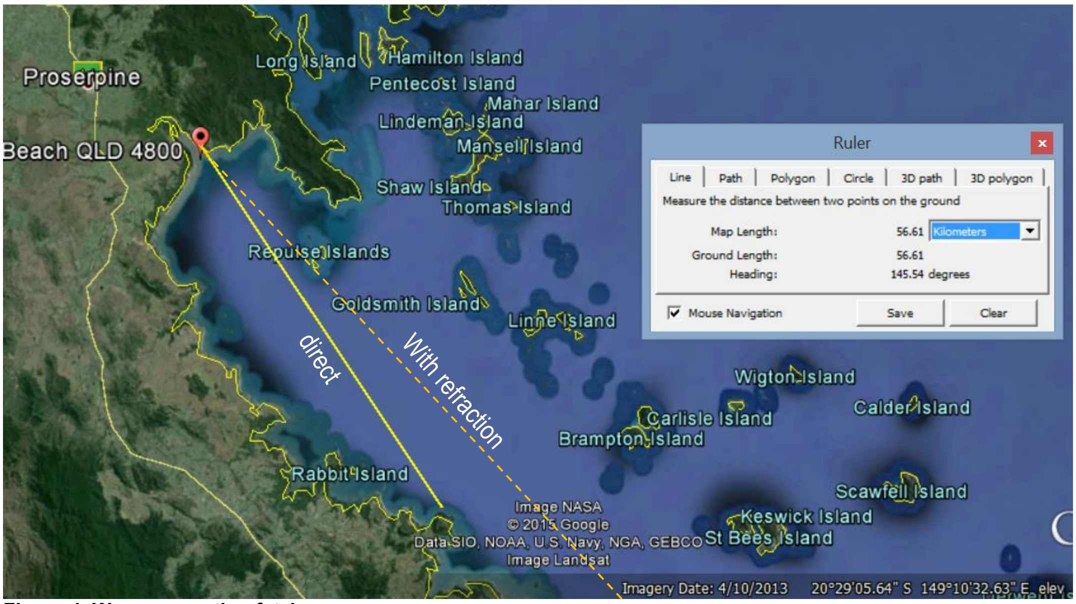

Figure 4: Wave generating fetch

4.2. Tides and Storm Surge

Tides at adjacent Laguna Quays Marina show significant tidal fluctuations with a spring tidal range of approximately 3.9m and a maximum tidal range of 6.3m [Table 1].

Table 1: Tidal Information for Laguna Quays Marina (MSQ Tide Tables, 2015)

Tidal Plane	Level (m LAT)	Level (m AHD)
Highest Astronomical Tide (HAT)	6.30	3.49
Mean High Water Springs (MHWS)	4.74	1.93
Mean High Water Neaps (MHWN)	3.74	0.93
Mean Sea Level (MSL)	2.74	-0.07
Australian Height Datum (AHD)	2.81	0.00
Mean Low Water Neaps (MLWN)	1.87	-1.66
Mean Low Water Springs (MLWS)	0.88	-1.93
Chart Datum (CD) / Lowest Astronomical Tide (LAT)	0.00	-2.81

Tropical cyclonic winds are typical of the region and cyclones have the potential to create significant storm surge, particularly if coincident with higher tides. Storm surge levels at Wilsons Beach may be exacerbated by flood flows from the Proserpine River but no data on this is available. Storm tides, calculated from the Storm Tide Modelling Study of the Whitsunday Coast and Resort Islands Final Report (GHD, November 2003) provide the following predictions for 100 year ARI (Figure 5):

- 5.0m AHD (2050) (including climate change; +0.5m SLR)
- 4.2m AHD (2004)

