APPENDIX

GROUNDWATER REPORT (GHD)

GHD Sydney

SADM - EIS - Hydrogeology

Hydrogeology Technical Report

August 2003

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Appendices

1. Introduction

The potential impact upon groundwater from the proposed south arm dredging development has been considered from the perspective of three conceptual areas. The first conceptual area is land to the north of Hunter River (i.e. the south arm of the Hunter River), including reclaimed land constituting Kooragang Island. The second conceptual area is the Hunter River itself. The third and final conceptual area is land to the south of the Hunter River, including reclaimed land constituting the OneSteel Rod and Bar Mills (Lot 222) and extending into the former BHP Steelworks Closure Area.

From a hydrogeological perspective, the proposed excavation and construction of the swing basin which will encroach on reclaimed land currently occupied by OneSteel Rod and Bar Mills (Lot 222) will potentially alter the groundwater equilibria. Due to historical filling and historical process waste residue disposal within the swing basin excavation area, there is a perceived risk of potential groundwater impact related the disturbance of potentially contaminated material.

In addition, due to the close proximity of the swing basin excavation area to the Mill Scale Storage and Transition Area, there is a perceived risk of potential groundwater impact if this area is breached, or through alteration of the groundwater equilibria through a reduction in the groundwater transport pathway length to the Hunter River.

There may also be a risk of potential groundwater impact from the short term storage of contaminated dredged or excavated material on land prior to treatment (either through immobilisation or thermal desorption techniques). However, engineered structures such as the proposed lined storage basin, and dewatering with geobags and associated water collection systems for the immobilisation treatment option and a bunded and lined area with specific surface water drainage controls for the thermal desorption unit, will all serve to minimise the potential risk of groundwater impact.

Groundwater impact from the emplacement of immobilised contaminated sediment and excavated material as engineered fill or for landscaping on the Closure Area site within the constraints of the DA for this site, is considered quite unlikely. As discussed within this EIS, the immobilised treated sediment produces a stabilised 'dewatered' product that does not produce seepage and is of very low to extremely low permeability (less than 1×10^{-9} m/s), significantly limiting any potential groundwater impact through leaching. Also, the thermally desorbed sediment or excavated material will have concentrations and leachability characteristics that meet the proposed treatment standards for the project, that are protective of groundwater.

Treated sediment or excavated material is to be placed above the water table and below the 0.5 m physical barrier meeting the MPT consent conditions for use as a separator/buffer, in areas of very low to negligible infiltration (such as underneath car parks, container storage areas etc.). This physical barrier will have very low to extremely low permeability (ranging from 1×10^{-8} m/s to 1×10^{-9} m/s (URS, 2000)).

In addition, the improvement of the surface water drainage system within the Closure Area, including recontouring and capping, will further reduce infiltration to the underlying shallow groundwater table, further reducing potential mobilisation of contaminants from emplaced treated material from this proposed project. As a result of the proposed treatment and selective emplacement procedures, leaching of contaminants to groundwater from immobilised or thermally desorbed sediments and excavations is highly unlikely. No discernable environmental impact upon groundwater is hence expected from this aspect of the proposed project.

The remaining minor identified potential impacts on groundwater relate to areas of OneSteel beyond the proposed swing basin area, the former BHP Steelworks Closure Area, Kooragang Island and the river itself. These minor potential impacts relate to the dredging to approximately –15m RL[1], of river sediments and clays and bedrock along the river, in areas that have not been previously dredged to this level.

The Hunter River is an active shipping port. It is understood that Newcastle Ports Corporation (NPC) continues to conduct periodic maintenance dredging in areas adjacent to and downstream of the subject site (to depths of –16.5m RL) for ship navigation purposes. In addition, the channel southeast of the former BHP Steelworks Closure Area has been previously dredged to approximately –15 m RL, to allow access by bulk carriers. The potential development of the closure area for the proposed multi-purpose terminal (MPT) will also require continued dredging of sediment to facilitate navigation of ships (URS, 2001a).

The Hunter River is tidal and will continue to be the local groundwater discharge zone for parts of the hydraulically connected aquifers south and north of the river after the dredging operations proposed as a part of this development. From a hydrogeological perspective, the proposed dredging operations represent a continuance upstream of historical and ongoing dredging undertaken for current port operations. The removal of sediment, clay and bedrock during the course of the proposed dredging operations will likely result in minor reductions in the length of time for groundwater takes to discharge into the surface water of the river. This may represent a minor reduction in the amount of time historically occurring possible groundwater contamination takes to reach the river, but is not considered to be a significant issue.

The proposed excavation and construction of the swing basin represents the largest potential hydrogeological impact due to the considerable alteration of the river foreshore. No discernable environmental impact upon groundwater is envisaged from the emplacement of treated sediments and excavations within the Closure Area. Dredging is considered only to represent a very minor potential hydrogeological impact on Kooragang Island, on OneSteel areas outside the proposed swing basin footprint and the Closure Area. As a result, the main focus of the hydrogeological assessment has been directed towards the proposed swing basin.

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[1] (relative level), Newcastle Harbour Tide Gauge (NHTG), -16m Australian Height Datum (AHD).

2. Scope of Works

This report details the hydrogeological assessment of the likely impacts of the proposed south arm dredging development to be undertaken by Newcastle Ports Corporation (NPC). This report was developed as a sub-component of the EIS for this proposed development and should be read in conjunction with this document.

The key steps involved in the hydrogeological assessment were to:

- Delineate areas of land surrounding the proposed development whose hydrogeological characteristics may be possibly affected from dredging, excavation and treatment operations;
- Review available hydrogeological and geochemical data pertaining to these delineated areas of land;
- Assess the likely environmental impacts upon hydrogeology from the proposed development, especially with respect to the excavation operations proposed for the construction of the Shortland Swing Basin;
- Prepare this report to discuss the significance of any identified environmental impacts upon hydrogeology; and
- Discuss possible mitigation measures to minimise any identified environmental impacts upon hydrogeology.

3. Existing Environment

3.1 Information Sources

Details on the existing hydrogeology in the vicinity of the proposed development were obtained from a review of geotechnical and geochemical investigations, undertaken for a variety of historical projects and ongoing environmental monitoring programs. The geotechnical data consisted of logs and associated geological descriptions of soil lithology encountered during drilling investigations and borelogs from monitoring well installation programs. The geochemical data set contains, in addition to groundwater quality data, standing water levels (SWLs) in monitoring wells installed within the vicinity of the proposed Basin (in addition to SWLs from wells installed throughout Lot 222).

The combination of the available data from the southern side of the river and additional geotechnical investigations recently undertaken that are associated with the initial planning stages of the proposed development (GHD-LM, 2001), has enabled the development of basic conceptual cross section models of the existing hydrogeology across the river (Section 3.2). It is noted that much more detailed geotechnical modelling associated with the actual design of the proposed development is understood to have been developed (GHD-LM, 2001).

The reports reviewed in this hydrogeological impact assessment included:

GHD-LM (2001) – "Geotechnical Report on Hunter River Dredging EIS South Arm Master Plan for Newcastle Port Corporation" (Ref 27/10134/02/AP473, 25 July 2001)

This reports presented the results from a geotechnical study undertaken by GHD-Longmac (GHD-LM) of the dredging conditions relevant to the proposed south arm dredging masterplan. The investigation area consisted of the south arm of the Hunter River from Tourle Street bridge to approximately 2.5 km downstream, adjacent to the proposed Port Waratah Coal Services (PWCS) Berth K7 and the BHP MPT Stage 2 area.

The geotechnical investigation was undertaken as a component of the EIS process, to provide geotechnical data and interpretation with respect to material distribution and broad bulk properties.

CH2MHill (2002) – "Final Assessment Report for the Voluntary Investigation – Lot 222 Characterisation Studies from February 2000 to September 2002" (Ref 110293.08, December 2002).

This comprehensive investigation comprised soil, groundwater and surface water characterisation on Lot 222 of OneSteel's Newcastle site at Mayfield between February 2000 and September 2002. Specifically the report summarised the characterisation work from;

- Seven rounds of groundwater sampling data to determine whether there was significant offsite impact;

- Soil sampling of large open exposed areas to determine if there was a potential for human health risk from exposure to soils; and
- Sampling of surface waters and seeps, during both dry and wet conditions to determine if there was any significant offsite impact.

URS (2001) – "BHP Billiton Newcastle Steelworks Lot 223 Groundwater Remediation Options Study" (Ref 24517/020/558, November 2001).

The aim of this investigation was to undertake a groundwater contamination assessment and formulation of groundwater treatment options for Lot 223 at the former BHP Newcastle Steelworks site on the south bank of the Hunter River. Lot 223 (approximately 24.4 ha in area) constituted two BHP delineated subareas, area M3 (western portion) and area M5 (eastern portion). Lot 223 is located directly south of the OneSteel Lot 222 area. Area M3 was historically used for the operation of a rotary lime kiln and stockpiling of raw materials (iron ore, lime and dolomite). Area M5 was historically used for spares storage for structural and mechanical parts used at the main steel mill.

URS (2000) – "Development of a Multi Purpose Terminal and Remediation of the Closure Area, BHP Newcastle Steelworks Environmental Impact Statement (Ref A8602704, August 2000).

Information relevant to the hydrogeological characteristics of the former BHP Newcastle Steelworks closure area was reviewed from this EIS.

Relevant hydrogeological information included details on the three aquifers which were related to the geology beneath of the closure area, data on aquifer permeabilities, discussion on the effects of tides on the aquifers, and a review of the groundwater discharge from the site and respective groundwater quality.

OneSteel (2002) – "Environmental Information Provision to Premiers Department/NPC for Potential Swing Basin and Foreshore Embankment Works"

Pertinent information directly relating to the proposed development was compiled by OneSteel for NPC in 2002 to assist in the dissemination and identification of key sources of relevant environmental information for the preparation of the EIS.

The major source document referred to by OneSteel was the recently completed comprehensive CH2MHill (2002) Lot 222 site characterisation investigation. Additionally, historical photos, excerpts from historical investigations and anecdotal operational data was provided by OneSteel.

