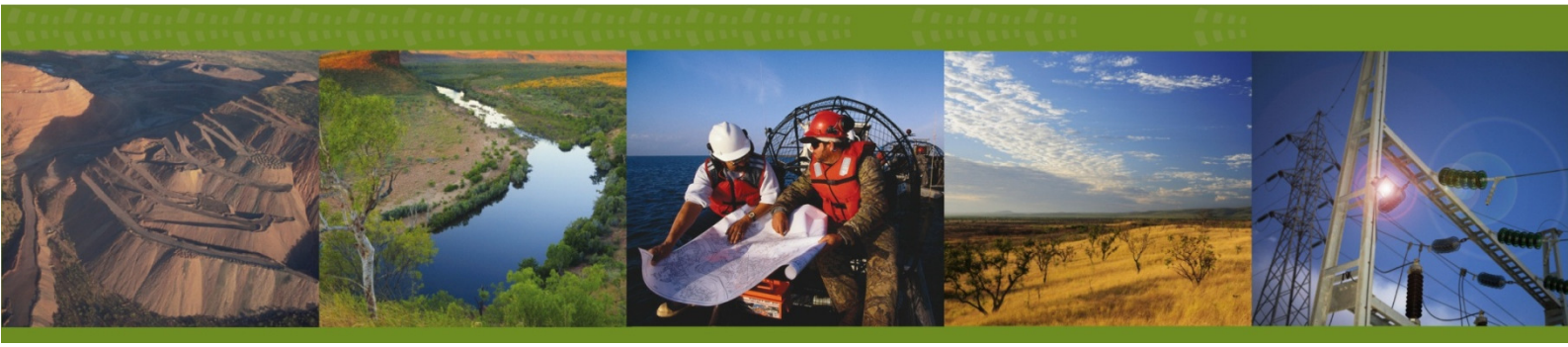


Mangles Bay Marina Based Tourist Precinct

Public Environmental Review

DRAFT

Prepared for
Cedar Woods Properties Ltd
by Strategen

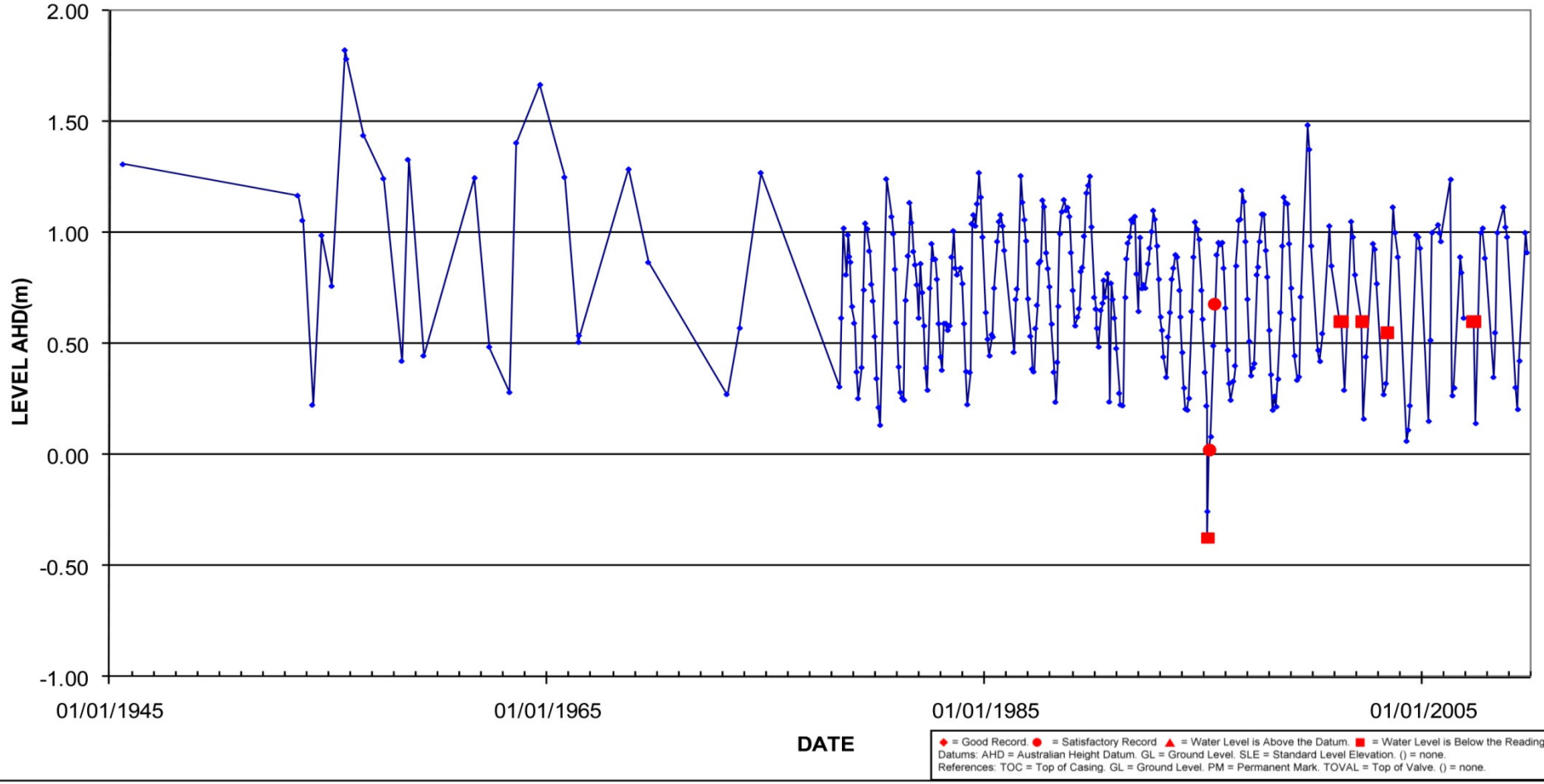
October 2011

STRATEGEN
environmental consultants

Government of Western Australia
Department of Water

6142501 LAKES AND WETLANDS LAKE RICHMOND

Easting = 378808.00 Northing = 6427609.00 Zone = 50 PM = 2.84mAHD WIN SITE ID = 13662



