Gosford-Wyong water supply desalination - identification of sites for subsurface saltwater intake

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IDENTIFICATION OF POTENTIAL SITES FOR SUBSURFACE SALTWATER INTAKE

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Technical Report 2004/22
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THE UNIVERSITY OF NEW SOUTH WALES
SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING
WATER RESEARCH LABORATORY

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1. INTRODUCTION

This report was prepared by Water Research Laboratory (WRL) of the University of New South Wales, to identify potential suitable sites for the subsurface intake of saltwater in the vicinity of the existing Toukley Sewerage Treatment Plant (STP).

WRL is undertaking these investigations in association with Manly Hydraulics Laboratory. Following the completion of Stage One (site inspection, collation of existing information and client meeting at Wyong Council), the information contained in this report comprises Stage Two of this three stage feasibility study.

This report presents a review of information gained from discussions with Council, field inspection and the collation of available site information. Based upon this information, the feasibility of sourcing subsurface seawater from Soldiers Beach and Tuggerah Lake is assessed. It is recommended that, based upon the available information, only one of these sites is likely to be suitable, and therefore warrants further consideration for the siting of a saltwater intake. The further investigations required to confirm and develop the recommended subsurface intake option are provided (i.e, Stage Three), along with indicative costs to complete these works.

2. BACKGROUND

It is understood that a 20ML/day desalinisation plant is proposed to supplement the Central Coast water supply. Various options are being examined, including a new water treatment plant (WTP) at the existing Toukley STP, sourcing water from Soldiers Beach or Tuggerah Lake. Brine from the WTP would be mixed with treated sewage effluent and released via the Norah Head tunnel to the ocean.

It is further understood that the desalinisation plant would require 40ML/day to 50ML/day to produce the required 20ML/day saltwater supply. Osmosis technology is proposed, with the resulting brine having a salinity approximately twice that of sea water.

Both open water and subsurface saltwater intakes are being considered. This report focuses on subsurface intakes only.

3. SITE HYDROGEOLOGY

3.1 Regional Geology

The geology of the Toukley - Norah Head region is predominantly rock of the Narrabeen formation. This comprises claystone, sandstone and shale, and according to the Sydney 1:250,000 Geological Map (series S1 56-5) this rock extends east from Toukley to Norah Head.

Overlying aeolian sand deposits extend from Soldiers Beach west to Canton Beach. The thickness of these deposits along the coastal strip at Soldiers Beach is inferred to be relatively shallow. This is evident by the rocky outcrops at both the northern and southern end of the beach, and further supported by the outcropping of rock in the shallow nearshore that can be seen in aerial photography (Figure 1).

Further, from visual inspection of the beach and foredune at Soldiers Beach it is evident that large quantities of gravel-sized material is incorporated within the sandy aeolian material, which because of its larger size must be of bedrock rather than aeolian origin. It is likely that rock was disturbed by shallow sand mining operations in the late 1970's, and/or that the higher relief 'dunes' that lie to the west of the beach may in fact be rock features overlain by a relatively shallow sandy veneer. This second explanation is consistent with the presence of the elevated rocky outcrop that forms Norah Head just to the north, and the evidence of surface outcropping of rock observed along the roadside north-west of Soldiers Beach.

3.2 Local Hydrogeology

3.3 Ocean Side (Soldiers Beach)

Drilling investigations completed by Manly Hydraulics Laboratory in the late 1970's (DPW, 1979) provide useful information from which the groundwater conditions in the vicinity of Soldiers Beach (Figure 2) may be inferred.

Shallow drilling was completed at a total of six (6) sites, with refusal at 4.5 - 7.5 m below ground at three locations, while at the remaining three sites depths of 5.5 m to 11.5 m were achieved, with indurated material but no bedrock encountered.

Most significantly, the phreatic surface encountered at these drilled sites ranged in elevation from around +8 mAHD (Australia Height Datum ≈ mean sea level) just behind the frontal dune, up to 13+ mAHD within the landward-most well.

Based upon the information presented in the DPW report and site inspection, it is concluded that it is unlikely that an extensive saltwater aquifer exists beneath the dunes that back Soldiers Beach. This conclusion is based upon the contradictory facts that significantly elevated groundwater levels and very steep hydraulic gradients were reported by DPW (1979), yet there is a limited area for rainfall recharge in this region that could account for these groundwater elevations and gradients. Instead, and in particular consideration of the regional geology (refer above), it is regarded as more likely that this site is instead underlain by relatively shallow rock. This would account for the elevated phreatic surface that has been monitored previously (DPW, 1979), being perched above this rock and/or by the presence of indurated sand layers.