BHP (1993) – "Site Management Plan Historical Investigation" (Ref PRE/REP/001 November 1993).

A historical investigation was undertaken by BHP Engineering on behalf of BHP Rod and Bar Products Division Newcastle in 1993. The aim of this historical investigation was to review past land uses and operating practices to identify areas on the plant which may have been contaminated or required further investigation or attention. Specifically the investigation considered: the development of the steelworks from 1915 to 1993; the changes in the landforms across the site from original water courses, through to the reclaimed land and fill history; the disposal of wastes at the site that were most likely to have an environmental effect; and the operations and practices of any previous land owners and present land owners.

GHD (2001) – "Remediation of Lot 223, Industrial Drive, Mayfield Environmental Impact Statement" (December 2001).

This EIS was focussed on the remediation of Lot 223, which was proposed to involve recontouring the site, capping of contaminated material and installation of drainage works.

The existing hydrogeological environment at Lot 223 was reviewed in this EIS, in addition to the soil contamination status.

Relevant hydrogeological information provided included details on the geology of the three aquifers present, soil contamination status, groundwater contamination status and soil and groundwater remediation options.

URS (2001a) – Stage 1 Problem Formulation Report, Final "Ecological Risk Assessment of Groundwater at the BHP Closure Area and Sediments in the South Arm of the Hunter River, Newcastle, NSW" (Report No. 24517/Ecological Risk/R003-A,May 2001).

The report presented the first stage of the ecological risk assessment associated with the discharge of groundwater from the former BHP Steelworks Closure Area and the sediments in the south arm of the Hunter River from the adjoining Closure Area upstream to the Tourle Street bridge.

ERM (1996) – "Kooragang Coal Terminal Stage Three Expansion Environmental Impact Statement" (Report No. 95190RP1, September 1996).

This EIS was associated with the third stage of the development of the PWCS Kooragang terminal. Information pertaining to the hydrogeology of Kooragang Island was reviewed, in addition to pertinent soil, sediment and groundwater data.

Egis (2000) – "Newcastle Steelworks Closure Area, Summary Site Audit Report" (Ref VA0120.001 Rev0, December 2000).

The site audit report of the former BHP Steelworks Closure Area involved an independent review of the Site Preparation and Remediation Plan (URS, 2000). The review focussed upon issues pertaining to contaminated land and groundwater within the closure area.

GHD-LM (2002) – "Geochemical report, Global Groundwater Review, Kooragang Coal Terminal" (Report No. 271/0223 April 2002).

This report reviewed eight years of groundwater monitoring data in the vicinity of PWCS Kooragang Island Terminal site at Kooragang Island.

The review involved the collation of historical data, a walk-over site inspection, review of available data, comparative assessment of the data, indicative assessment of relative risk and conclusions.

3.2 Discrete Aquifer Units

The land originally present in the area of the proposed swing basin was known as Spit Island. Spit Island was originally separated from the southern shore by Platt's Channel. In 1950, after NSW State Government approval, reclamation of Platt's Channel and Spit Island commenced using steel making process materials and associated wastes. Reclamation was completed by the 1970's.

As a result of reclamation, three main aquifer units (including four geological layers) may be encountered on land south of the Hunter River.

The first layer encountered is generally comprised of fill material. This layer consists of a mixture of steelworks process slag, process by-products and residues. In addition, minor quantities of waste building materials (bricks, wooden beams, metal girders etc), general waste materials and previously dredged sands may also be encountered within this layer (CH2MHill, 2002, OneSteel 2002). CH2MHill (2002) noted that the depth of fill across Lot 222 ranges between 5 and 12 m, with an average depth of 8 m. A review of available geotechnical data (GHD-LM, 2001) confirms this conclusion. Depending upon the water table depth, this layer can be referred to as the fill aquifer.

Underlying the fill layer/aquifer is a second unit generally referred to as the estuarine aquifer. This aquifer unit can be generally described as a grey/white fine to medium sand. Shell fragments are generally noted in geotechnical borelogs recorded during drilling within this layer. This layer can extend to a depth of 30 m in some locations (CH2MHill, 2002).

It is noted that a layer of dark grey/brown silty sands or clays can be encountered overlying the estuarine aquifer. This layer is considered representative of the previous island/mudflat landform, which has now been subsequently covered by reclamation works (GHD-LM, 2001). This layer has variable consistency ranging from a silty sand to a silty clay depending upon the location. There is evidence to suggest that this layer is semi-confining and not of uniform thickness across the area of consideration. It is considered likely that hydraulic connections exist between the fill aquifer and the underlying estuarine aquifer.

The third and final unit is referred to as the bedrock aquifer. This bedrock aquifer is comprised of the Tomago Coal Measures. It is described as a sequence of mudstones, siltstones and shales ranging between 7-16 m below ground surface (URS, 2001; GHD-LM, 2001). Geotechnical investigations compiled by GHD-LM (2001) generally confirm this conclusion. The topography of the bedrock surface is variable, which reflects erosion and drainage patterns prior to deposition of the estuarine sands. The depth to bedrock tends to increase from the south heading towards the river (GHD-LM, 2001).

The groundwater system of Kooragang Island north of the river is influenced by the historical filling of low-lying deltaic islands (ERM, 1996). Generally three aquifer units are prevalent. The first unit is an anthropogenic watertable aquifer of reclaimed dredged river sediment (sand) and former Steelworks process wastes (i.e. slag). This aquifer ranges between approximately 0.5 m and 5 m in thickness. Underlying this first aquifer is a clay aquitard, which is representative of the natural ground surface prior to reclamation. This unit has variable vertical extent, but is typically 2 m to 3 m thick, ranging to 14 m. The third aquifer is a silty sand aquifer up to 30 m in thickness, which extends from the bottom of the clay aquitard unit down to the final bedrock aquifer.

Conceptual cross sections of the existing hydrogeology across the south arm of the Hunter River have been developed from available groundwater monitoring well and geotechnical investigation data. A plan view of these cross sections is featured in Figure Hydro-1, Appendix A. The conceptual cross sections 1 to 4 are featured in Figures Cross-1 to Cross-4, Appendix A. These cross sections feature indicative groundwater flow directions, marked by plain blue arrows. It is noted that there is no significance to the size of the blue arrows, as they are included for explanatory purposes only.

Five geological layers/aquifer units are featured in Figures Cross-1 to Cross-4. These geological layers correspond respectively to the predicted ground surface (labelled as "Ground Surface"); the fill aquifer (labelled as "Fill"); the semi-confining silty sands/clay layer associated with the underlying estuarine aquifer, which also includes river sediments and clays (labelled as "estuarine clay"); the estuarine aquifer (labelled as "Estuarine") and finally the bedrock aquifer (labelled as "Bedrock").

It is noted that much more detailed and accurate geotechnical modelling has been undertaken associated with the actual design of the proposal (GHD-LM, 2001), than the conceptual cross-sections presented in Figures Cross-1 to Cross-4, Appendix A. These long and cross-sections are featured in Figures C.1, and C.8 to C.13.

3.3 Hydrogeology

On a regional basis groundwater to the south of the river typically flows in a north-easterly direction towards the river. This groundwater flow is influenced by a combination of the river, the former Platt's Channel, the original Spit Island and the prevalent regional groundwater flow heading towards the river, originating from the residential area of Mayfield. The hydrogeology to the south of the river is somewhat complex, as a result of extensive historical filling of estuarine mudflats and former tributaries.

The permeabilities of the three main aquifer units that are encountered in this area have been evaluated previously through a series of groundwater pumping tests (RCA, 1999). The estimated aquifer permeabilities are presented in Table 3.1.

The permeability of the fill aquifer varies over five orders of magnitude (5.6×10^{-4} m/s to 7.9×10^{-9} m/s), with a geometric mean of approximately 1.2×10^{-5} m/s. The source of this variability originates from the variability in the mixtures of steelworks process slag, process by-products and residues present in the vicinity of each of the wells tested.

The estuarine aquifer has a similar geometric mean permeability as the fill aquifer, however the range of permeabilities recorded varied only over three orders of magnitude (1×10^{-4} m/s to 3.1×10^{-7} m/s). This range of variability is considered to be representative of natural / residual materials.

Similarly, the variability of the permeability of the bedrock aquifer ranges over three orders of magnitude (2×10^{-5} m/s to 1×10^{-8} m/s), with a geometric mean of 5×10^{-7} m/s. Similar to the conclusions drawn for the estuarine aquifer, this range of variability is indicative of natural / residual materials.

The permeability of the three main aquifer units increases from the bedrock aquifer, to the estuarine aquifer and then finally to the fill aquifer.

For reference purposes, the immobilised contaminated sediments are planned to have very low permeabilities (less than 1×10^{-9} m/s), an order of magnitude less permeable than the minimum tested permeability for the bedrock.

Table 3.1: Estimated aquifer permeabilities (RCA, 1999)

	Permeability (m/s)		
Parameter	Fill Aquifer	Estuarine Aquifer	Bedrock Aquifer
Geometric Mean	1.2×10^{-5}	9.4×10^{-6}	5×10^{-7}
Median	1.1×10^{-5}	1×10^{-5}	9×10^{-7}
Max	5.6×10^{-4}	1×10^{-4}	2×10^{-5}
Min	7.9×10^{-9}	3.1×10^{-7}	1×10^{-8}
Number of Samples	62	23	11

The groundwater flux to the Hunter River from the fill and estuarine aquifers has been calculated by CH2MHill (2002) for the Lot 222 site (page 160). They estimated an average flow to the Hunter River from the fill aquifer of 211 m^3/day and the estimated average flow from the estuarine aquifer of 401 m^3/day. This calculation was based upon assuming 2300 m of foreshore.

For the proposed excavation of the swing basin, a coarse estimation of the groundwater flux in the fill aquifer can be made by assuming that the east-west extent of the basin would be approximately 400 m. This results in the groundwater flux to the Hunter River from the fill aquifer of 37 m^3/day. Due to the coarse nature of the calculation, this preliminary flow estimate is considered to be accurate only to within +/- 50% and is dependent upon the assumed extent of the swing basin excavation, in this case, a linear 400 m.