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Mangles Bay Marina Based Tourist Precinct

Lake Richmond historical surface water levels graph

Figure 29

strategen
Oct-2011

Source:
Aerial photography supplied by Landgate (2010)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

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Lake Richmond historical surface water levels and extent of waterbody

Figure No:
30

Hydrology and Water Quality Monitoring Program

Lake Richmond has been monitored by MWH since January 2010, and monitoring is planned to continue until October 2011. This report includes monitoring results up to, and including, March 2011. The surface water investigations undertaken to date (MWH 2011b, provided in Appendix 4) include:

- depth transects of the lake
- lake water level monitoring using a datalogger
- monthly water quality monitoring at two sites; each sample is analysed for standard water quality (pH, EC, TDS, Na, K, Ca, Mg, Fe, Cl, SO_4, NO_3, HCO_3 and CO_3), TSS, DO, TN, TP, nitrite, RFP (subsequent anions), eight standard metals (As, Cd, Cu, Cr, Hg, Pb, Ni, Zn), hydrocarbons (TRH $C_6 – C_{36}$), turbidity (NTU) and colour
- monthly stratification monitoring at three sites in the lake with EC, pH, DO and temperature recorded at 1 metre depth intervals.

Monitoring locations are shown in Figure 32. Additional detail regarding the monitoring program and results can be found in Appendix 4.

Bathymetry and depth transects

Depth transects of Lake Richmond were undertaken by MWH in January 2010 (MWH 2011a). An additional detailed survey of the lake fringe bathymetry was undertaken by Strategen in August 2011 (Figure 30). Cross sections of Lake Richmond are provided in Figure 38, Figure 39, Figure 40 and Figure 41.

The lake has a comparatively flat, shallow edge between approximately 0 and 1.5 mAHD (Figure 30). Beyond this, a steep descent (generally greater than 1 in 6) occurs to a depth of -10 to -14 mAHD (MWH 2011a). The base in the middle of the lake appears to be relatively flat. Based on an average water level variation between 0.2 and 1.2 mAHD, the area of inundation in the lake would be expected to vary from between 31 ha and 55 ha over an average year.

Water levels

Water levels in the lake varied between approximately -0.1 and 0.85 mAHD over the monitoring period (MWH 2011a) (Figure 33). Water levels peaked in September 2010 following winter rains, and were at their lowest in March 2011 (Figure 33). Water levels were above the 0.58 mAHD level that allows water to flow out of the lake via the Outlet Drain between July and November 2011 (Figure 33). A July to November flow period was also recorded in 2002 (Naragebup 2003). The long-term average water level in the lake is 0.74 m (MWH 2011d) (Figure 29).

Water quality

Water quality was monitored monthly at two locations within the lake, and on one occasion at the stormwater outlet over the period January 2010 to March 2011 (Figure 32). The lake was generally alkaline, with pH varying between 7.6 and 9, which can be expected given the high concentrations of calcium carbonate (lime) in the local soils (MWH 2011a). The water was slightly brackish, with salinity between 520 and 660 mg/L (MWH 2011d).

Table 10 ANZECC/ARMCANZ (2000) guidelines for water quality in slightly disturbed ecosystems in south west Australia

Item	Freshwater lake guideline (mg/L)	Wetland guideline (mg/L)	Lake Richmond (average and maximum) (mg/L)
Total Phosphorus (TP)	0.01	0.06	0.02 0.03
Total Nitrogen (TN)	0.35	1.5	0.92 1.9

Nitrogen and phosphorus are important environmental chemicals, in that they provide nutrients for biological growth. However, elevated nitrogen and phosphorus concentrations can result in algal blooms, such as the *Microcystis* blooms that have occurred in the lake (Ecoscape 2008). Water quality in the lake exceeded the ANZECC/ARMCANZ (2000) guidelines for TN and TP in freshwater lakes in slightly disturbed ecosystems in south west Australia (Table 10). This is consistent with the results of Naragebup (2003), which noted that nitrogen and phosphorus levels in the lake exceeded the ANZECC guidelines with respect to nitrogen and phosphorus. This is not surprising given the urban nature of the surrounding areas and volumes of urban stormwater entering the lake. Nitrogen and phosphorus in the lake are likely to come from stormwater and groundwater from urbanised areas, due to the use of fertilisers on gardens and POS.

Stratification monitoring

Stratification monitoring was undertaken at three locations within the lake to determine whether the chemical and physical properties of the lake varied with depth (Figure 32) (MWH 2011d). This is an important parameter for deep lakes, such as Lake Richmond, where physical and chemical properties may vary significantly with depth. These changes may represent a lake interacting with saline water or represent changes in physical processes with depth that may impact on the behaviour of the lake. Properties may vary over the year due to changes in air temperature; solar radiation; degree of mixing due to wind; and, groundwater salinity following rainfall. All three locations showed similar results. Results for Site 2 are discussed under this heading. Results for all sites are provided in Appendix 4.

Lake Richmond appears to be a comparatively well mixed lake, with pH, temperature and EC remaining relatively stable above -10 mAHD, except during the summer months (MWH 2011d). Temperature in the lake varied between approximately 14 and 28°C, with deeper waters being a few degrees cooler than shallower waters in summer (Figure 34). There is a slight decrease of pH from approximately 9 to 7(Figure 35) and an increase in EC from 0.9 mS/cm (approximately 550 mg/L TDS) to 1.4 mS/cm (approximately 840 mg/L TDS) (Figure 36) with depth. While salinity at the bottom of the lake is slightly brackish, it is well below the salinity of seawater at approximately 35 000 mg/L.

