OPTION 1

Legend

- Pond
- Long grasses
- Shrubs/understorey
- Revegetation and screening
- Access road
- Treatment plant 4 x (12.7 x 14.2 x 7.5m)
- Balance tank (15m dia x 4m)
- Pump station (13 x 7 x 5m)
- Office (4.5m x 4.5m x 4.5m)
- Discharge point
- Pipeline
- Bore location
- Reed bed for treated groundwater and stormwater
- Future storage pond or helipad

0 30 60 90m N

OPTION 1 - PIPEWORK

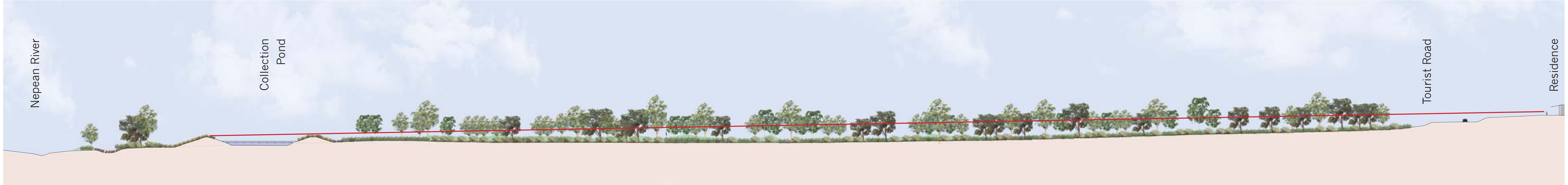
Legend

- Inlet pipe from borefield
- Scour and pipe outlet
- External pipes
- Pump suction pipework
- Pump delivery pipe work
- Discharge channel
- Treated water discharge pipe
- Backwash waste water outlet

0 15 30 45m N

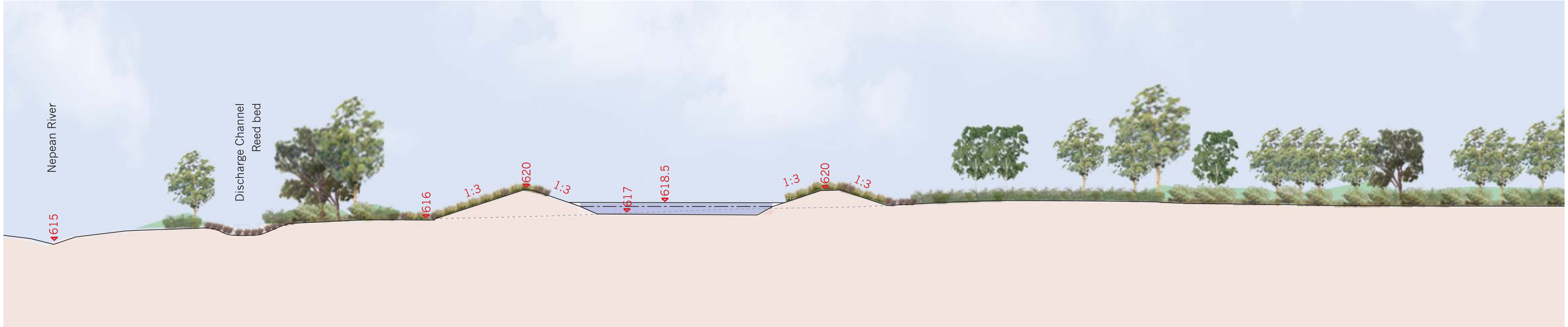
OPTION 1

Option 1. Key plan



NTS

Section A – A. Long view from adjacent dwelling



Section A – A. Dam and berm detail

1:500 @ A3

OPTION 1

Option 1. Key plan

NTS

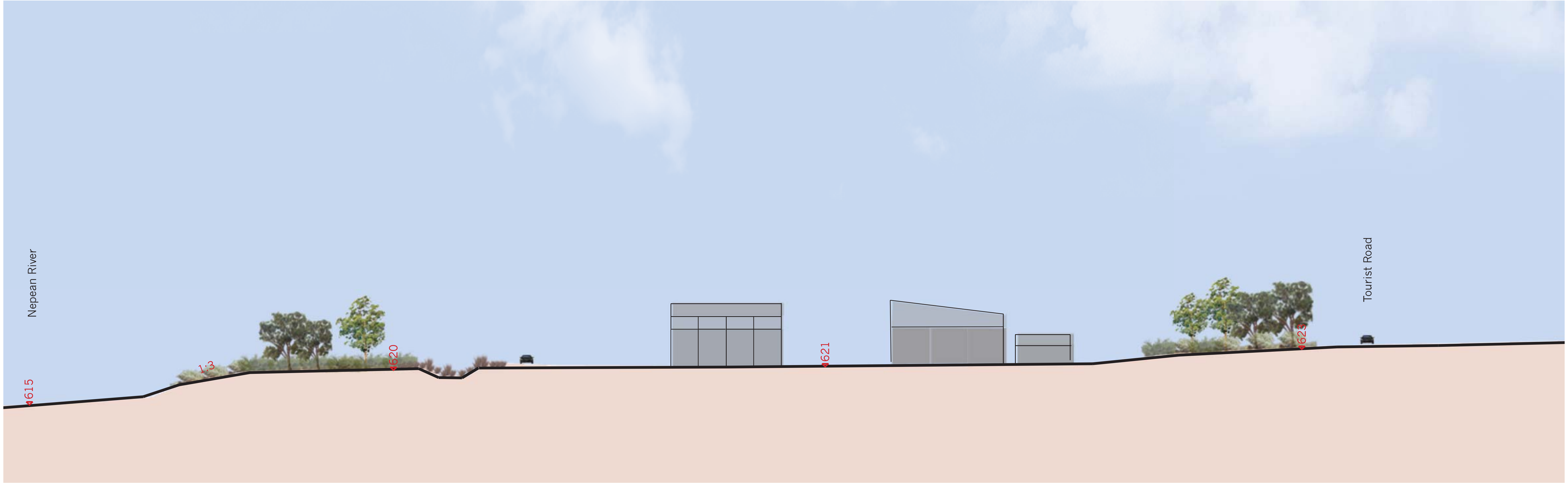
Section B – B. Long view from adjacent dwelling