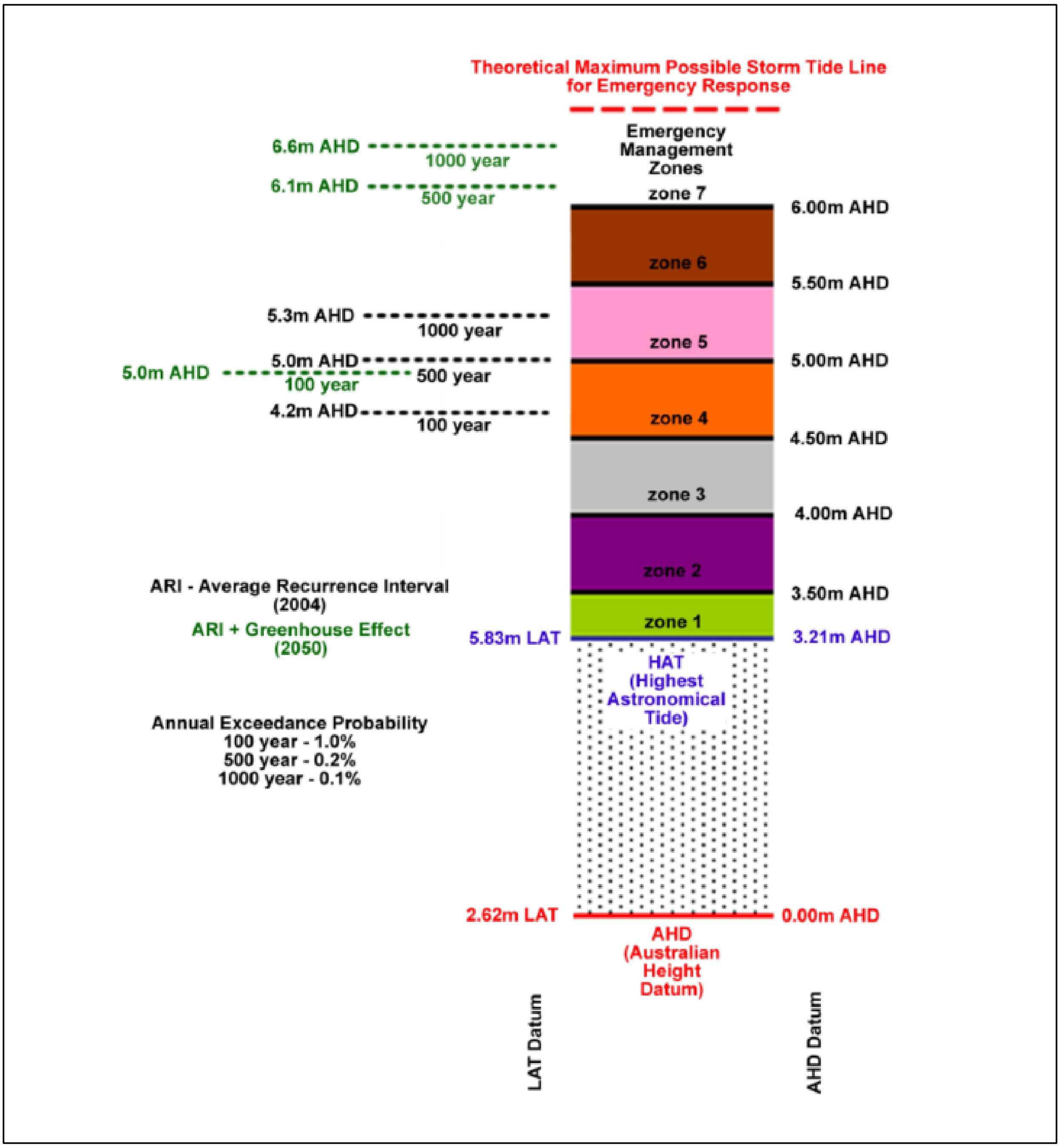

Figure 5: Calculated Storm Tides [WRC website extracted from GHD, 2003]

4.3. Nearshore Conditions

Wilson's Beach is characterized by a dunal area at approximately 4.5 – 5.2m AHD, a sloping upper beach and a wide intertidal sand flat at approximately RL0.0m AHD (Figure 6).

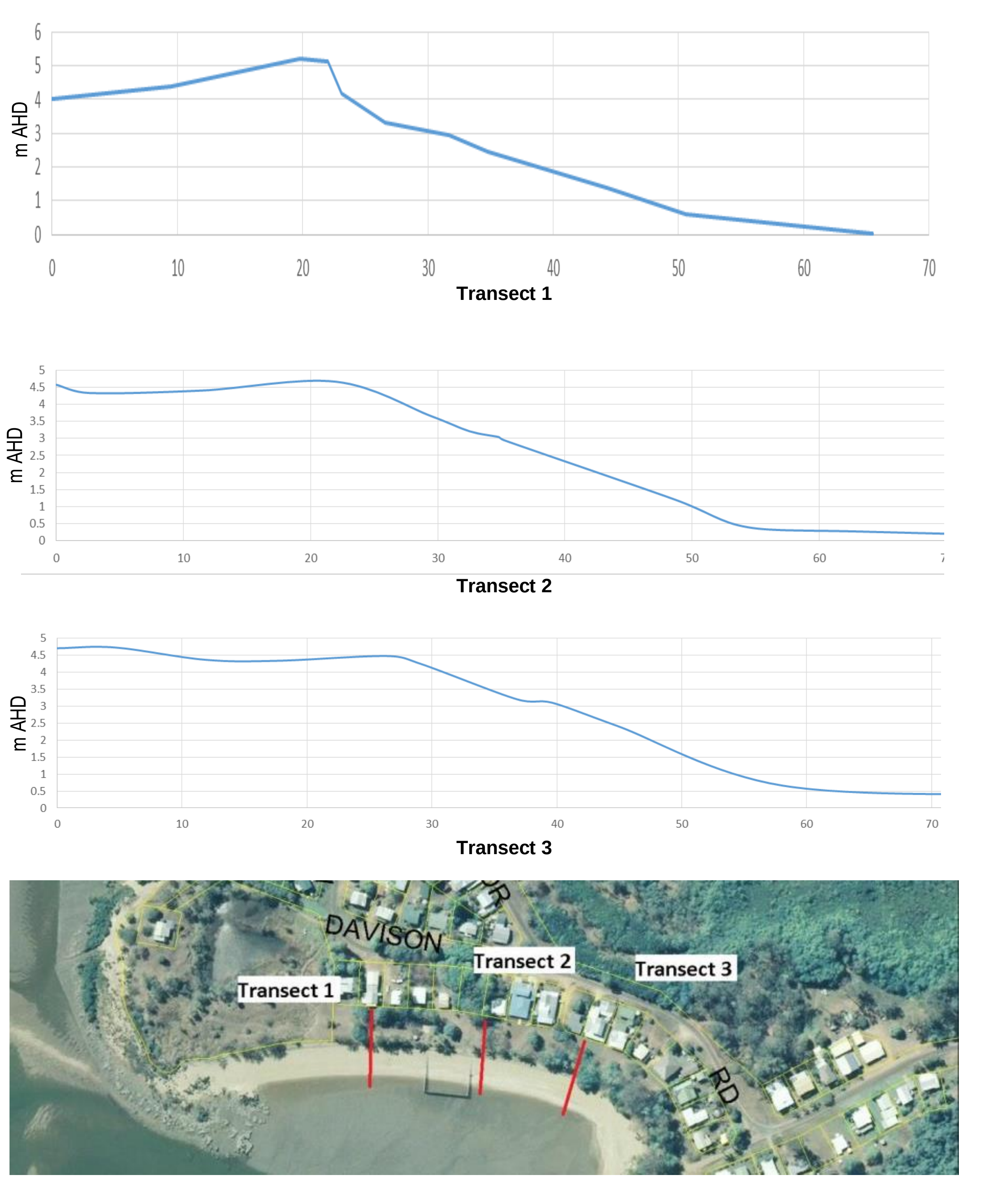

Figure 6: Profiles along Wilson Beach (21st of July 2014) [Source: WRC]

Due to the shallow low tide flats seaward of Wilsons Beach, waves will break and are effectively depth-limited (Figure 7). Modelling using SBEACH predicts the evolution of offshore waves and water levels over this profile. Resultant wave heights (Hs) and water levels (m AHD) experienced at the shoreline of Wilsons Beach are presented in Table 2. This indicates that for a design event, water levels of 4.2m AHD could be experienced at the height of the storm with 2.5m waves impacting on the structure. With climate change, storm tides could be expected to increase to ~5.0m AHD, allowing a larger 3m swell to impact on the structure.

These are independent conditions and a Joint Probability Analysis of water levels and waves or wave direction has not been undertaken. Given the waves are depth limited, this wave height would be experienced at the peak of the storm tide and reduce as the tide falls.