Between January and April, a layer of more saline, alkaline and less oxygenated water occurs in the lower four metres of the lake. This appears to disappear in autumn, possibly due to increased wind mixing or freshwater inputs.

Functional Ecology

Thrombolites

The Thrombolite TEC is an association of microorganisms that aggregate in rock-like formations, formed by the deposition of calcium carbonate during growth and metabolic activity within the community micro-environment (Figure 31) (Moore 1991). The area of thrombolite habitat is not well defined. No formal mapping of the thrombolites has occurred (English V [DEC] 2011, pers. comm. 26 September).

Thrombolite structures at Lake Richmond occur from perhaps 0 mAHD to within the vegetated fringe of the lake (CALM 2003b). Old stranded thrombolites (no longer living) have been reportedly identified immediately to the east of Lake Richmond (CALM 2003b). It is therefore difficult to establish the veracity of the area covered by the active community or the ecological water requirements of the thrombolites. It is inferred that at least seasonal inundation and seasonal drying is required for thrombolites to persevere.

An unconfirmed observation made by a member of the public indicates that the Thrombolites have also established near the weir in the Lake Richmond Outlet Drain, since this was constructed in 1968. Whilst this is unsubstantiated (due to water levels being too high during the writing of this PER) (this potentially indicates that the community is capable of colonising new areas over time.

The survival and growth of the community is considered to be dependent upon light and a continuing supply of fresh water which is rich in calcium and bicarbonate/carbonate (ESSS 2007). Groundwater in the area contains these chemical components as a result of the dissolution of the shell fragments commonly found in the Safety Bay Sands (Davidson 1995). The thrombolites at Lake Richmond appear to be adapted to fresh or brackish water, and would be unlikely to survive major increases in salinity (ESSS 2007).

Sedgelands in Holocene dune swales

The Sedgelands TEC occurs in linear damplands and occasionally sumplands between Holocene dunes. The TEC is not limited to Lake Richmond, occurring at eight locations in the Rockingham Becher Plain area and at two other locations in the South West, with a total estimated area of 130 ha (CALM 2002). Approximately 11 ha of this TEC occurs in a band around the edge of Lake Richmond (CALM 2002). This band extends to the edge of Safety Bay Road.

Hydrological regime is considered to be the primary non-biological factor that influences the characteristics of this TEC (CALM 2002). Depth, timing and duration of flooding and length of the dry period affect vegetation composition and distribution (CALM 2002). Sedgelands in damplands and sumplands of the Holocene dune swales have relatively specific water regime requirements to maintain current biology, but are tolerant of seasonal and longer-term variations that reflect natural climatic patterns. Maintenance of water level and quality is considered critical for this TEC (CALM 2002).

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Thrombolites at Lake Richmond

FIGURE 31

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Fauna

Aquatic vertebrates in Lake Richmond were surveyed by Rose (1998) and Rose *et al.* (2004). The 2004 survey found that the native *Pseudogobius olorum* (Swan River goby) was the most common species (Rose *et al.* 2004). The feral *Gambusia holbrooki* (mosquito fish) was also recorded in large numbers, and one native *Mugil cephalus* (sea mullet) was also caught (Rose *et al.* 2004). Feral *Carassius auratus* (goldfish) were also considered likely to be present in the lake.

Rose *et al.* (2004) also noted the presence of numerous introduced *Cherax destructor* (yabbies) in the lake, which "were observed coming out of holes that they had presumably constructed, within the thrombolites".

Five species of amphibians have also been observed in the area (ENV 2011a).

The minimal impacts modelled to occur to water levels in Lake Richmond, are not sufficient to impact these species.

Additional information regarding fauna in the Lake Richmond area can be found in Section 9.3.2.

Conservation Status and Buffers

Lake Richmond is listed as an EPP lake and as a Conservation Category wetland in the Geomorphic Wetlands of the Swan Coastal Plain dataset. Conservation Category wetlands are considered to support a high level of ecological attributes and functions. Lake Richmond is not listed under the Directory of Important Wetlands in Australia (Commonwealth) or List of Wetlands of International Importance of the Ramsar Convention (Commonwealth).

7.3.3 Rotary Park Lake

A small, artificial lake called Rotary Park Lake is located approximately 300 m east of the eastern boundary of the Proposal (Figure 1). The lake is a permanent water body maintained by City of Rockingham and has aesthetic value but little environmental value. The lake also has a drainage function (Ecoscape 2009). Ecoscape (2009) recorded a brackish salinity of 2220 to 2230 mg/L in this lake.

Rotary Park Lake is not listed as an EPP lake. It is not included in the Geomorphic Wetlands of the Swan Coastal Plain dataset.

Because of the limited size, limited environmental value of the lake and the limited potential for the Proposal to impact the lake, it was not monitored as part of this Proposal.

