Coastal engineering scoping study for a tidal swimming facility: Port River, Adelaide

WRL TR 2022/15, May 2023

By I R Coghlan and J T Carley

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Contents

List of tables

List of figures

1 Introduction

The Water Research Laboratory (WRL) of the School of Civil and Environmental Engineering at UNSW Sydney was engaged by the Estuary Care Foundation (ECF) to prepare a desktop coastal engineering scoping study for a tidal swimming facility in Port River, Adelaide.

ECF and the North Haven Surf Life Saving Club (NHSLSC) are partnering as proponents for a swimming facility (i.e. a tidal pool) to be constructed at one of four potential sites within the Inner Harbour of Port Adelaide (Figure 1.1 and Figure 1.2). The desktop coastal engineering scoping study, summarised in this report, forms a part of the planning processes for a tidal pool. It is understood that the ECF/NHSLSC will share the outcomes of this scoping study with representatives of federal, state and local governments and the community, to promote the establishment of a tidal swimming facility.

This scoping study is limited to the coastal engineering aspects of a tidal pool, including preliminary capital and operational cost estimates and the potential economic benefits of its usage. It does not assess other professional engineering aspects, planning and policy issues, liability issues and environmental impacts.

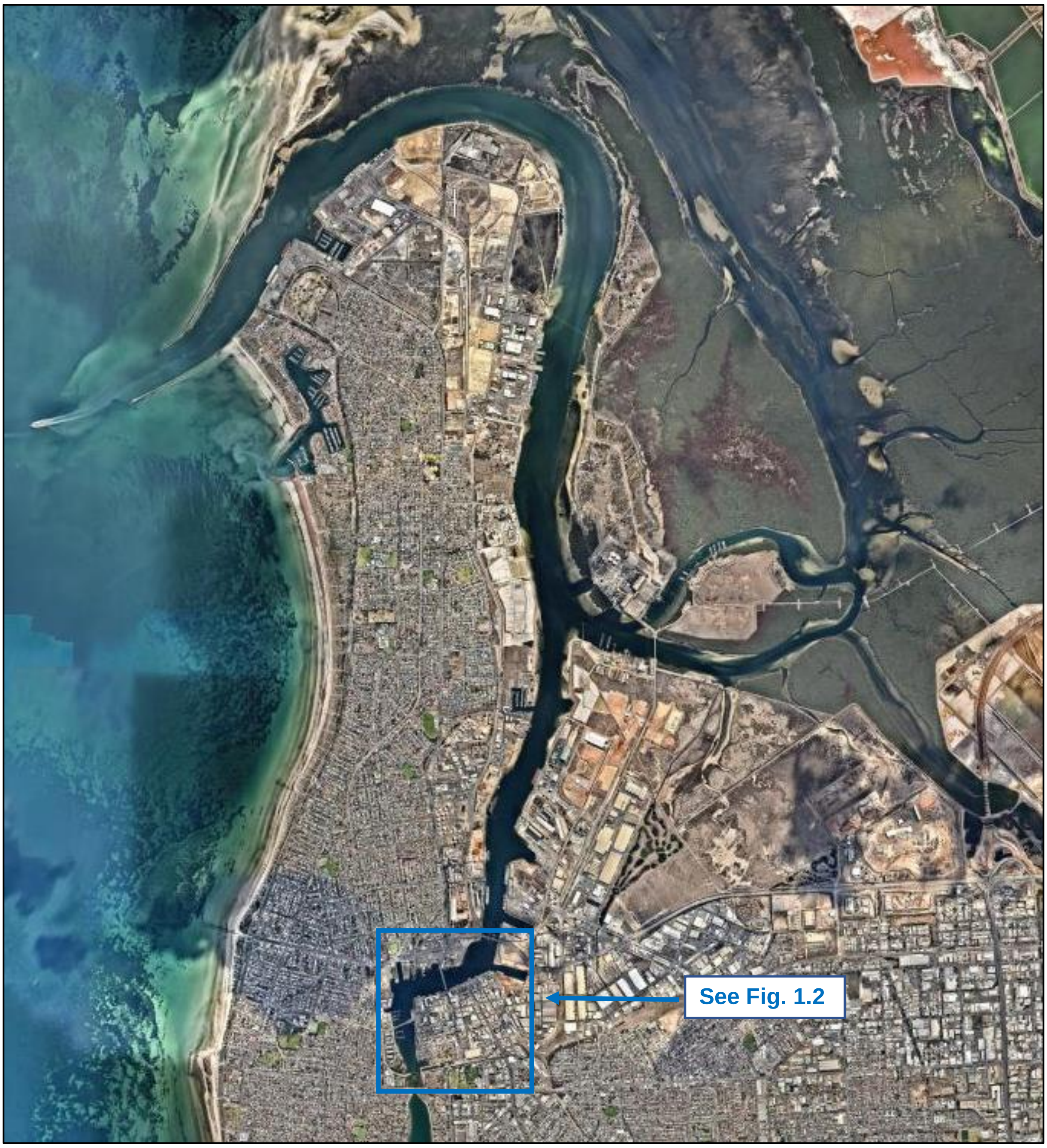

Figure 1.1 Overview of Port River

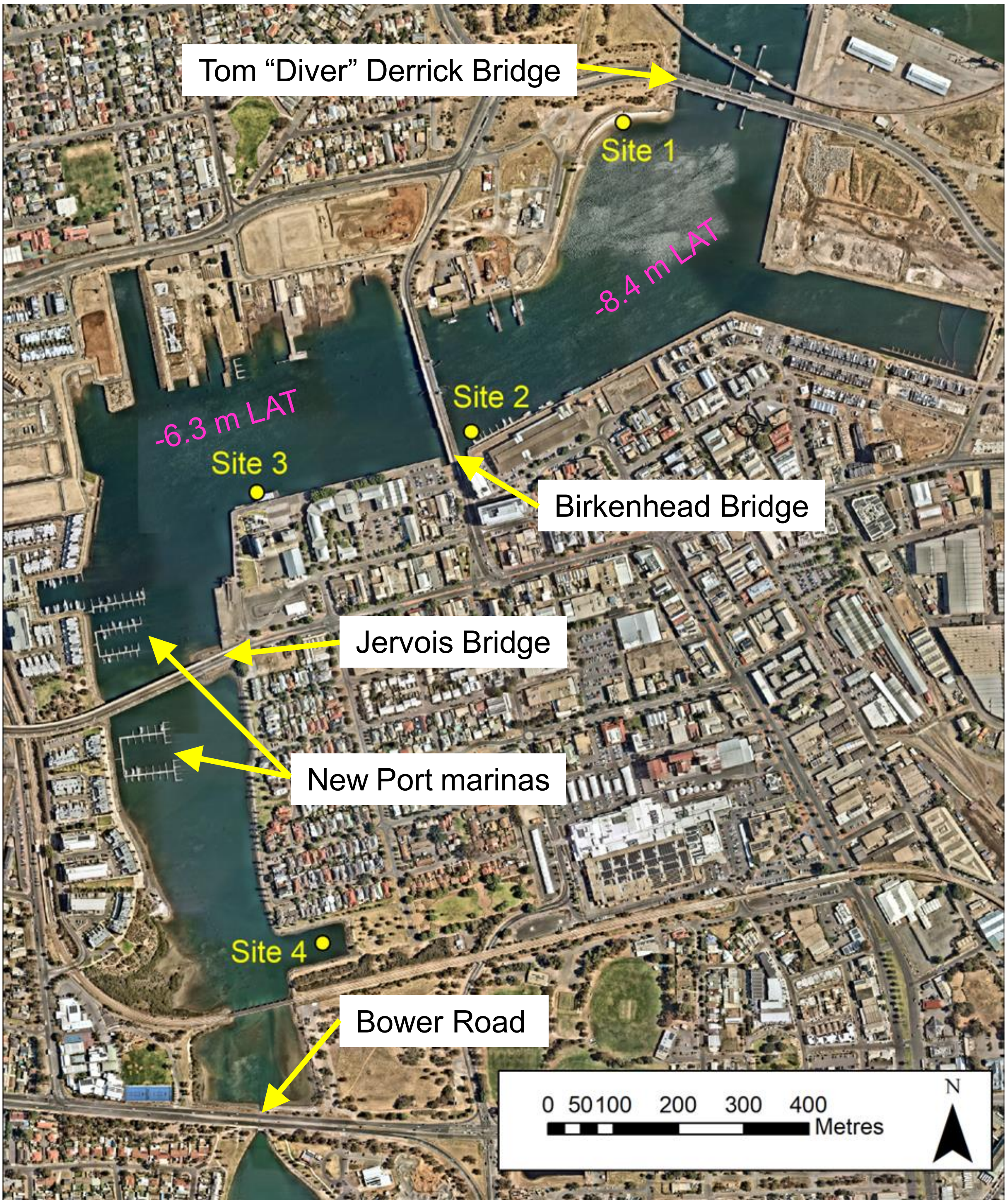

Figure 1.2 Zoomed in view of four potential sites for a tidal pool (19 December 2022, Source: Nearmap)

2 Overview of potential tidal pool sites

2.1 Preamble

ECF provided WRL with four potential tidal pool sites in the Port River (Figure 1.2) for consideration. General considerations regarding pool access and future dredging in the area are documented in the following Sections 2.2 and 2.3. Each of the four potential tidal pool sites are then outlined in Sections 2.4 to 2.7.

The environmental constraints associated with these potential sites are later discussed in Section 3.

2.2 Types of pool entry considered

An important consideration is how swimmers would access a tidal pool at each of the four potential sites.

As later discussed in Section 4, the better existing tidal pools that WRL is familiar with use a natural sand floor in shallow regions, with a beach-entry; also known as a zero-entry pool (that is, zero water depth at entry). This type of pool, with a sloping entrance, differs from most conventional adult pools which have a vertical, moderate depth entry. Beach-entry allows pool access to a larger proportion of the community, such as infants, children, people with low mobility, non-swimmers and weak swimmers.

However, as later discussed in Section 3.3, bed sediments at the four potential tidal pool sites are likely to be contaminated and may have a significant proportion of silt/clay, rather than mainly comprising sand. As such, while a beach-entry pool may be possible at two sites in the Port River (due to their existing shallow bathymetry), it would be necessary to add artificial sand, via beach nourishment, to cover the existing bed sediments. Alternatively, as later discussed in Section 5, swimmers may instead access a tidal pool in the Port River by a timber jetty/walkway only. That is, the tidal pool would be located in sufficient water depth so that swimmers' feet do not touch the existing bed sediments, negating the need for beach nourishment.

2.3 Potential future dredging in the immediate area

WRL understands that the South Australia government is required to maintain the following minimum channel depths in the area (Flinders Ports, 2007; see also Figure 1.2):

- Bed elevation 8.4 m below Lowest Astronomical Tide [LAT] (approximately -9.85 m below 0 m Australian Height Datum [AHD]) between Birkenhead Bridge and Tom "Diver" Derrick Bridge (adjacent to potential tidal pool sites 1 and 2)
- Bed elevation 6.3 m below LAT (approximately -7.75 m below 0 m AHD) between Birkenhead Bridge and Jervois Bridge (adjacent to potential tidal pool site 3)

However, WRL understands that no maintenance dredging has occurred in this area since at least the mid-1990s. Future dredging in the area may temporarily affect water quality within a new tidal pool.

2.4 Site 1

Site 1 is located immediately to the north of the boat ramp at Cruickshanks Beach (Figure 2.1), just upstream of Tom "Diver" Derrick Bridge. Open space is available on land adjacent to the proposed site that could be used for amenities to support a tidal pool. WRL understands that the sand forming Cruickshanks Beach is not naturally occurring, and has been placed via artificial beach nourishment. With additional beach nourishment, a beach-entry pool may be possible at this site. In 2017, *The Long Swim Through Port Adelaide*, a reinstated river swimming event, used the boat ramp adjacent to this site for swimmers to enter and exit the water.