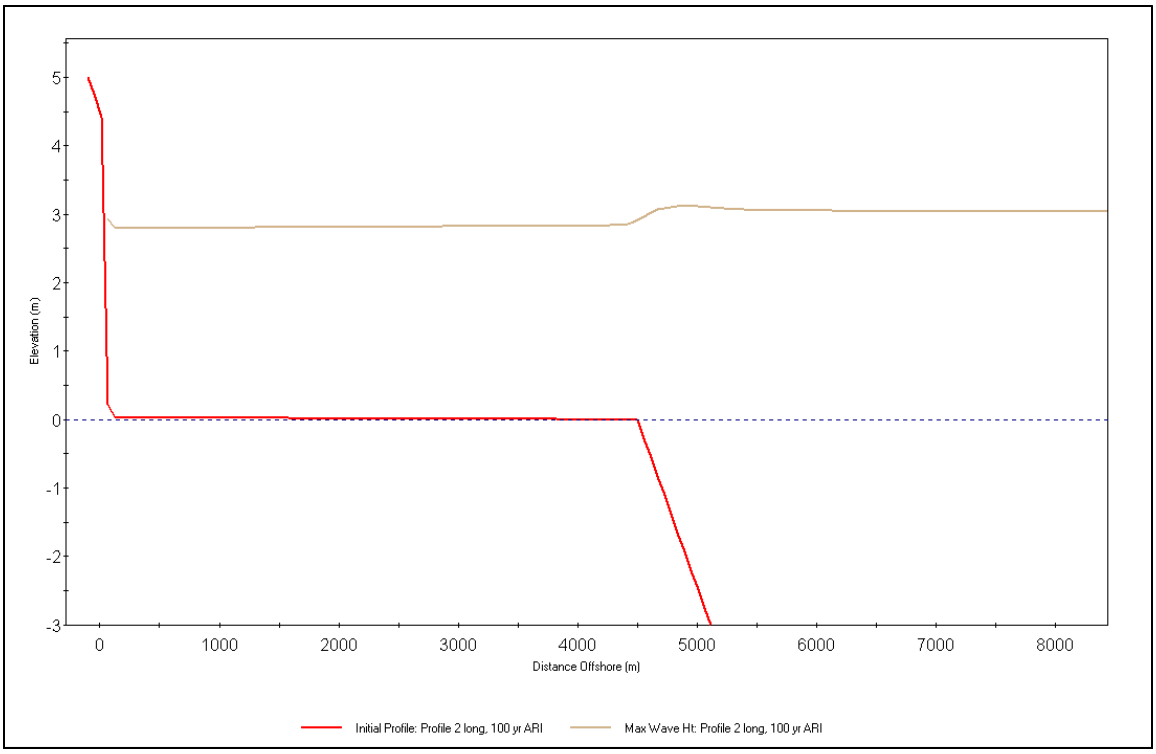

Figure 7: SBeach Model results showing depth-limited breaking in 2100

Table 2: Nearshore Conditions at Structure [from SBeach modelling]

1 in 100 yr ARI conditions (individual probabilities)	2004	2100 (includes Climate Change)
Storm tide level (m AHD)	4.2m	5.0m
Depth limited Hs (m) at structure	2.5m	2.9m

4.4. Sand Characteristics

Sediment testing indicates the upper beach is characterized by a fine-medium grained suitable for beach scraping above the low water "mud line".

4.5. Erosion Trends

The erosion prone width (as nominated by the Department of Environment and Heritage Protection) is some 65m (Figure 8). This includes long-term erosion (previously observed and as a result of climate change) as well as potential for short-term storm erosion.

Erosion to this extent would extend beyond the property boundaries of beachfront homes at Wilsons Beach and has the potential to cause significant damage and loss to infrastructure.

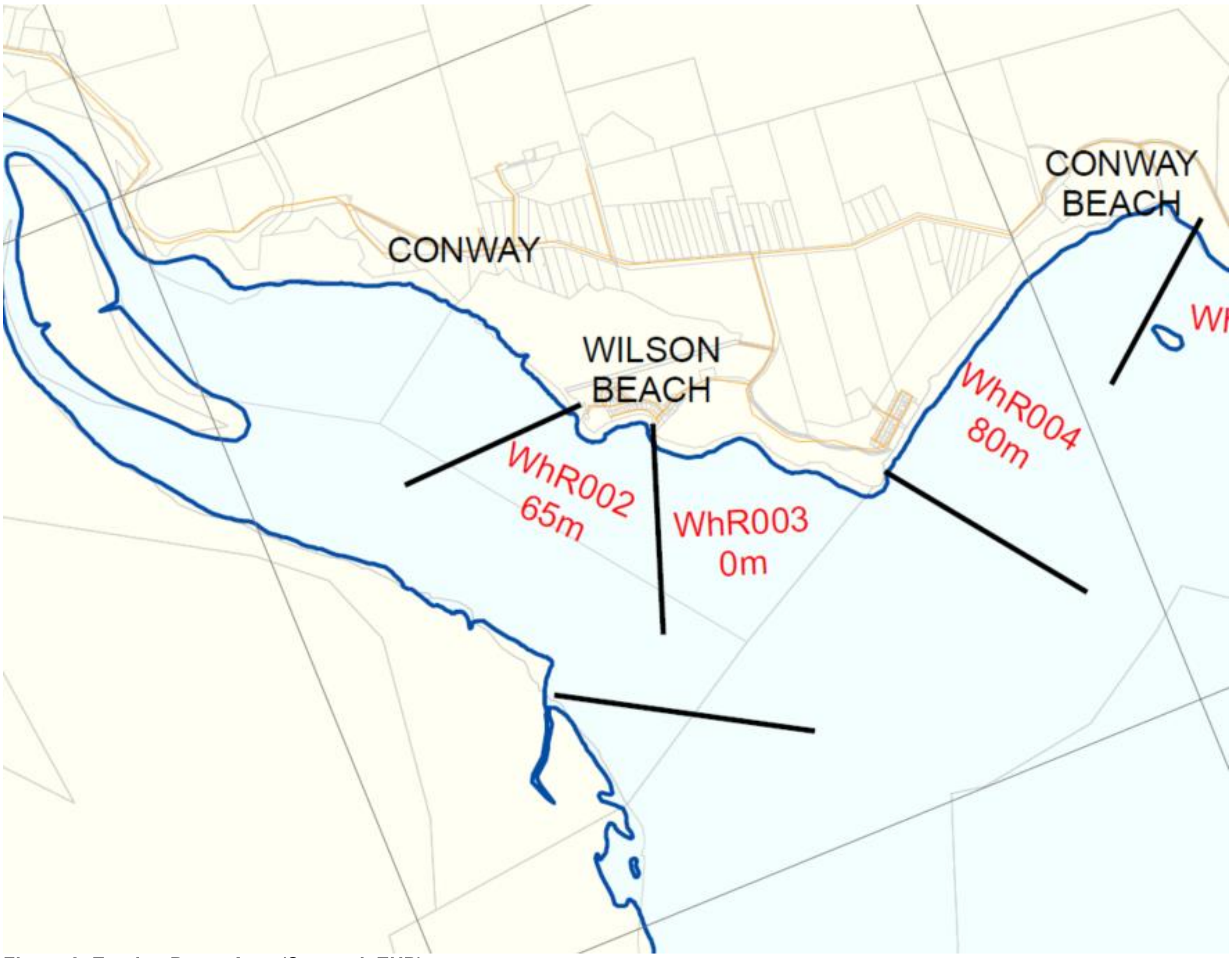

Figure 8: Erosion Prone Area (Sourced: EHP)