Source: Aerial Photography supplied by Landgate (2010)
Water monitoring data supplied by MWH (2010)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

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Surface water monitoring locations and transects

Figure No:
32

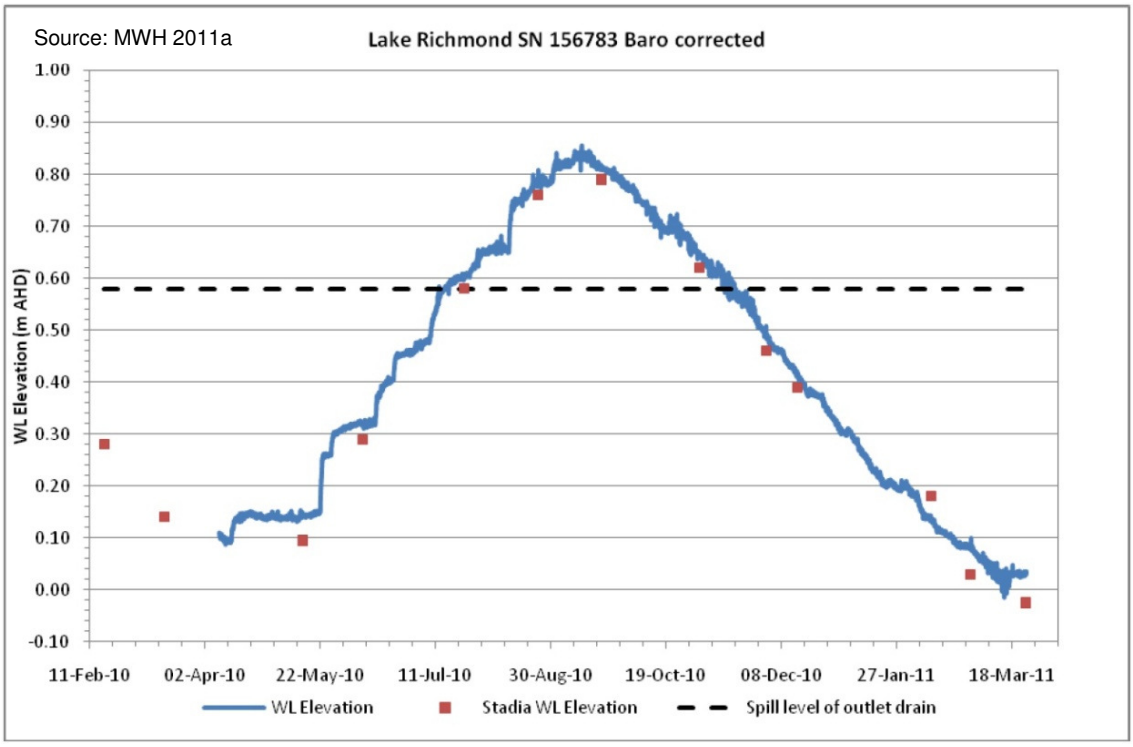


Figure 33 Lake Richmond surface water levels during monitoring

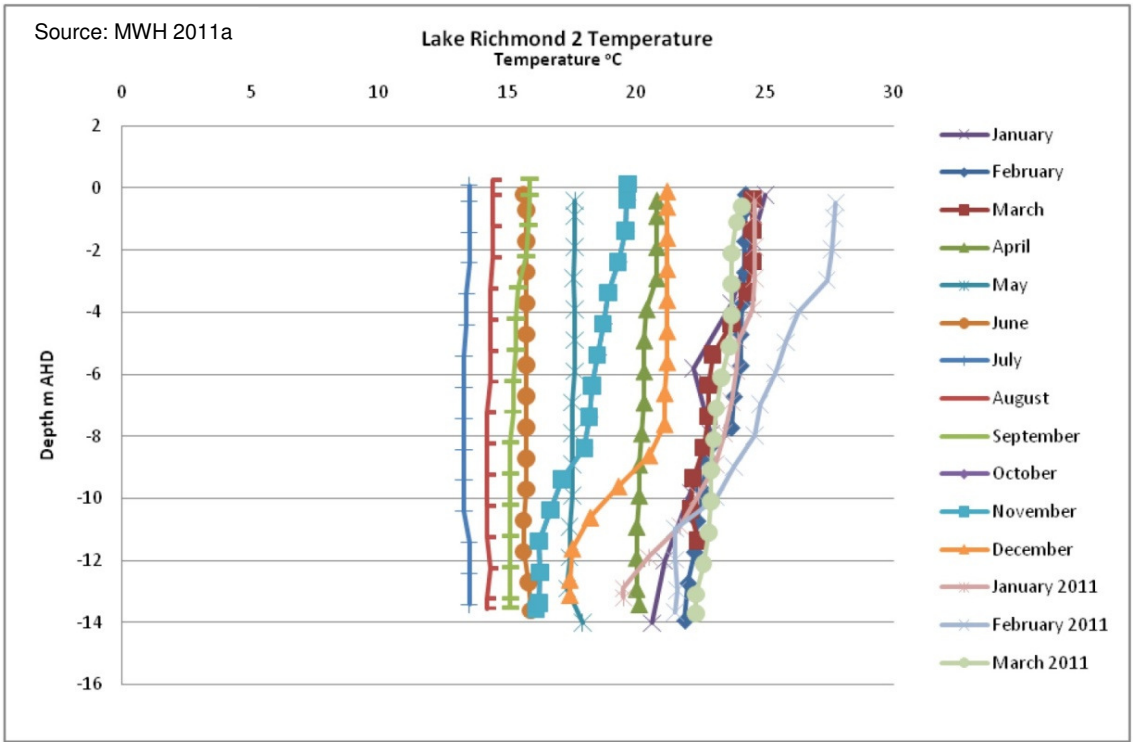


Figure 34 Lake Richmond temperature profiles during monitoring (Site 2)