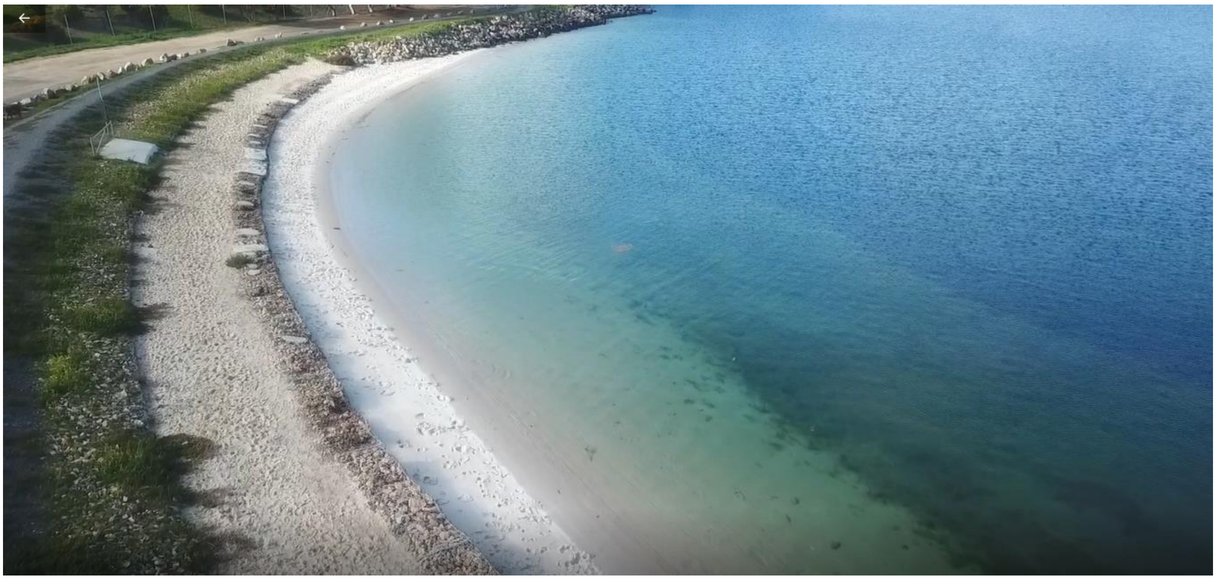

Figure 2.1 Potential tidal pool site 1: Cruickshanks Beach (Source: ECF)

2.5 Site 2

Site 2 is located at Queens Wharf, adjacent to Quest Port Adelaide apartment hotel (Figure 2.2). A range of boats are temporarily moored at the floating wharf. A beach-entry pool is not possible at this site, at mid-tide the water depth at the wharf is approximately 8.8 m (bed elevation 7.5 m below LAT) based on bathymetric data provided by Flinders Ports (Flinders Ports, 2007).

Figure 2.2 Potential tidal pool site 2: Queens Wharf (Source: ECF)

2.6 Site 3

Site 3 is located adjacent to Hart's Mill Playground, just upstream of Folklore Cafe (Figure 2.3). A floating pontoon exists which is used for boating and fishing. A beach-entry pool is not possible at this site, at mid-tide the water depth at the wharf is approximately 4.3 m (bed elevation 3.0 m below LAT; Flinders Ports, 2007). In 2019, *The Long Swim Through Port Adelaide*, used the pontoon at this site for swimmers to enter and exit the water.

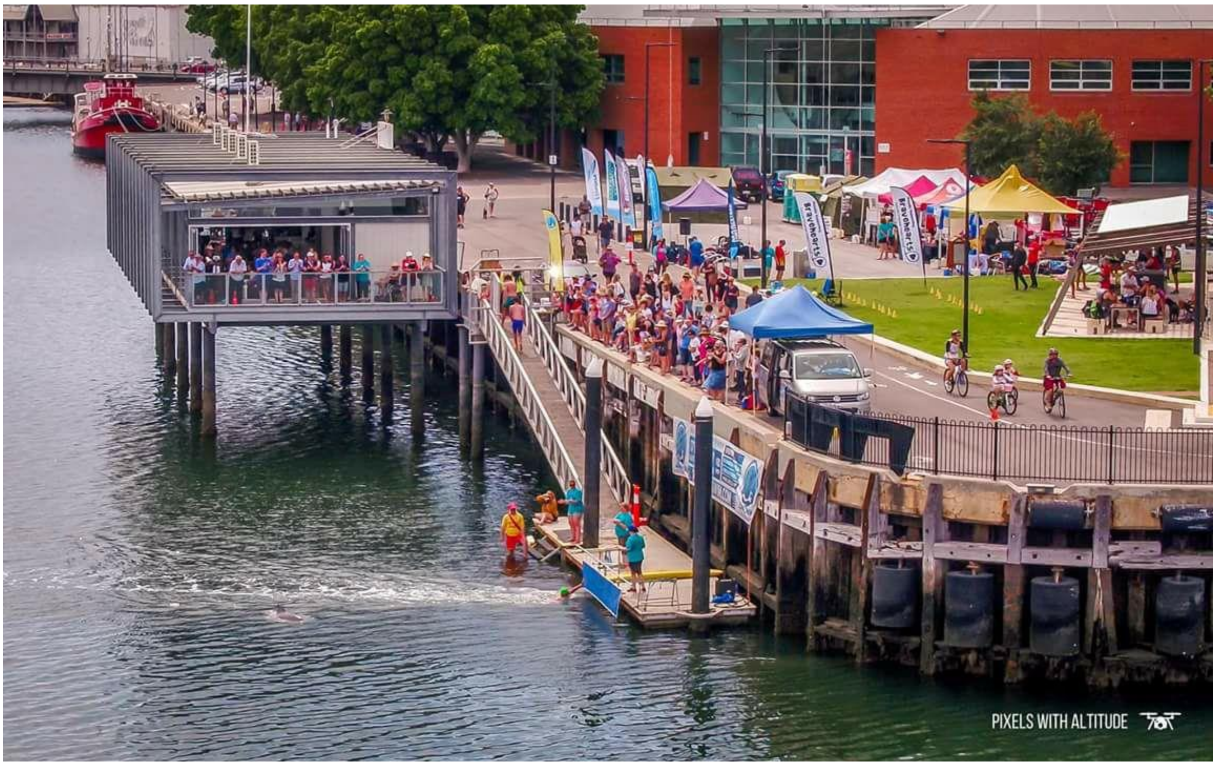

Figure 2.3 Potential tidal pool site 3: Hart's Mill Playground (Source: Pixels With Attitude)

2.7 Site 4

Site 4 is located within an enclosed bay adjacent to Joyce Snadden Reserve (Figure 2.4). Open space is available on land adjacent to the proposed site that could be used for amenities to support a tidal pool. With the addition of some beach nourishment, a beach-entry pool may be possible at this site (based on review of bathymetric data provided by Flinders Ports [Flinders Ports, 2022]). A pipe in the south-east corner of the embayment discharges stormwater into the Port River from the Hack Street pumping station (see also Figure 3.3).

Figure 2.4 Potential tidal pool site 4: Joyce Snadden Reserve (Source: ECF)

3 Site-specific environmental constraints

3.1 Water quality

3.1.1 Tidal water levels and flushing

Elevated water levels consist of (predictable) tides, which are forced by the sun and moon (astronomical tides), a tidal anomaly (later discussed in Section 3.2) and other local processes. Astronomical tidal planes for Port Adelaide are shown in Table 3.1, based on values from AusTides (2017). While the Mean High Water Springs (MHWS) mark is approximately 1.0 m above Mean Sea Level (MSL) (-0.152 m AHD), some tides will reach up to approximately 1.5 m above mean sea level without any additional tidal anomaly. Chart datum, which is used in bathymetric charts and tidal predictions, is approximately 1.452 m below 0 m AHD (BoM, 2010a).

Table 3.1 Astronomical tidal water levels for Adelaide (Source: AusTides, 2017; BoM, 2010a)

Description	Water Level (m relative to datum)	
	LAT	AHD
Highest Astronomical Tide (HAT)	2.8	1.348
Mean High Water Springs (MHWS)	2.3	0.848
Mean High Water Neaps (MHWN)	1.3	-0.152
Mean Sea Level (MSL)	1.3	-0.152
Mean Low Water Neaps (MLWN)	1.3	-0.152
Mean Low Water Springs (MLWS)	0.3	-1.152
Lowest Astronomical Tide (LAT)	0.0	-1.452

It can be seen in Table 3.1 that the tidal water levels for MSL, Mean High Water Neaps (MHWN) and Mean Low Water Neaps (MLWN) are approximately equal. During neap tide periods (between new and full moon); the tidal range is smallest because the lunar and solar influences are opposed and cancel each other out to an extent. An unusual situation will occur during neap tide periods near the equinoxes, known as “dodge tides”; where water levels will remain approximately constant throughout a whole day (BoM, 2010b). Minimal tidal flushing (and inflows from West Lakes; Section 3.1.2) will occur during neap tide periods; especially on “dodge tides”.

For spring tide conditions (when the predicted tidal range is at its greatest; at or soon after the new or full moon), based on a 2 m elevation water level difference between MHWS and MLWS, an estimated water surface area of 484,000 m^2 between Tom “Diver” Derrick Bridge and the upstream tidal limit and representative bed elevations, WRL estimates that approximately 970 ML of estuarine water enters and leaves the area in 12.5 hours. This tidal flushing (exchange) process is an important consideration for water quality at the potential pool sites.

While coupled hydrodynamic-water quality modelling has not been undertaken, tidal flushing is expected to reduce with distance from the mouth of the Port River. That is, tidal flushing is highest at Site 1, reducing for Sites 2 and 3, and lowest at Site 4.

Further to this, WRL considers that forces from tidal currents are not expected to be a significant influence on the design, or usage, of the tidal pool. Based on the same assumptions above for spring tide conditions, peak tidal velocities in this area of the Port River are estimated to be below 0.05 m/s.

3.1.2 Inflows from West Lakes

At the head of the Port River estuary at Bower Road, outflows from the constructed West Lakes system enter the Port River. Ocean water is drawn into the West Lakes system on the upper part of the tide, and released into the Port River on the lower part of the tide (Figure 3.1). In this manner, the entire volume of West Lakes is replaced approximately every 10 days (Dyer, 2012). The average daily flow of sea water through West Lakes is approximately 358 ML (LWC, 2021) (split unevenly across two high tides). Considering the magnitude of these outflows, in addition to tidal flushing, the quality of water released from West Lakes is a significant contributor to water quality at all of the potential pool sites (Figure 3.2). Note that water quality measurements from within the West Lakes system were not available to WRL.

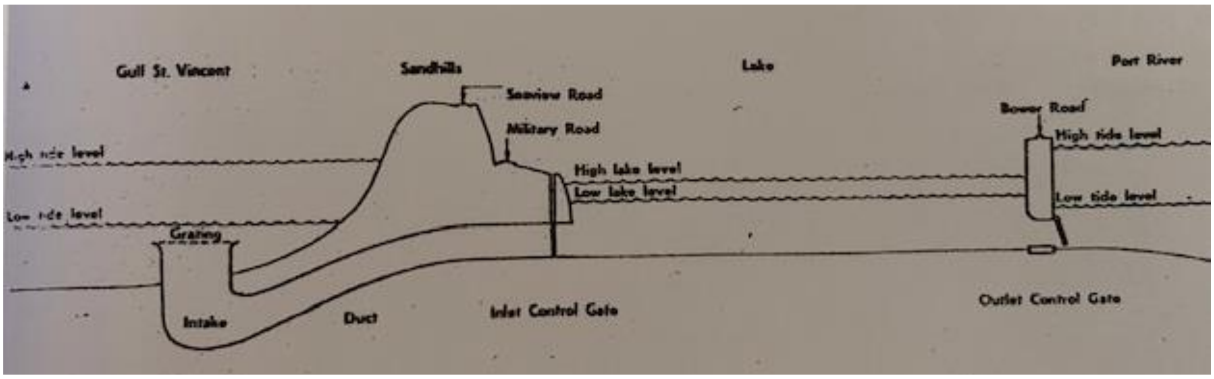

Figure 3.1 Schematic of West Lakes tidal flushing system (Source: Dyer, 2012)