Section B – B. Dam, berm, building detail

1:1000 @ A3

OPTION 1

Option 1. Key plan

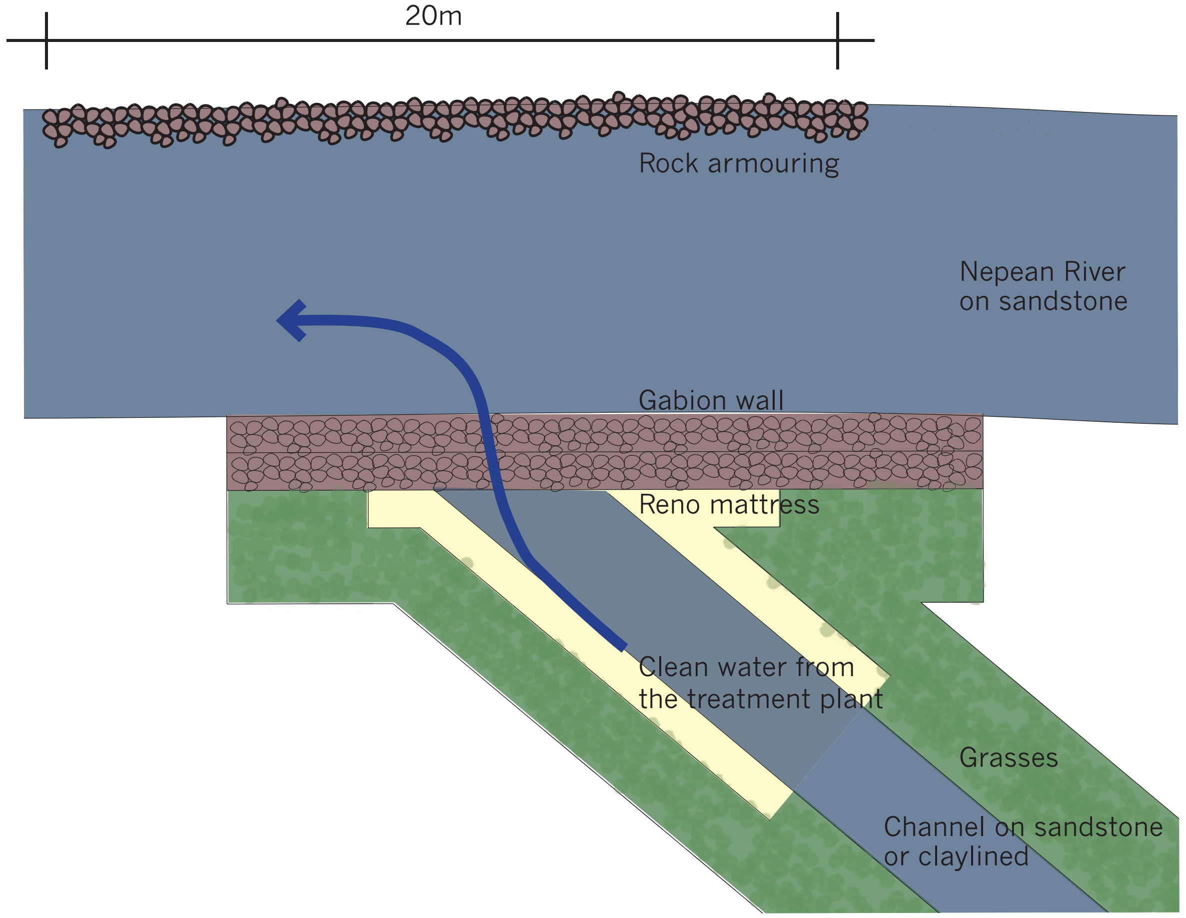


Section C – C. Dam, berm, building detail

1:500 @ A3

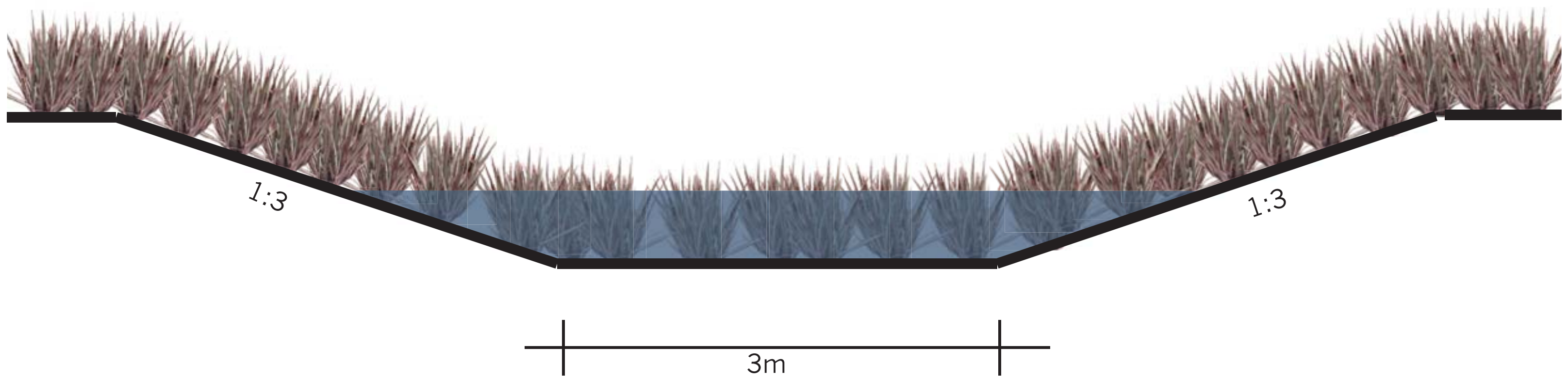
REED CHANNEL FOR TREATED WATER DISCHARGE

Option 1. Key plan



Treated water discharge channel discharge point

1:200 @ A3



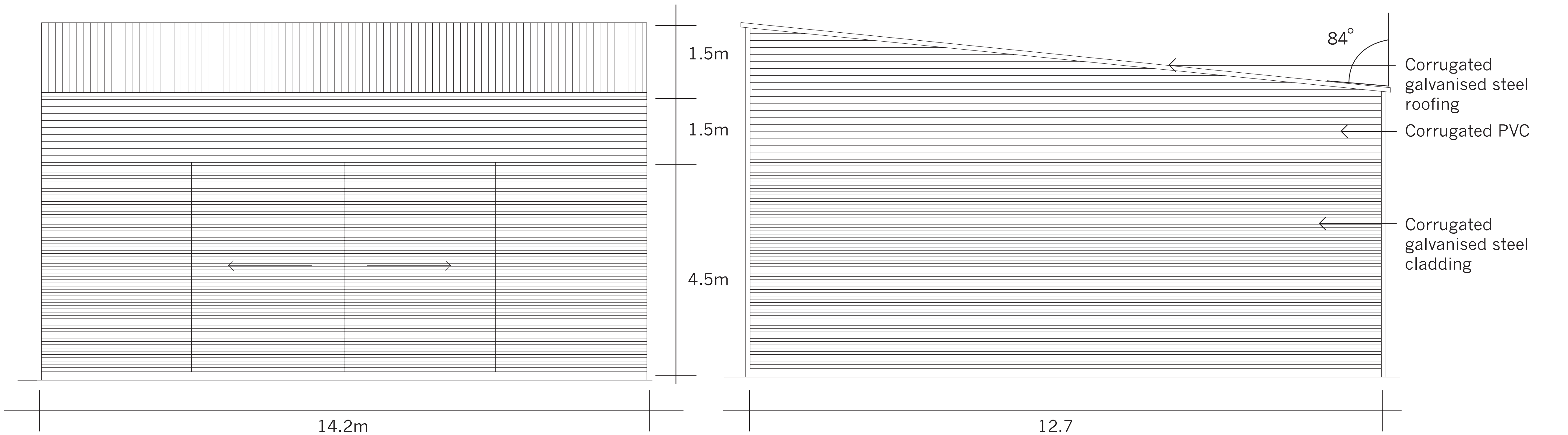
Discharge channel upstream of reinforced gabion/mattress area

1:50 @ A3

Water treatment plant

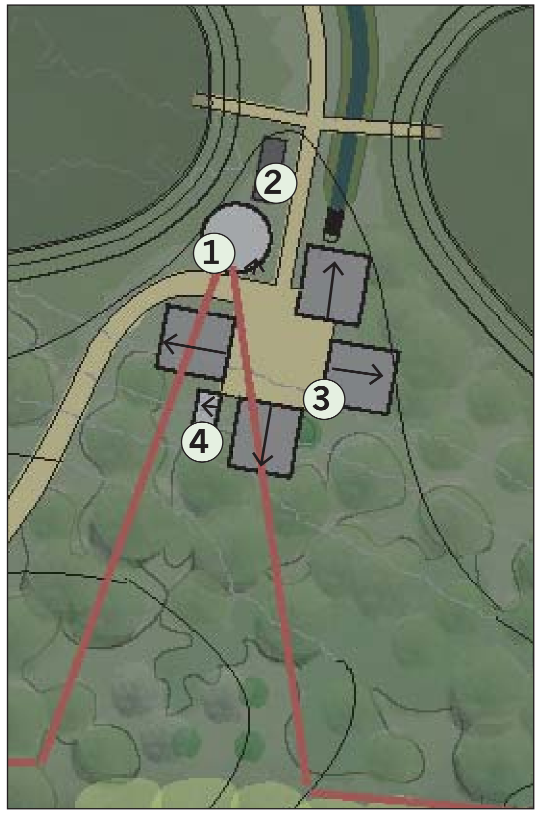
Design Guidelines

- Buildings are to be modulated and located in a formal arrangement defining a yard or hardstand.
- Maximum building footprint of 14.2 x 12.7m
- Maximum building height to be 7.5m
- Hardstand is not to be viewable from Tourist Road.
- Dual use of materials for example corrugated PVC and corrugated galvanised steel.