As a general 'rule-of-thumb', within sandy coastal aquifers the depth of the saline-fresh interface can be anticipated at a depth approximately 40 times the height that the watertable stands above mean sea level (e.g., Freeze and Cherry, 1979). For example, if the watertable measured 50m landward of the shoreline is observed to be at an elevation of +1.5 mAHD, then the depth of the saltwater aquifer that could be anticipated to underlie this site would be of the order of -60mAHD. The measured groundwater levels of the order of 10mAHD with the 'dune' area behind Soldiers Beach are not consistent with the presence of an extensive sandy saltwater aquifer underlying the site.

3.4 Tuggerah Lake (Canton Beach)

No information is known of previous groundwater investigations completed around the north-east foreshore of Tuggerah Lake. However, from visual inspection and consideration of the available geological mapping, it is evident that the foreshore in vicinity of Canton Beach due west of the Toukley STP (Figure 3) is composed of sandy deposits. The foreshore relief is very low (<0.5 m), and the existence of water-loving Melaleuca Forest adjacent to the foreshore reserve are both indicative of a shallow groundwater system. There is limited area for freshwater rainfall recharge, and therefore it could be anticipated that, immediately adjacent to the Lake shore, a thin freshwater lens overlies an unconsolidated saltwater aquifer of unknown depth.

4. SUBSURFACE INTAKE OPTIONS

There are fundamentally two different options for sourcing sub-surface coastal saltwater for desalinisation: vertical wells or horizontal collection systems. An excellent and very timely review and discussion of these options is provided by Voutchkov (2004). Summarised below is a synthesis of key concepts and issues pertinent to this assessment.

4.1 Vertical Wells

Vertical wells consist of one or more vertical bores installed to the depth of the saltwater aquifer. A pump is used to raise the water to the surface, and pumped to the treatment facility.

The yield from vertical 'beach wells' is generally relatively small, typically 0.4 - 4 ML/day. Voutchkov reports that their use for large plants is typically less favourable. At present there are just four operational facilities with capacity larger than 20 ML/day using subsurface intakes. One of these incorporates 16 vertical wells each with a capacity of 5.6 ML/day, and a second with 15 vertical wells with unit capacity of 3.8 ML/day.

4.2 Horizontal Collection Systems

Horizontal collection systems, whereby one or more buried perforated 'drains' may extend radially or in series parallel to the shore, and drain to a central collection sump, are generally more efficient than vertical wells. The largest desalinisation plant in North America sources water from three horizontal radial collectors, each with a capacity of 15 ML/day.

4.3 Favourable site conditions

Voutchkov (2004) reports that the geological conditions favouring construction of beach-well intakes (horizontal or vertical) are permeable (i.e., minimal clay content) sand formations of 15m or greater depth. If site-specific geological conditions allow, high productivity horizontal wells can be used to reduce the number of comparable vertical wells that are needed.

A further consideration that is especially important along the high energy NSW coastline is the potential exposure of infrastructure located within the coastal zone to storm damage by coastal erosion. Open coast sites must be protected from the impacts of coastal erosion,

either by siting wells sufficiently landward that they are away from the zone of potential storm impact, or by the use of protective coastal engineering structures such as a seawall or revetment. The siting of beach-well intakes in more protected environments can reduce or remove the cost and aesthetic impacts of such structures.

4.4 Expected Useful Life

Voutchkov (2004) states that beach wells may have a shorter useful life compared to open water intakes. Without major refurbishment, it is suggested that beach wells would typically operate at a design capacity for 15 - 20 years, compared to the 30-50 years anticipated from a open ocean intake system.

Over time, beach well yield can be anticipated to reduce, due to chemical precipitates within the well collectors, and/or bacterial growth. The rate of decrease of yield with time is difficult to predict, and typically beach wells are designed with at least 25% reserve/standby capacity.

5. ASSESSMENT OF POTENTIAL INTAKE SITES

5.1 Soldiers Beach

Based upon existing information, two principal factors indicate that Soldiers Beach is unlikely to be a suitable site for a subsurface saltwater intake. The first factor is the available hydrogeological information, which suggests that a shallow rock, rather than an extensive sandy aquifer, may underlie the site. To circumvent this, a subsurface intake located close (say, within 30 m) from the shoreline could potentially be used to draw water through shallow beach sediment into a collection system. However, such a concept would be impractical, due to the second factor, namely that Soldiers Beach is located along a high energy coastline. Any beach well structures located seaward of the existing surf club would be exposed to severe erosion impacts from storms, and major coastal protection works would be required that would significantly reduce the public amenity at Soldiers Beach.

Secondary factors that further reduce the likelihood for the favourable siting of a subsurface intake at Soldiers Beach include the high elevation of the 'dunes', and the aesthetic/amenity impact that would result should beach well infrastructure be installed. During discussions with Council the car park area adjacent to the surf club was proposed as a possible site for consideration. The elevation of around +10mAHD would generally preclude the extensive excavations that are required to install a horizontal collection system, and the number and spacing of less efficient vertical wells would be relatively extensive, and would likely extend significantly beyond the area available within the existing car park.