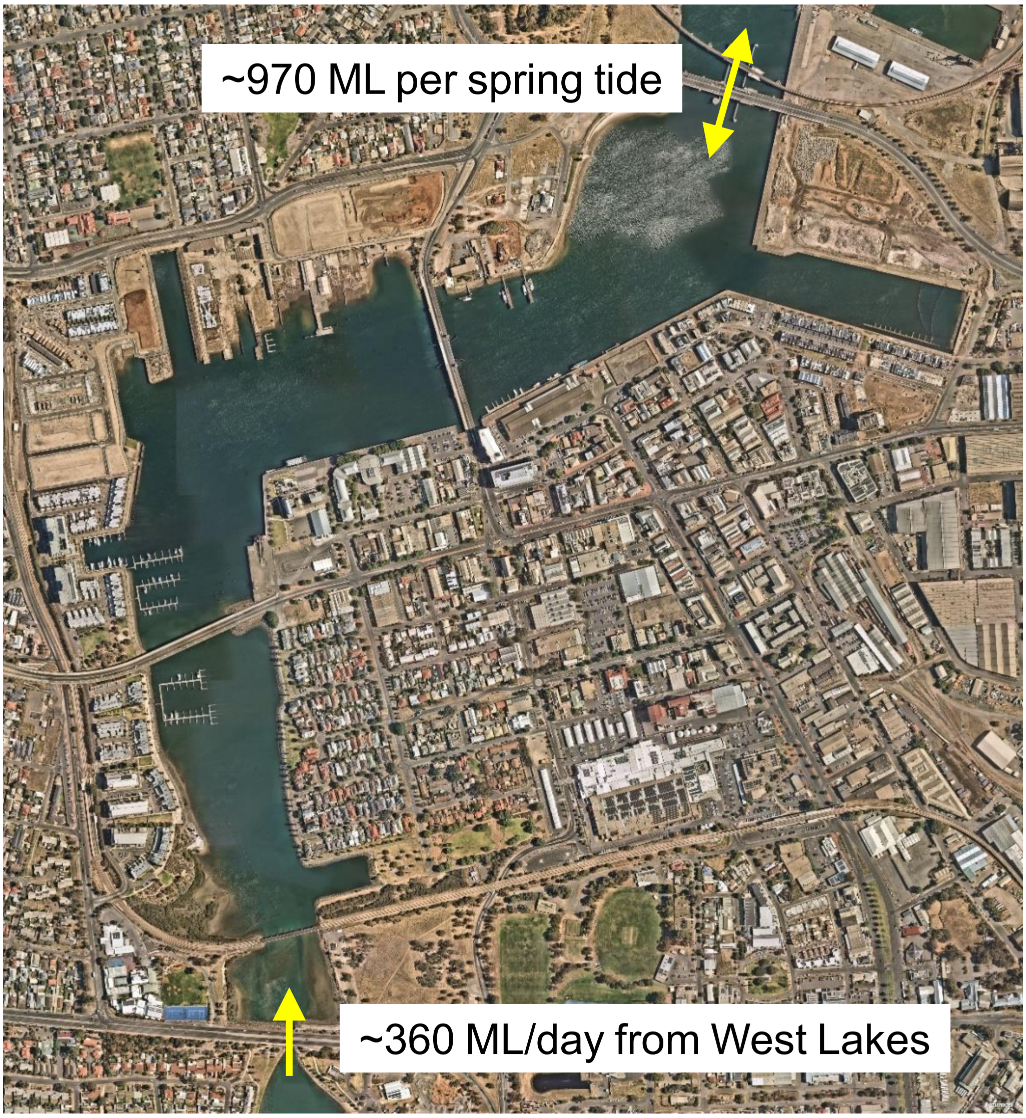

Figure 3.2 Magnitude of tidal exchange and inflows from West Lakes system (19 December 2022, Source: Nearmap)

3.1.3 Stormwater

Stormwater inputs to the area containing the four potential tidal pool sites are discussed in two separate stormwater management plans regarding the eastern side (Southfront, 2018) and western side (Southfront, 2019) of the Port River. Figure 3.3 shows the key stormwater infrastructure in the area including stormwater drains, pump stations and rising mains.

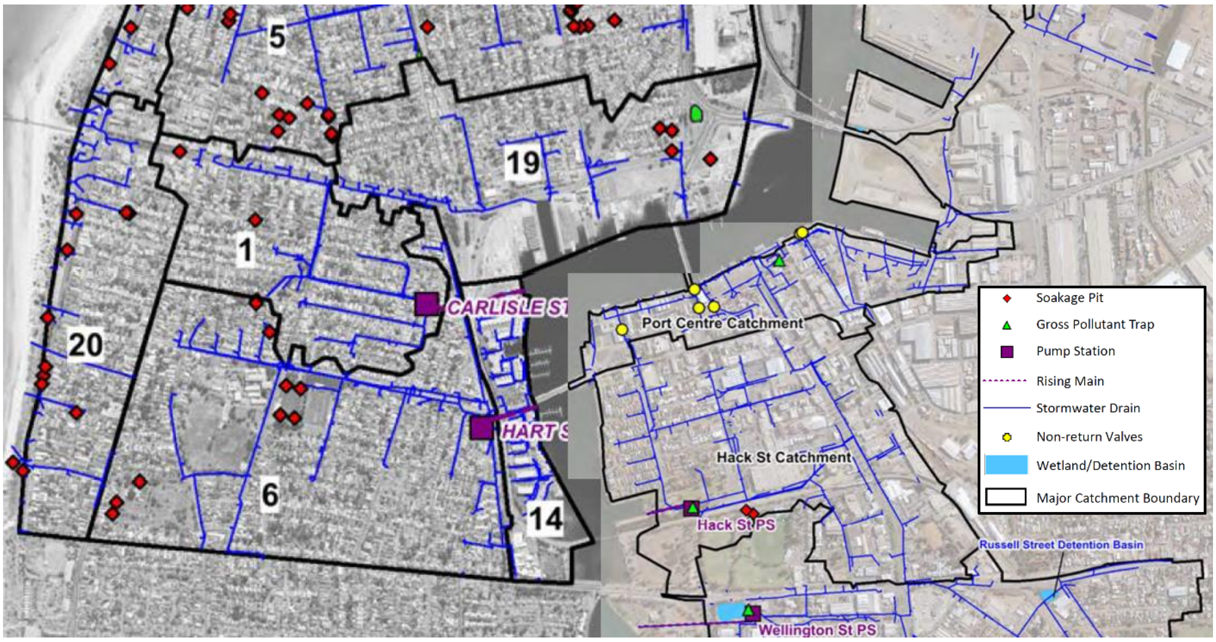

Figure 3.3 Stormwater drainage infrastructure near the four potential tidal pool sites (adapted/merged by WRL from Southfront, 2018 and Southfront, 2019)

It can be seen that all four potential tidal pool sites have adjacent stormwater outlets. Coupled hydrodynamic-water quality modelling would be required to assess the differences in water quality at each of the four sites.

Land use for sub-catchments discharging near the four potential pool sites are predominantly residential and industrial/commercial (i.e. high impervious percentage). Potential water quality risks from the stormwater for pool users are increased suspended sediments (turbidity and sedimentation), nutrients, metals, pesticides, hydrocarbons, emerging organic contaminants, litter and reduced salinity.

The South Australian Environment Protection Authority (EPA) advises the public that swimming should be avoided in West Lakes for 2 to 3 days after rain (EPA, 2023a) for health reasons. WRL understands that this same advice applies for swimming in the Port River.

3.1.4 Water quality measurements

The closest location where available water quality samples have been collected by the EPA is Location 9 shown in Figure 3.4 (EPA, 2023b). Measurements were collected at this location approximately monthly over the following two periods:

- July 1996 to June 2008 (EPA, 2008)
- December 2017 to June 2018 (EPA, 2022)

Figure 3.4 Water quality sampling location near four potential tidal pool sites (19 December 2022, Source: Nearmap)

The outlet of the Port Adelaide Waste Water Treatment Plant (WWTP) was previously at the head of the estuary (Figure 3.4) but outflows were diverted in October 2004. The improvement in water quality at Location 9 as a result of the diversion of the WWTP can be seen in time series plots of total phosphorus and total nitrogen in Port River in Figure 3.5.

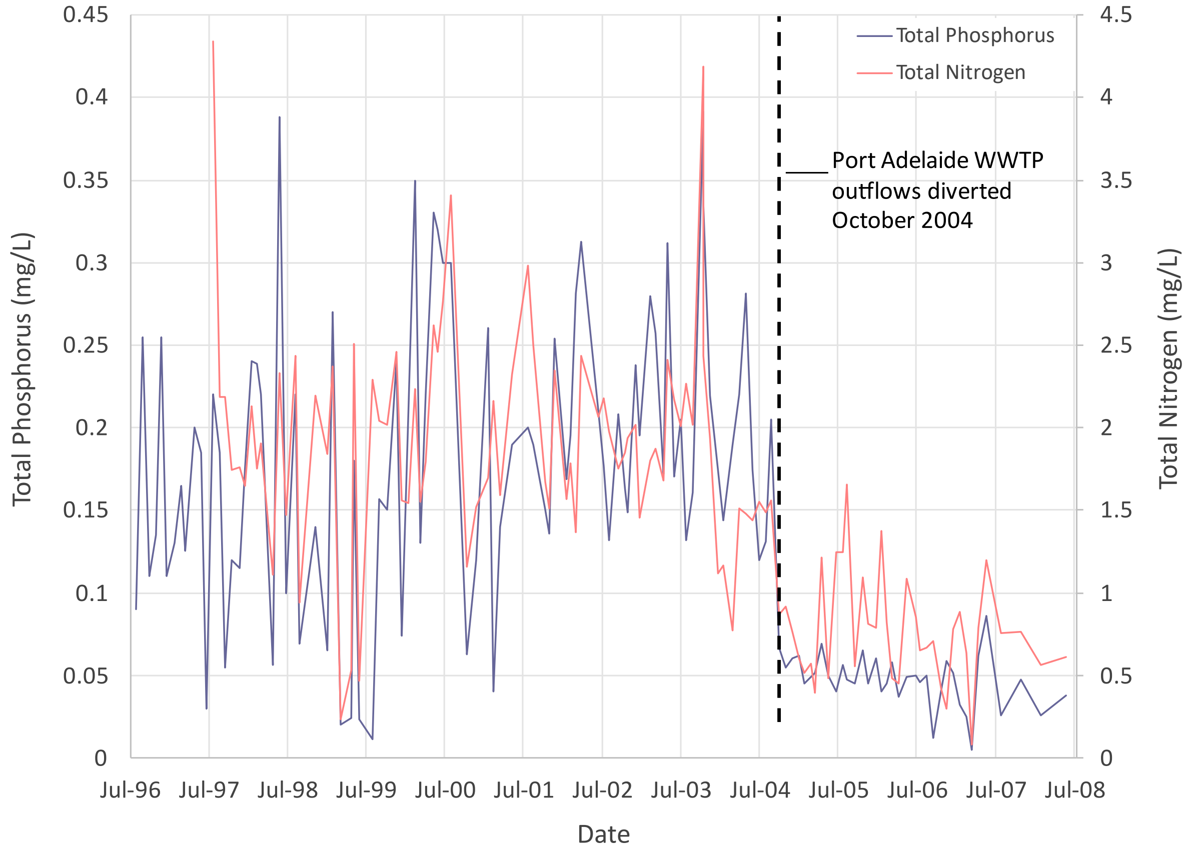

Figure 3.5 Time series plot of total phosphorus and total nitrogen and at water quality sampling Location 9

All water parameters analysed for first sampling period, following diversion of the WWTP, are compared with guideline values (where available) from the Guidelines for Managing Risks in Recreational Water (NHMRC, 2008) in Table 3.2. These guidelines state that there is not a significant risk of adverse health effects to people for concentrations below the guideline values. Where a guideline value is available, the minimum, median and maximum measured values are shaded green (satisfying threshold) or red (failing threshold). Median values satisfy the thresholds for all water quality parameters except cadmium.

Similarly, all water parameters for the second sampling period (December 2017 to June 2018) are compared with guideline values in Table 3.3. While it is acknowledged that this is a much smaller dataset, the data appears to suggest that water quality in the area of the potential tidal pool sites has further improved over the intervening period of almost 10 years. Median and maximum values satisfy the thresholds for all water quality parameters during this time. Based on these water quality measurements, it appears that swimming at the four potential tidal sites is safe assuming that the guidance to avoid swimming for 2 to 3 days after rain is followed. WRL recommends that a human health risk assessment (e.g. EnRiskS, 2022) be undertaken as part of a later stage of design for the tidal pool.

Table 3.2 Comparison of water quality measurements with guideline values (January 2005 – June 2008, total 34 samples)

Parameter	Guideline	Minimum	Median	Maximum
Cadmium (total) (mg/L)	<0.002*	<0.0005	0.0035	0.0077
Copper (total) (mg/L)	<2*	0.0016	0.01	0.0365
Lead (total) (mg/L)	<0.01*	<0.0005	0.005	0.005
Mercury (total) (mg/L)	<0.001*	<0.0003	0.0003	0.0004
Nickel (total) (mg/L)	<0.02*	0.0005	0.005	0.02
Zinc (total)(mg/L)	<3*	<0.03	0.03	0.082
Chlorophyll a (µg/L)	n/a	2.05	9.505	42.2
Dissolved oxygen (mg/L)	>5.9**	4	6.8	11.95
Enterococci (per 100 mL)	<200*	0	6	100
Turbidity (NTU)	n/a	0.51	1.275	4.2
Ammonia (as N) (mg/L)	<0.5*	0.011	0.252	0.613
Total Nitrogen (mg/L)	n/a	0.076	0.73	1.659
Oxidised Nitrogen (as N) (mg/L)	n/a	0.026	0.14	0.369
TKN (as N) (mg/L)	n/a	<0.05	0.48	1.29
Phosphorus (sol) (mg/L)	n/a	<0.005	0.009	0.028
Total Phosphorus (mg/L)	n/a	0.005	0.047	0.086

* Guideline value for this parameter sourced from the Guidelines for Managing Risks in Recreational Water (NHMRC, 2008).