Groundwater flow to the north of the river generally flows towards the river in a south to south-easterly direction in the upper anthropogenic fill aquifer and towards the ocean in an easterly direction in the lower silty sand aquifer (ERM, 1996). This groundwater flow is influenced by a combination of the river (upper fill aquifer), the ocean (lower silty sand aquifer) and the historical low-lying deltaic islands in this area.

With respect to vertical hydrogeology, on a regional basis on land south of the river, there is a prevalent upward hydraulic gradient from the estuarine and bedrock aquifers into the upper aquifer units and into the river (URS, 2001, RCA, 1999). On a local basis, the trend of an upward hydraulic gradient from the estuarine to the fill aquifer is less pronounced as the river is approached. From land north of the river, hydraulic connections have been noted between the upper fill aquifer and the underlying confined silty sand aquifer (ERM, 1996).

Groundwater flow in the fill aquifer in the vicinity of the swing basin footprint is generally towards the river to the northeast (Figure Hydro-1). The hydrogeology within this aquifer is influenced by mounding of groundwater to the west of the swing basin footprint, in the Steelstone area and in the vicinity of the Mill Scale Storage and Transition Area (CH2MHill, 2002). This mounding of groundwater within the fill aquifer has also been observed in other previous studies (URS, 2000). The mounding is attributed to the collection of oily water run-off from the oily Mill Scale and other iron bearing sludge from the backwash pits from the Rod and Bar Mills in the Mill Scale Storage and Transition Area prior to recycling offsite. This pit is understood to be historically unlined and OneSteel currently has plans and budgets in place to seek and install a better alternative to the current Mill Scale and Backwash Pit sludge handling system, and will continue its ongoing liaison with the EPA regarding the current and alternative systems.

Groundwater flow in the fill aquifer towards the eastern end of Lot 222 (towards the former BHP Steelworks Closure Area) is generally either in a north-easterly direction towards the river, or in a more southerly direction towards Industrial Channel / Drain 17 (i.e. the former Platt's Channel) depending upon the distance inland from the river. Some minor localised mounding of groundwater is evident at the eastern edge of Lot 222 (Figure Hydro-1). It is noted that the groundwater contours plotted are in terms of Australian Height Datum (AHD), not NHTG, which is a difference of 1 m. It is also noted that the blue arrows broadly indicate groundwater flow direction. No significance is placed upon the relative size of the arrows, which are only included to aid in the interpretation of the discussed text.

Towards the western end of Lot 222, groundwater flow is clearly in a north to north-westerly direction (Figure Hydro-1), influenced by the mounding of groundwater to the west of the swing basin footprint in the Steelstone area and Mill Scale Storage and Transition Area.

The groundwater flow in the estuarine aquifer in the vicinity of the swing basin footprint is generally in a north to north-easterly direction. It can be seen in Figure Hydro-2 that a small degree of groundwater mounding is evident even within the estuarine aquifer to the west of the swing basin footprint, although it is not as pronounced as observed for the fill aquifer. This infers a hydraulic connection between the fill aquifer and the underlying estuarine aquifer in this area. Further to the southwest of the swing basin footprint, elevated groundwater levels can also be observed, which are a function of the prevalent groundwater flow from the southern residential area of Mayfield.

From a review of available historical records, the groundwater flow within the estuarine aquifer is also influenced by former tributaries and estuarine mudflats present prior to development on the site for steelworks operations (BHP, 1993). These former tributaries and estuarine mudflat areas have resulted in minor preferential flowpaths existing across Lot 222, which tend to complicate localised groundwater flow patterns within the estuarine aquifer. The fill aquifer is similarly influenced.

There are only a limited number of bedrock aquifer monitoring wells installed on land south of the river. Previous investigations have highlighted that the river is the dominant hydraulic control in the area and that the flow from the bedrock aquifer is towards the north to northeast and discharges into the river (RCA, 1999). This conclusion is supported by the available geotechnical data (GHD-LM, 2001).

3.4 Groundwater Quality

3.4.1 Approach to Assessing Potential Groundwater Quality Impacts

From a contaminant hydrogeological perspective, the proposed swing basin construction will have the largest potential for impact. No discernable environmental impact upon groundwater is envisaged from the emplacement of treated sediments and excavations within the Closure Area. The remaining minor identified potential impacts on contaminant hydrogeology in areas of OneSteel beyond the proposed swing basin area, the Closure Area and Kooragang Island, relate to a relatively insignificant reduction in the time potentially contaminated groundwater takes to discharge into the river.

As a result, the discussion on the assessment of groundwater quality in areas north and south of the Hunter River is focussed upon data relevant to the area of the proposed swing basin within Lot 222, with only minor discussions included on groundwater quality within the former BHP Steelworks Closure Area and Kooragang Island.

3.4.2 Assessment Criteria

NSW EPA recommends, that when assessing contamination of groundwater, consideration needs to be given to the impact of any contaminants to the beneficial uses or resources of the groundwater. The beneficial uses of groundwater include providing recharge to rivers, lakes, bays etc., being a source of water for drinking, irrigation and industrial uses. For Lot 222 the beneficial uses of the groundwater are likely providing recharge to the Hunter River and possibly industrial use.

ANZECC and the Agriculture Resource Management Council of Australia and New Zealand (ARMCANZ) finalised and released in mid 2001 the "Australian and New Zealand Guidelines for Fresh and Marine Water Quality" (2000). The Guidelines were officially endorsed by NSW EPA on 6 September 2001, and a letter from NSW EPA to Site Auditors stated that all relevant assessment of water quality commenced after this date should use the ANZECC (2000) Guidelines.

ANZECC (2000) states that generally the Guidelines should apply to the quality both of surface water and of groundwater since the environmental values that they protect relate to above-ground uses. Hence groundwater should be managed in such a way that when it comes to the surface it will not cause the established water quality objectives for the surface waters to be exceeded, nor compromise their designated environmental values.

3.4.3 Area of Proposed Swing Basin

CH2MHill have reported the results from extensive soil, groundwater and surface water sampling on behalf of BHP-Billiton and then OneSteel within Lot 222 (south of the river) from February 2000 to September 2002, as a part of a Voluntary Investigation Proposal submitted to the EPA under the NSW Contaminated Land Management Act (1997) (CH2MHill, 2002).

For the Lot 222 assessment, CH2MHill adopted a management aim to achieve water quality consistent with a slightly to moderately disturbed system, and therefore the ANZECC(2000) Marine Water Quality guidelines (trigger values) were selected to provide a level of protection of aquatic ecosystems for 95% of species. It is recognised that these trigger values for some particular parameters may not protect particular species against chronic effects for, or allow for, potential bioaccumulation. For these parameters, trigger values were selected to provide a level of protection for 99 percent of species. As a result, the combination of trigger values selected, were considered to be appropriately conservative for the purposes of the assessment (CH2MHill, 2002).

The groundwater quality of the fill aquifer (95% upper confidence limit (UCL)) in the vicinity of the proposed swing basin (along the Hunter River foreshore) generally meets the ANZECC(2000) Marine Water Quality trigger values, with some exceptions. Elevated concentrations of copper, lead, vanadium, arsenic, mercury, manganese, cyanide, ammonia, total petroleum hydrocarbons (TPH), polyaromatic hydrocarbons (PAHs, specifically phenanthrene, anthracene, fluoranthene, benzo(a)pyrene) above the relevant assessment criteria were reported within the fill aquifer (CH2MHill, 2002).

Listed in Table 3.2 is a comparison of groundwater quality within the fill aquifer in the vicinity of the proposed swing basin within Lot 222 and the ANZECC(2000) Marine Water Quality 95% protection of species trigger values. Exceedences of the relevant trigger values are highlighted with grey shading in Table 3.2.

It is noted that the data listed in Table 3.2 are the mean concentrations of groundwater samples analysed during the course of the seven rounds of the CH2MHill investigations from February 2000 to September 2002. The mean concentrations are presented for simplicity as the 95% UCL concentrations of some analytes can be significantly influenced by the sample distributions selected, the number of sample data points available, the consistency of the data (i.e. presence of obvious outliers) and other factors and may hence require interpretation. This comparison is considered only to be an indicative guide of the potential contaminants that may be encountered in the vicinity of the proposed swing basin on Lot 222. Detailed statistical comparison between the 95% UCL groundwater concentrations and the relevant assessment criteria and discussions relating to the significance of the results from Lot 222, and their relative impact from a Significant Risk of Harm perspective (as defined under the Contaminated Land Management Act (NSW, 1997), are beyond the scope of this hydrogeological review and are presented elsewhere (CH2MHill, 2002).

Table 3.2: Groundwater quality in the fill aquifer in the vicinity of the proposed Basin within Lot 222, wells W-7F, W-6F, F2,W-10F, M2/5, M2/6 (CH2MHill, 2002).