Water treatment building module

1:100 @ A3



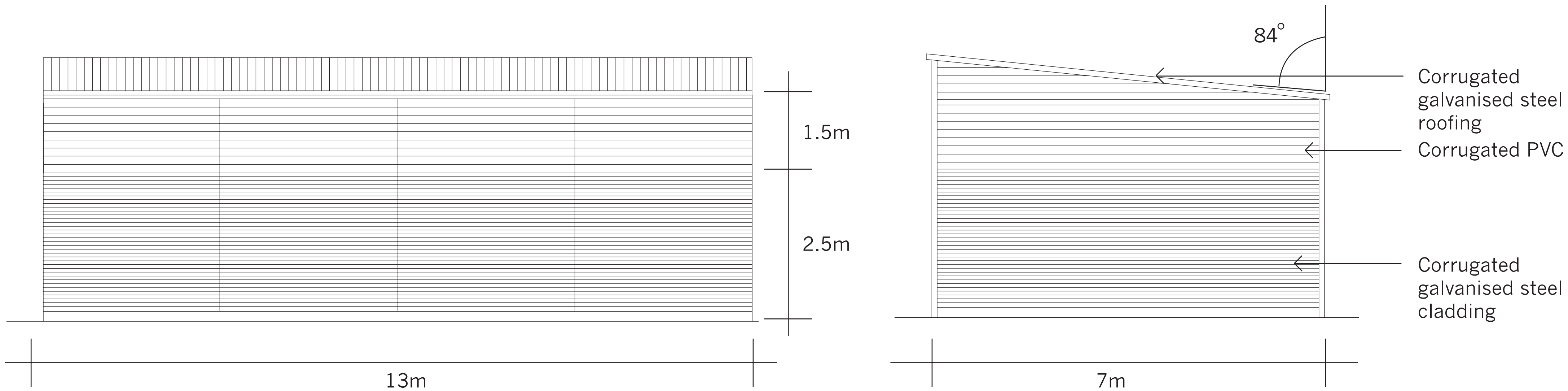
Inset of drawing 7 - Option 1

1.Balance tank

2. Pump station

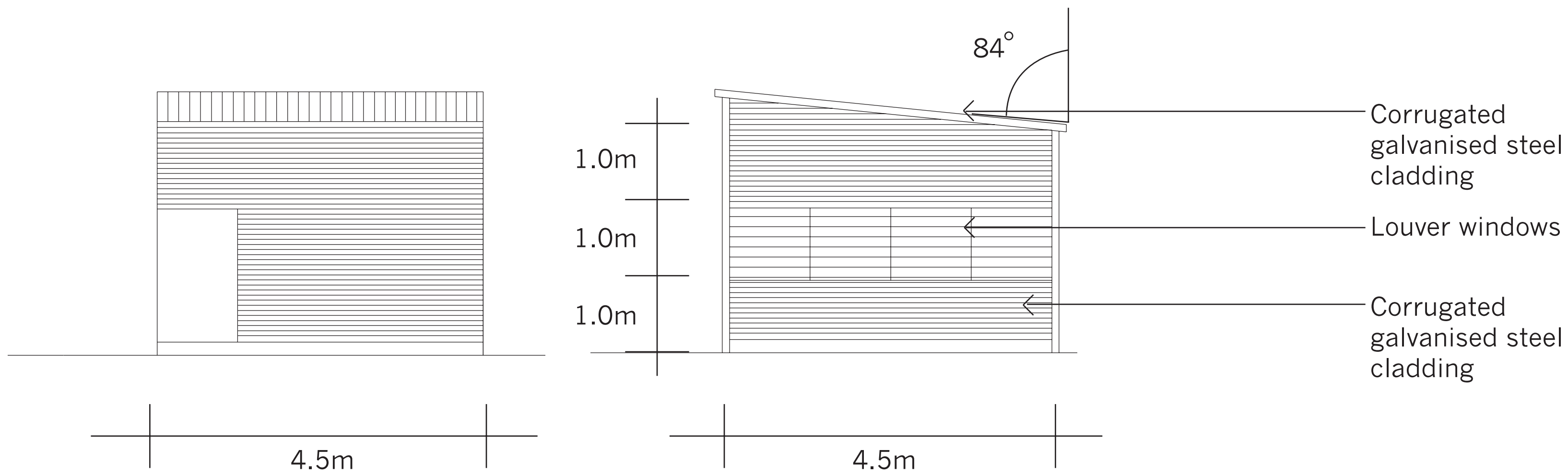
3. Water treatment buildings

4. Office



Pump station

1:100 @ A3



Office/ amenities

1:100 @ A3

Artist impression prior to re-vegetation

Artist impression of the Upper Nepean Groundwater Project - East Kangaloon

MAGUIRES CREEK CROSSING LAYOUT PLAN

Legend:

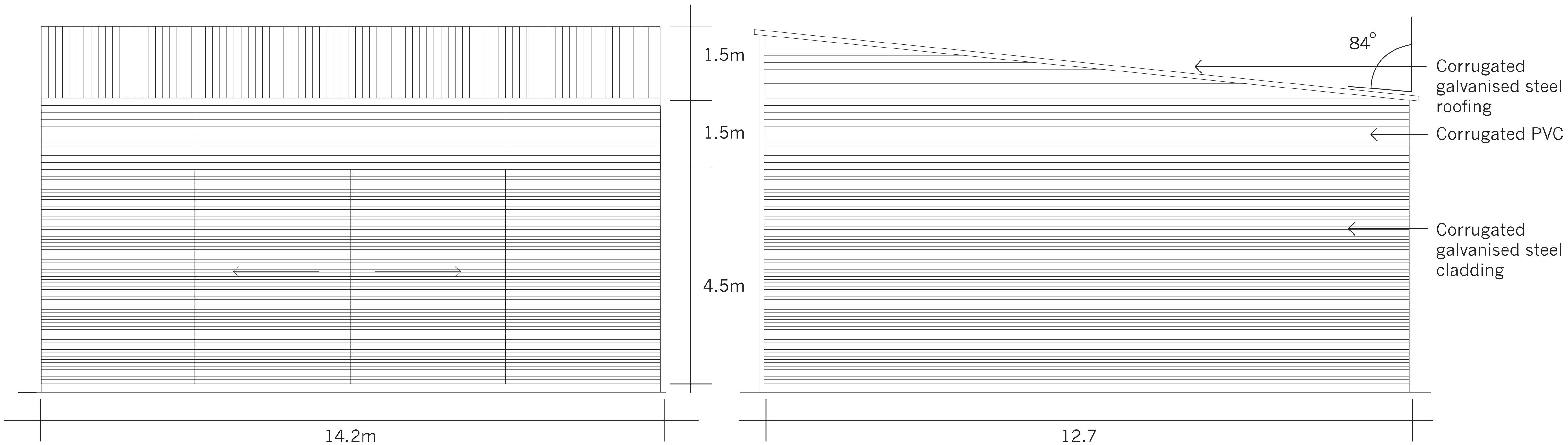
- Pond 2 x (27 x70m)
- Access road
- Treatment plant 1 x (12.7 x 14.2 x 7.5m)
- Balance tank (9m dia x 3m)
- Pump station (6 x 7 x 4m)
- Office/Amenities (4.5m x 4.5m x 4.5m)
- Cleared vegetation
- Discharge point
- Pipeline

0 30 60 90m N

Water treatment plant

Design Guidelines

- Buildings are to be located in a formal arrangement defining a yard or hardstand.
- Maximum building footprint of 14.2 x 12.7m
- Maximum building height to be 7.5m
- Dual use of materials for example corrugated PVC and corrugated galvanised steel.