** Guideline value for Dissolved Oxygen in mg/L inferred by WRL from 80% saturation value sourced from the Guidelines for Managing Risks in Recreational Water (NHMRC, 2008) assuming a temperature of 20°C and salinity of 35 ppt.

Table 3.3 Comparison of water quality measurements with guideline values (December 2017 to June 2018, total 6 samples)

Parameter	Guideline	Minimum	Median	Maximum
Cadmium (total) (mg/L)	<0.002*	<0.001	<0.001	<0.001
Copper (total) (mg/L)	<2*	<0.001	0.003	0.01
Lead (total) (mg/L)	<0.01*	<0.001	<0.001	0.001
Mercury (total) (mg/L)	<0.001*	<0.0003	<0.0003	0.0007
Nickel (total) (mg/L)	<0.02*	<0.001	0.003	0.009
Zinc (total)(mg/L)	<3*	<0.003	0.026	0.086
Chlorophyll a (µg/L)	n/a	0.48	1.78	6.78
Phaeophytin a (µg/L)	n/a	<0.1	0.60	2.05
Turbidity (NTU)	n/a	0.33	1.05	1.50
Ammonia (as N) (mg/L)	<0.5*	<0.005	0.019	0.072
Total Nitrogen (mg/L)	n/a	0.18	0.34	1.50
Oxidised Nitrogen (as N) (mg/L)	n/a	<0.003	0.009	0.027
TKN (as N) (mg/L)	n/a	0.18	0.32	1.50
Phosphorus (sol) (mg/L)	n/a	<0.003	0.009	0.023
Total Phosphorus (mg/L)	n/a	0.007	0.032	0.044

* Guideline value for this parameter sourced from the Guidelines for Managing Risks in Recreational Water (NHMRC, 2008)

3.1.5 Circulation concerns (flows/wind)

While it is not possible to quantitatively comment on water quality differences between the four sites without undertaking hydrodynamic-water quality modelling, it should be noted that the enclosed nature of Site 4 (Joyce Snadden Reserve) may lead it to have poorer water quality. This is due to reduced flushing with the main flows in the middle of the channel and the potential for floating debris to accumulate within the embayment with prevailing winds.

3.2 Extreme water levels (storm surge)

Extreme water levels are an important consideration for the design of a tidal pool to ensure that any floating components can tolerate the range of vertical excursion experienced during a flood and fasteners for fixed components can withstand buoyancy forces when submerged.

Tidal anomalies primarily result from factors such as regional wind setup (or setdown) and barometric effects, which are often combined as “storm surge”. Additional anomalies occur due to “trapped” long waves propagating along the coast. Design storm surge levels (astronomical tide + anomaly) are recommended in the Port Adelaide Seawater Stormwater Flooding Study (City of Port Adelaide Enfield, 2005) based on data from the Outer Harbor and Inner Harbour tide gauges in Port River and reproduced in Table 3.4. These values exclude wave setup and runup effects which can be significant where waves break on shorelines. Note that the 100 year ARI water level at the Inner Harbour (nearest the four potential tidal pool sites) is higher than at the Outer Harbor due to tidal amplification.

Table 3.4 Design water levels Tide + Storm Surge (Source: City of Port Adelaide Enfield, 2005)

Average recurrence interval (years)	Water level excl. wave setup and runup (m AHD)	
	Outer Harbor	Inner Harbour
1.111	1.602	
2	1.787	
5	1.948	
10	2.047	
20	2.138	
50	2.248	
100	2.325	2.50

Water levels at any specific shoreline location are also subject to local wind setup, wave setup and wave runup. Local wind setup and wave setup are considered negligible due to the relatively small wave heights and short wave periods in the area. Local freshwater flooding of the Port River is also a negligible contributor to extreme water levels (runoff in Adelaide is largely directed to the River Torrens to the south); “storm surge” is the major source of flooding.

While not discussed further here, later stages of design for a tidal pool will need to consider other processes effecting water depths including land subsidence, which is prevalent in Adelaide (City of Port Adelaide Enfield, 2005), and sea level rise (noting that the time scale for sea level rise is generally longer than the renewal cycle for a tidal pool).

3.3 Bed sediments

3.3.1 Sediment quality

Bed sediments, and the potential for any toxicants bound to them, to be disturbed in relation to the construction and use of a tidal pool is also an important consideration for the health of swimmers. Bed sediment samples have previously been collected at three locations (Sites 19, 23 and 25) shown in Figure 3.6 by the EPA in 2000 (EPA, 2000). An additional sediment sample was also collected by the EPA close to Site 19 (denoted then as Site E1) in 2005 (EPA, 2005). While further away from the four potential tidal pool sites, 42 bed sediment samples have most recently been collected for Flinders

Ports in November 2020 in the zone shown in Figure 3.6 (Golder, 2020) in relation to planned maintenance dredging within that zone.

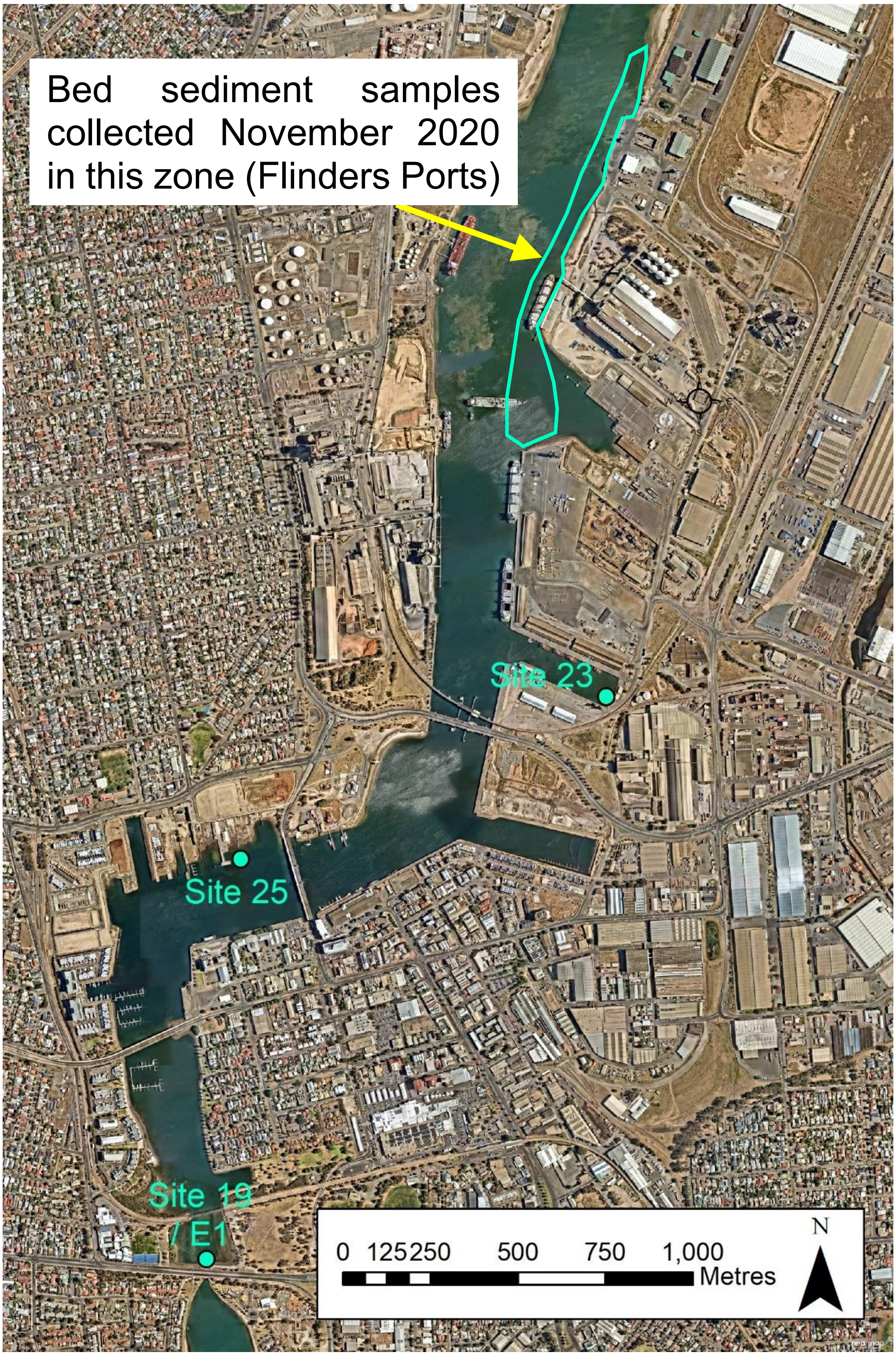

Figure 3.6 Bed sediment sampling locations near four potential tidal pool sites (19 December 2022, Source: Nearmap)

Guideline values from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) used to assess the bed sediment parameters are summarised in Table 3.5. These guidelines state that ecosystems should be protected for concentrations below the default guideline values (shaded green) but that toxicity-related adverse effects are expected to be observed for concentrations above the guideline values - high (shaded red). The bed sediment samples collected by the EPA in 2000 and 2005 are compared with these guideline values in Table 3.6.

Table 3.5 Guideline values used to assess bed sediment samples (Source: ANZG, 2018)

Parameter	Below default guideline value	Above default guideline value	Above guideline value - high
Mercury (mg/kg)	<0.15	0.15-1	>1
Cadmium (mg/kg)	<1.5	1.5-10	>10
Lead (mg/kg)	<50	50–220	>220
Zinc (mg/kg)	<200	200-410	>410
Copper (mg/kg)	<65	65-270	>270
Chromium (mg/kg)	<80	80-370	>370
Nickel (mg/kg)	<21	21-52	>52
Tributyltin (µg/kg)	<9	9-70	>70
Chlordane (µg/kg)	<4.5	4.5-9	>9

Table 3.6 Comparison of bed sediment samples (EPA 2000; 2005) with guideline values

Parameter	Site 19: Bower Road (EPA, 2000)	Site 23: No. 1 Dock (EPA, 2000)	Site 25: Jenkins Street, Birkenhead (EPA, 2000)	Site E1: Bower Road (EPA, 2005)*
Mercury (mg/kg)	1.2	0.4	4.6	
Cadmium (mg/kg)	7	<1.0	<1.0	
Lead (mg/kg)	300	60	1,200	
Zinc (mg/kg)	940	200	1,900	
Copper (mg/kg)	460	44	1,200	
Chromium (mg/kg)	240	16	60	n/a**
Nickel (mg/kg)	36	8	32	n/a**
Tributyltin (µg/kg)	n/a**	n/a**	n/a**	
Chlordane (µg/kg)	n/a**	n/a**	n/a**	

* Values for each parameter from the EPA (2005) study are unavailable, however they were classified according to the same guideline values in ANZG (2018) based on an earlier guideline document.

** Not available: bed sediment sample not analysed for this parameter.

The results in Table 3.6 show that the bed sediments near the four potential pool sites had high concentrations of heavy metals (mercury, lead, zinc and copper) in 2000 and 2005. Tributyltin (an antifouling agent for the hulls of ships) was also analysed in the 2005 bed sediment sample and found to be present in a high concentration as well. The presence of these toxicants is likely to be as a result of the historical use of the area as shipyards.

It should be noted that the 2000 and 2005 samples were analysed for polychlorinated biphenyls (PCBs) and the 2005 samples were also analysed for arsenic and herbicides. The concentrations of these three toxicants were either below the laboratory reporting detection limit or very low.

While an extensive number of parameters were analysed from the 42 bed sediment samples collected for Flinders Ports in 2020 (downstream of the four potential tidal pool sites), for brevity, only those relating to heavy metals are compared with the guideline values in Table 3.7. This table shows how the measured values from the 42 samples were distributed across the three ANZG (2018) ranges specified in Table 3.5. WRL appreciates that the purpose for collecting these samples was compliance with the EPA's dredge spoil disposal requirements, rather than assessing estuarine health as with the earlier studies (EPA, 2000 and 2005). However, it is considered that the difference in intent should not affect the results.