4.5.1.Long-Term Erosion

No long term morphology or erosion data of the Proserpine River, or Wilsons Beach, are available which makes it difficult to estimate the extent of natural recession or accretion of the beach. Council officers have reviewed air photographs from 1995 of Wilson's Beach (scale-1:25,000) which show a similar extent of the beach, indicating that over the last 20 years long-term erosion appears to have been limited. It is noted that a long-term erosion trend could develop as a result of climate change.

4.5.2.Short-Term Erosion

A section of rock seawall was constructed about 20 years ago (Figure 2) indicating severe erosion in that location around that time. The beach has recovered and no erosion was evident from aerial photos until 2014 when erosion and damage to the seawall with inundation of the land behind occurred.

Erosion has been observed more recently in response to storm events. On the 20th February 2014, the erosion damage at Wilson's Beach was investigated. Scarp heights along Wilson's beach typically varied between 0.1 to 0.4m with heights up to 1.5m adjacent to the rock wall (Figure 9). Reported storm cut (by residents) was of the order of 5m.

Site	Scarp Height (m)
1	0.1
2	0.2
3	0.4
4 (rock wall)	1.5
5	0.1

Figure 9: Scarp Heights along Wilson's Beach [WRC, Feb 2014]

An assessment of potential storm cut has been undertaken using SBEACH modelling. It should be noted that these models have not been able to be calibrated or validated for the site given the lack of data available. Data required to calibrate and validate the SBEACH modelling would include the measured terrestrial and bathymetric survey before and after a known weather event as well as recorded data of the event itself (where data is not available locally, regional modelling may be required to determine conditions experienced at the site during the event).

Modelling clearly shows that storm tides result in variable exposure of the seawall over the course of the storm, but during periods of peak storm tide the low-lying sections of the park can experience significant inundation (Figure 10) which is consistent with overtopping of the wall experienced during 2014 storm events (Figure 11). Without protection, modelling indicates that storm cut can be substantial (Figure 12), potentially extending through the park and into private property. The beach sand is expected to largely remain in the nearshore system above low tide.

The construction of a seawall (assumed crest RL 5.2m AHD) would prevent storm cut but would result in deeper scour at the toe (Figure 13). It is shown that for a 48 hour storm event the beach could erode down to a level of +1.5m AHD, with a local scour hole in front of the seawall to approximately +0.5m AHD.