Well		W-7F	W-6F	F2	W-10F	M2/5	M2/6
Factor	Marine Criteria (2000)*	Mean	Mean	Mean	Mean	Mean	Mean
Heavy Metals (mg/L)							
Copper (Cu)	0.0013	0.0026	0.0016	0.0012	0.0075	0.0007	0.0016
Lead (Pb)	0.0044	0.0005	0.0015	0.0012	0.0095	0.0006	0.0005
Zinc (Zn) – filtered	0.015	0.0058	0.0046	0.0091	0.0100	0.0079	0.0098
Zinc (Zn) – total	ng	Zero Data	Zero Data	Zero Data	Zero Data	Zero Data	Zero Data
Total Chromium (Cr)	ng	0.0005	0.0005	0.0005	0.0030	0.0011	0.0014
Trivalent Chromium (Cr III)	0.0274	0.0020	0.0010	0.0010	0.0010	0.0010	0.0010
Hexavalent Chromium (Cr VI)	0.0044	0.0020	0.0023	0.0020	0.0025	0.0020	0.0023
Cadmium (Cd)	0.0007	0.0001	0.0001	0.0002	0.0004	0.0003	0.0005
Nickel (Ni)	0.007	0.0033	0.0023	0.0050	0.0008	0.0009	0.0045
Vanadium (Vn)	0.1	0.0738	0.1033	0.0050	0.0050	0.0050	0.0667
Arsenic (As)	0.0023	0.0170	0.0043	0.0026	0.0010	0.0031	0.0046
Mercury (Hg)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002
Manganese (Mn)	0.08	0.0029	0.0008	0.0015	0.0045	0.1000	0.0017
Inorganics							
Cyanide (free) (CN) (mg/L)	0.004	0.0031	0.0025	0.0181	0.0025	0.0025	0.0181
Weak Acid Dissociable Cyanide (mg/L)	ng	0.0031	0.0025	0.0029	0.0025	0.0025	0.0025
Total Ammonia (mg/L) (ammonia -N)	#	27.7600	2.9250	4.0014	3.2500	0.2229	3.3867
Ammonia (% of Criteria at pH value)	ng	19828.6%	2089.3%	2858.2%	2321.4%	30.2%	2419.0%
Phosphorous as P - Total	ng	Zero Data	Zero Data	Zero Data	Zero Data	Zero Data	Zero Data
TPH (ug/L)							
C6-C9	ng	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000
C10-C14	ng	745.7500	151.2500	365.7143	52.5000	31.2857	907.5000
C15-C28	ng	1400.0000	1260.2500	890.2857	595.0000	458.0000	3198.3333
C29-C36	ng	181.0000	264.5000	114.7143	154.0000	225.7143	572.6667
Total TPH	0.7	2542.5000	1624.0000	1518.2000	Zero Data	656.0000	4640.8000
BTEX (ug/L)							
Benzene	500	0.4375	0.4375	0.4429	0.7500	0.4286	0.5417
Toluene	180	0.8125	0.8125	0.8643	1.0000	0.8214	1.0417
Chlorobenzene	55	0.8125	0.8125	0.8125	1.0000	1.0000	1.0000
Ethylbenzene	5	0.8125	0.8125	0.7643	1.0000	0.8214	0.7917
m&p-Xylenes	75	1.0000	1.0000	1.3714	1.0000	1.3929	1.5417
o-Xylenes	350	1.0000	1.0000	1.3714	1.0000	1.3929	1.5417
PAHs (ug/L)							
Naphthalene	50	0.2500	1.5375	9.6857	0.6500	3.8071	1.4917
2-Methylnaphthalene	ng	0.2500	0.4125	1.6200	0.2500	0.8200	0.2500
2-Chloronaphthalene	ng	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500
Acenaphthylene	ng	0.2500	0.2500	0.9000	0.2500	0.2214	0.2167

Well		W-7F	W-6F	F2	W-10F	M2/5	M2/6
Factor	**Marine Criteria (2000)[a]**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
Acenaphthene	ng	0.2500	0.5000	1.2000	0.2500	1.4500	0.2417
Fluorene	ng	0.2500	0.3375	0.6071	0.2500	1.2071	0.2167
Phenanthrene	0.6	0.2500	2.4750	1.4000	0.2500	4.1500	0.5500
Anthracene	0.01	0.2500	0.5000	0.2214	0.2500	1.1357	0.2167
Fluoranthene	1	0.2500	1.6250	0.3643	1.1000	2.0214	0.2583
Pyrene	ng	0.2500	1.4500	0.3357	1.0500	1.6929	0.2583
N-2-Fluorenylacetamide	ng	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500
Benz(a)anthracene	ng	0.2500	0.2500	0.2286	0.2500	0.5000	0.2167
Chrysene	ng	0.2500	0.2500	0.2286	0.2500	0.4571	0.2167
Benzo(b) & (k)fluoranthene	ng	0.5000	0.5000	0.4571	0.5000	0.5857	0.4333
7.12-Dimethylbenz(a)anthracene	ng	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500
Benzo(a)pyrene	0.1	0.1500	0.1500	0.1429	0.1500	0.3429	0.1333
3-Methylcholanthrene	ng	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500
Indeno(1.2.3-cd)pyrene	ng	0.2500	0.2500	0.2286	0.2500	0.2571	0.2167
Dibenz(a.h)anthracene	ng	0.2500	0.2500	0.2214	0.2500	0.2429	0.2167
Benzo(g.h.i)perylene	ng	0.2500	0.2500	0.2214	0.2500	0.2214	0.2167
Total PAHs	ng	Zero Data	7.2500	13.3600	Zero Data	16.2750	2.3000
Phenols (ug/L)							
Phenol	400	27.4000	0.2500	6.7143	0.8250	0.2857	3.5000
2-Chlorophenol	340	0.1500	0.1500	0.2000	0.1500	0.2000	0.2083
2-Methylphenol	ng	1.4375	0.2500	0.9286	0.2500	0.2857	0.4333
3&4-Methylphenol	ng	3.4500	0.4750	2.3286	0.2500	0.2857	2.2583
2-Nitrophenol	2	1.9875	0.2500	0.2857	0.2500	0.2857	0.2917
2.4-Dimethylphenol	2	0.5625	0.3875	1.1786	0.2500	0.3357	1.0000
2.4-Dichlorophenol	120	0.1500	0.1500	0.2000	0.1500	0.2000	0.2083
2.6-Dichlorophenol	34	0.1500	0.1500	0.2000	0.1500	0.2000	0.2083
4-Chloro-3-methylphenol	ng	0.1500	0.1500	0.2357	0.1500	0.2000	0.2083
2.4.5-Trichlorophenol	4	0.1500	0.1500	0.2000	0.1500	0.2000	0.2083
2.4.6-Trichlorophenol	3	0.1500	0.1500	0.2000	0.1500	0.2000	0.2083
2.4-Dinitrophenol	45	Zero Data	Zero Data	2.5000	Zero Data	2.5000	2.5000
4-Nitrophenol	58	Zero Data	Zero Data	1.0000	Zero Data	1.0000	1.0000
2.3.4.6-Tetrachlorophenol	ng	Zero Data	Zero Data	1.0000	Zero Data	1.0000	1.0000
4.6-Dinitro-2-methylphenol	ng	Zero Data	Zero Data	2.5000	Zero Data	2.5000	2.5000
Pentachlorophenol	11	0.1500	0.1500	0.2714	0.1500	0.2714	0.2917
4.6-Dinitro-2-sec-butylphenol	ng	Zero Data	Zero Data	2.5000	Zero Data	2.5000	2.5000

[a] ANZECC - Marine Water Quality Guidelines (2000), "Slightly to moderately disturbed system".

ng = No trigger value available.

Shading indicates values in excess of the ANZECC (2000) Marine Water Quality 95% protection of species trigger values.

The groundwater quality of the estuarine aquifer (95% UCL) generally meets the ANZECC(2000) Marine Water Quality trigger values. The groundwater quality of the estuarine aquifer is generally better, with respect to less exceedences of the relevant assessment criteria, than that observed for the fill aquifer. This is to be expected, given that the materials used during the infilling of Platt's Channel and Spit Island are likely to influence groundwater quality within the fill aquifer. In addition, the presence of the semi-confining layer of estuarine clay above the estuarine aquifer would tend to constrain potential groundwater contamination from the fill aquifer migrating down into the estuarine aquifer. Nonetheless, concentrations of copper, zinc, cadmium, arsenic, manganese, cyanide, ammonia, total petroleum hydrocarbons (TPH) and polyaromatic hydrocarbons (PAHs, specifically naphthalene, anthracene, benzo(a)pyrene) above the relevant assessment criteria were reported within the estuarine aquifer (CH2MHill, 2002).

Listed in Table 3.3 is a comparison of the mean estuarine aquifer groundwater analyte concentrations from seven rounds of the CH2MHill investigations from February 2000 to September 2002 and the ANZECC(2000) Marine Water Quality 95% protection of species trigger values.

Table 3.3: Groundwater quality in the estuarine aquifer in the vicinity of the proposed Basin within Lot 222, wells W-7E, W-6E, E13, W-10E and M6/3 (CH2MHill, 2002).

Well		**W-7E**	**W-6E**	**E13**	**W-10E**	**M6/3**
Factor	Marine Criteria (2000)[a]	Mean	Mean	Mean	Mean	Mean
Heavy Metals (mg/L)						
Copper (Cu)	0.0013	0.0045	0.0025	0.0029	0.0960	0.0048
Lead (Pb)	0.0044	0.0005	0.0009	0.0008	0.0005	0.0005
Zinc (Zn) - filtered	0.015	0.0138	0.0150	0.0107	0.0085	0.0245
Zinc (Zn) - total	ng	Zero Data	Zero Data	Zero Data	Zero Data	Zero Data
Total Chromium (Cr)	ng	0.0041	0.0021	0.0062	0.0015	0.0023
Trivalent Chromium (Cr III)	0.0274	0.0053	0.0023	0.0063	0.0010	0.0023
Hexavalent Chromium (Cr VI)	0.0044	0.0020	0.0020	0.0030	0.0010	0.0010
Cadmium (Cd)	0.0007	0.0002	0.0009	0.0003	0.0001	0.0001
Nickel (Ni)	0.007	0.0033	0.0018	0.0056	0.0015	0.0008
Vanadium (Vn)	0.1	0.0050	0.0233	0.0667	0.0200	0.0050
Arsenic (As)	0.0023	0.0011	0.0019	0.0053	0.0040	0.0015
Mercury (Hg)	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001
Manganese (Mn)	0.08	0.3578	0.6630	0.1227	0.0020	0.2170