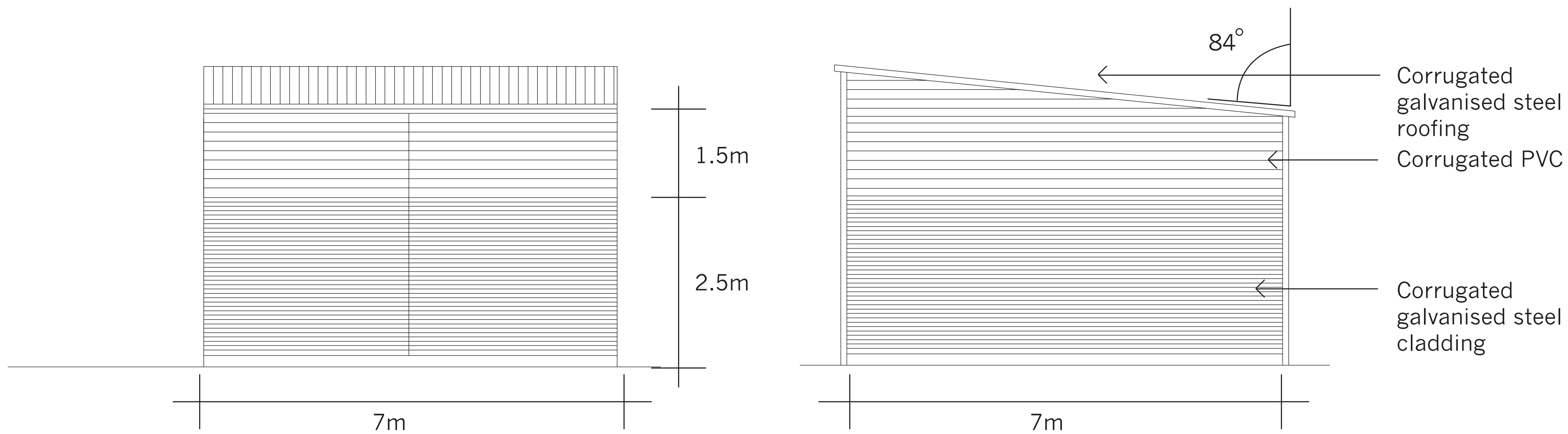


Water treatment building

1:100 @ A3

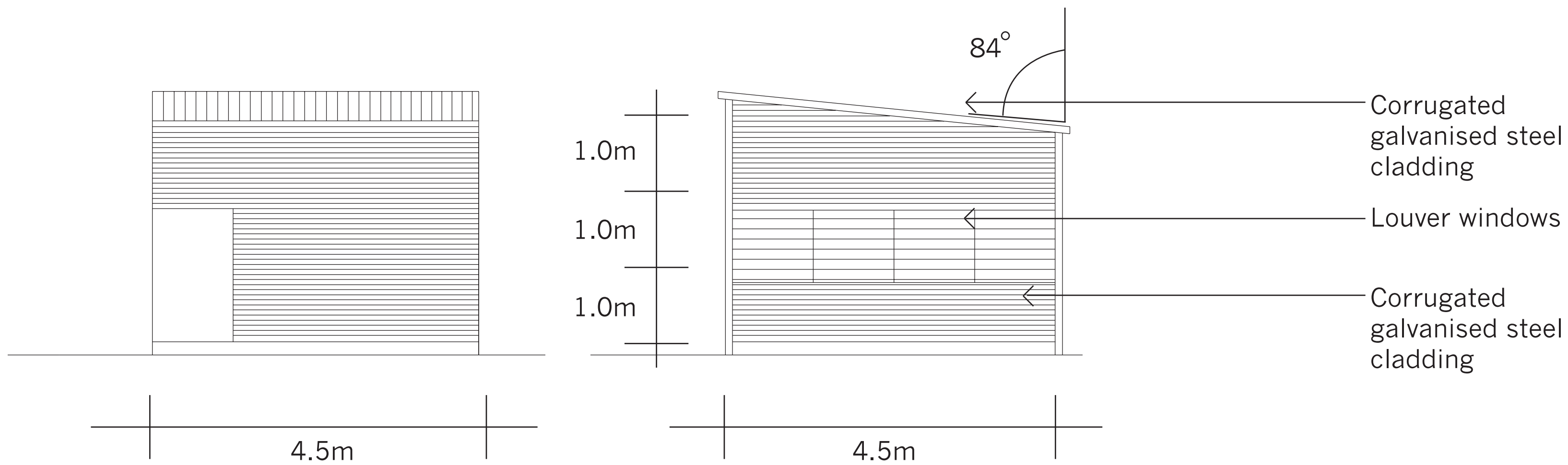
Inset of Maguires Creek Crossing Layout Plan (previous page)

1. Balance tank
2. Pump station
3. Water treatment building
4. Office



Pump station

1:100 @ A3



Office/ amenities

1:100 @ A3

Appendix E

Executive Summary (Numerical Modelling) for Preferred Project Report

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

UPPER NEPEAN (KANGALOON) BOREFIELD

EXECUTIVE SUMMARY FOR PREFERRED PROJECT REPORT

31 October 2008

TABLE OF CONTENTS

TABLES

FIGURES

1 EXECUTIVE SUMMARY

1.1 Background

This summary presents the important results of a Groundwater Modelling Study for the proposed Upper Nepean (Kangaloon) Borefield to be located in the area immediately surrounding the Tourist Road at Kangaloon (east of Bowral and north of Robertson) in the Southern Highlands of NSW. The borefield will be operated by the Sydney Catchment Authority (SCA) and is intended for use as an adjunct to Sydney's water supply during severe drought periods.

The study was undertaken by Coffey Geotechnics Pty Ltd (Coffey) at the request of the SCA. The aim of the study was to assess the impact of future borefield operation on the surrounding groundwater system (in support of planning approvals and licence applications, and for operational guidance) using a transiently calibrated numerical groundwater flow model. The latest transient model builds on the steady state model that was developed in 2006. The study was conducted in two stages as follows:

- Stage 1: Development and steady state calibration of a numerical groundwater flow model to be used for assessment of aquifer response due to pumping from the proposed borefield. Preliminary predictive simulations were also carried out to support a borefield feasibility assessment. Stage 1 was completed in July 2006.
- Stage 2: Transient calibration of the model from Stage 1 (using groundwater monitoring data collected since 2006) and further predictive simulations (using the transient calibrated model) for groundwater impact assessment. Stage 2 was completed in November 2008.

This summary focuses on the Stage 2 model development and predictive modelling results.

1.1.1 Objectives

The objectives of this Stage 2 study were to:

1. Improve the predictive capacity of the existing groundwater model by upgrading the model aquifer structure, and aquifer parameter distribution, and undertake transient calibration using the data collected in the borefield area since the Stage 1 studies (June 2006); and
2. Conduct new predictive simulations using the recalibrated model to more reliably assess borefield performance. Borefield capacities of 10000 to 15000 ML per year (from a network of 75 production bores) for periods of several years were assessed.

1.1.2 Data Review

In recent years the SCA has conducted a number of investigations across the borefield area that are relevant for assessment of the groundwater system and development of the groundwater model. These investigations included:

- Groundwater level and quality monitoring at a dedicated monitoring piezometer network and production bores in the borefield area. Monitoring of groundwater levels has been conducted for a period of almost 3 years (since late 2005) using automatic water level recorders and manual dippers.
- Aquifer hydraulic testing comprising:
    - The Tourist Road Pumping Trial. This comprised a 4-month pumping trial along Tourist Road using seven production bores. The bores were pumped at an average total rate of about

4ML/day over the period. Streamflow was also monitored at 5 gauging stations on the Nepean River and its tributaries, upstream and downstream of the group of pumping bores.

  - The Stockyard Swamp Pumping Trial. This comprised a 3-month pumping trial at Stockyard Swamp using three production bores. The bores were pumped at an average total rate of about 2ML/day over the period.
  - The Surface Water-Groundwater R&D Study and Bore 1C Pumping Trial. This comprised a 2-month pumping trial at production bore 1C (Doudles Folly Creek). Bore 1C was pumped at an average rate of about 2ML/day over the period.
  - Short to medium term (24-hour to 7-day) pump tests conducted in 20 bores drilled within the borefield area by the SCA during Stage 2 and later studies.
- An aeromagnetic survey over the borefield area from which geological structural features have been interpreted.

Results from these investigations, and a review of pre-existing information from other sources, have been used in reassessing the hydrogeological conceptual model for the borefield area.

1.2 Hydrogeological Conceptual Model

The fundamental elements of the hydrogeological conceptual model from the Stage 1 studies comprised:

- Groundwater recharge mainly by rainfall infiltration.
- Groundwater discharge mainly at escarpments and rivers, and potentially at Stockyard Swamp. Ephemeral streams are not connected to the regional sandstone aquifer and are not included in the model.
- Five major streams (Nepean River, Doudles Folly Creek, Burke River, Little River and Dudewaugh Creek) are permanent streams and are supported by baseflow from the basalt aquifer in the headwaters of the respective catchments during periods of drought.
- Upland swamps are disconnected from the regional sandstone aquifer and are therefore not included in the model, except for Stockyard Swamp.
- Perched water in shallow alluvial, colluvial and weathered sandstone profiles is excluded.

The following elements of the conceptual model have been updated to incorporate the results of the investigations conducted since the Stage 1 study:

- Evapotranspiration (ET): Previously, ET was simulated only at Stockyard Swamp. The updated conceptual model incorporates the explicit simulation of ET over the entire model domain.
- Hawkesbury Sandstone aquifer: Previously the sandstone was simulated as a single layer. In Stage 2 the sandstone is simulated as 3 layers. The upper layer is a water table (unconfined) aquifer where it is not overlain by saturated sequences of shale or basalt. The middle and lower layers are confined.
- Wetlands: The pumping trial information indicated that the base of the surficial sediment aquifers in Stockyard and Butlers Swamps were above the potentiometric surface in the perennially saturated part of the Hawkesbury Sandstone, with an unsaturated zone separating these systems. No

induced drawdowns were evident during any of the pumping trials. Based on this interpretation, no wetland has been simulated in the model.

- Rock Structure: Geophysical investigations and recent drilling have revealed the presence of the Mt Butler intrusion. This is simulated as an igneous body with relatively high permeability on its perimeter and relatively low permeability in its core. Fault zones interpreted previously from drilling and aerial photography have been slightly adjusted based on an expanded permeability database of airlift flows (during drilling) and pump tests.
- Perennial Streams: Field assessments of groundwater discharge zones (by visual assessment) over limited reaches of the Nepean River and Doudles Folly Creek indicated groundwater seepage zones every several hundred metres (and sometimes kilometres) apart. The assessment of modelled river baseflows is conducted over river reaches of several kilometres in length.

An assessment of water levels and stratigraphy suggests that an unsaturated zone exists between the base of the basalt that caps the high ground in the area, and the top of the potentiometric surface in the underlying Wianamatta Group or Hawkesbury Sandstone. Based on this assessment, the basalt aquifer across the Mittagong Ranges is not explicitly simulated in the model, however its presence is taken into account when assessing rainfall recharge to underlying shale and sandstone. The Mt Butler basalt intrusion is included in the model because it is in direct contact with the Hawkesbury Sandstone.

