











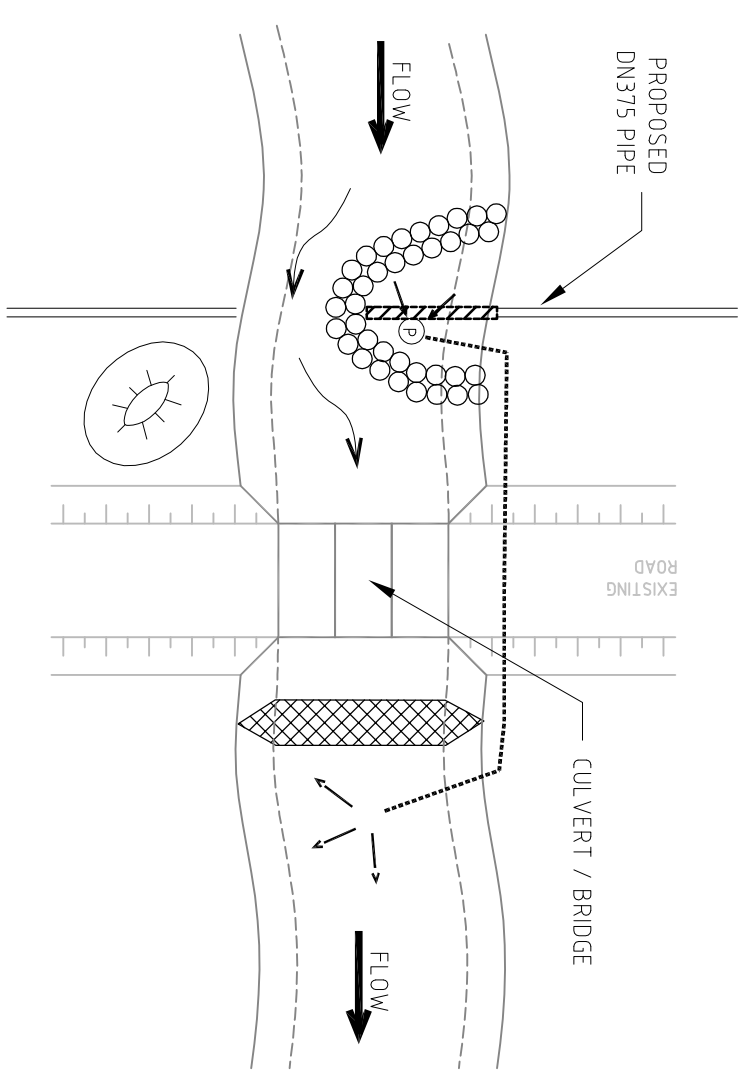


Appendix A

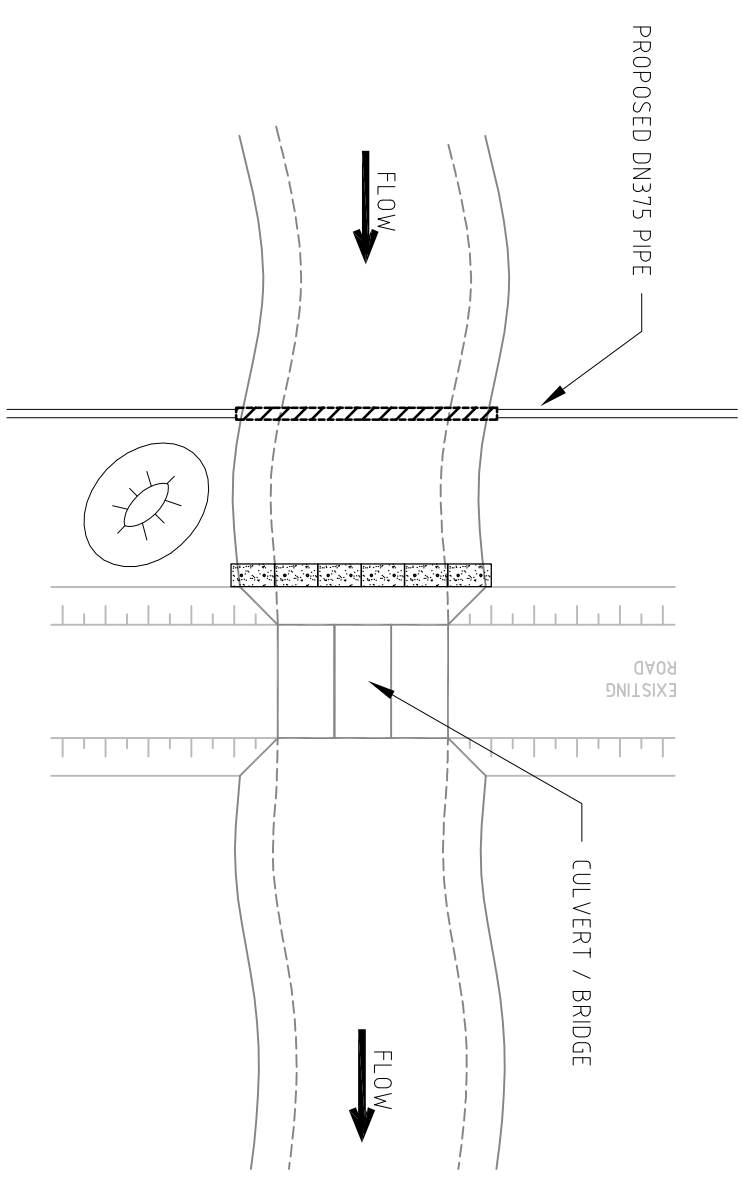
Example Erosion & Sediment Control

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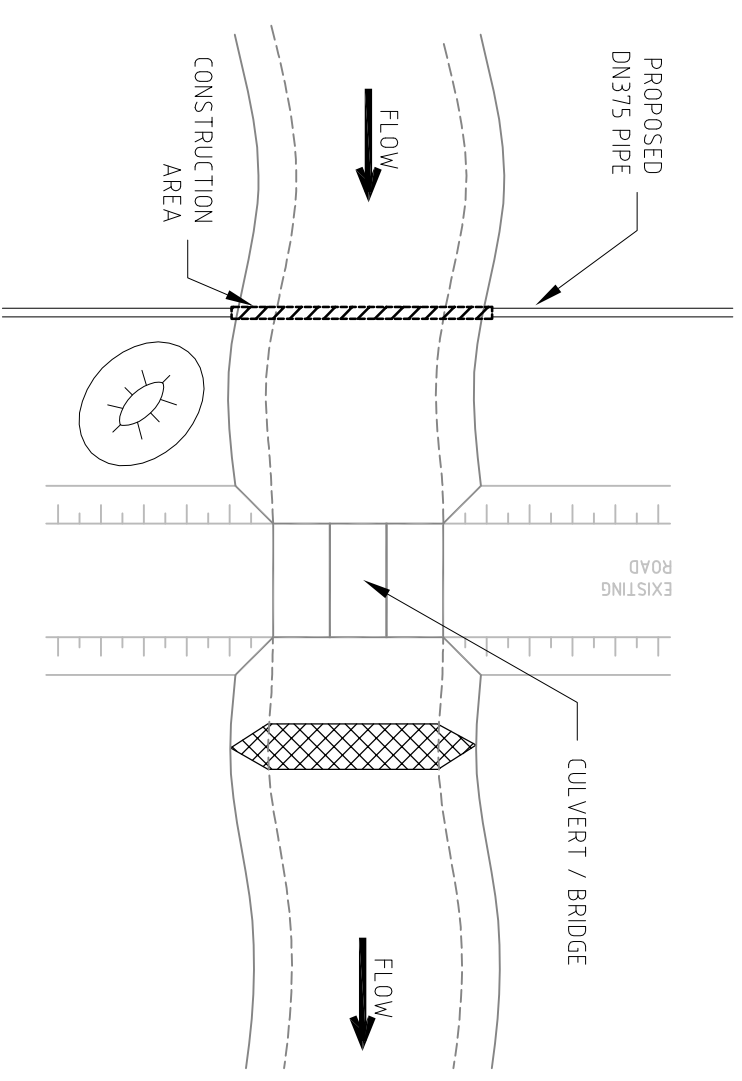
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-  GRAVEL FILTER
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-  SANDBAG DIVERSION DAM
(REFER DWG No. W4916-2)
-  CLAY COFFER DAM
(REFER DWG No. W4916-2)
-  BATTERED SLOPE
-  CONSTRUCTION AREA
-  DIRECTION OF FLOW
-  TEMPORARY PIPE
-  TEMPORARY SUBMERSIBLE PUMP
-  TEMPORARY STOCKPILE AREA
(REFER DWG W4916-2)
-  TOP OF BANK
-  BOTTOM OF BANK