Well		W-7E	W-6E	E13	W-10E	M6/3
Inorganics						
Cyanide (free) (CN) (mg/L)	0.004	0.0031	0.0025	0.0045	0.0025	0.0025
Weak Acid Dissociable Cyanide (mg/L)	ng	0.0031	0.0025	0.0030	0.0025	0.0025
Total Ammonia (mg/L) (ammonia -N)	#	11.3900	2.8575	6.5467	3.1700	1.1850
Ammonia (% of Criteria at pH value)	ng	324.3%	97.5%	2190.1%	2264.3%	59.5%
Phosphorous as P - Total	ng	Zero Data	Zero Data	Zero Data	Zero Data	Zero Data
TPH (ug/L)						
C6-C9	ng	32.0000	10.0000	10.0000	95.0000	10.0000
C10-C14	ng	36.7500	25.0000	139.0000	128.5000	25.0000
C15-C28	ng	121.0000	260.7500	707.1667	626.5000	265.0000
C29-C36	ng	38.7500	111.5000	155.5000	116.0000	73.5000
Total TPH	0.7	454.0000	1264.0000	1043.7500	Zero Data	Zero Data
BTEX (ug/L)						
Benzene	500	0.4375	0.4375	0.5083	1.2500	0.5000
Toluene	180	0.8125	0.8125	0.7917	1.0000	1.0000
Chlorobenzene	55	0.8125	0.8125	0.8125	1.0000	1.0000
Ethylbenzene	5	0.8125	0.8125	0.7917	1.0000	1.0000
m&p-Xylenes	75	1.0000	1.0000	1.1667	1.0000	1.0000
o-Xylenes	350	1.0000	1.0000	1.0000	1.0000	1.0000
PAHs (ug/L)						
Naphthalene	50	0.3625	0.2500	1.6917	54.7500	0.7750
2-Methylnaphthalene	ng	0.2500	0.2500	0.2500	2.6000	0.2500
2-Chloronaphthalene	ng	0.2500	0.2500	0.2500	0.2500	0.2500
Acenaphthylene	ng	0.2500	0.2500	0.2167	0.8000	0.2500
Acenaphthene	ng	0.2500	0.2500	0.2167	1.5000	0.2500
Fluorene	ng	0.2500	0.2500	0.2167	0.9000	0.2500
Phenanthrene	0.6	0.2500	0.2500	0.2167	0.2500	0.2500
Anthracene	0.01	0.2500	0.2500	0.2167	0.2500	0.2500
Fluoranthene	1	0.2500	0.2500	0.2167	0.2500	0.2500
Pyrene	ng	0.2500	0.2500	0.2167	0.2500	0.2500
N-2-Fluorenylacetamide	ng	0.2500	0.2500	0.2500	0.2500	0.2500
Benz(a)anthracene	ng	0.2500	0.2500	0.2167	0.2500	0.2500

Well		W-7E	W-6E	E13	W-10E	M6/3
Chrysene	ng	0.2500	0.2500	0.2167	0.2500	0.2500
Benzo(b) & (k)fluoranthene	ng	0.5000	0.5000	0.4333	0.5000	0.5000
7.12-Dimethylbenz(a)anthracene	ng	0.2500	0.2500	0.2500	0.2500	0.2500
Benzo(a)pyrene	0.1	0.1500	0.1500	0.1333	0.1500	0.1500
3-Methylcholanthrene	ng	0.2500	0.2500	0.2500	0.2500	0.2500
Indeno(1.2.3-cd)pyrene	ng	0.2500	0.2500	0.2167	0.2500	0.2500
Dibenz(a.h)anthracene	ng	0.2500	0.2500	0.2167	0.2500	0.2500
Benzo(g.h.i)perylene	ng	0.2500	0.2500	0.2167	0.2500	0.2500
Total PAHs	ng	0.7000	Zero Data	1.9667	Zero Data	Zero Data
Phenols (ug/L)						
Phenol	400	0.4125	0.2500	0.7083	0.7000	0.2500
2-Chlorophenol	340	0.1500	0.1500	0.2083	0.1500	0.1500
2-Methylphenol	ng	0.2500	0.2500	0.6667	0.9500	0.2500
3&4-Methylphenol	ng	3.7375	0.2500	0.7500	1.4500	0.2500
2-Nitrophenol	2	0.2500	0.2500	0.2917	0.2500	0.2500
2.4-Dimethylphenol	2	0.2500	0.2500	0.6083	0.9250	0.2500
2.4-Dichlorophenol	120	0.1500	0.1500	0.2083	0.1500	0.1500
2.6-Dichlorophenol	34	0.1500	0.1500	0.2083	0.1500	0.1500
4-Chloro-3-methylphenol	ng	0.1500	0.1500	0.2500	0.1500	0.1500
2.4.5-Trichlorophenol	4	0.1500	0.1500	0.2083	0.1500	0.1500
2.4.6-Trichlorophenol	3	0.1500	0.1500	0.2083	0.1500	0.1500
2.4-Dinitrophenol	45	Zero Data	Zero Data	2.5000	Zero Data	Zero Data
4-Nitrophenol	58	Zero Data	Zero Data	1.0000	Zero Data	Zero Data
2.3.4.6-Tetrachlorophenol	ng	Zero Data	Zero Data	1.0000	Zero Data	Zero Data
4.6-Dinitro-2-methylphenol	ng	Zero Data	Zero Data	2.5000	Zero Data	Zero Data
Pentachlorophenol	11	0.1500	0.1500	0.2917	0.1500	0.1500
4.6-Dinitro-2-sec-butylphenol	ng	Zero Data	Zero Data	2.5000	Zero Data	Zero Data

[a] ANZECC - Marine Water Quality Guidelines (2000), "Slightly to moderately disturbed system".

ng = No trigger value available.

Shading indicates values in excess of the ANZECC (2000) Marine Water Quality 95% protection of species trigger values.

It should be noted that although the groundwater concentrations (95% UCLs) of the fill and estuarine aquifers exceeded the ANZECC(2000) Marine Water Quality trigger values along the foreshore of the Hunter River for some analytes, the upgradient groundwater concentrations (95% UCLs) entering Lot 222 for copper, zinc, manganese, ammonia, phenanthrene, anthracene and benzo(a)pyrene are generally higher. These results infer that there are potential upgradient groundwater sources of some heavy metals and PAHs that are migrating onto Lot 222.

CH2MHill (2002) considered that the application of the ANZECC(2000) Marine Water Quality guidelines to Lot 222 overall, with "slightly to moderately disturbed system" trigger values, provided an extremely conservative assessment compared to the Hunter River, which they regarded as a "highly disturbed system". When this conservative approach was considered, CH2MHill concluded that groundwater, seeps and drains that are directly impacted by Lot 222 did not pose a Significant Risk of Harm (as defined under the Contaminated Land Management Act (NSW, 1997)), given comparison to upgradient groundwater coming onto the site, natural background concentrations, mass loadings and other contextual risk assessment.

The footprint of the proposed swing basin will partly intersect the northern edge of the Mill Scale Storage and Transition Area on Lot 222. It was reported in CH2MHill (2002) that elevated concentrations of arsenic, copper, manganese, nickel, lead, free cyanide, ammonia and TPHs, beyond the relevant environmental assessment criteria were detected in a water sample recently taken from the pit (sample Mill Scale 1, 24 July 2002, CH2MHill (2002)).

Given the drainage of oily water from the Mill Scale and Backwash Pit, CH2MHill (2002) were not surprised by the results. Apparently all waters collected in the Mill Scale Transfer and Storage Area are contained so that discharge offsite via stormwater is limited. It is understood that these materials are dispatched offsite for recycling/re-use (OneSteel, 2002). The Mill Scale Pit is noted to be unlined, and hence there is a potential for groundwater contamination (CH2MHill, 2002; OneSteel, 2002). It should be noted however, that there has been no discernable impact on downgradient groundwater monitoring wells associated with this area to date (CH2MHill, 2002). It is understood that investigations have been instigated regarding an alternative material handling system for this area to replace the unlined pit system, possibly involving a concrete pad. The disruption of the pit through the construction of the swing basin may potentially affect groundwater quality, especially if the pit is breached. Specific management systems will need to be implemented to ensure that groundwater contamination and Hunter River surface water contamination relating to the integrity of the pit does not occur during the construction of the swing basin. Groundwater in this area will require ongoing monitoring to ensure there is no adverse groundwater contamination, whilst considering that groundwater flows onto the site from upgradient industrial and residential areas.

3.4.4 East and West of Swing Basin

It was noted in the Egis (2000) audit of the Closure Area and the Multi Purpose Terminal (MPT) EIS (URS, 2000), that groundwater contaminants in exceedence of relevant guidelines included PAHs, ammonia, benzene, cadmium, copper, cyanide, manganese, nickel, lead and zinc. From the Egis (2000) review of the RCA (2000) report on groundwater contaminant fluxes (entering the Hunter River) post-closure of the steelworks, the most significant groundwater contaminants were found to be PAHs and cyanide. Contaminants other than PAHs and cyanide (i.e. ammonia, benzene, cadmium, copper, manganese, nickel, lead and zinc), were noted to require only relatively minor dilution to meet environmental water quality guidelines, inferring that the latter contaminants were not likely to affect Hunter River ecosystems.

For land west of the footprint of the swing basin, within Lot 222, CH2MHill (2002) noted the presence of the small benzene impacted area (only 75 m by 75 m) and a stable benzene plume which is considered to present no significant risk to the surrounding environment in its present state. The current swing basin design does not include excavation within the benzene impacted area, hence will have no impact on the benzene plume area.

3.4.5 Kooragang Island

For land north of the river, the historical and current groundwater quality at the Kooragang Coal Terminal (KCT) on Kooragang Island was recently reviewed (GHD-LM, 2002). The KCT site was divided into six sub-areas in the review; Fines Disposal Facility (FDF), Area 4, Stage 1 Stockyard, Stage 2 Stockyard, Stage 3 Stockyard and the Northern Perimeter.

It was concluded by GHD-LM (2002), that only temporarily elevated concentrations of some heavy metals and sulphide (which only marginally exceeded the relevant environmental assessment criteria) were recently recorded throughout the extensive groundwater monitoring network at the KCT site. GHD-LM (2002) concluded in their review that the KCT site did not represent a significant risk of harm to the environment or human health.

Fines Disposal Facility (FDF)

Specifically, post construction of the FDF elevated concentrations of selenium, mercury, cyanide, copper, nickel, zinc, PAHs sulphide and cyanide were detected within upper aquifer groundwater wells. In the lower aquifer in the FDF area, only marginally elevated selenium, copper and nickel concentrations in groundwater were recorded.

Area 4

Recent groundwater sampling in the upper and lower aquifers in Area 4 revealed only marginally elevated concentrations of copper and nickel above relevant environmental criteria.