Table 3.7 Distribution of 42 bed sediment samples (Golder, 2020) across guideline values

Parameter	No. samples below default guideline value	No. samples above default guideline value	No. samples above guideline value - high
Mercury	5	37	-
Cadmium	41	1	-
Lead (mg/kg)	13	29	-
Zinc (mg/kg)	30	11	1
Copper	17	25	-
Chromium	42	-	-
Nickel (mg/kg)	41	1	-

While it is acknowledged that the results in Table 3.7 are from bed sediment samples further away from the four potential tidal pool sites, these more recent samples show that the trend for elevated concentrations of mercury, lead, zinc and copper persists in the Port River, likely due to legacy contamination.

WRL recommends that the human health risk assessment, incorporating water quality (noted in Section 3.1.4), to be undertaken as part of a later stage of design for the tidal pool, also include an assessment of the potential disturbance of contaminated bed sediments during construction and ongoing use of the tidal pool.

3.3.2 Sediment size

At two of the locations (Sites 19 and 25) in the EPA (2000) study, the distribution of grain sizes within the bed sediment samples was analysed (Table 3.8). Australian Standard 1726 (2017) classifies particles less than 75 µm as silt/clay, particles between 75 µm and 2.36 mm as sand and particles between 2.36 and 63 mm as gravel. While the upper range in Table 3.8, doesn't exactly match the classification transition from sand to gravel, it can be seen that the samples from the two sites comprised very different particle sizes. At Site 19 (Bower Road; the upstream tidal limit), there was a very high (70%) silt/clay content but further downstream at Site 25 (Jenkins Street, Birkenhead), the silt/clay content was much less (12%), with sand content of at least 64%.

Table 3.8 Grain size of bed sediment samples (EPA 2000)

Grain size of sediments (% of sample)	Site 19: Bower Road	Site 25: Jenkins Street, Birkenhead
<75 µm	70	12
<75 µm – 2 mm	29	64
>2 mm	1	24

While further sediment grain size analysis is not available near the four potential tidal pool sites, these results indicate that sediments forming the bottom of the tidal pool will likely be a combination of sand and silt/clay, and that the proportion of silt/clay may be significant.

3.4 Dolphins

All four potential tidal pool sites are located within the Adelaide Dolphin Sanctuary (Figure 3.7); a marine park home to approximately 30 resident bottlenose dolphins, with additional transient dolphins that visit at various times (NPWS, 2023). The design of the tidal pool should consider the presence of the bottlenose dolphins to avoid harming them, particularly selection of materials for the perimeter screen/wall.

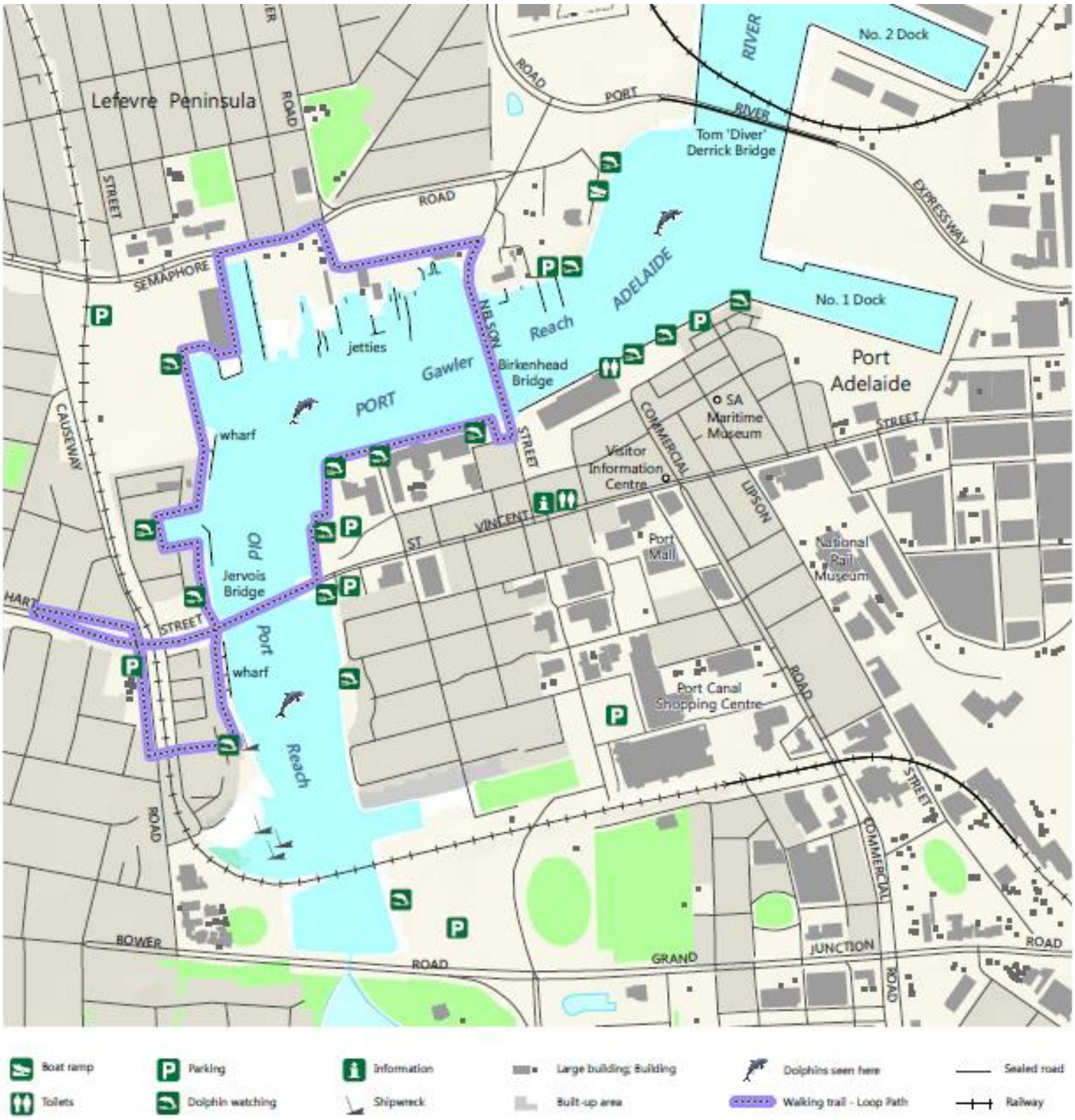

Figure 3.7 Adelaide Dolphin Sanctuary - Sightings near four potential tidal pool sites (Source: NPWS, 2023)

3.5 Shellfish and barnacles

A range of native and feral shellfish (Pacific Oysters, mussels, cockles, scallops and razorfish) and barnacles are present within the Port River in the area where the four potential tidal sites are located. It is expected that they will grow and attach themselves to components of the tidal pool. The regular removal of these shellfish and barnacles from tidal pool components will be required to maintain swimmer safety and prevent lacerations. This is a consideration for ongoing maintenance of the tidal pool facility.

3.6 Boat activity

Based on information provided by Flinders Ports (Port of Adelaide operator), it is understood that the maximum allowable boat speed in the vicinity of the four potential tidal pool sites is 7 knots but that vessels are not permitted to anchor. Flinders Ports commercial vessels do not operate in the area, however, the following range of ships/boats/craft regularly pass all sites (except the most upstream; Site 4):

- The One and All (a tall ship; Figure 3.8a)
- Commercial fishing boats (e.g. Satori; Figure 3.8b)
- Small recreational fishing boats
- Small tourist vessels (e.g. Port River Cruises and the SA Maritime Museum's Archie Badenoch)
- Boats moving to and from the marinas at New Port (Figure 1.2 and Figure 3.8c)
- Yachts
- Dragon boats (Figure 3.8d), row boats and kayaks

Figure 3.8 Ships/boats/craft which pass the four potential pool sites
(a: The One and All, b: Satori, c: boats at a New Port marina, d: dragon boat)

WRL considers that the potential for negative impacts on water quality (specifically turbidity) at Sites 1, 2 and 3 from propeller turbulence is low based on the speed limit and the existing vessels using the area. However, the design of the tidal pool will need to consider how the pool may change navigability in the Port River and the potential for vessel collisions with the facility.

3.7 Wave climate

WRL considers that wave climate, from a range of sources, is not a significant influence on the design of the tidal pool. Based on the speed limit and existing vessel types, waves generated by boats adjacent to the four potential tidal pool sites will have small wave heights and short wave periods. Similarly, due to the short fetches within this part of the Port River (less than 400 m), wind generated waves have small heights and short periods. Long period ocean swell waves also do not penetrate into the Port River upstream to the four potential tidal pool sites. Tsunamis are extremely rare and have not been considered in this study.

3.8 Pool entry

As discussed in Section 2, a beach-entry pool may be possible at Sites 1 and 4 with the addition of beach nourishment. This is not possible at Sites 2 and 3 since they interface with the wharf.

A conventional pool with a vertical, moderate depth entrance (so that swimmers' feet do not touch the existing bed sediments) is also possible at all four sites.

3.9 Summary of environmental constraints

As outlined in the preceding discussion, based on available data, the following environmental constraints cannot be differentiated between the four potential pool sites:

- Water quality (general)
- Extreme water levels (storm surge)
- Bed sediments
- Dolphins
- Shellfish and barnacles
- Wave climate
- Pool entry (conventional vertical, moderate depth entrance)

For those constraints for which the four potential pool sites can be differentiated, a summary is presented in Table 3.9.

Table 3.9 Comparison of four potential tidal pool sites based on environmental constraints

Potential tidal pool site	Environmental constraints			
	Tidal flushing (rank)*	Circulation concerns (flows/wind)	Boat activity	Beach-entry pool
1: Cruickshanks Beach	1	-	Present	Possible with nourishment
2: Queens Wharf	2	-	Present	-
3: Hart's Mill Playground	3	-	Present	-
4: Joyce Snadden Reserve	4	Enclosed	-	Possible with nourishment

* Tidal flushing ranked from 1 (highest) to 4 (lowest).

3.10 Adopted site for tidal pool concept design

Following a presentation of the information summarised in Sections 3.1 to 3.8 (excluding types of pool entry) in a progress meeting on 20 June 2022, ECF directed WRL to adopt Site 1 (Cruickshanks Beach) for the site-specific, conceptual tidal pool design (discussed in Section 5) primarily on the basis that it is expected to have the highest tidal flushing (since it is closest to the mouth of the Port River and it is free of the circulation concerns associated with enclosed bays). ECF also advised WRL that Site 1 has the following additional merits:

- Good public visibility
- Ready access for locals and tourists
- Available open space on adjacent land for amenities to support a tidal pool
- Free of the competing uses present at Sites 2 and 3

Following the decision to adopt Site 1 for design progression, WRL advised ECF that tidal pools attract more community use when they have a beach-entry and that a beach-entry pool may be possible at Sites 1 and 4 with the addition of beach nourishment. ECF directed WRL to include beach-entry and conventional pool entry as options within the tidal pool concept designs at Site 1.

4 General design elements of good tidal pools

4.1 Body of knowledge

4.1.1 Site inspections

The 30 tidal pools shown in Table 4.1 were inspected as part of this project, other projects and/or incidentally by WRL engineers.

Table 4.1 Tidal pools visited by WRL engineers

Facility	Local Government Area	State
Manning Point Baths	Mid Coast Council	NSW
Belmont Baths	Lake Macquarie Council	NSW
Brooklyn Baths	Hornsby Shire Council	NSW
Bayview Baths	Northern Beaches Council	NSW
Taylors Point	Northern Beaches Council	NSW
Paradise Beach (Avalon)	Northern Beaches Council	NSW
Little Manly	Northern Beaches Council	NSW
Manly Cove	Northern Beaches Council	NSW
Forty Baskets (Balgowlah)	Northern Beaches Council	NSW
Clontarf	Northern Beaches Council	NSW
Sangrado Baths (Seaforth)	Northern Beaches Council	NSW
Pickering Point (Seaforth)	Northern Beaches Council	NSW
Davidson Park	Northern Beaches Council	NSW
Northbridge Baths	Willoughby City Council	NSW
Balmoral Baths	Mosman Council	NSW
Clifton Garden Baths	Mosman Council	NSW
Dawn Fraser Baths	Inner West Council	NSW
Greenwich Baths	Lane Cove Council	NSW
Murray Rose Redleaf Pool (Double Bay)	Woollahra Municipal Council	NSW
Kyeemagh Baths	Bayside Council	NSW
Brighton Le Sands Baths	Bayside Council	NSW
Monterey Baths	Bayside Council	NSW
Ramsgate Baths	Bayside Council	NSW
Dolls Point Baths	Bayside Council	NSW
Sandringham Baths	Bayside Council	NSW
Carss Point Baths	Georges River Council	NSW
Lilli Pilli Baths	Sutherland Shire Council	NSW
Gymea Bay Baths	Sutherland Shire Council	NSW
Bermagui Tidal Pool	Bega Valley	NSW
Brighton Baths	City of Bayside	VIC

4.1.2 Interviews

Interviews were conducted with individual asset managers from 12 local government areas to document contemporary management, management issues and general advice related to tidal pools. The individuals were advised that they would not be directly quoted, but that rather their opinions and observations would be collated to form an overall picture.