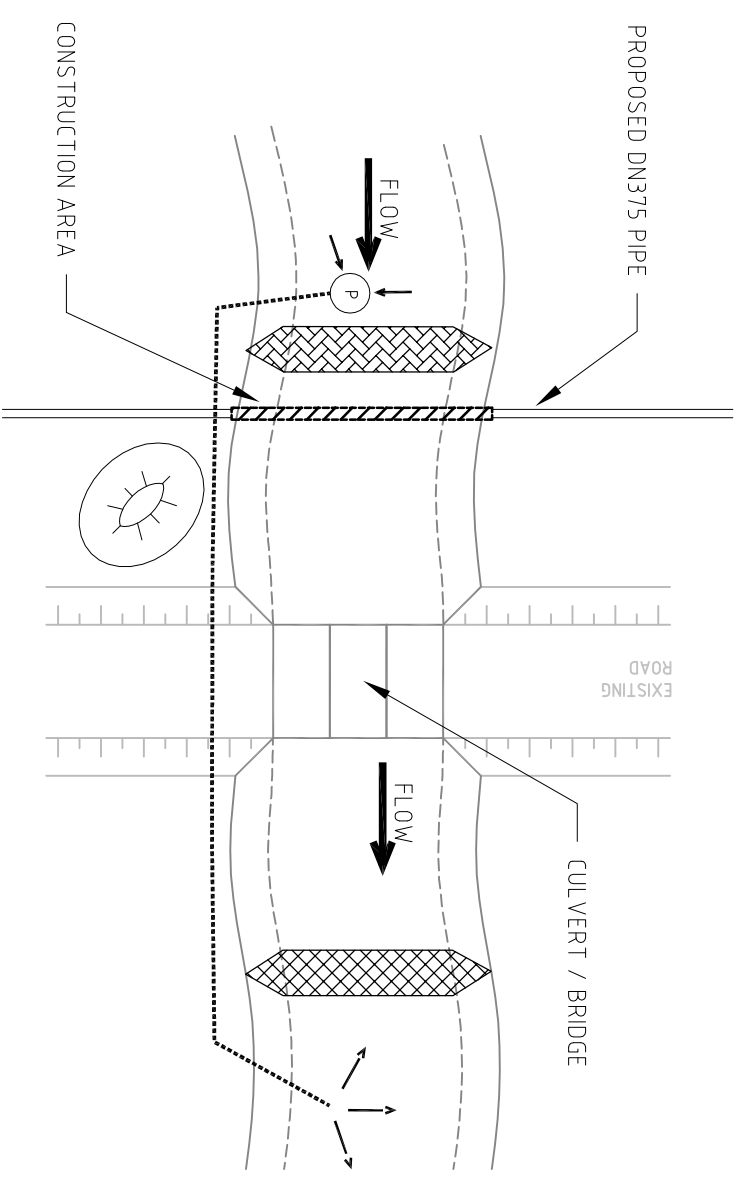
DIVERSION WALL & GRAVEL FILTER
E.G. PERMANENT CREEK



HAY BALE FILTER
E.G. WET WEATHER CREEK



GRAVEL FILTER