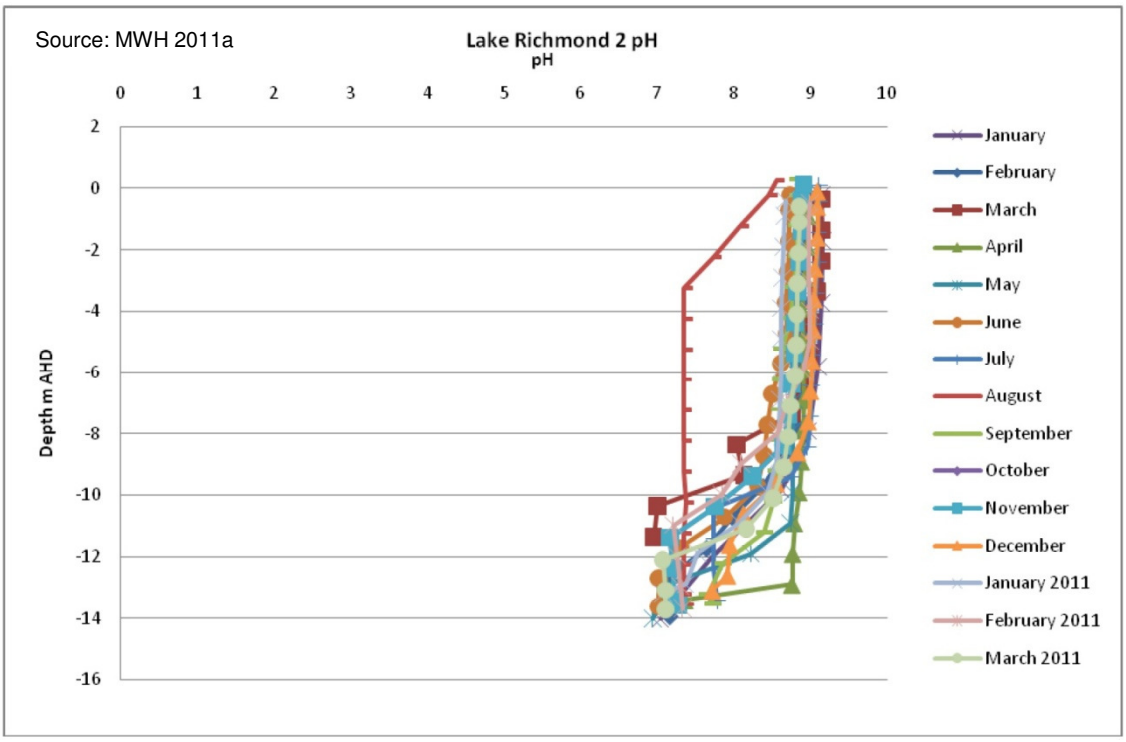


Figure 35 Lake Richmond pH profiles during monitoring (Site 2)

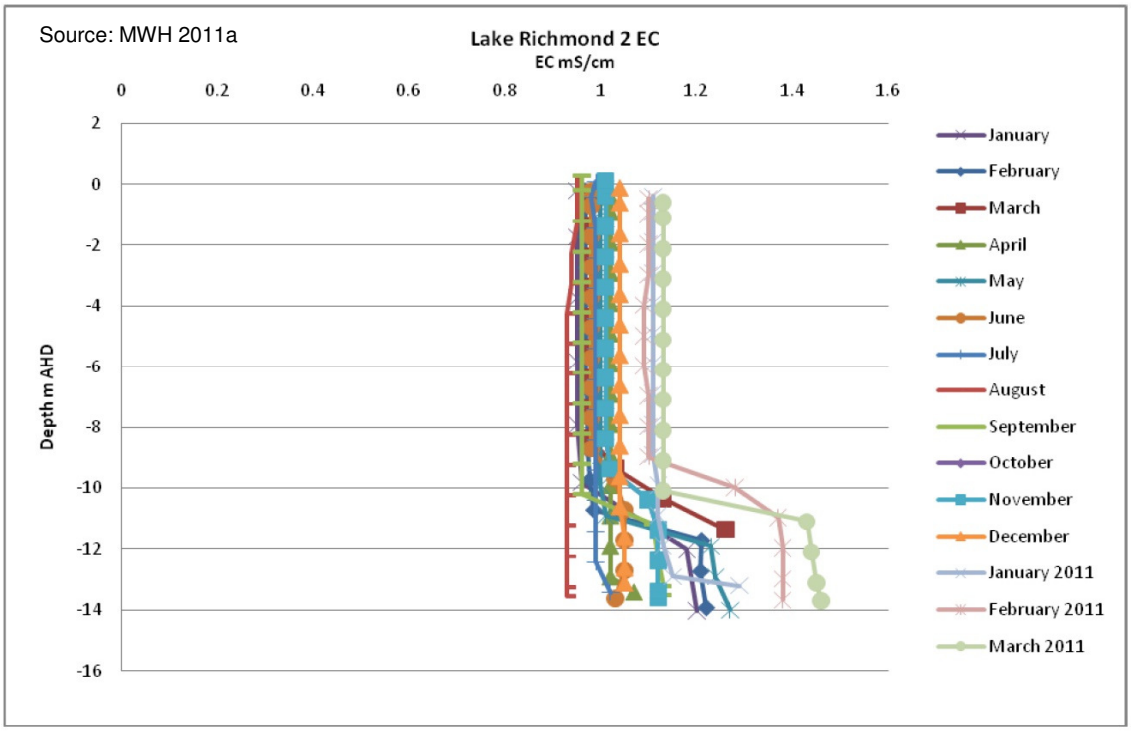
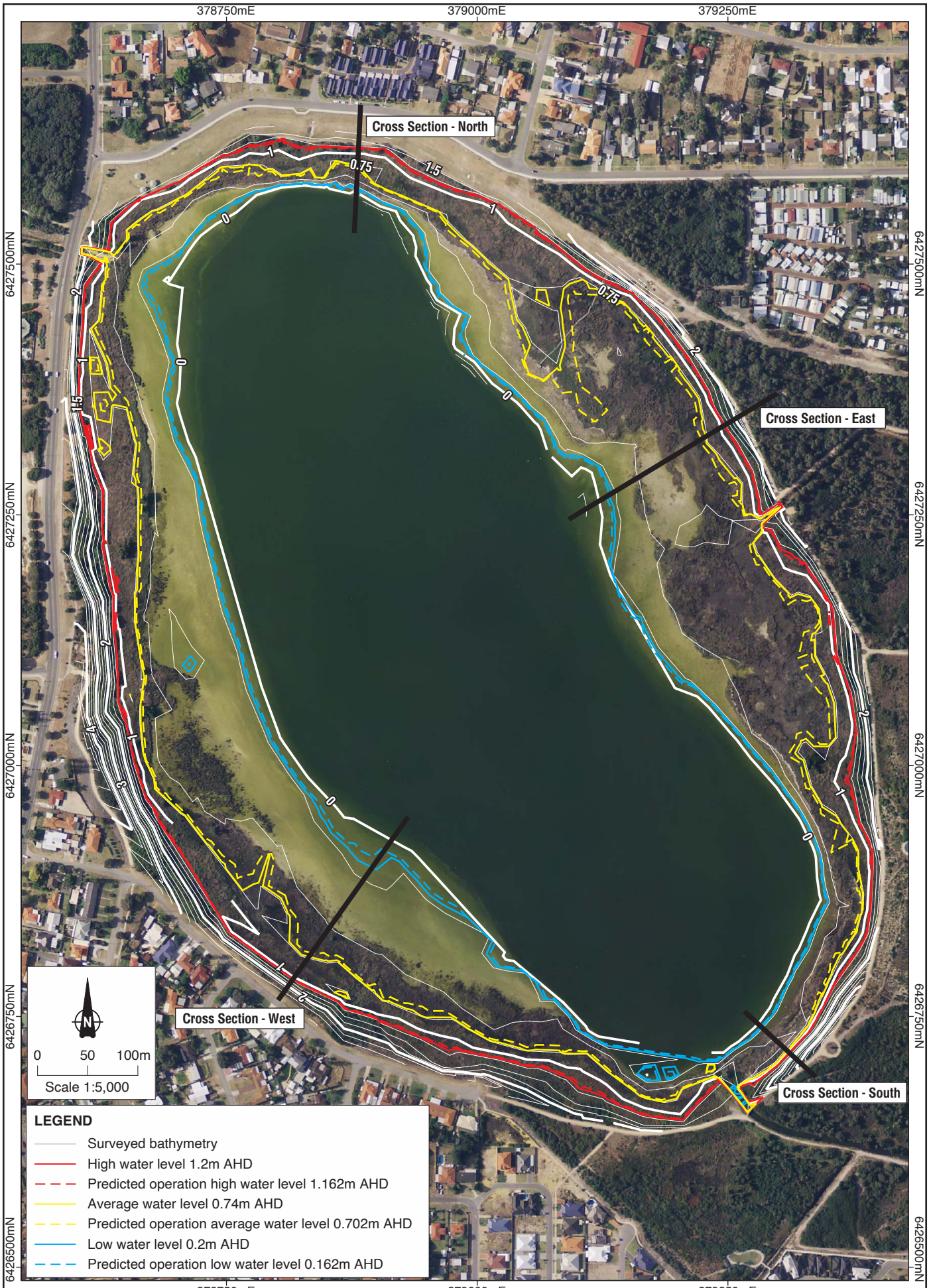