1.3 Numerical Model Development

The model domain for the transient model covers an area of approximately 1,300km^2. The model grid consists of a uniform mesh of 100m over the borefield area, expanding to 200m by 200m cells at the extremities of the model domain. Four active model layers have been used, representing the following hydrogeological units:

- Layer 1: Wianamatta Group shale and sandstone
- Layer 2: Upper 25% (by vertical thickness) of the Hawkesbury Sandstone
- Layer 3: Middle 35% (by vertical thickness) of the Hawkesbury Sandstone
- Layer 4: Lower 40% (by vertical thickness) of the Hawkesbury Sandstone

Layer 1 includes the Ashfield Shale and the Mittagong Formation where present. Layer 4 includes the transitional Garie and Newport Formations. All layers were designated as variable type layers (a layer that will allow both unconfined and confined behaviour).

All model layers contain multiple hydraulic conductivity zones.

1.3.1 Model Limitations and Assumptions

Modelling is a useful tool to simulate complex aquifers and to predict water balances and water levels when pumping stresses are applied. In a complex fractured rock aquifer, with substantial pumping stresses, the modelling results are unlikely to exactly represent conditions on a local scale but on a sub-catchment and regional basis are likely to be more representative. This numerical model simulates the sandstone aquifer system subject to a number of assumptions and limitations including:

- Rewetting has not been activated in predictive runs after a pumping cell has been dewatered. Pumped volumes are therefore underestimated because pumping does not recommence..

- Structural deformation zones are simulated only where they are known to exist. Other deformation zones are likely to be present but are not included in the model. Their omission limits the maximum attainable total borefield pumping rate.
- No private bore usage is included as it is minimal by comparison with planned borefield pumping.
- Potential (additional) recharge from upland swamps, springs and spring-fed creeks is not included.

1.4 Model Calibration

The numerical model was calibrated initially in steady state mode to assess model response and preliminary estimates of lateral hydraulic conductivity and rainfall recharge. The model was subsequently calibrated in transient mode using data collected over the period 27 January 2007 to 6 March 2008, and includes long-term pumping at:

- The Tourist Road Pumping Trial
- The Stockyard Swamp Pumping Trial
- The Surface water-Groundwater R&D study and Bore 1C Pumping Trial

Calibrated model parameters are:

- Riverbed vertical hydraulic conductivity: An average of 0.0013m/day.
- Specific storage: 1 x 10^{-6} m^{-1} for all rock types
- Specific yield: 0.015 for all rock types.
- Hydraulic conductivity: Calibrated hydraulic conductivities are listed in Table 1. The values vary over each sandstone layer and between layers.

Table 1. Calibrated Hydraulic Conductivity for the Hawkesbury Sandstone

Sandstone Permeability Zone	Upper Layer		Middle Layer		Lower Layer	
	Kh* (m/day)	Kv/Kh^	Kh* (m/day)	Kv/Kh^	Kh* (m/day)	Kv/Kh^
Very High (fault zone, east side of intrusion)	5.1	0.001	1.6	0.03	0.88	0.5
High	2.8	0.001	0.89	0.03	0.48	0.5
Moderate to High (east-west trending structure)	0.81	0.001	0.26	0.03	0.14	0.5
Moderate	0.23	0.001	0.074	0.03	0.040	0.5
Regional Background (typical)	0.19	0.001	0.059	0.03	0.032	0.5
Mountain Core	0.005	0.3	0.005	0.5	0.005	1
Mountain Fringe	0.010	0.3	0.010	0.5	0.010	1

* Kh denotes horizontal hydraulic conductivity.
^ Kv denotes vertical hydraulic conductivity.

- Rainfall recharge: Calibrated rates are listed in Table 2.

Table 2. Calibrated Rainfall Recharge

Rainfall Zone	Rainfall Pattern	Recharge rate as percentage of rainfall in Zone (%)	Recharge rate as percentage of rainfall at Moss Vale (%)
A	Uncovered Sandstone, double the rainfall at Moss Vale	3.0	6.0
B	Uncovered Sandstone, 1.5 times the rainfall at Moss Vale	3.6	5.4
C	Uncovered Sandstone, same rainfall as at Moss Vale	3.1	3.1
D	Covered sandstone, same rainfall as at Moss Vale	0.29	0.29
E	Covered sandstone, 1.5 times the rainfall at Moss Vale	0.29	0.43
F	Covered sandstone, double the rainfall at Moss Vale	0.29	0.58

1.5 Water Balance Components

The flow components of the groundwater model as described in the conceptual model are shown schematically as a block diagram in Figure 1, together with the average flow balance rates for the whole model domain (over the entire 405 days of simulation) for the calibrated transient model. The average pumping rate over the calibration period is low but represents higher pumping rates that occurred over shorter time intervals (for each pumping trial).

1.6 Predictive Simulations

Predictive simulation has been conducted for two borefield pumping schedules as follows:

- Low pumping: Borefield target of 10,000 ML/year (27.4 ML/day)
- High pumping: Borefield target of 15,000 ML/year (41.1 ML/day)

The borefield consists of 75 bores, each with a set pumping rate that represents the pumping potential at each bore site (based on actual or nearby pumping test results).

Each of the pumping schedules is simulated under the following two rainfall scenarios:

- Scenario A (Recent Drought): Applied rainfall equivalent to the recorded rainfall for:
  - July 1993 to June 2008 inclusive (15 years total)

  This scenario represents the worst drought on record. Simulated pumping allows for one drought pumping period (to a maximum of 30,000 ML or 45,000 ML) over the borefield operational period. Borefield pumping commences in July 2002 and continues to September 2006 under the following rules:

  - If 100 mm or more of rainfall occurs in a month, borefield pumping ceases for the following 60 days (2 months).

    - If 250 mm or more of rainfall occurs in a month, borefield pumping ceases for the following 180 days (6 months).
    - A maximum of 10,000 ML (low pumping case) or 15,000 ML (high pumping case) is pumped in any one year.
- Scenario B (Extreme Drought): Applied rainfall equivalent to the recorded rainfall for:
    - July 2000 to June 2008 inclusive (8 years), then
    - July 1936 to June 1953 inclusive (17 years) (25 years total).

  This scenario represents the worst drought on record followed by the second worst drought on record, followed by a very wet (recovery/recharge) period. The pumping allows for two drought pumping periods (to a maximum of 60,000 ML or 90,000 ML) over the borefield operational period. Borefield pumping commences in July 2002 and continues to September 2006, then recommences 12 months later in July 1936 and continues to March 1941. Pumping occurs under the same monthly rainfall threshold and maximum annual pumping rules as for Scenario A.

Each rainfall scenario has also been run for high, most likely, and low riverbed conductance scenarios.

To assess the impact due to pumping from the borefield, each predictive run was compared to the results of the corresponding no-pumping scenario (for the same historical period). Thus, for each rainfall case, 9 simulations have been conducted (either high, low, or no borefield pumping, with each pumping case simulated under high, most likely, or low riverbed conductance). These are summarised in Table 3.

Table 3. Predictive Simulation Runs

Target Borefield Pumping (ML/year)	Riverbed Conductance		
	Low	**Most Likely**	**High**
10,000	Rainfall A or B	Rainfall A or B	Rainfall A or B
15,000	Rainfall A or B	Rainfall A or B	Rainfall A or B
Nil	Rainfall A or B	Rainfall A or B	Rainfall A or B

1.7 Predictive Simulation Results

Results are presented in this summary for the most likely riverbed conductance scenarios.

1.7.1 Severe Drought (Scenario A: July 1993 to June 2008 Inclusive – 15 Years – Worst Drought on Record)

Flow budgets and groundwater level drawdowns have been calculated at 4 months prior to the end of the pumping period (12.9 years into the simulation). At this time the drawdown due to pumping is at or near its maximum.

The main elements of the groundwater flow balance at the model time of 31 May 2006 are presented in Table 4.