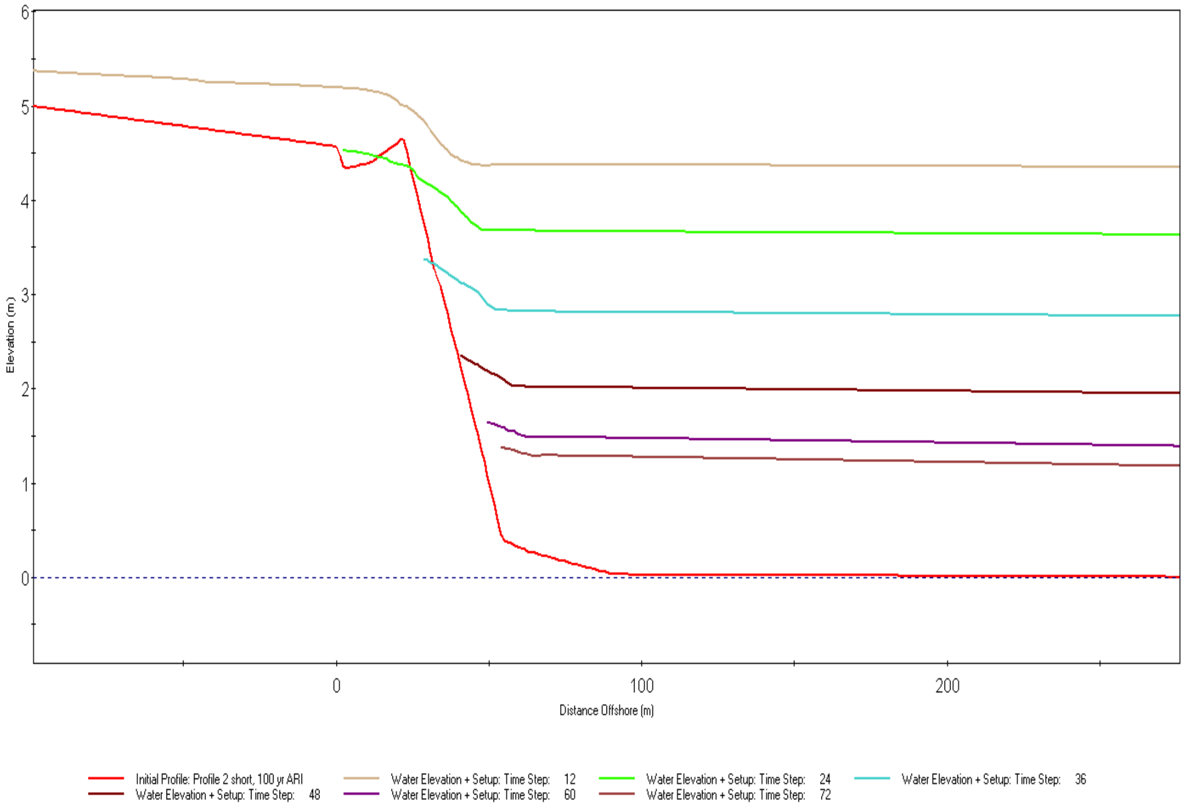

Figure 10: Storm tide water levels (2004 predictions) through spring tidal range

Figure 11: Seawall after Cyclone Dylan

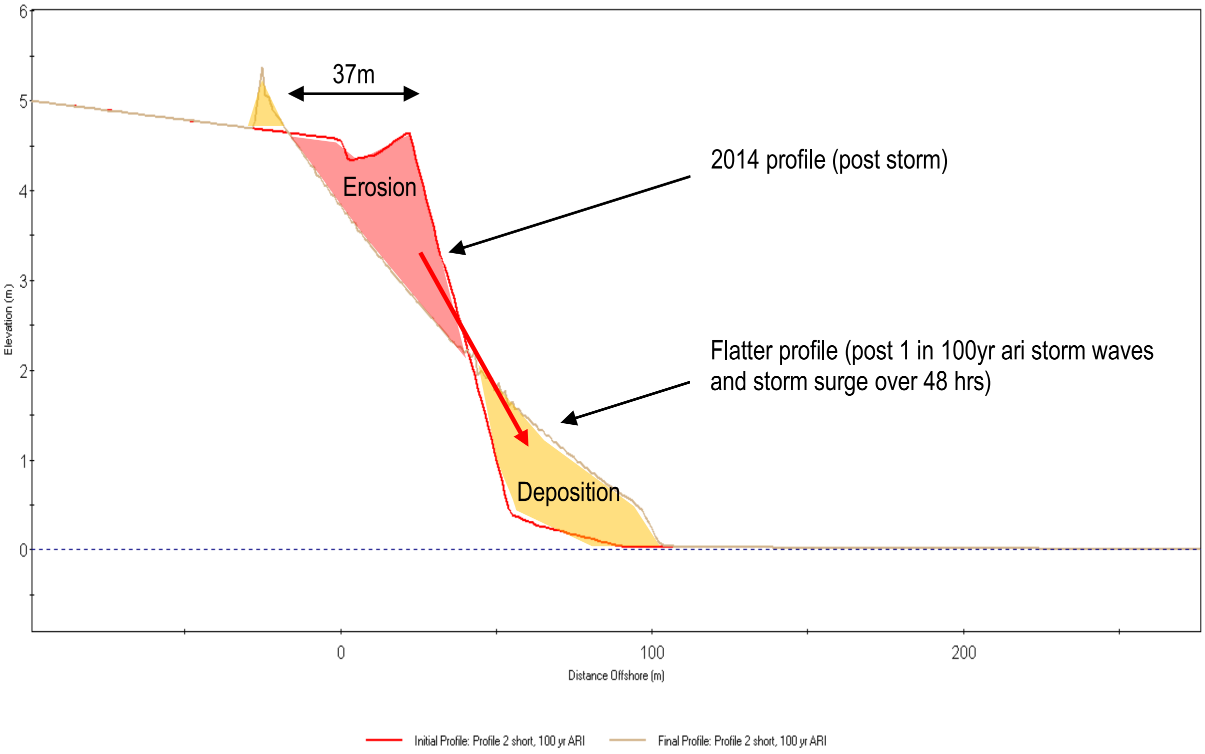

Figure 12: Uncalibrated SBeach Storm Cut 100 year ARI storm (2004)

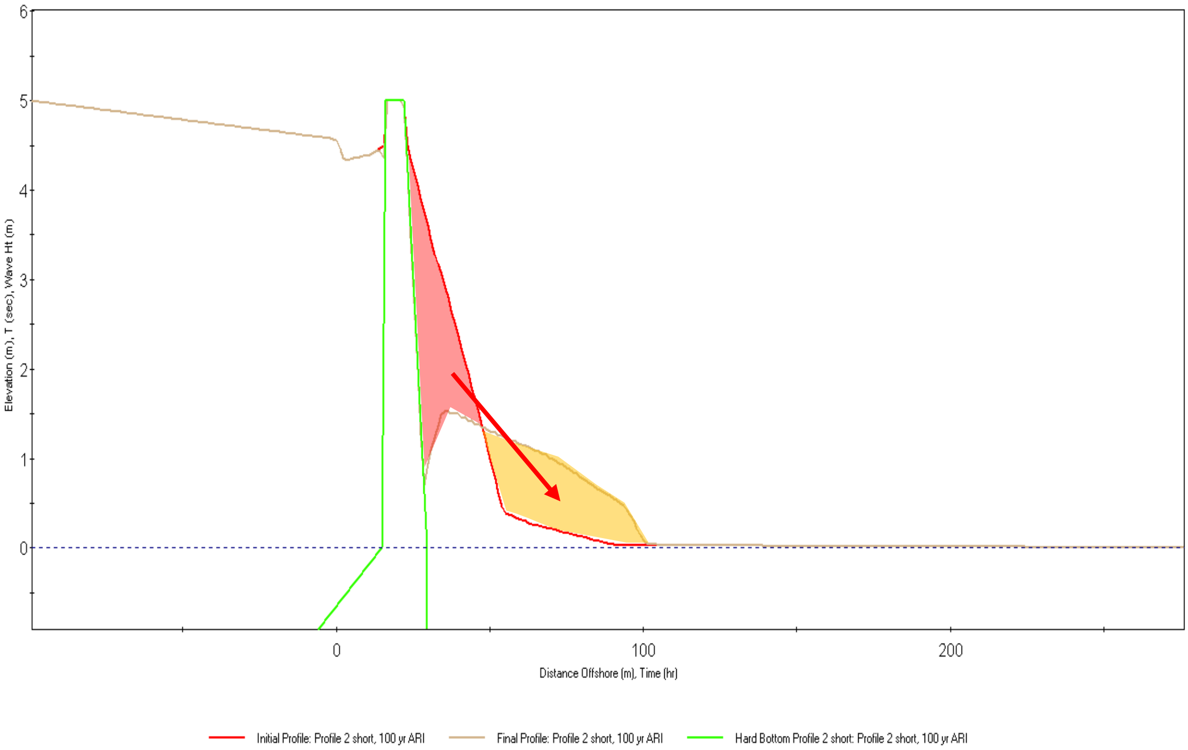

Figure 13: Uncalibrated SBeach Storm Cut 100 year ARI storm with seawall (2004)

5. Assessment of Erosion Issues

The 30m strip of park seaward of beachfront properties is largely grassed with a number of large mature trees. While there is no obvious dunal area, it is possible that this is the result of the dunal area being colonized by grass from the park over time.

There are 2 coastal process elements to consider in the design of any protection works:

- Storm tide inundation of the back beach area
- Erosion due to storm cut

5.1. Storm Tide Inundation

From the recent bathymetry and terrestrial survey of the area (Attachment 1), the natural surface level of foreshore is approximately 4.5m AHD. The 100 year ARI storm tide without waves or wave setup is 4.2m AHD, increasing to about 4.9m by 2100 due to climate change. As such, inundation of the developed back dune area, including private properties, could occur infrequently at high tide during severe storm surge events combined with cyclonic waves from the south east quarter, as was observed during the 2014 events. The frequency and extent of inundation would be expected to increase over time due to climate change.