Stage 1 Stockyard

In the upper aquifer at the Stage 1 Stockyard area, marginal exceedences of the relevant criteria were reported for copper, lead, nickel, selenium and PAHs. For the lower aquifer in this area, exceedences of nickel, copper, arsenic, cadmium, zinc were detected at various times throughout the historical groundwater monitoring program.

Stage 2 Stockyard

For the Stage 2 Stockyard area, recent marginal exceedences of copper and zinc groundwater concentrations were reported for the upper and lower aquifers.

Stage 3 Stockyard

For the Stage 3 Stockyard area, no groundwater contamination issues were associated with the upper aquifer. For the lower aquifer, marginal exceedences of copper, chromium, nickel, lead, selenium and zinc were reported at various times throughout the monitoring program.

Northern Perimeter

For the Northern Perimeter area, only marginal exceedences of copper, nickel and zinc have been recently reported at this location. Marginal exceedences of copper, chromium and arsenic have been periodically measured from the lower aquifer.

4. Impact Assessment

From a hydrogeological perspective, the proposed excavation and construction of the swing basin is considered to have a potential impact. As noted above, these excavations are to be partially undertaken on the reclaimed land constituting the OneSteel Rod and Bar Mills (Lot 222). Due to historical filling within the vicinity of this area and the presence of the Mill Scale Storage Transition Area, there is a perceived risk of potential groundwater impact related to the proposed excavation operations in this area.

Plotted in Figures Hydro-3 and Hydro-4 are the predicted impacts on groundwater flow in the fill and estuarine aquifers due to the proposed swing basin excavations. It can be seen in these figures that no alterations in groundwater flow direction have been predicted for either aquifer unit.

The construction of a small geotechnical sheet pile wall along the southern foreshore, from the closure area to Tourle Street bridge may have a minor impact upon groundwater flow within the estuarine aquifer. It is understood that this sheet pile wall will be installed from 1 m NHTG to approximately –9 m NHTG, to ensure geotechnical stability of the foreshore during and post dredging within the river.

At this depth, groundwater flowing within the fill aquifer and discharging into the river will not be significantly affected. Groundwater flowing within the upper portions of the estuarine aquifer will be forced underneath the sheet pile wall prior to discharge into the river, noting that the estuarine aquifer is some 30 m in depth in sections and the sheet pile wall will not encroach greatly into the estuarine aquifer.

From a groundwater quality perspective, it is likely that the pathflow length of groundwater migrating from Lot 222 will be reduced as a result of the proposed development, principally in the immediate vicinity of the proposed swing basin. This may affect groundwater equilibria and groundwater quality discharging into the Hunter River as there is less time (i.e. groundwater migration pathflow length) for the potential any retardation/degradation of groundwater contaminants which may be present.

Currently, there has been no discernable impact on groundwater downgradient from the Mill Scale Storage and Transition Area (heavy metals, cyanide, ammonia and TPHs are potentially associated with this area (CH2MHill, 2002)). Post construction of the swing basin, there may be a possibility of a change in groundwater equilibria in the vicinity of this facility. It is noted that specific management systems will need to be implemented relating to the integrity of the pit to ensure that contamination of groundwater and Hunter River surface water does not occur during the construction of the swing basin. It is noted that OneSteel, liasing with the EPA, has plans and budgets in place for the investigation and replacement of the current Mill Scale Storage and Transition Area system with an alternative materials handling process.

Downgradient groundwater wells associated with monitoring the Mill Scale Storage and Transition Area will need to be replaced if destroyed during the excavation of the swing basin, to facilitate continued monitoring of groundwater in this area. It is considered beneficial to replace these wells as soon as practical after construction of the swing basin to provide immediate evidence that no impact to groundwater is occurring.

The potential impact on groundwater quality resulting from a reduction in the pathflow length of groundwater in the vicinity of the proposed swing basin may be partly mitigated through the construction of a sheet pile wall. This may result in groundwater from Lot 222 being forced to migrate underneath the sheet pile wall before discharging into the Hunter River, or alternatively migrating around the sheet pile wall to reach the discharge point (i.e Hunter River).

Due to historical filling and waste residue disposal in the vicinity of the swing basin footprint, there is also the possibility of encountering TPH, BTEX, PAH, heavy metal, cyanide and phenol contamination during the excavation works. If such contamination is uncovered during the excavation works, there may be a possibility of an environmental impact through a reduction in the length of time this contaminated material takes to potentially impact groundwater and then discharge offsite, or alternatively, groundwater may be directly impacted through seeps of contamination. These issues will need to be addressed in the management systems to be implemented during the construction of the swing basin. Use of a sheet pile wall, as mentioned above, would minimise the amount of material to be excavated (reducing the risk of likelihood of encountering areas of contamination), and would allow for some selective excavation to be undertaken, if necessary, to avoid direct interface of such areas with the new surface water area of the swing basin.

For OneSteel areas outside the footprint of the proposed swing basin, the former BHP Steelworks Closure Area and Kooragang Island, the pathflow length of groundwater (with potentially elevated concentrations of some analytes) will be reduced as a result of the proposed extension of dredging upstream. However, this reduction would be much less significant than that potentially associated with the swing basin excavations and the Mill Scale Storage Transition Area. Hence, no additional significant environmental impact on the Hunter River is envisaged relating to the dredging component of the proposed development.

With respect to the contamination potential of the proposed development from the temporary storage of contaminated excavation and dredging wastes on land (it is estimated for this project that approximately 280,000 m^3 of material may possibly require some form of treatment, 250,000 m^3 of contaminated dredged sediments and 30,000 m^3 of contaminated embankment material from the excavation of the swing basin), no significant alteration in groundwater quality is expected. Management procedures (including engineered structures, such as the lined storage basin, and dewatering with geobags and associated water collection systems for the immobilisation treatment option and a bunded and lined area with specific surface water drainage controls for the thermal desorption unit) are to be implemented to protect groundwater quality from any contaminated excavated or dredged material stored temporarily prior to treatment either by immobilisation or thermal desorption.

Groundwater impact from the emplacement of immobilised and/or thermally desorbed contaminated sediment and excavated material as engineered fill or for landscaping on the Closure Area site within the constraints of the DA for this site, is considered quite unlikely.

As discussed within this EIS, the immobilised treated material produces a stabilised 'dewatered' product that does not produce seepage and is of very low to extremely low permeability (less than 1 x 10^{-9} m/s), significantly limiting any potential groundwater impact through leaching. In addition, the thermally desorbed sediment or excavated material will be of sufficiently low concentration and leachability to meet the proposed treatment standards for the project that are protective of groundwater.

Treated sediment or excavated material is to be placed above the water table and below the 0.5 m physical barrier meeting the MPT consent conditions for use as a separator/buffer. This barrier will have very low permeability (possibly less than 1 x 10^{-7} m/s, URS (2000)), approximately two orders of magnitude more permeable than the proposed permeabilities of the immobilised sediments.

In addition, the improvement of the surface water drainage system within the Closure Area, including recontouring and capping, will further reduce infiltration to the underlying shallow groundwater table, further reducing potential mobilisation of contaminants from emplaced treated material from this proposed project. As a result of the proposed treatment and selective emplacement procedures, leaching of contaminants to groundwater from immobilised or thermally desorbed sediments and excavations is highly unlikely. No discernable environmental impact upon groundwater is hence expected from this aspect of the proposed project.

With respect to the potential for interception of groundwater (and the subsequent licensing requirement under the Water Act (NSW, 1912)) raised in the Director General's requirements, no interception and extraction of groundwater through the drilling of bores is envisaged to be undertaken in the proposed development. It is noted that any new groundwater monitoring wells (eg those constructed to replace any destroyed wells) will require licensing through the Department of Land and Water Conservation (DLWC).

5. Recommended Safeguards

For land south of the river, the groundwater quality within the OneSteel areas outside the footprint of the proposed swing basin and Closure Area will continue to be sampled and assessed as a component of the environmental monitoring programs already undertaken within these areas. For land north of the river, the groundwater quality at the KCT will also continue to be sampled and assessed as component of this site's environmental monitoring program. In summary, no discernable change in groundwater quality beyond the swing basin excavation area is envisaged from the proposed dredging component of the development.

As discussed in Section 4, the largest potential for environmental impact with respect to the contamination of groundwater and surface water from the presence excavated soil material (i.e. slag, steelworks refuse etc.) and the Mill Scale Transition Area is associated with the construction of the swing basin. These issues are proposed to be managed through the development of a specific management plan relating to the construction of the swing basin.

At this preliminary stage, a number of design options have been considered for the construction of the swing basin. Possible options include a revetment wall, a sheet pile wall, a hybrid or a clay lined with a thinner revetment wall. The optimal design will be finalised during the post-EIS detailed design phase of the project.

Given the logistical complexities associated with the excavation and construction of the swing basin and the uncertainties associated with the environmental data on potential soil contamination within the swing basin footprint (which is proposed to be addressed with a specific site investigation), only preliminary details of a groundwater and surface water management plan can be given at this stage.

At this preliminary stage a number of environmental issues associated with the construction of the basin have been identified and are listed in Table 5.1 below.

Table 5.1: Preliminary groundwater and surface water management plan for construction of swing basin.

Impact	Receptor	Risk Minimisation / Mitigation Measures
A number of groundwater monitoring wells installed within the footprint of the proposed swing basin will be destroyed as a consequence of the excavation works (e.g. fill wells W-7F, W-6F, F2, W-10F, M2/5, M2/6 and estuarine wells W-7E, W-6E, E13, W-10E, M6/3).	Groundwater	A number of fill and estuarine groundwater monitoring wells are recommended to be installed at appropriate locations around the radius of the proposed swing basin to replace the destroyed wells, especially in the vicinity of the Mill Scale Storage and Transition Area. These new wells will enable continued monitoring of groundwater quality in the vicinity of the swing basin to provide indications of potential future groundwater impact issues. New data obtained could be compared to available historical data.