Figure 36 Lake Richmond electrical conductivity profiles during monitoring (Site 2)



Source:
Aerial photography supplied by Landgate (2010)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

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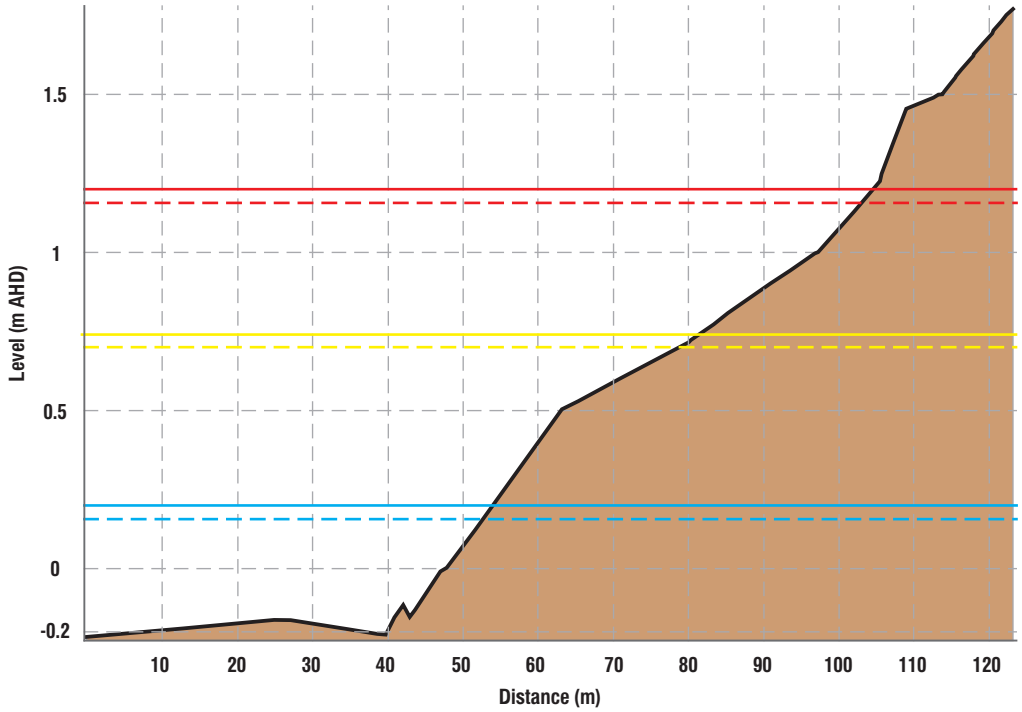
Predicted operational impact on Lake Richmond water levels