Table 4. Simplified Groundwater Flow Balance at 31 May 2006 for Recent Drought with Most Likely Riverbed Conductance

	No Pumping	High Pumping	Low Pumping	Change from the No Pumping Case	
				High Pumping	Low Pumping
INPUTS (ML/day)					
Rainfall recharge	14.9	14.9	14.9		
Discharge from Storage	12.1	31.0	28.1	18.9	16.0
OUTPUTS (ML/day)					
Evapotranspiration	<0.1	<0.1	<0.1		
Borefield Pumping	Nil	24.2	20.8	24.2	20.8
Baseflow to Nearby Rivers	9.9	5.4	5.9	-4.5	-4.0
Baseflow to Distant Rivers and discharge to escarpments	15.3	14.9	15.3	-0.4	0.0

An assessment of the flow balance indicates the following:

- The total reduction in baseflow to rivers is 4.9ML/day for high pumping and 4.0ML/day for low pumping, equivalent to about 20% of the pumping rate for both cases (see Table 4). This is similar to the lower bound estimates from Stage 1 studies. In both cases, about 80% of pumping is sourced from aquifer storage.
- These reductions are small compared to the actual flows in the permanent streams across the model domain which range from around 20ML/day for very low baseflow situations to in excess of 600ML/day when Shoalhaven transfers are in progress.
- All streams remain gaining streams except for all, or part of, the reach of the Nepean River from its beginning to Belmore Crossing.
- The total borefield pumping rate decreases from 41 to around 24 ML/day (high pumping) and from 27 to around 21 ML/day (low pumping) due to drying of bore screen cells.

The hydrographs of reduction in baseflow to rivers indicate that baseflow losses continue after the cessation of pumping in both pumping cases.

The modelled drawdown at 31 May 2006 for each sandstone layer for the high pumping case is shown in Figure 2 and indicates the following:

- Potentiometric surfaces are very steep (drawdowns increasing markedly) in the vicinity of each pumping bore. Drawdowns reach a maximum of 45m (upper sandstone), 81m (middle sandstone), and 100m (lower sandstone) in the southeast of the borefield.
- The 1m drawdown contour extends up to 5km from the borefield, with the 10m drawdown contour extending to a maximum of around 2km from the centres of pumping.
- For the high pumping case, the model suggests that 24 pumping bores go dry (in high extraction areas) however in general there is still groundwater in adjacent cells.

1.7.2 Extreme Drought (Scenario B: July 2000 to June 2008 then July 1936 to June 1953 Inclusive – 25 Years – Two Worst Droughts on Record Back-To-Back)

Flow budgets and groundwater level drawdowns have been calculated at 12 months prior to the end of the second pumping period (11.75 years into the simulation). At this time the drawdown due to pumping is at or near its maximum.

The main elements of the groundwater flow balance at the model time of 31 March 2012 (historical drought date 31 March 1940) are presented in Table 5.

Table 5. Simplified Groundwater Flow Balance at 31 March 2012 (Historical Drought Date 31 March 1940) for Extreme Drought with Most Likely Riverbed Conductance

	No Pumping	High Pumping	Low Pumping	Change from the No Pumping Case	
				High Pumping	Low Pumping
INPUTS (ML/day)					
Rainfall recharge	0.3	0.3	0.3		
Discharge from Storage	25.0	42.2	38.9	17.2	13.9
OUTPUTS (ML/day)					
Evapotranspiration	<0.1	<0.1	<0.1		
Borefield Pumping	Nil	20.2	18.0	20.2	18.0
Baseflow to Nearby Rivers	9.7	5.0	5.3	-4.7	-4.4
Baseflow to Distant Rivers and discharge to escarpments	14.7	13.9	13.9	-0.9	-0.8

An assessment of the flow balance indicates the following:

- The total reduction in baseflow to rivers is 5.6ML/day for high pumping and 5.2ML/day for low pumping, equivalent to just under 30% of the pumping rate for both cases (see Table 5). In both cases, about 70% of pumping is sourced from aquifer storage.
- All streams remain gaining streams except for all, or part of, the reaches of:
  - the Nepean River from its beginning up to Maguires Crossing; and
  - Doudles Folly Creek
- The total borefield pumping rate decreases from 41 to around 20ML/day (high pumping) and from 27 to around 18ML/day (low pumping) due to drying of bore screen cells.

The hydrographs of reduction in baseflow to rivers indicate that baseflow losses continue for about 8 years after cessation of pumping in both pumping cases.

The modelled drawdown at 31 March 2012 (historical drought date 31 March 1940) for each sandstone layer for the high pumping case is shown in Figure 3 and indicates the following:

- Potentiometric surfaces are very steep (drawdowns increasing markedly) in the vicinity of each pumping bore. Drawdowns reach a maximum of 46m (upper sandstone), 80m (middle sandstone), and 118m (lower sandstone) in the southeast of the borefield.

- The 1m drawdown contour extends up to 8km from the borefield, with the 10m drawdown contour extending to a maximum of around 2.5km from the centres of pumping.
- For the high pumping case, the model suggests that 29 pumping bores go dry (in high extraction areas) however in general there is still groundwater in adjacent cells.

1.8 Conclusions

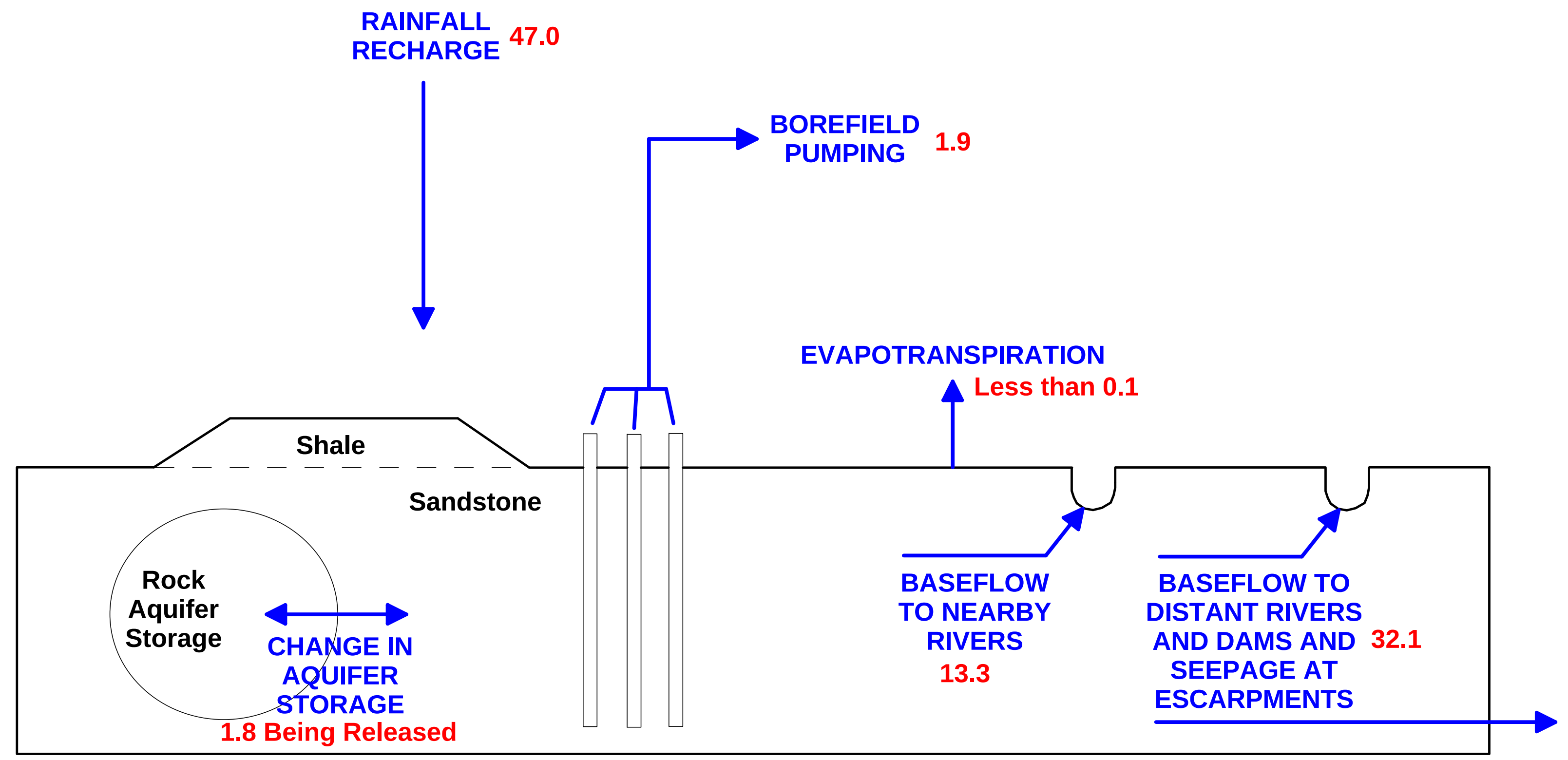
The two modelling scenarios presented represent the recent drought period (a severe drought) and a combination of severe droughts never experienced before in the historical record (an extreme drought). The transient model is calibrated against the available data and is a useful tool to assess borefield performance under drought conditions. The simulated groundwater pumping from the 75 production bores across the borefield is also the maximum stress ever likely to be continuously applied.