Impact	Receptor	Risk Minimisation / Mitigation Measures
Due to historical filling and waste residue disposal in the vicinity of the swing basin footprint, there is also the possibility of encountering contamination such as TPH, BTEX, PAH, heavy metal, cyanide and phenol during the excavation works above and below the water table.	Groundwater and surface water	If such contamination is uncovered during the excavation works above the water table, then impacted material will be excavated as quickly as possible by the excavators operating within the basin and transferred to the fleet of transport trucks. The material will then be transported to the Closure Area for treatment. By excavating this material in a dry state this system should minimise potential contact of free phase with the groundwater table or surface water, thereby minimising the potential increase of dissolved phase concentrations of hydrocarbons. If such contamination is uncovered during the excavation works below the water table, then it is likely that dissolved phase hydrocarbon contamination is already occurring. It is acknowledged that disturbance of this material may increase the surface area of the potential free phase and may increase the rate of dissolution. As a result, it is proposed that should pockets of hydrocarbon impacted material be encountered, then a similar strategy as described above should be implemented, whereby excavators/dredgers quickly remove the material to lined trucks. In addition, a combination oil containment boom and oil skimmer pump system proposed to be installed at the bottom of the southern edge of the swing basin to capture any potential free phase product which may seep from the excavation face.
Breaching Mill Scale Transition Area and potentially releasing hydrocarbon impacted pit water.	Groundwater and surface water	Currently, there has been no discernable impact on groundwater downgradient from the Mill Scale Storage and Transition Area, even though heavy metals, cyanide, ammonia and TPHs are potentially associated with this area (CH2MHill, 2002). The swing basin footprint intercepts the northern edge of the unlined Pit area, which OneSteel plan to replace with a more suitable impervious concrete pad style system in the future. There may be a possibility of a change in groundwater equilibria in the vicinity of this facility, in addition to the mobilisation of hydrocarbon impacted surface water through the construction of the swing basin. The provision of the oil containment boom and oil skimmer pump system described above will be used to contain any hydrocarbon impacted entering the excavation area from the Pit area. Downgradient groundwater wells associated with monitoring the Mill Scale Storage and Transition Area will need to be replaced as soon as practical after construction of the swing basin to provide immediate evidence that no additional impact to groundwater is occurring post construction.

Impact	Receptor	Risk Minimisation / Mitigation Measures
Potentially contaminated surface water within the excavation area being released during removal of temporary haul road.	Surface water	Prior to the final removal of the proposed temporary haul road on the northern edge of the excavation area, an analysis of surface water quality will need to be undertaken. The surface water within the excavation area may be impacted by seepage of potentially contaminated groundwater or seepage originating from soil contamination. The provisions described previously are intended to minimise any additional impacts resulting from the excavation. If the surface water in this area is considered to be contaminated, then it will be treated prior to discharge, with various methods depending upon the nature of the contamination. More specific details will be provided in the Groundwater Management Plan to be developed when more data is available. The northern foreshore bank where the proposed temporary haul road will be constructed has been subject to many years of tidal flushing and as a result, is not expected to be contaminated.
Groundwater quality of any land where potentially contaminated excavations or dredging material is temporally stored may be impacted.	Groundwater	Contaminated excavations or dredged sediments temporarily stored prior to treatment via immobilisation or thermal desorption will be stored within a lined storage basin and a program of environmental monitoring will be implemented to ensure the integrity of the system. Treated material, depending upon engineered fill requirements and specific material engineering properties are envisaged to be emplaced on the Closure Area site above the water table and below the 0.5 metre separator/buffer barrier, underneath areas of very low to negligible infiltration or disposed of to sea, if environmental criteria are met. Due to the very low to extremely low permeability of the immobilised contaminated sediment and excavated material, coupled with permeability characteristics of the 0.5 metre covering barrier and the surface water drainage system, limited groundwater infiltration is expected within the Closure Area. As a result, leaching of contaminants to groundwater from immobilised or thermally desorbed sediments and excavations is highly unlikely. No environmental impact upon groundwater is hence expected.

6. Limitations

This report presents the results of a hydrogeological assessment as a component of the EIS for NPC on the south arm dredging masterplan prepared for the purposes of this commission. The data and advice provided herein relate only to the project described herein and must be reviewed by a competent Engineer/Scientist, experienced in hydrogeology, and contaminated site and geotechnical investigations, before being used for any other purpose. GHD accepts no responsibility for other use of the data.

The advice tendered in this report is based on a review of information obtained from the documentation listed in this report and is not warranted in respect to any information regarding the condition or past use of the site not contained in the documentation reviewed. GHD accepts no responsibility for the accuracy of the information contained in the documentation reviewed.

No soil or groundwater samples have been collected or analysed in preparation of this report.

An understanding of the site conditions and likely environmental impacts associated with the proposed development depends on the integration of many pieces of information, some regional, some site specific, some structure-specific and some experienced-based. Hence this report should not be altered, amended or abbreviated, issued in part and issued incomplete in any way without prior checking and approval by GHD. GHD accepts no responsibility for any circumstances that arise from the issue of the report that has been modified in any way as outlined above.

7. References

Ref #1 GHD-LM (2001) – "Geotechnical Report on Hunter River Dredging EIS South Arm Master Plan for Newcastle Port Corporation" (Ref 27/10134/02/AP473, 25 July 2001).

Ref #2 CH2MHill (2002) – "Final Assessment Report for the Voluntary Investigation – Lot 222 Characterisation Studies from February 2000 to September 2002" (Ref 110293.08 December 2002).

Ref #3 URS (2001) – "BHP Billiton Newcastle Steelworks Lot 223 Groundwater Remediation Options Study" (Ref 24517/020/558).

Ref #4 URS (2000) – "Development of a Multi Purpose Terminal and Remediation of the Closure Area, BHP Newcastle Steelworks Environmental Impact Statement (Ref A8602704, August 2000).

Ref #5 OneSteel (2002) – "Environmental Information Provision to Premiers Department/NPC for Potential Swing Basin and Foreshore Embankment Works"

Ref #6 BHP (1993) – "Site Management Plan Historical Investigation" (Ref PRE/REP/001 November 1993).

Ref #7 RCA (1999) – "Hydrogeology and Water Balance Report BHP Main Site, Newcastle Steelworks" (Report No. 859f August 1999) (Cited in URS (2001a).

Ref #8 GHD (2001) – "Remediation of Lot 223, Industrial Drive, Mayfield Environmental Impact Statement" (December 2001).

Ref #9 URS (2001a) – Stage 1 Problem Formulation Report, Final "Ecological Risk Assessment of Groundwater at the BHP Closure Area and Sediments in the South Arm of the Hunter River, Newcastle, NSW" (Report No. 24517/Ecological Risk/R003-A,May 2001).

Ref #10 ERM (1996) – "Kooragang Coal Terminal Stage Three Expansion Environmental Impact Statement" (Report No. 95190RP1, September 1996).

Ref #11 Egis (2000) – "Newcastle Steelworks Closure Area, Summary Site Audit Report" (Ref VA0120.001 Rev0, December 2000).

Ref #12 RCA (2000) – "Recent Groundwater Contamination Flux Investigation" (November 2000), (cited in Egis 2000).

Ref #13 GHD-LM (2002) – "Geochemical report, Global Groundwater Review, Kooragang Coal Terminal" (Report No. 271/0223 April 2002).

Appendix A
Figures

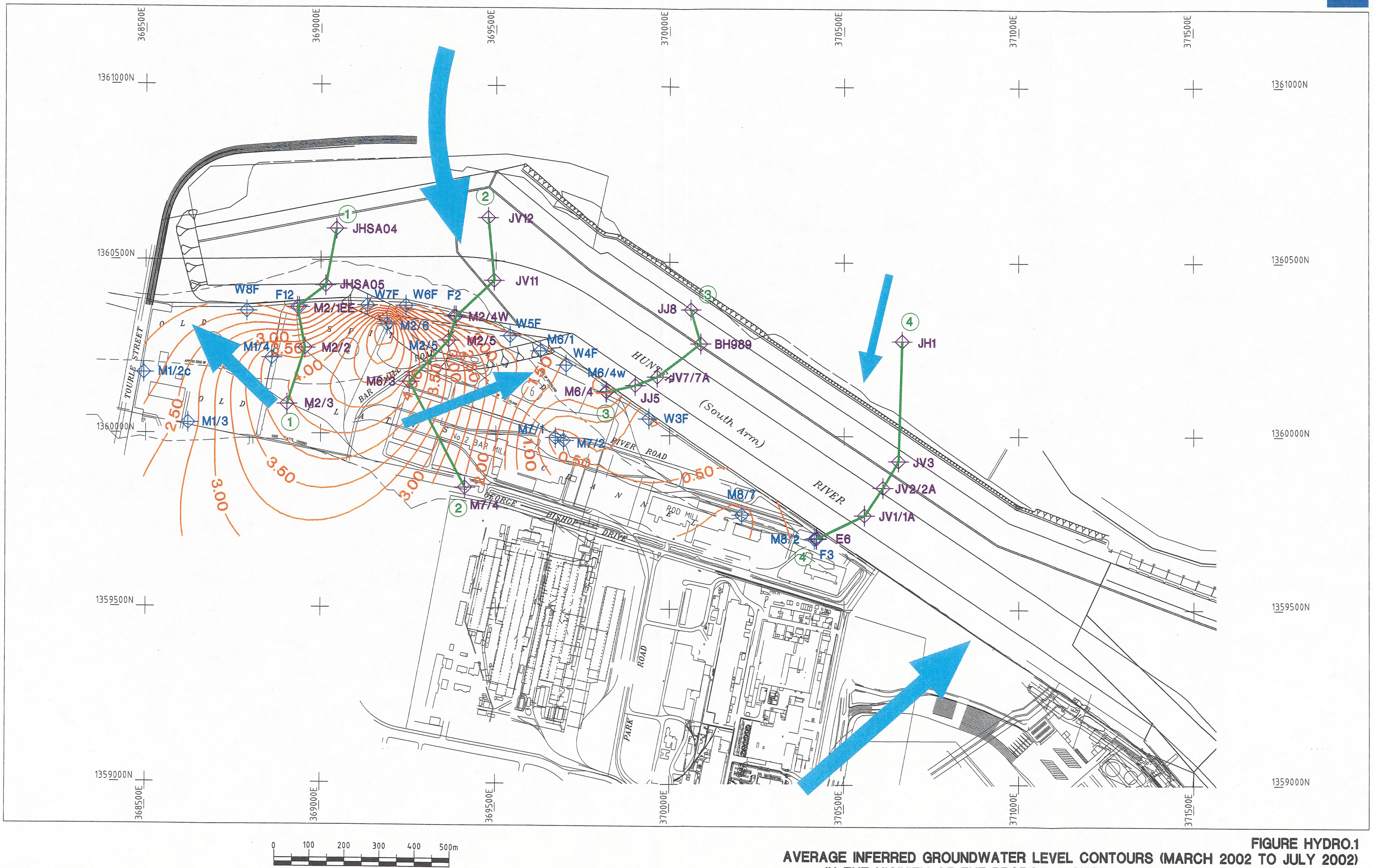

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FIGURE HYDRO.1
AVERAGE INFERRED GROUNDWATER LEVEL CONTOURS (MARCH 2002 TO JULY 2002) IN THE VICINITY OF THE PROPOSED SHORTLAND SWING BASIN - FILL AQUIFER. LOCATION OF CONCEPTUAL HYDROGEOLOGICAL CROSS SECTIONS