Figure No:
37



0 40m

Horizontal Scale 1:1,000

0 1m

Vertical Scale 1:40,000

LEGEND

- Surveyed bathymetry
- High water level 1.2m AHD
- Predicted operation high water level 1.162m AHD
- Average water level 0.74m AHD
- Predicted operation average water level 0.702m AHD
- Low water level 0.2m AHD
- Predicted operation low water level 0.162m AHD

Source:
Bathymetry supplied by ST Spatial
Date: 12/10/2011
NB: Potential errors may occur in some areas

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CAD Resources File No:
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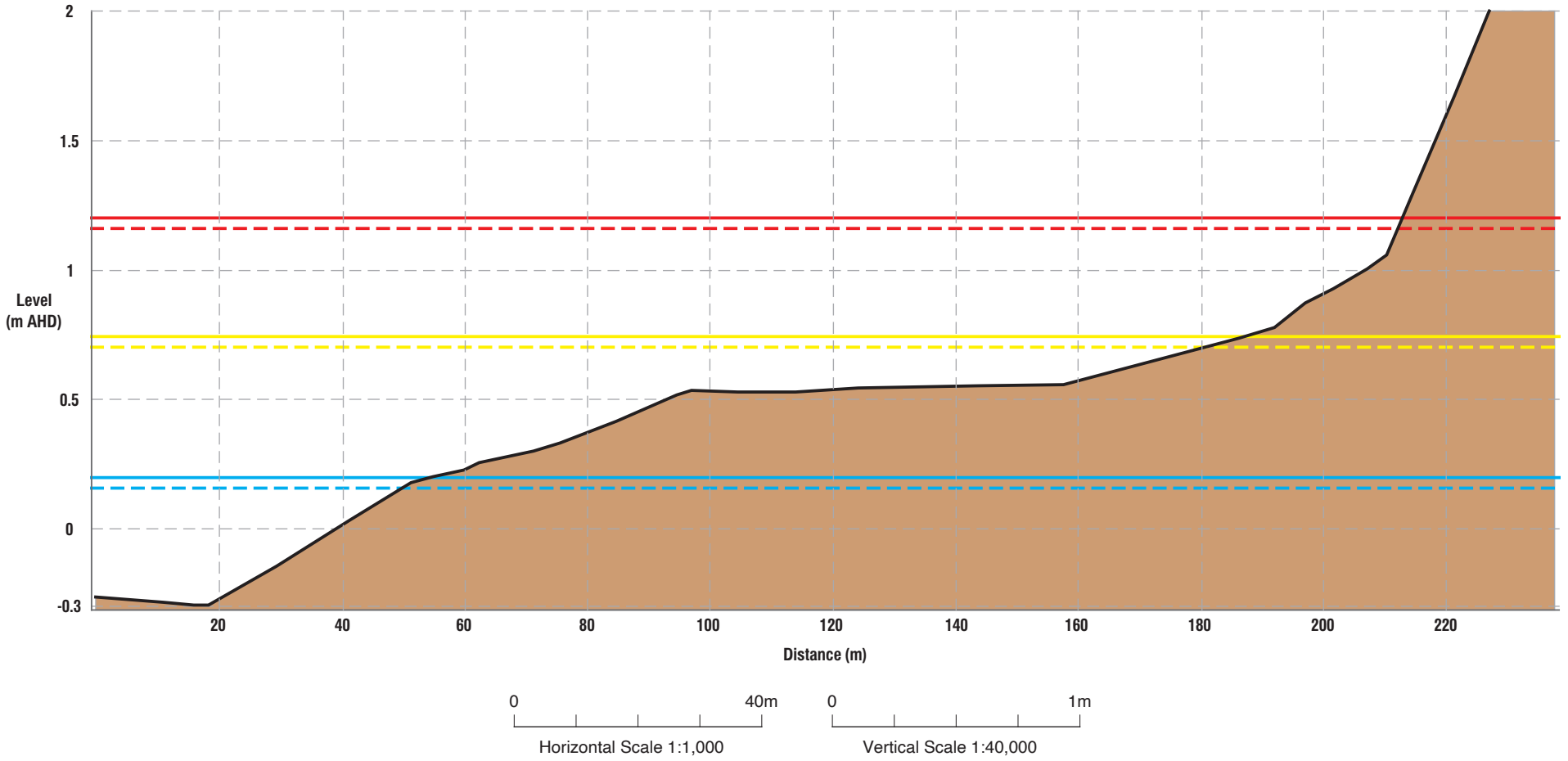
Lake Richmond cross section north

Figure No:
38



LEGEND

- Surveyed bathymetry
- High water level 1.2m AHD
- Predicted operation high water level 1.162m AHD
- Average water level 0.74m AHD
- Predicted operation average water level 0.702m AHD
- Low water level 0.2m AHD
- Predicted operation low water level 0.162m AHD

Source:
Bathymetry supplied by ST Spatial
Date: 12/10/2011
NB: Potential errors may occur in some areas