4.1.3 Literature

There is minimal available literature regarding tidal pools. Most literature is contained in guidebooks such as Sydney's Best Beaches & Rock Baths (Proctor and Swaffer, 2009).

Some tidal pools are also documented in the Survey of harbourside & ocean pools of the Sydney Metropolitan Region (EJE Landscape Architects and Ludlow, 1994) commissioned by The National Trust of Australia.

4.2 Tidal pool design elements

4.2.1 Perimeter screen/wall

It is recommended that a perimeter screen/wall be present (Figure 4.1). This prevents the perception that hazardous marine life may enter the pool, keeps drifting swimmers inside the pool and prevents boats from entering the pool. Tidal pool walls were traditionally constructed from timber and/or steel bars (Figure 4.1), but this is now somewhat superseded by newer materials.

Contemporary pool walls are now constructed from a timber, glass reinforced plastic (GRP) or aluminium structure, with synthetic netting supported by stainless steel cable. An example is shown in Figure 4.2. Note also that regular maintenance of touchable surfaces is required to remove sharp marine growth if the cut hazard is to be eliminated. Alternatively, this may be undertaken only partially at access points, with an acceptance of the hazard in other places.

WRL was advised of one pool which utilised both a coarse outer shark net and a finer inner net to screen out jellyfish.

As discussed in Section 3.4, the selected materials for, and extent of, the perimeter screen/wall should be sensitive to the presence of the bottlenose dolphins to avoid harming them. Consideration could also be given to 'eco-friendly' swimming enclosures (Figure 4.3), which may reduce the risk of entanglements. Furthermore, acoustic sonar 'pingers' could be considered. These are installed on NSW open coast shark meshing to alert cetaceans (dolphins and whales) of the presence of the netting.

4.2.2 Ramp entry to water

Ramp entry to the water, constructed from glass reinforced plastic grating (Figure 4.4) is helpful for people with low mobility.

4.2.3 Public space

Overwater space (i.e. jetty/boardwalk) is particularly favoured by communities, as it provides a psychological connection with the water. Where the budget allows, a fully traversable jetty/boardwalk on three sides is preferable. (Figure 4.5 and Figure 4.6). These are extremely popular for walking, relaxing (Figure 4.7) and fishing (i.e. casting out away from the pool). Where the scale of the project cannot justify this, a jetty/boardwalk on one side is common (Figure 4.8 and Figure 4.9). Some pools use netting on all three sides (Figure 4.10), however in the opinion of the authors, such pools have diminished ambience.

WRL recommends that the jetty/walkway be fixed at an elevation above the Highest Astronomical Tide to minimise the need for maintenance (removal of marine growth) on its components. This is in contrast to a floating walkway which would have a much greater area requiring ongoing removal of marine growth.

Public space around a pool can also be in the form of timber decking, concrete, grassed areas and sandy beaches (Figure 4.11).

Later stages of design for a Port River tidal pool should consider the benefits and drawbacks of implementing any management controls outside of daylight hours (e.g. lighting or a security gate(s) at the landward end(s) of the jetty/boardwalk).

4.2.4 Lifeguards

Very few tidal pools utilise lifeguards, instead relying on bystander action and installed lifesaving aids. A small number of tidal pools (e.g. Dawn Fraser Baths and Greenwich Baths) use paid lifeguards, noting that these pools have paid entry and high visitation. The lifeguards may also staff the gate and/or café. It is also noted that some tidal pools had cafes that had operated in the past, but the cafes were no longer deemed economically viable.

4.2.5 Pool shell and floor

Many tidal pools use a natural sand floor in shallow regions, with a natural beach the most common entry (Figure 4.11); also known as a beach-entry pool or zero-entry pool. This is sometimes artificially nourished. Mud (silt/clay) bottoms (which may be present at Site 1, as discussed in Section 3.3.2) are acceptable where entry water depths are sufficient.

Concrete pool floors are occasionally present when an entire concrete pool shell is adopted, but this means that alternative means (usually pumping) are needed for flushing, beyond normal tides.

4.2.6 Pontoons

Pontoons (Figure 4.12 and Figure 4.13) provide a good solution for accessing the water at different tides and also allow a push board for lap swimming. Detailed design would need to consider the range of tides and gradients. As with most design elements, these need periodic removal of hazardous marine growth.

4.2.7 Lap swimming aids

Lane ropes (Figure 4.12, Figure 4.13 and Figure 4.14) are used in the most heavily used pools to increase the useability for lap swimmers and reduce collision risk.

Push boards, in the form of fixed timber plates (Figure 4.15), floating timber plates (Figure 4.14) or actual floating pontoons (Figure 4.12 and Figure 4.13) are favoured by lap swimmers for turning at each end.

Figure 4.1 Timber and steel bar perimeter – Brighton Baths, VIC (James Carley)

Figure 4.2 Netting detail – Taylors Point Baths, NSW (James Carley)

Figure 4.3 Example ‘eco-friendly’ swimming enclosure, Cottesloe, WA (Andrew Ritchie)

Figure 4.4 GRP walkway and ramp for people with low mobility into water – Belmont Baths, NSW (James Carley)

Figure 4.5 Three-sided walkway tidal pool – Balmoral Baths, NSW (Facebook)

Figure 4.6 Three-sided walkway tidal pool – Murray Rose Redleaf Pool, NSW (James Carley)

Figure 4.7 Walkway popularity – Balmoral Baths, NSW

Figure 4.8 Single-sided walkway tidal pool – Belmont Baths, VIC (homely.com.au)

Figure 4.9 Single-sided walkway tidal pool – Taylors Point Baths, NSW (James Carley)

Figure 4.10 Net only enclosure – Vanston Baths, Sandringham, NSW (oceanpoolsnsw.net.au)

Figure 4.11 Public space with beach-entry (zero-entry pool) – Kingscote, Kangaroo Island, SA (James Carley)

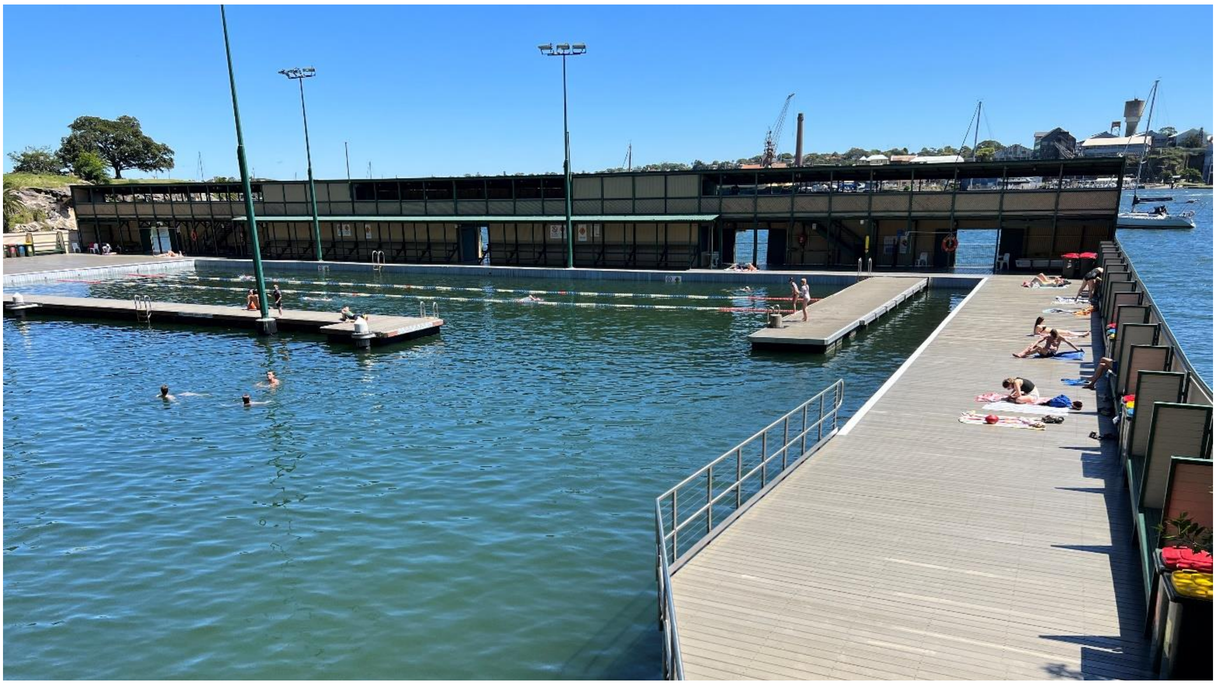

Figure 4.12 Pontoons and lane ropes – Dawn Fraser Baths, NSW (James Carley)

Figure 4.13 Pontoons and lane ropes – Northbridge Baths, NSW (https://swimming.coffee/)

Figure 4.14 Floating turning boards for lap swimmers – Greenwich Baths, NSW

Figure 4.15 Fixed turning boards for lap swimmers – Brighton Baths, VIC

5 Site-specific tidal pool concept design

5.1 Adopted design elements

Following discussions with ECF, the following design elements were adopted for Concept Design 1 for the Port River tidal pool, which WRL considers to be best practice:

- A beach-entry pool (including initial beach nourishment), with the (periodic) addition of additional sand if required
- Netting on three sides, with additional studies needed to confirm a low hazard to dolphins
- A continuous timber jetty/walkway on three sides to provide overwater space (especially for swimmers to relax and locals/tourists to enjoy walking in close proximity to the Port River)
- Lap swimming area of 50 m length, with lane ropes deployed at busy times
- Accessibility ramp and pontoons, plus ladder access to lap swimming area
- Ancillary structures on the land – toilets, change rooms, showers, shade structures, tables and seating

Three other alternative tidal pool concept designs were also developed by adopting the following modified design element combinations:

- A beach-entry pool (beach nourishment), jetty/walkway on one side and netting on three sides
- Conventional pool entry, continuous jetty/walkway on three sides and netting on four sides
- Conventional pool entry, jetty/walkway on one side and netting on four sides

Table 5.1 summarises the key design elements included in each of the four tidal pool concept designs.

Table 5.1 Comparison of design elements included in each tidal pool concept design

Design element	Concept Design 1 (Figure 5.1)	Concept Design 2 (Figure 5.2)	Concept Design 3 (Figure 5.3)	Concept Design 4 (Figure 5.4)
Pool entry	Beach-entry	Beach entry	Conventional entry from jetty/walkway	Conventional entry from jetty/walkway
Beach nourishment	Included	Included	-	-
Netting	3 sides	3 sides	4 sides	4 sides
Timber jetty/walkway	3 sides	1 side	3 sides	1 side
Usage areas	Lap swimming and wading	Lap swimming and wading	Lap swimming and ‘fun and splash’	Lap swimming and ‘fun and splash’
Accessibility ramp	Included	Included	Included	Included

A sketch of tidal pool Concept Design 1 which includes a continuous timber jetty/walkway on three sides with beach nourishment (i.e. a beach-entry pool) at Site 1 (Cruickshanks Beach) is shown in Figure 5.1. Synthetic netting is located underneath the jetty/walkway on all three sides. Contours (water depths below LAT) are overlain on this sketch based on bathymetric data provided by Flinders Ports (Flinders Ports, 2009). It includes a lap swimming area (50 × 20 m) closest to the main channel of the Port River, and a wading area which interfaces with the beach. Pontoons are included at either end of the lap swimming area to act as push boards for swimmers to turn at each end. A lane rope has been included to separate the two usage areas. The pool has been located and orientated to minimise impacts on access to and from the boat ramp immediately to the south, and also to avoid its footprint extending into the main channel to minimise impacts on boat navigability. Jetty/walkway widths of 3.6 m (on the western and southern sides of the pool) and 2.4 m (on the eastern side of the pool) have been adopted. These are sufficient to allow vehicular traffic for maintenance and also provide public space (particularly on the southern side, which faces north and will be warmer during the cooler months, due to solar angles). An elevation of 3.3 m LAT (~ 1.85 m AHD) was adopted for the jetty/walkway such that it is 0.5 m above the Highest Astronomical Tide (2.8 m LAT; Table 3.1). An accessibility ramp (adopted slope 1V:14H) has been included (similar to that shown in Figure 4.4) to facilitate access to the wading area for people with low mobility. While not included in the sketch, it is envisaged that amenities to support the tidal pool (e.g. toilets, change rooms, showers, seating, tables, etc.) would be located on land adjacent to the site. The adopted thickness of the initial beach nourishment was 0.3 m with extents as follows:

- Alongshore extent: between boat ramp (to the south) and the vertical seawall (to the north) under Tom “Diver” Derrick Bridge
- Cross-shore extent: between the toe of the gabion seawall and approximately -1 m LAT

Concept Design 2 has a timber jetty/walkway on only one (western) side as shown in Figure 5.2. This has a similar but slightly smaller footprint than Concept Design 1. The width of the jetty/walkway is only 2.4 m. The perimeter on the southern and eastern sides comprises synthetic netting only.