5.2. Storm Erosion

The erosion prone area width (as nominated by EHP) is 65m (i.e. erosion of the park and beach-front residences with a scarp in close proximity to Davison Road).

With no clear long-term erosion trend, this primarily represents short-term storm erosion risk. Preliminary SBeach numerical modelling indicates that current storm cut has the potential to result in erosion of about 40m (although data is not available to fully calibrate the model). This is much greater than the 2014 event (estimated to be 5m) and may be conservative. It is noted, however, that storm tide, wave direction and event duration can be significant factors influencing actual erosion experienced so a different storm (or multiple smaller events) could easily result in much greater erosion than recently observed.

Without any protection or nourishment works, both the public park and private properties will be increasingly vulnerable to erosion.

6. Design Options

There are numerous options and combinations of options. The options considered include:

- Do nothing
- Beach scraping / Nourishment
- Seawalls
  - Boulder seawall
  - Sand filled geotextile containers
  - Concrete blocks

6.1. Do Nothing

Preliminary modelling (Figure 14) shows that significant inundation and storm cut can be expected if no works are undertaken.

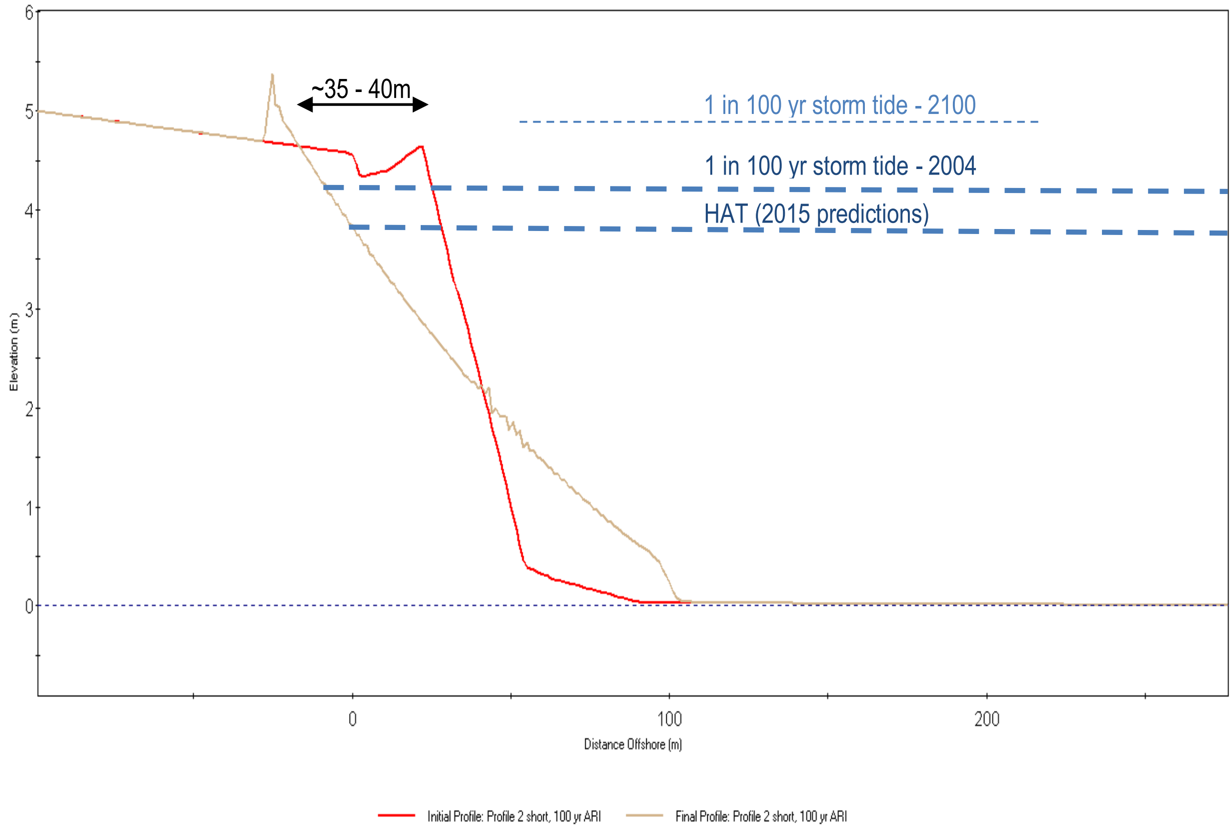

Figure 14: Storm cut for do nothing option (100yr ARI in 2004)

Advantages:

- Low impact on coastal processes

Disadvantages:

- Erosion and inundation of the developed low back dune areas will continue to occur during severe events and cause damage to vulnerable infrastructure including private properties.

Estimated Capital Cost: Nil (not accounting for damage and repair costs).

6.2. Beach Scraping / Nourishment

Beach scraping involves scraping a layer of sand from lower sections of the profile to upper sections of the profile, mimicking a natural post-storm recovery which would normally occur over months or years (Figure 15). Generally undertaken as a post storm measure, this has been successfully carried out by WRC at relatively low cost in 2014/15 to repair the erosion cut. Future beach scraping could be considered (both alone and in conjunction with other options). It could also be undertaken in conjunction with dune vegetation and fencing.

Nourishment is a further option which could be effective in this location. While there are general references to sand reserves in the Proserpine River and the delta in a number of publications (including GBRMPA Research Publication No 22, 1991), no suitable sources appear to be approved and readily available at reasonable cost. As such, this has not been considered further.

Figure 15: Beach Scraping Diagramme (Source: WRC)

6.2.1. Beach Scraping Design

Raising of the dune height might also be considered if adequate material was available (Figure 16).