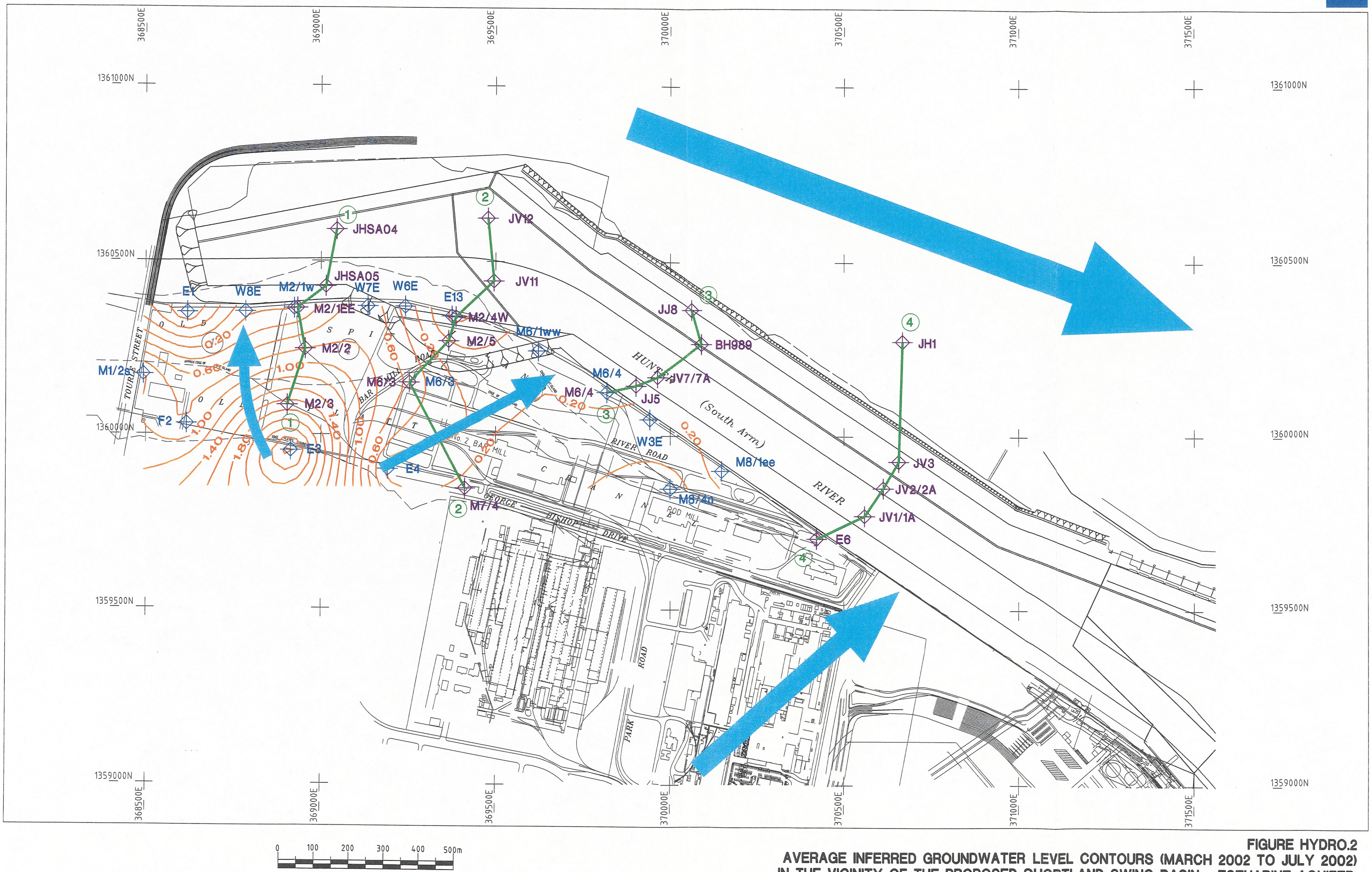

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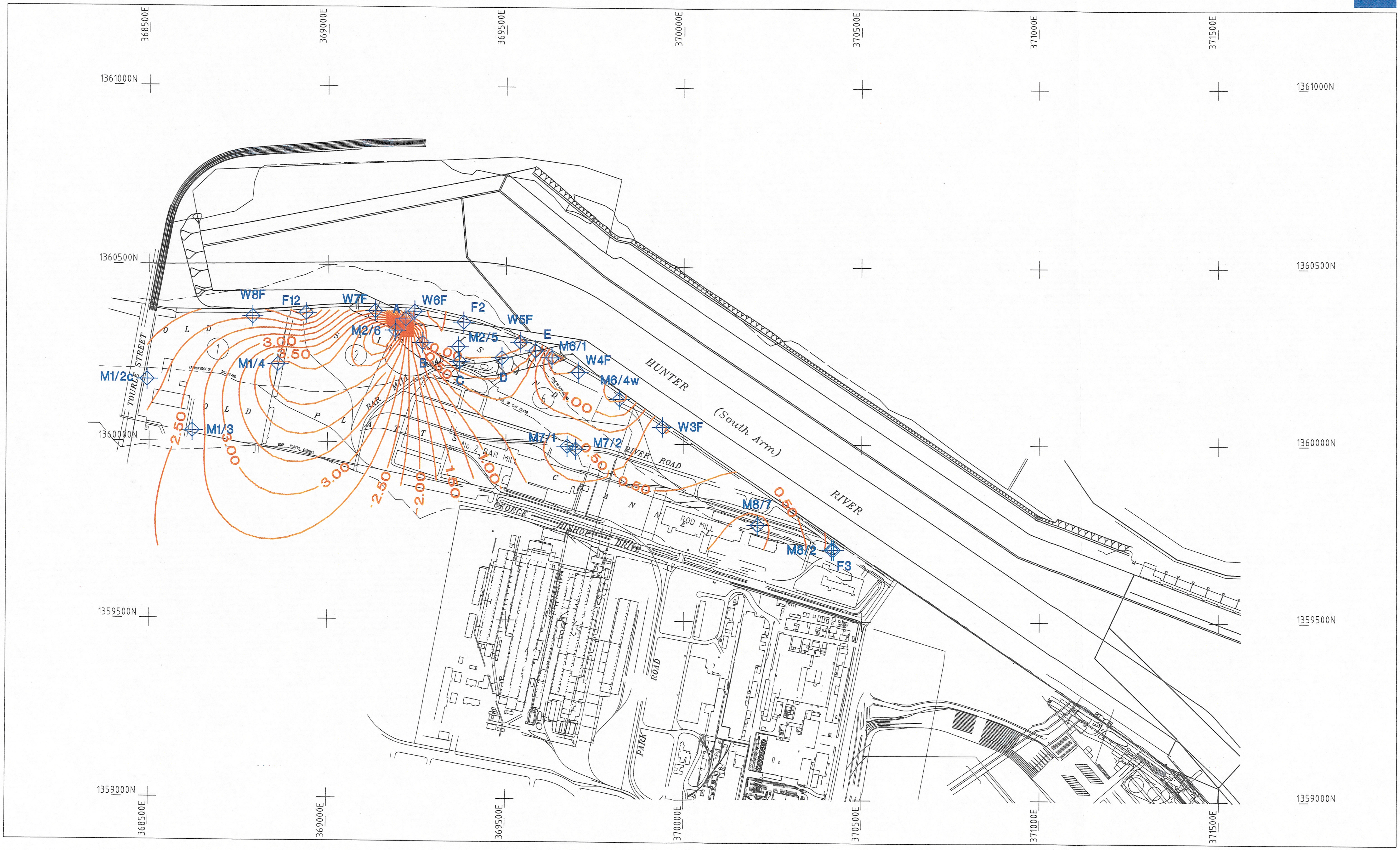
FIGURE HYDRO.2
AVERAGE INFERRED GROUNDWATER LEVEL CONTOURS (MARCH 2002 TO JULY 2002) IN THE VICINITY OF THE PROPOSED SHORTLAND SWING BASIN - ESTUARINE AQUIFER. LOCATION OF CONCEPTUAL HYDROGEOLOGICAL CROSS SECTIONS



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(1:10000 for A3 Size Plot)

FIGURE HYDRO.3

ESTIMATED GROUNDWATER LEVEL CONTOURS POST CONSTRUCTION OF THE PROPOSED SHORTLAND SWING BASIN - FILL AQUIFER.

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FIGURE HYDRO.4
ESTIMATED GROUNDWATER LEVEL CONTOURS POST CONSTRUCTION OF THE PROPOSED SHORTLAND SWING BASIN - ESTUARINE AQUIFER.

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GHD Pty Ltd ABN 39 008 488 373

352 King St Newcastle NSW 2300
PO Box 5403 Newcastle West NSW 2302
T: (02) 4979 9999 F: (02) 4979 9988 E: ntlmail@ghd.com.au

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		Name	Signature	Name	Signature	Date
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