Modelling indicates that around 80% or more of borefield pumping is sourced from aquifer storage during a single pumping event, and around 70% if there were back-to-back drought pumping events. Based on this result the borefield provides a useful contribution to water supply in times of severe drought. When the borefield ceases pumping, the river baseflow losses continue for about 8 years with the loss being used to replenish aquifer storage. Baseflow losses are small in comparison to actual river and creek flows, and during operation, the treated groundwater discharges from the water treatment plants to the Nepean River more than make up for the minor baseflow losses along the Nepean River.

The modelling confirms that the borefield provides groundwater which, although it is ultimately supplied by rainfall and streamflow, is water that can be made available during a critical time, but which would otherwise not be available. Following the critical times, the expected wetter times (when excess water supply is likely to be available) will allow the depleted aquifer storage to replenish.

Borefield capacities in excess of 35 to 40ML/day can be sustained for the first 12 months of borefield operation, however rates decline as areas dewater. The total borefield pumping rate in Year 3 of an extended pumping event is predicted to be around 20 to 25ML/day (based on no bores restarting after local dewatering and recovery of levels).

If bores were strategically placed on high permeability features, and recovery in dewatered areas was recognised (allowing the recommencement of pumping), the attainable borefield pumping rate could be up to 35ML/day (around 13,000 ML/year) at the end of an extended pumping event.



NOTE:

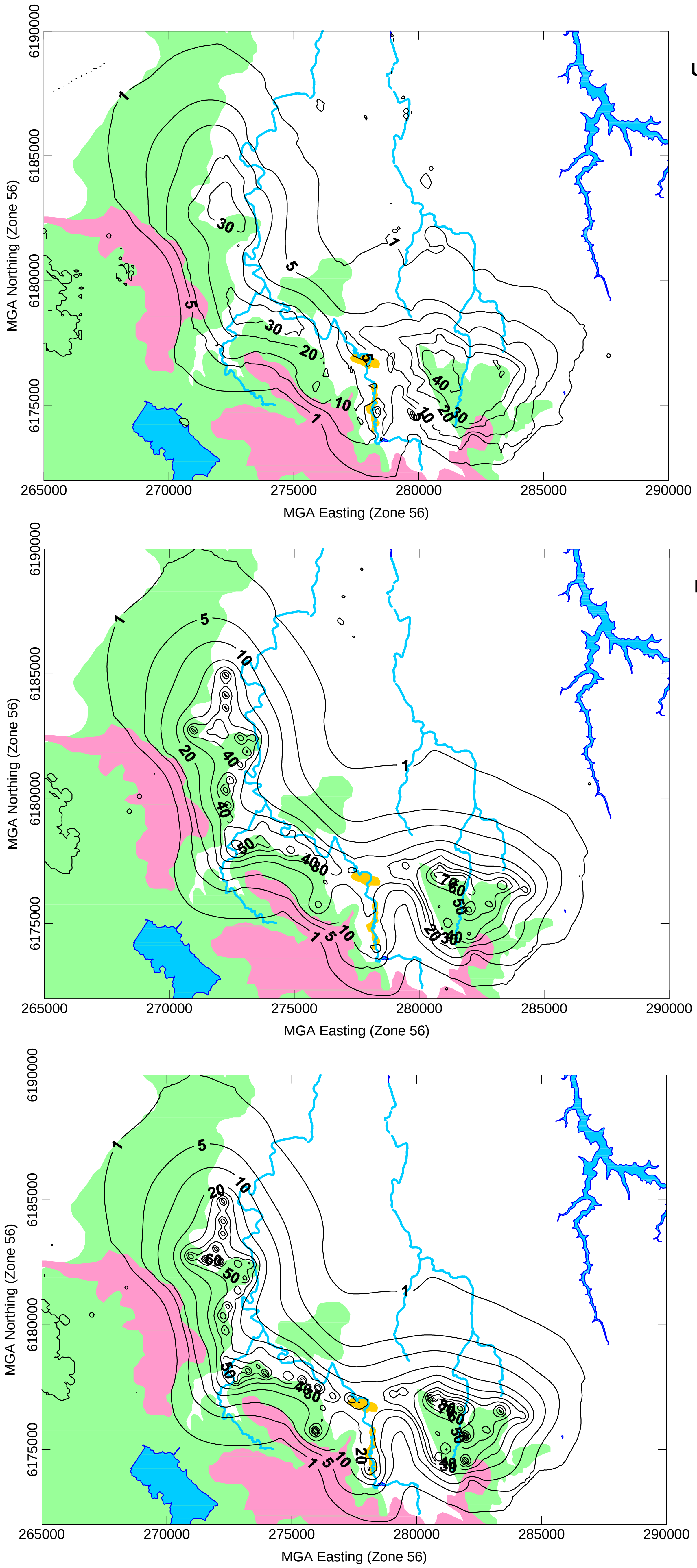
Red number denotes average flowrate for the calibrated model (in ML/day) over the calibration period.

Calibrated Flow Budget Discrepancy = 1.4 ML/day or 3% of total.

drawn	PT
approved	RJB
date	29 Oct 2008
scale	N/A
original size	A4

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client:	Sydney Catchment Authority
project:	Upper Nepean (Kangaloon) Borefield Borefield Development Transient Groundwater Modelling
title:	**GROUNDWATER BALANCE COMPONENTS FOR THE HAWKESBURY SANDSTONE AQUIFER**
project no:	GEOTLCOV23386AB-AA
figure no:	**FIGURE 1**



UPPER Sandstone

MIDDLE Sandstone

LOWER Sandstone

N

Rainfall Scenario A

Calibrated Riverbed Conductance

High Borefield Pumping

Drawdown at 31 May 2006

0 5000 10000

Basalt

Wianamatta Group (and Mittagong Formation)