Concept Design 3 is shown in Figure 5.3 and is based on Concept Design 1. The key differences are that access is via conventional pool entry from the timber jetty/walkway only (rather than beach-entry), beach nourishment is omitted and netting is required on the fourth (northern) side because the swimming pool does not extend all the way to the beach. In lieu of a wading area, a ‘fun and splash’ area (58 × 7.5 m) has been included for pool users who are not swimming laps.

Concept Design 4 is shown in Figure 5.4 and is based on Concept Design 2, except that access is via conventional pool entry only (rather than beach-entry), beach nourishment is omitted and netting is included on the fourth side.

Additional design elements used in some tidal pools include:

- Double row of netting – an outer coarser layer for sharks and a finer inner layer for jellyfish
- A floating pollution boom to reduce litter entry into the pool

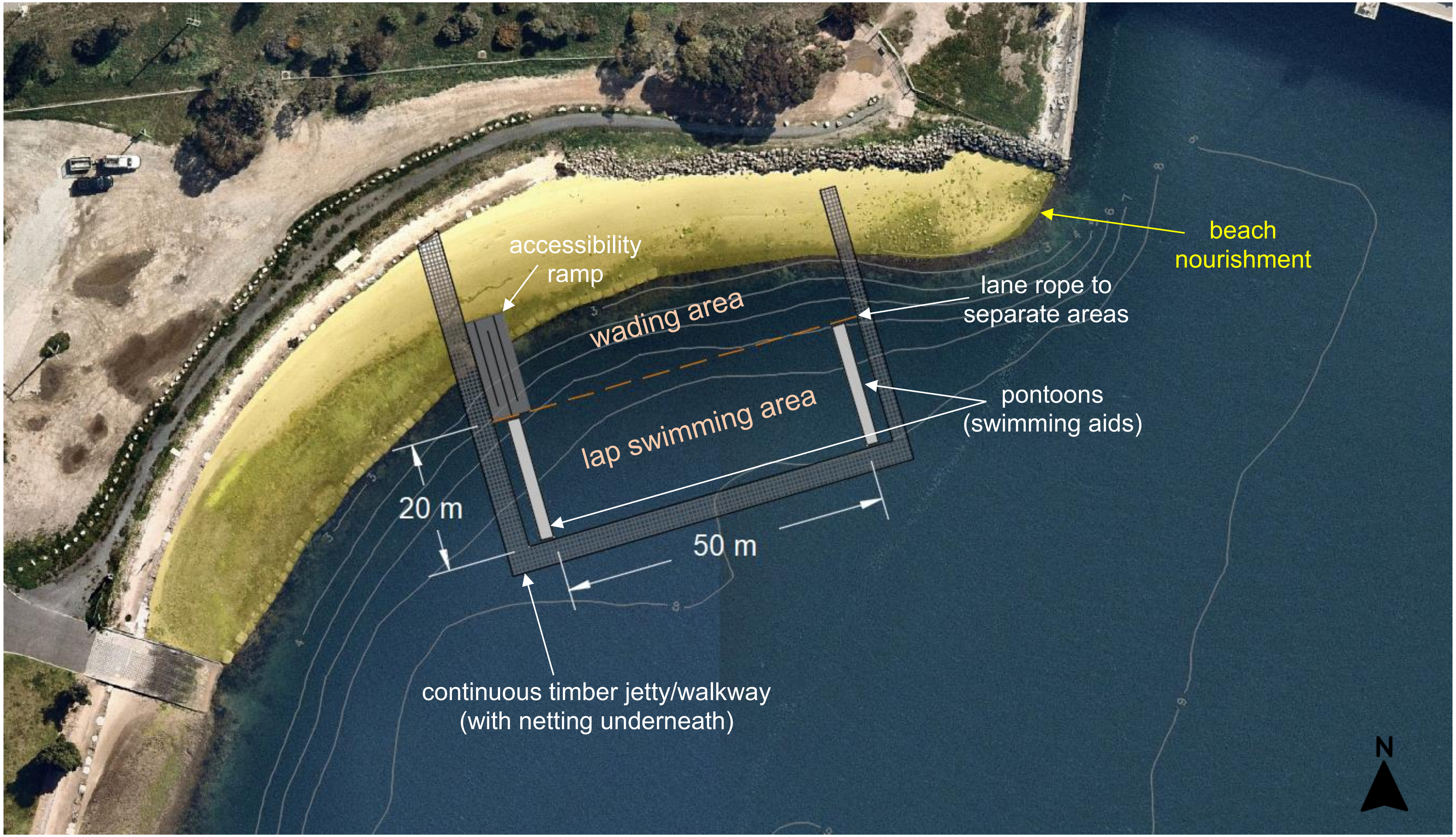

Figure 5.1 Tidal pool Concept Design 1
jetty/walkway on three sides, netting on three sides, includes beach nourishment – contours are water depths below LAT from Flinders Ports, 2009 (13 September 2022, Source: Nearmap)

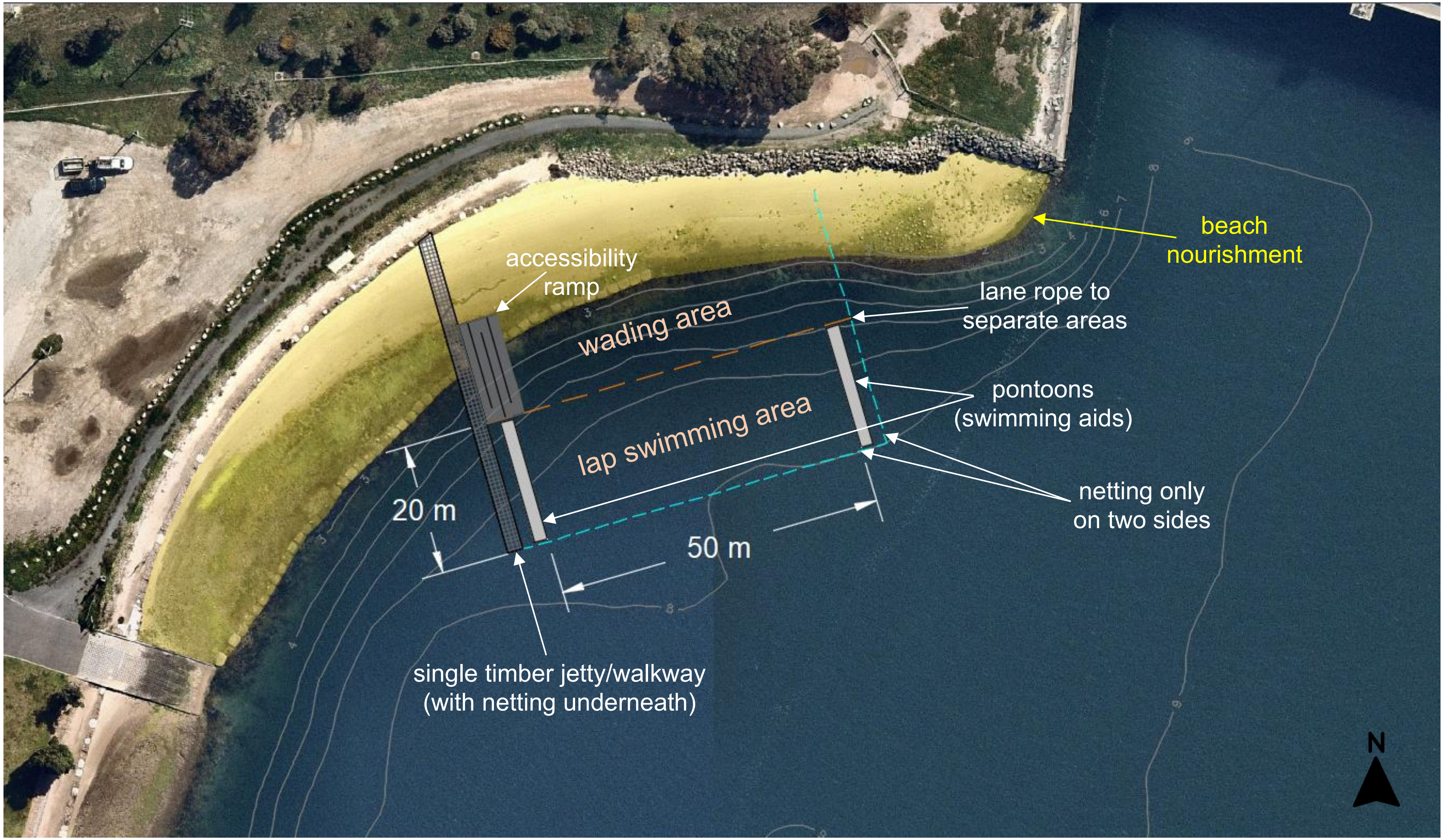

Figure 5.2 Tidal pool Concept Design 2
jetty/walkway on one side, netting on three sides, includes beach nourishment – contours are water depths below LAT from Flinders Ports, 2009 (13 September 2022, Source: Nearmap)

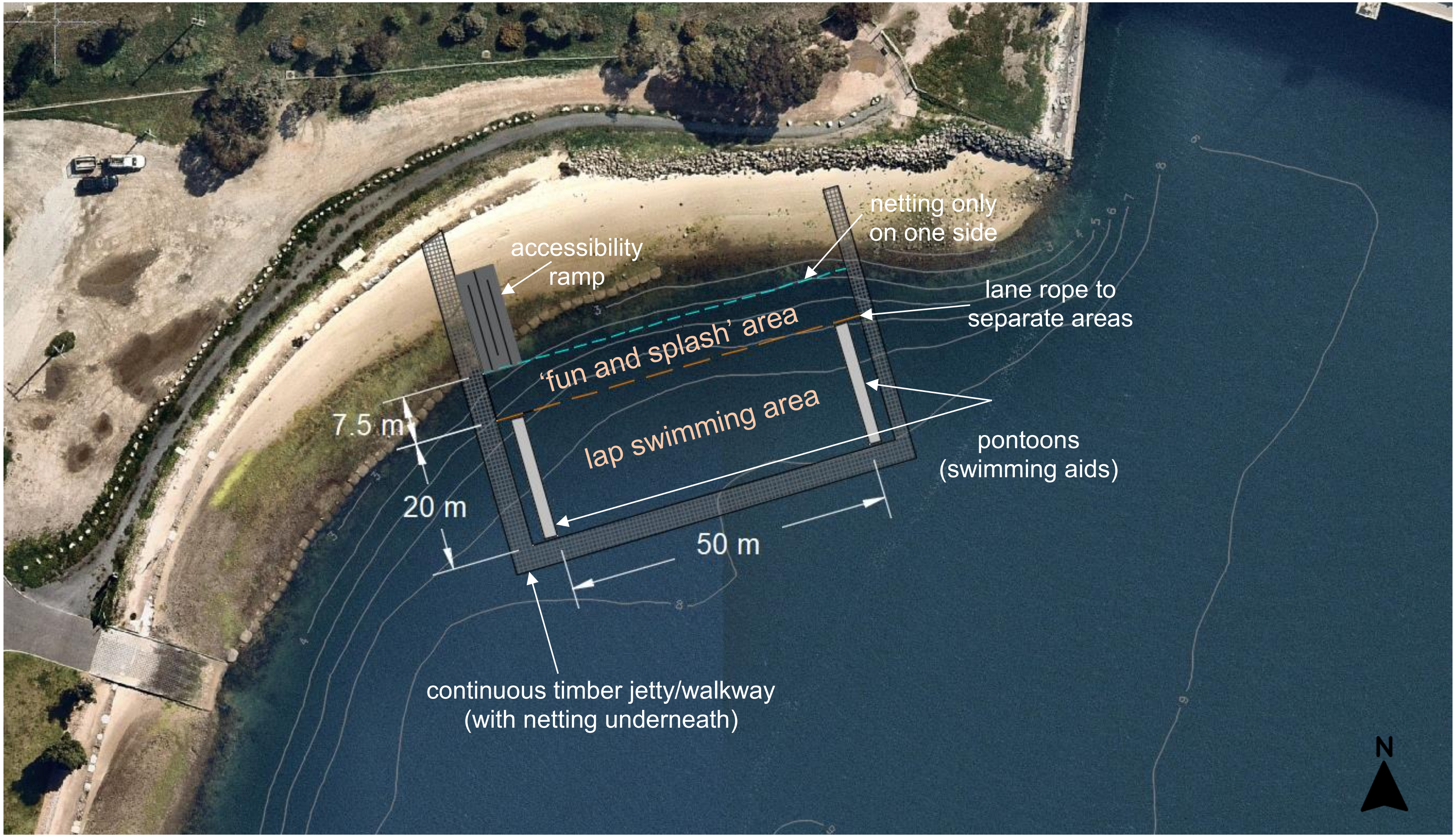

Figure 5.3 Tidal pool Concept Design 3
jetty/walkway on three sides, netting on four sides, no beach nourishment – contours are water depths below LAT from Flinders Ports, 2009
(13 September 2022, Source: Nearmap)