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CAD Resources File No:
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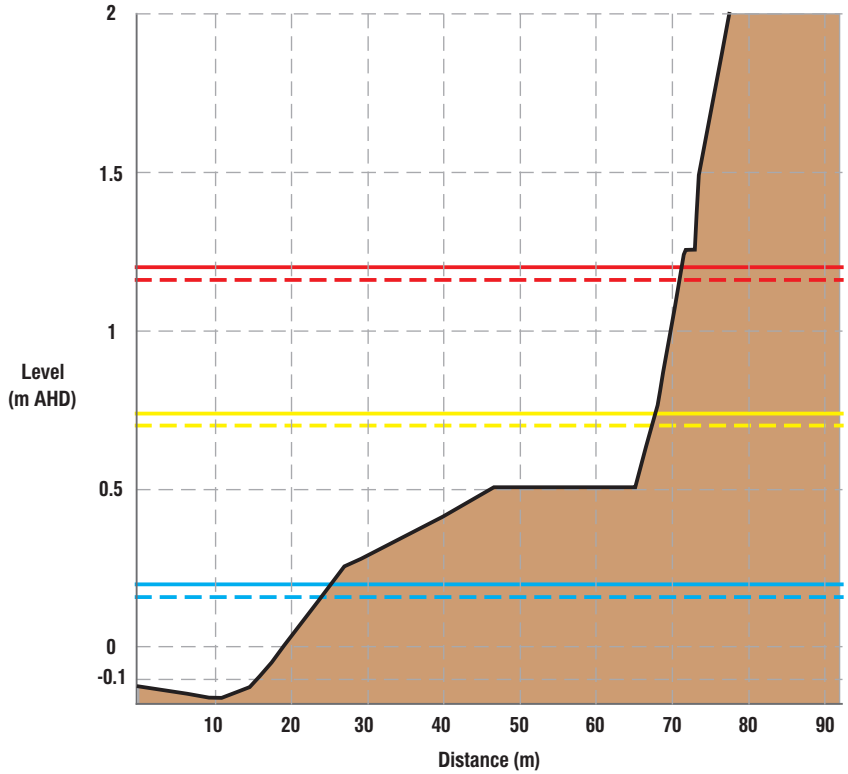
Lake Richmond cross section east

Figure No:
39



LEGEND

- Surveyed bathymetry
- High water level 1.2m AHD
- Predicted operation high water level 1.162m AHD
- Average water level 0.74m AHD
- Predicted operation average water level 0.702m AHD
- Low water level 0.2m AHD
- Predicted operation low water level 0.162m AHD

Source:
Bathymetry supplied by ST Spatial
Date: 12/10/2011
NB: Potential errors may occur in some areas

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CAD Resources File No:
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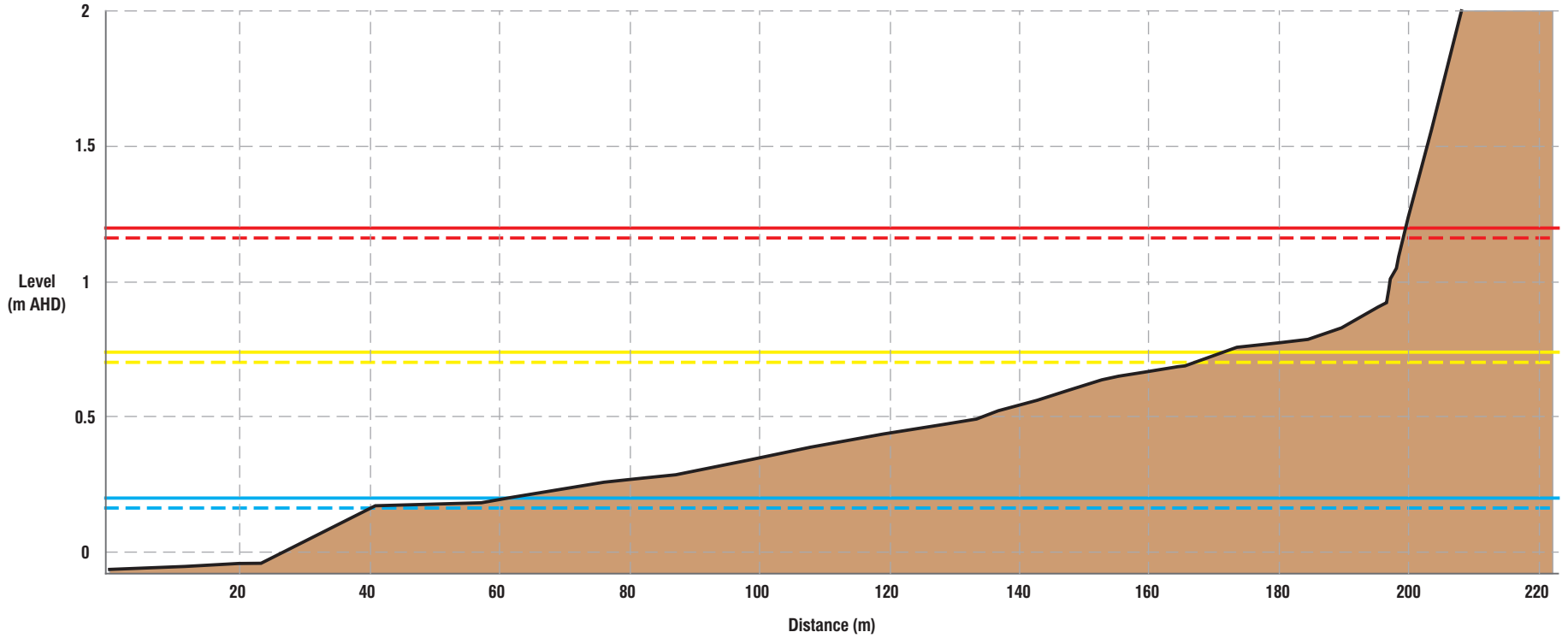
Lake Richmond cross section south

Figure No:
40



0 40m

Horizontal Scale 1:1,000

0 1m

Vertical Scale 1:40,000

LEGEND

- Surveyed bathymetry
- High water level 1.2m AHD
- Predicted operation high water level 1.162m AHD
- Average water level 0.74m AHD
- Predicted operation average water level 0.702m AHD
- Low water level 0.2m AHD
- Predicted operation low water level 0.162m AHD

Source:
Bathymetry supplied by ST Spatial
Date: 12/10/2011
NB: Potential errors may occur in some areas

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CAD Resources File No:
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Lake Richmond cross section west

Figure No:
41