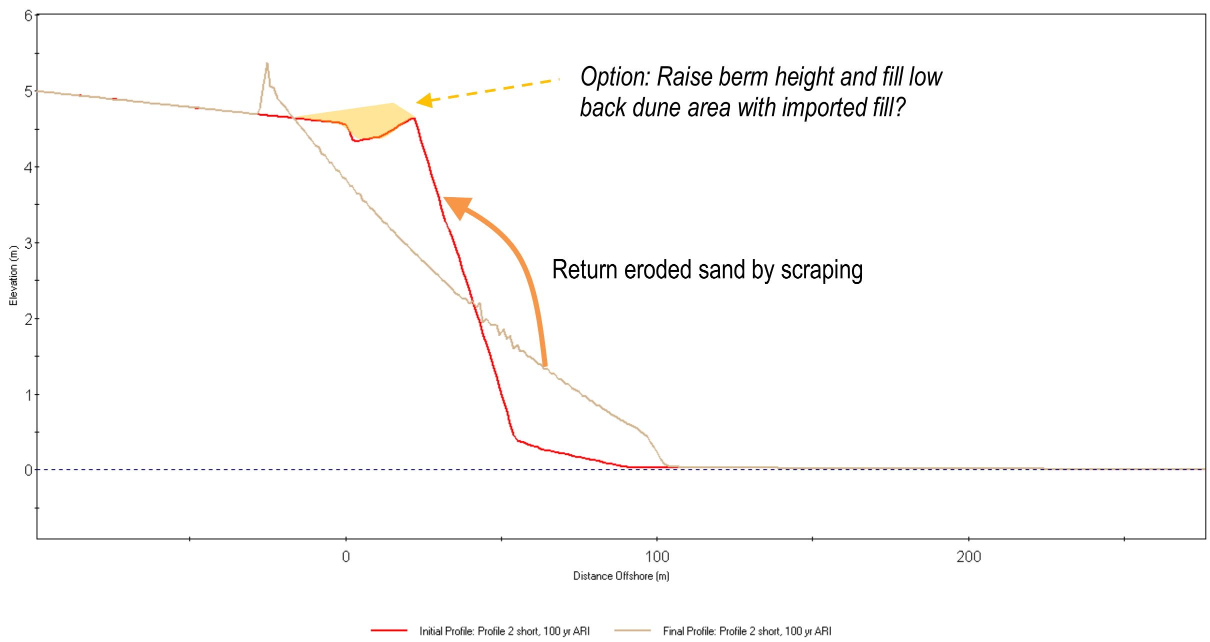

Figure 16: Sketch showing post-storm beach scraping

Advantages:

- Provides a buffer against storm cut during smaller events (given volume of sand available).
- Soft approach
- Improves visual amenity and safe access to foreshore
- Low impact on coastal processes
- Low initial cost
- Easy

Disadvantages:

- Does not provide complete protection during larger storm cut events (given volume of sand available).
- Requires regular post-storm maintenance works.
- Cannot be conducted during marine turtle nesting season (1st November to 31st March).
- Sand volume may slowly be depleted.

Estimated Cost: $15/m (from recent 2014/15 works)

6.3. Seawall

Seawalls are permanent structures which limit the landward migration of the storm cut. Different types of seawall would be suitable for the site and consideration has been given to the use of rock, sand-filled containers and interlocking concrete blocks. Construction could be phased starting at the western end of the existing seawall.

The existing placed rock has been reasonably effective in limiting storm cut although it was overtopped and damaged during the 2014 events.

6.3.1. Seawall Design

The alignment of the seawall should be as landward as possible to limit impact on the natural coastal processes and ideally remain buried for the majority of its life – only to be exposed by prolonged erosion events threatening infrastructure and property. Post erosion-event, sand can naturally (or assisted with beach scraping methods) build back up and cover the seawall. Where a seawall is required to protect infrastructure or residences, the preferred alignment by state agencies is as landward as practicable (in other locations an alignment ~10m seaward of property boundaries has been considered acceptable). A more seaward alignment would need to be justified. The benefits of more landward construction include:

- Lower cost (smaller seawall can accommodate the same design event)
- Less visually invasive (rock wall only exposed when necessary so beach retains a more natural appearance)
- Safer (since rocks are generally buried)
- Lower impact to the coastal system (wider beaches and less end effects)
- Effectively protects infrastructure and homes.

The crest height of the wall has been taken to be 5.2m AHD. This matches the height of the existing rock structure although it would be slightly higher (approx. 0.5m – 1m) than the natural surface levels along the majority of the park and some backfill will be required. It is expected that overtopping and inundation of the park will still occur during higher storm tide events, but with a wider crest detail it should not compromise the structure. The risk to private property may need to be assessed separately. Over time, in response to climate change, adaptation of the structure (including raising of the crest levels) would likely be required to address inundation issues.

The toe depth will depend on the selected alignment. For a wall along the present alignment, the beach level scours to +1.5m AHD with an additional local scour adjacent to the structure. Experience with other structures suggests that where local scour holes form they are typically only present during the event and in many cases flexible structures can accommodate a small amount of undermining on this basis. As such, for an alignment along the present scarp alignment a toe depth of +1.5m has been adopted. Every 10m landward raises the required toe level by about 0.5 – 0.75m and reduces the impact on beach amenity and coastal processes. The present rock wall could be removed and relocated landward but this would mean loss of mature trees. For costing comparison, it has been assumed that an alignment at least 10m landward of the current scarp will be adopted, allowing the toe level to be raised to approximately +2.25m AHD (subject to detailed design). Over time, in response to climate change, adaptation of the structure (including installation of a flexible toe) would likely be required to address increased scour.

6.3.2. Boulder Seawall

Figure 17: Present boulder wall at Wilsons Beach (overtopping damage evident)

Advantages / Disadvantages:

Face stability	Flexible structure. In large events where toe scour occurs, there can be displacement of boulders and reshaping of the face. Need for rock top-up/ maintenance.
Response to scour	Accommodated by slumping of rock. Need for rock top-up/maintenance.
Durability	Rock quality is a potential issue. Isn't regularly exposed to wave action, so expected lifetime is significant, with maintenance.
Constructability	Achievable during good and poor beach/weather conditions.
Maintenance	Placement of additional rock can be undertaken from top provided good access. Can be adaptable to changing conditions. i.e. climate change.
Impact on foreshore	Wave dissipation in voids results in lower reflection than other structures
Access	Needs to be provided separately (i.e. stairs over rock)
Safety	Known issues associated with voids and unstable rocks, partially mitigated through post-storm maintenance.
Visual impact	High impact although considered to blend with natural rocky headlands- , limited to periods when exposed.

Estimated Capital Cost: $5,000-$8,000 /m [10m landward from scarp]

For an alignment along the scarp, expected costs would be $6,500-$10,500 /m for the deeper toe alone. This would be suitable for current climate conditions, but as water levels and wave heights increase with climate change, the structure would need to either be removed or armoured with larger boulders (representing a significant future cost).