Extensive (and therefore expensive) drilling investigations would be required to determine if indeed the bedrock is shallow beneath the Soldiers Point site. These drilling investigations would need to be undertaken prior to any further concept development or design of a suitable subsurface saltwater intake system at Soldiers Beach.

If, contrary to the presently available evidence (summarised in Section 3), it were determined by these drilling investigations that a deep saltwater aquifer was present beneath the Soldiers Beach site, further caution as to the sourcing of this resource is warranted. Due the elevated groundwater levels which have been monitored at the site, this would generally imply that the saltwater would be located at considerable depth (refer Section 3.3), and therefore deep vertical abstraction wells would be the only suitable option for saltwater intake. The construction and maintenance of deep wells may add significantly to the cost of system installation and ongoing operations. A second issue which would require further consideration is that groundwater abstraction within this area may result in a

general lowering of watertable levels. The extent of this watertable lowering would need to be carefully examined and quantified, to assess the potential impact of these changes upon the exiting wetlands and National Park located to the south and west of the site.

5.2 Canton Beach

Though not originally identified in the study brief as a possible site for the sourcing of a subsurface saltwater intake, at the completion of the initial site inspection (Stage One), and following a second visit to the site during Stage Two to examine this area in further detail, it is concluded here that Canton Beach offers a number of advantages.

The area is located in close proximity to the Toukley STP, and the Tuggerah Lake foreshore in this region is clear, yet relatively undeveloped. The area is very low relief, and due to the combination of a protected lake foreshore as well as a shallow and low gradient lake floor, the wave energy that could be anticipated to impact upon this NE corner of the Lake is minimal (i.e. depth limited). Surficial sandy sediments are evident.

Subject to the above site conditions, an efficient horizontal intake structure could be installed immediately adjacent to the foreshore, say within 5 m of the Lake edge. Minimum wave protection would be required.

By siting the intake this close to the foreshore, the subsurface saltwater resource is anticipated to be close to the surface, and hence shallow excavation only would be required.

Even if the bedrock is relatively shallow in this region, as long as there is sufficient sediment depth to install the horizontal collection system (say, <5m depth), the requirement for thick sandy deposits is no longer necessary. This is due to the proposed close proximity of the intake to the fixed-head saltwater source (ie, Tuggerah Lake). The likelihood of disturbance to the inferred shallow, overlying fresh groundwater lens at this site (refer Section 3) is reduced, the closer the horizontal intake can be located to the edge of the Lake.

6. RECOMMENDATIONS AND FURTHER INVESTIGATIONS

Recommendations:

- Based upon the available information, the Soldiers Beach site is regarded as having a low potential likelihood of providing a suitable site for the siting of a subsurface saltwater intake in the vicinity of the Toukley STP. Due to the significant costs that would be incurred, it is recommended that this option not be investigated further.
- The location and observed site characteristics at Canton Beach immediately west of the Toukley STP are favourable to the siting of a subsurface saltwater intake. It is recommended that the feasibility of this option be investigated further by the completion of the targeted investigations as outlined below.

Recommended Further Investigations:

- Resistivity geophysical survey to assess the variability of subsurface conditions and possible identification of depth to bedrock along the Canton Beach foreshore.
- Alongshore shallow test drilling to ~ 5m depth at 20 m spacing along 200m of the Canton Beach foreshore to confirm subsurface conditions and to obtain sediment samples
- Grain size analysis of recovered sediment samples to obtain estimates of aquifer hydraulic conductivity
- Installation of cross-shore transect of four (4) nested mini-piezometers for fluid EC extraction to determine thickness and extent of the overlying freshwater lens and depth to freshwater/saltwater interface
- 2D numerical modelling (inclusive of dual salt/fresh aquifer system) to determine
  (a) the local extent of watertable and freshwater groundwater draw-down due to saltwater extraction
  (b) relative saltwater versus freshwater intake, and
  (c) optimisation of sizing and placement of horizontal intake system.

The indicative cost for WRL to complete these works (incl. reporting) is: $40,000.

7. REFERENCES

DPW (1979). *Soldiers Beach. Investigation of a Breach in the Frontal Dune*. Manly Hydraulics Laboratory, Report No.273.

Freeze, RA and Cherry JA (1979). *Groundwater*. Prentice -Hall, New Jersey.

Voutchkov, N (2004). *Thorough study is key to large beach-well intakes*. The International Desalinisation and Water Reuse Quarterly, Volume 14, No.1, p.16-20.

WRL Report No. 2004/22	AERIAL PHOTOPGRAPH SHOWING LOCATION OF SOLDIERS BEACH AND CANTON BEACH	Figure 1 2004-22.doc

WRL Report No. 2004/22	SOLDIERS BEACH	Figure 2 2004-22.doc

WRL Report No. 2004/22	CANTON BEACH	Figure 3 2004-22.doc