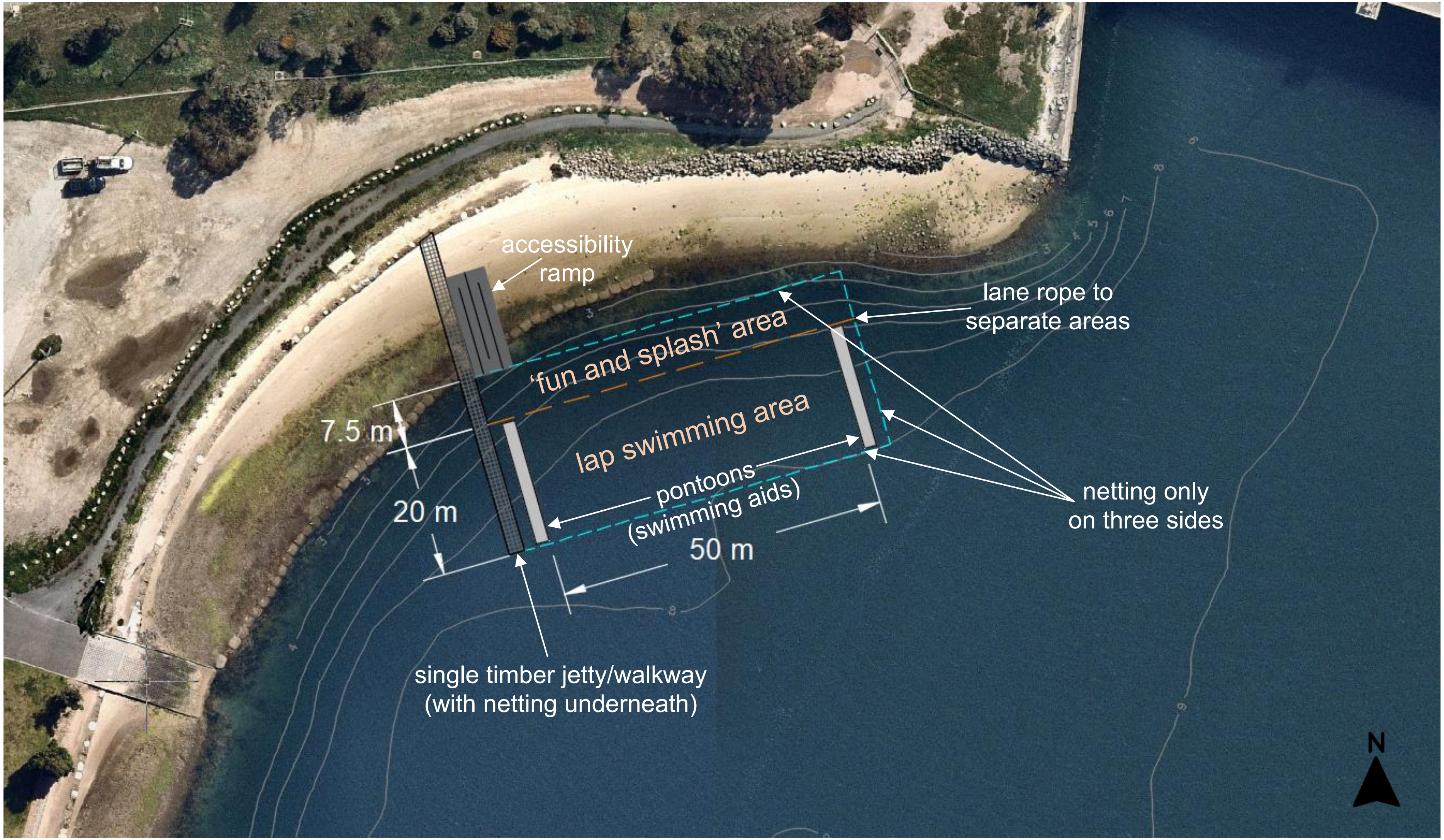

Figure 5.4 Tidal pool Concept Design 4
jetty/walkway on one side, netting on four sides, no beach nourishment – contours are water depths below LAT from Flinders Ports, 2009 (13 September 2022, Source: Nearmap)

5.2 Maintenance

Typical maintenance items include:

- Water quality testing
- General cleaning and rubbish removal
- Removal of sharp marine growth from touchable surfaces
- Antifouling of pontoons
- Repairs to decking
- Repairs to signage
- Placement of sand at beach-entry (if a beach-entry pool is adopted)

Periodic renewal items include:

- Replacement of perimeter netting
- Replacement of superstructure

5.3 Indicative budget

5.3.1 Indicative capital costs

Based on discussions with asset owners and the reported cost of recent projects, indicative capital costs for each of the four tidal pool concept designs are shown in Table 5.2. These costs are highly dependent on features incorporated and the scale of the works. A contingency sum of 15% has been added to the sub-total costs. This is based on standard industry practice for concept design estimates of this nature.

Table 5.2 Indicative capital cost estimates for each tidal pool concept design

Item	Concept Design 1 (Figure 5.1)	Concept Design 2 (Figure 5.2)	Concept Design 3 (Figure 5.3)	Concept Design 4 (Figure 5.4)
Approvals and design	$170,000	$140,000	$150,000	$120,000
Piling	$690,000	$420,000	$690,000	$420,000
Timber jetty/walkway deck	$1,509,000	$360,000	$1,509,000	$360,000
Netting	$120,000	$120,000	$136,000	$136,000
Pontoons	$140,000	$140,000	$140,000	$140,000
Accessibility ramp	$150,000	$150,000	$150,000	$150,000
Beach nourishment	$85,000	$85,000	-	-
SUB-TOTAL	$2.86M	$1.42M	$2.78M	$1.33M
Contingency (15%)	$429,600	$212,250	$416,250	$198,900
TOTAL	**$3.29M**	**$1.63M**	**$3.19M**	**$1.52M**

5.3.2 Indicative maintenance costs

Based on discussions with asset owners, indicative annual maintenance costs for each of the four tidal pool concept designs are shown in Table 5.3.

Table 5.3 Indicative annual maintenance cost estimates for each tidal pool concept design

Item	Concept Design 1 (Figure 5.1)	Concept Design 2 (Figure 5.2)	Concept Design 3 (Figure 5.3)	Concept Design 4 (Figure 5.4)
Timber jetty/walkway deck repairs	$30,000	$10,000	$30,000	$10,000
Netting inspection and repairs	$60,000	$60,000	$70,000	$70,000
Antifouling of pontoons	$10,000	$10,000	$10,000	$10,000
Beach nourishment (ongoing)	$10,000	$10,000	-	-
TOTAL	**$110,000**	**$90,000**	**$110,000**	**$90,000**

5.4 Potential usage

Discussions with asset managers for numerous tidal pools did not yield definitive estimates of overall usage. Data is generally available only from facilities with paid entry, except as detailed below.

WRL operated a camera at Belmont Baths on Lake Macquarie, approximately 100 km north of Sydney from January to June 2020 (WRL, 2020). Entry to Belmont Baths is free. The results were reported as person-hours and doubled to reflect an entire year. That is, it assumed that people stayed for 1 hour, which remains untested. If the average visit was half an hour, the actual individual visits would be double the person-hour numbers.

Images were taken each daylight hour, with users defined as being either:

- In the water: 6,908 person-hours per year
- On the pool jetty: 7,062 person-hours per year
- On the promenade landward of the pool: 5,508 person-hours per year
- Total: 19,478 person-hours per year

Patronage for tidal pools and general aquatic facilities is summarised in Table 5.4. Of these pools, only Belmont Baths has free entry. Carley et al. (2019) also estimated patronage for nine NSW ocean pools, which ranged from 47,000 to 260,000 person-visits per year.

Table 5.4 Pool visitation data

Facility	Year	Entry type	Patronage
Belmont Baths (a)	2020	Free	20,000
Dawn Fraser Baths (b, c)	2016-17	Paid	102,000
Greenwich Baths	2015-16	Paid	60,000
Illawarra aquatic facilities	2016	Paid	128,000
Australian pool visits (d)	c2020	Paid	333,000,000
Average per aquatic facility (d)	c2020	Paid	255,000
NSW ocean pool low	c2019	Free	47,000
NSW ocean pool high	c2019	Free	260,000

(a) WRL camera study quoting person-hours

(b) Upscaling based on data for family tickets and season passes

(c) 2016-2017 data from C Leisure (2017)

(d) PwC (2021)

For the proposed Port River tidal pool, a plausible range of visits is 20,000 to 100,000 per year (this includes both swimmers and non-swimmers who only recreate on the timber jetty/walkway).

5.5 Potential economic benefits of pool usage

PwC (2021) undertook economic modelling of aquatic facilities for the Royal Life Saving Society (RLSS) and developed estimates of their annual national economic benefit, including dollar values for economic gross domestic product (GDP), health and social benefits (Table 5.5). Based on 333,000,000 visits to Australian pools, as reported in PwC (2021), WRL also inferred the value of these benefits per pool visit in Table 5.5. The economic GDP benefit is primarily related to employment of staff within the aquatic industry, but also includes the value of travel/tourism to visit pools. The economic health benefit arises through mechanisms such as reduction of lifestyle diseases. The social health benefit arises through enhancement of leisure time, increased life satisfaction, increased community amenity (space) and bringing people together. It is acknowledged that the PwC (2021) report considers a much wider range of pool types than just tidal pools; all indoor and outdoor council-owned pools and publicly accessible, privately owned pools (e.g. commercial learn-to-swim centres, fitness centres and gyms, clubs with pools, universities and schools) were included in the study.

Table 5.5 Economic benefits of Australian aquatic industry (Source: PwC, 2021)

Economic benefit type	Annual national total value	Value per pool visit*
Gross domestic product (GDP)	$2.8 billion	$8.41
Health	$2.5 billion	$7.51
Social	$3.8 billion	$11.41

* Benefit values per visit inferred by WRL based on 333,000,000 visits to Australian pools as reported in PwC (2021).

Since the proposed Port River tidal pool is unlikely to have paid entry; the economic GDP benefit per pool visit has been conservatively omitted from subsequent analysis (noting that this omits some value from travel/tourism to the proposed tidal pool). Based on the national values reported in PwC (2021), the total economic health ($7.51) and social ($11.41) benefits of the Port River tidal pool could plausibly be $18.92 per pool visit.

By combining the plausible range of visits to the proposed Port River tidal pool from Section 5.4 (20,000 to 100,000 visits per year) with the benefit values per pool visit inferred from the PwC (2021) report, the following economic benefits of a tidal pool are possible:

- Possible health economic annual benefit $150,000 to $751,000
- Possible social economic annual benefit $228,000 to $1,141,000
- Possible total (health + social) economic annual benefit $378,000 to $1,892,000

The above analyses show strong economic benefits for a tidal pool, but do not indicate the distribution of costs and benefits. That is, an entity such as the City of Port Adelaide Enfield or the South Australian government may fund construction and maintenance, while another part, such as residents from other local government areas or the Commonwealth health budget may benefit from the project.

5.6 Suggested future studies

Following this scoping study, it envisaged that the following subsequent studies may be required to progress towards a “for construction” tidal pool for the Port River (depending on the requirements of local and state governments, community members and stakeholders):

- Human health risk assessment
- Engineering design (preliminary and detailed)
- Potential patronage study
- Environmental studies and approvals
- Indigenous and cultural heritage issues
- Car parking demand study
- Architectural design input
- Economic cost-benefit assessment
- Contract documentation

6 References

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