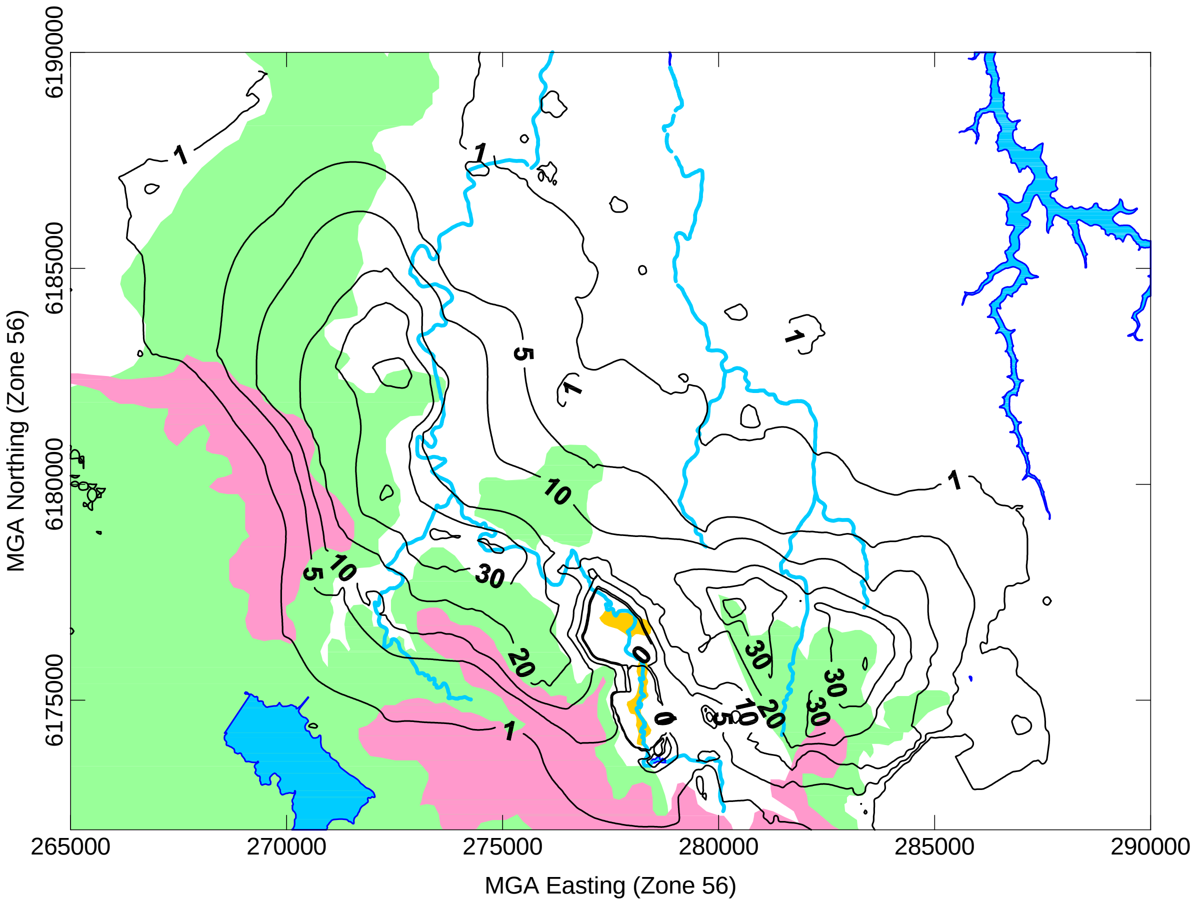
Hawkesbury Sandstone

drawn	PT
approved	RJB
date	29 Oct 2008
scale	1:175,000
original size	A3

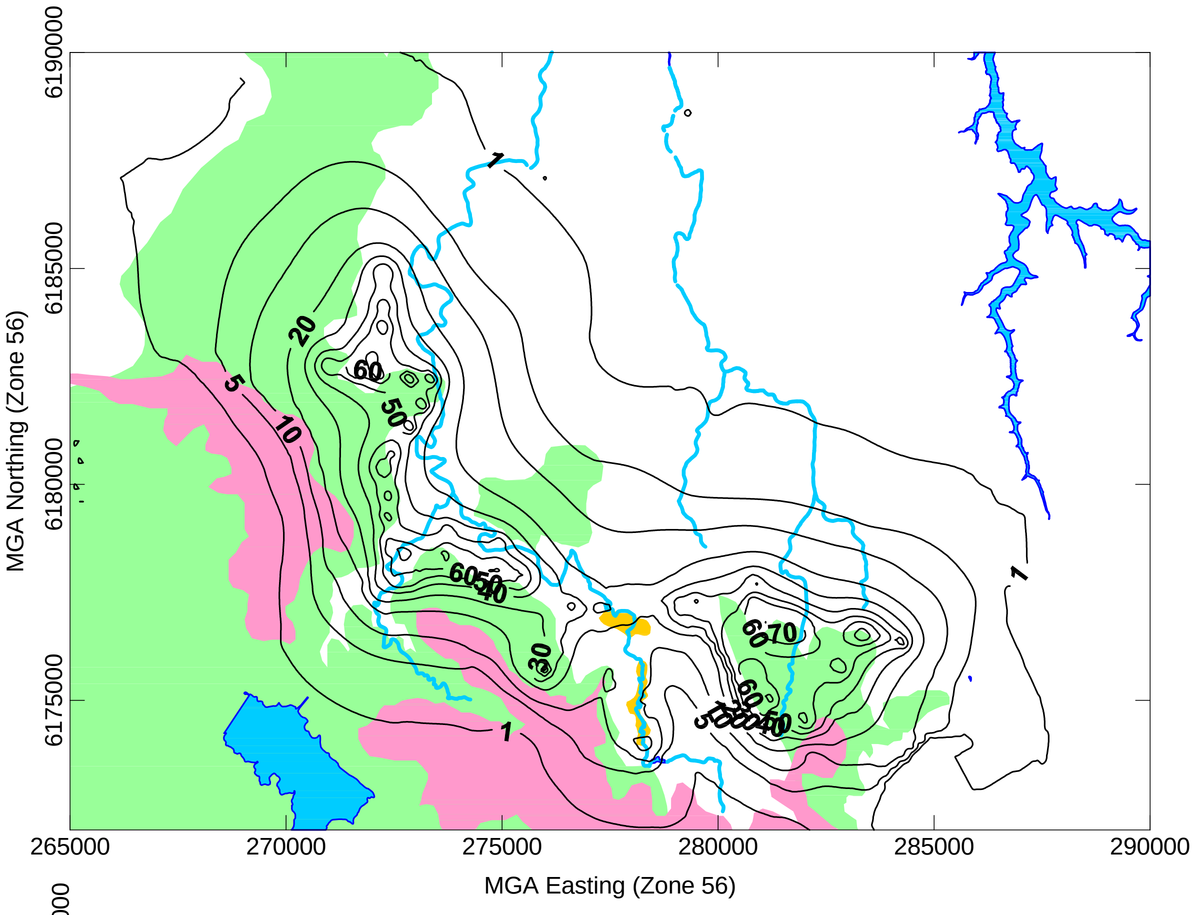
coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client:	Sydney Catchment Authority
project:	Upper Nepean (Kangaloon) Borefield Borefield Development Transient Groundwater Modelling
title:	**DRAWDOWN IN SANDSTONE AT AN INSTANT IN TIME**
project no:	GEOTLCOV23386AB-AA
figure no:	**FIGURE 2**

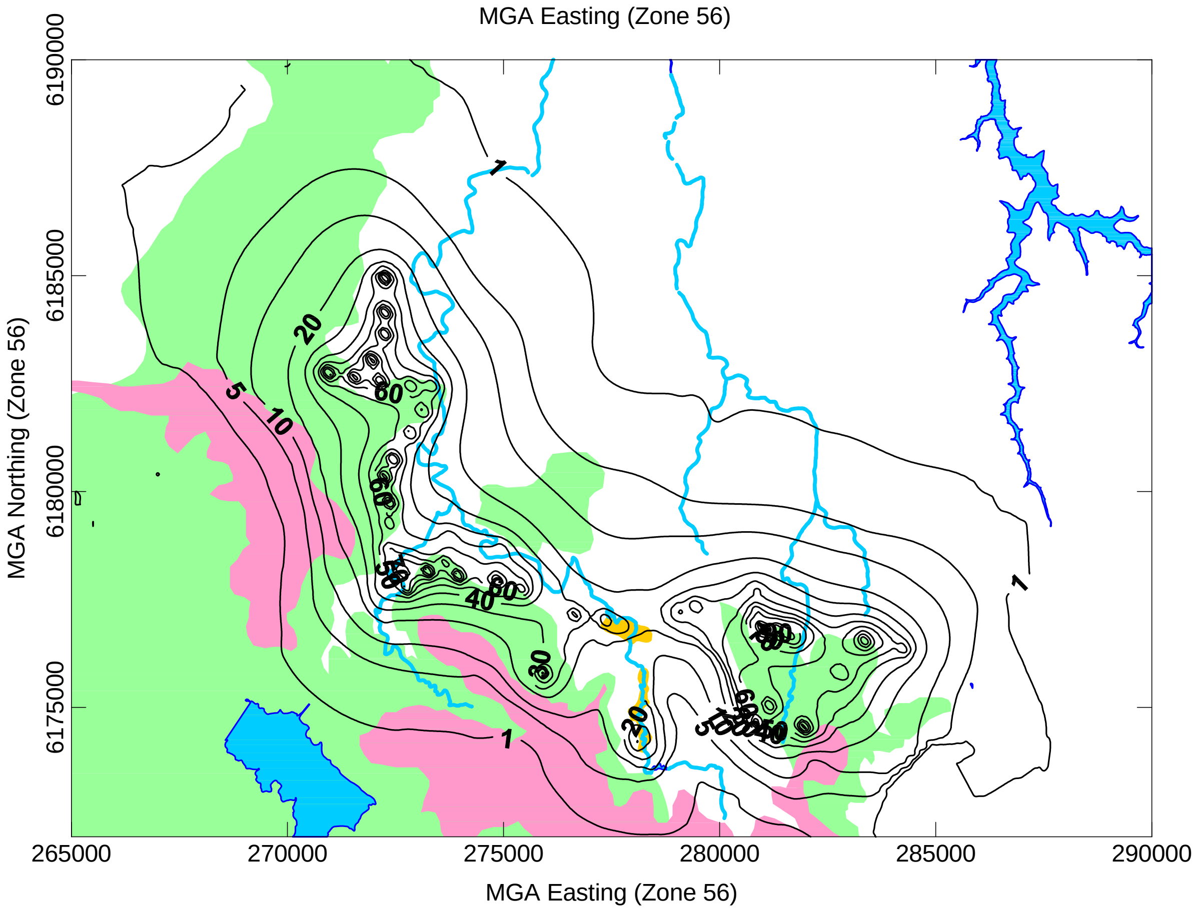
N



UPPER Sandstone



MIDDLE Sandstone



LOWER Sandstone

Rainfall Scenario B

Calibrated Riverbed Conductance

High Borefield Pumping

Drawdown at 31 March 2012 (Historical Drought Date 31 March 1940)

0 5000 10000

Basalt

Wianamatta Group (and Mittagong Formation)

Hawkesbury Sandstone

drawn	PT
approved	RJB
date	29 Oct 2008
scale	1:175,000
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client:	Sydney Catchment Authority
project:	Upper Nepean (Kangaloon) Borefield Borefield Development Transient Groundwater Modelling
title:	**DRAWDOWN IN SANDSTONE AT AN INSTANT IN TIME**
project no:	GEOTLCOV23386AB-AA
figure no:	**FIGURE 3**