Suitability: It is considered advantageous to construct the seawall landward of the scarp to protect residences against short-term erosion threats (and reestablish the dune in front of the seawall to maximize amenity).

6.3.3. Sand-filled-Geotextile Containers

Figure 18: Typical Geotextile Sand Filled Container Wall

Advantages / Disadvantages:

Face stability	Stability needs to be verified to ensure adequate safety factor. Failure through pull-out of containers at water level. Will require modification of existing units.
Response to scour	Some scour accommodated by flexible toe detail. Flexible structure can accommodate further scour, with lowered crest levels.
Durability	For the heavy duty geotextile, expected life is greater than 25yrs [when exposed] with monitoring and maintenance. Cheaper geotextiles and lower cost systems (such as geotubes and trapbags) are available but these are more vulnerable to vandalism or incidental damage from Council beach equipment.
Constructability	Achievable during good and poor beach/weather conditions.
Maintenance	Damaged containers can be repaired very easily soon after damage. Loss of individual containers accommodated by “self-healing”. Major damage addressed through restacking or additional crest layers.
Impact on foreshore	Higher reflection may result in increased erosion.
Access	Provides practical access and egress from beach for fit persons (0.7m “steps”), but doesn’t provide access to the Australian Standards requirements. NB: tracking may discourage dune development if not a designated access point.
Safety	Structure is soft and user-friendly. Potential issue associated with partially dislodged containers, but can be addressed through maintenance.
Visual impact	Low impact, integrates well with sandy foreshore.

Estimated Price: $3,000 - $6,000 /m

Suitability: May be suitable (provided well-constructed and maintained). Design would need to be verified to ensure stability prior to implementation. Temporary walls such as tubes, trapbags or gabions could be constructed at lower cost but would have higher maintenance costs.

6.3.4. Concrete Blocks

Figure 19: Typical concrete block wall

Advantages / Disadvantages:

Face stability	Stable if founded on bedrock
Response to scour	In event of scour below design levels, failure mode could be catastrophic. Minimum toe depths need to be ensured.
Durability	Good, provided footing covered
Constructability	Good, quick.
Maintenance	Low [with correct concrete]
Impact on foreshore	Very high reflection expected to result in increased erosion when exposed.
Access	Public access points can be incorporated into structure.
Safety	Fencing required at top of seawall. Can be stepped.
Visual impact	Can use colored concrete to fit in with surroundings.
Face stability	Stable
Response to scour	In event of scour below design levels, failure mode could be catastrophic. Minimum toe depths need to be ensured.
Durability	Good, provided footing covered
Constructability	Good, quick.
Maintenance	Low [with correct concrete]
Integration with adjacent boulder walls	Could be addressed through provision of a transition zone for longer lengths, but impractical for short sections.
Impact on foreshore	Very high reflection expected to result in increased erosion when exposed.
Access	Public access points can be incorporated into structure.
Safety	Fencing required at top of seawall. Can be stepped.
Visual impact	Can use coloured and textured concrete to better fit in with surroundings.

Estimated Capital Cost: $8,000-$12,000 /m

Suitability: Considered difficult as not likely to be a bedrock platform and may require toe piling at additional cost. Design would need to be verified to ensure stability prior to implementation.

7. Summary

A summary of the options considered is shown in Table 3, based on data available, preliminary modelling and concept design.

Table 3: Summary of Options

Option	Approx Comparative Costs		Comments
	Capital	Maintenance	
Do Nothing	0	$15/m	erosion, innundation and damage will continue. will need beach scraping after severe erosion
Beach Scraping	$15/m		Will provide some buffer against erosion and innundation - damage will continue.
Seawalls			
Geotextile bags	$3,000-$6,000 /m	say 5% pa	very effective, particularly if crest raised as levee. high cost, needs benefit cost analysis
Boulders	$5,000-$8,000 /m	low	
Concrete	$8,000-$12,000 /m	low	

8. Recommendations

There is no simple low cost solution that provides comprehensive protection. Erosion and inundation has been infrequent but the potential risks as a result of a major event could be significant and are expected to increase over time.

Beach scraping is a relatively low-cost solution that effectively addresses the amenity and safety of the foreshore and provides a level of protection during smaller storms, but the volume available is not sufficient to provide a significant level of protection during a design event. Nourishment may be a possibility if a suitable cost-effective sand source could be identified.

To effectively mitigate erosion, a seawall as far landward as practical (while still being acceptable to the community) is preferred. Costing has been based on an alignment at least 10m landward of the present scarp. Given the uncertainty regarding stability of sand-filled geotextile containers and the potential for vandalism and maintenance costs, a rock seawall is preferred in this location. Unfortunately, the cost for a fully engineered wall able to withstand the design storm required by EHP is high and may be prohibitive for such a community project.

Depending on the available funding, the following is recommended:

- Continue beach scraping after erosion events
  - If possible, amend final profile to increase natural surface levels to limit inundation (i.e. create a 'dune' feature).
  - Stabilise nourishment with dunal vegetation and fencing.
- Investigate any potential sand sources for nourishment which may be identified.
- If funding for a seawall is available (potentially staged):
  - Discuss preferred seawall alignment with Community and EHP.
  - Discuss the role of the seawall in mitigating inundation.
  - Undertake final design, approvals and construction.
  - Adapt works as required in response to climate change.

Regardless of the works undertaken, additional data collection would be beneficial to provide a better understanding of coastal processes and design conditions and potentially provide justification for adoption of a more optimized design. This could include collection of any historic data not previously identified as well as undertaking regular (annual) and post-storm surveys along identified transects. Regional wave modelling or local data collection and joint probability analysis would also be of benefit to better understanding risks.

9. References

Development approval and an operational works permit to undertaken prescribed tidal works within a coastal management district (beach protection work) at Wilson's Beach, Proserpine – sand scraping. Whitsundays Regional Council, 12/8/2014.

EA, ENW, KFLI. (2007) "EurOtop Wave Overtopping of Sea Defences and Related Structures: Assessment Manual"

Goda, Y. (2007) "Reanalysis of Regular and Random Breaking Wave Statistics", 54th Japanese Coastal Engineering Conference

Mabin M.C.G. (October 1991) Field Survey for Carbonate, Silica and Quartzose Sediment Deposits
RESEARCH PUBLICATION No.22, Department of Geography, James Cook University of North Queensland

GHD 2003 Storm Tide Modelling Study of the Whitsunday Coast and Resort Islands Final Report,

2015 Tide Tables, Queensland Transport

ATTACHMENT 1

WILSONS BEACH SURVEY
July 2014