E.G. WET WEATHER CREEK ONLY



COFFER DAM & GRAVEL FILTER
E.G. PERMANENT CREEK

NOTES

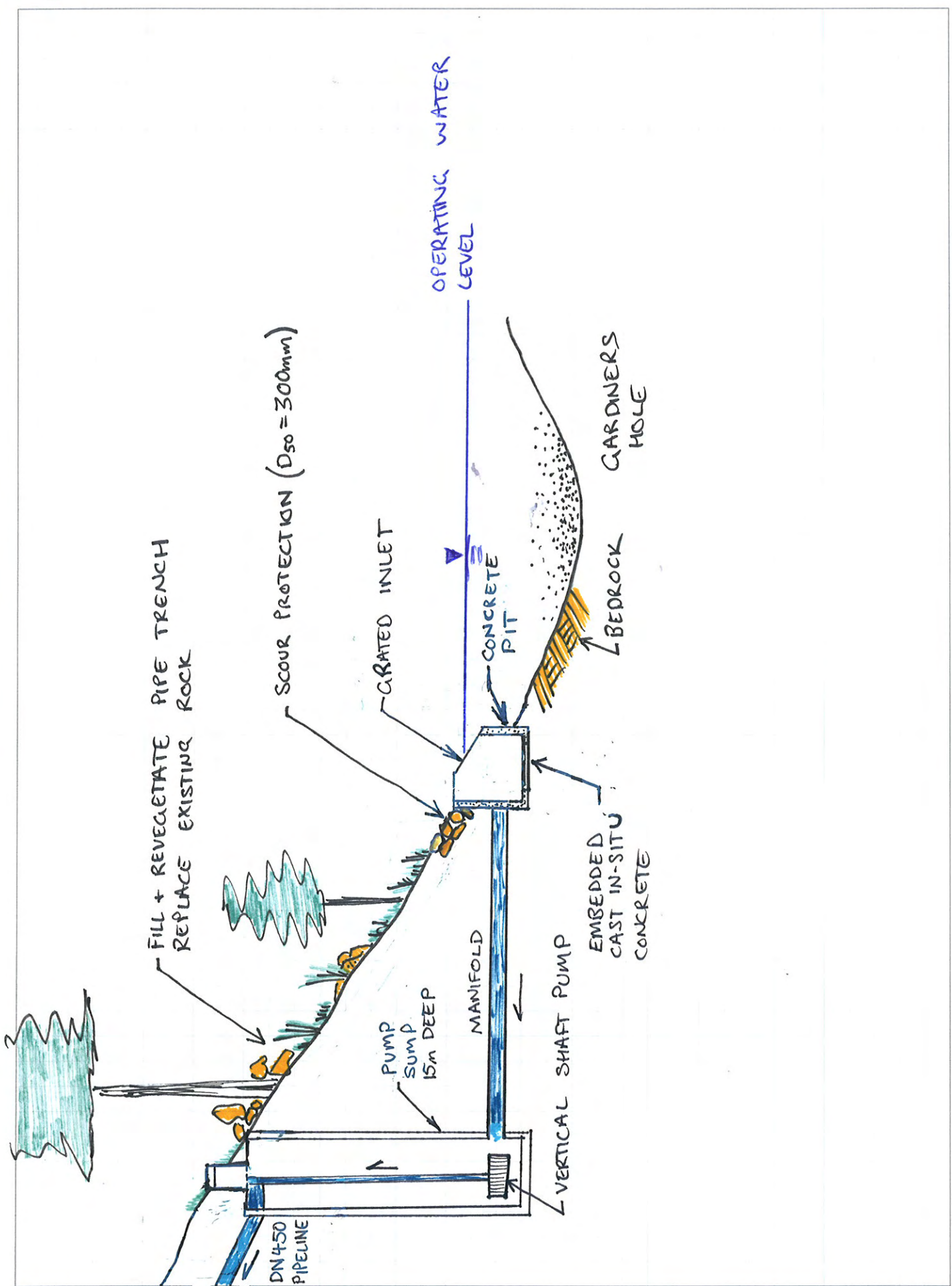
1. THESE SEDIMENT & EROSION CONTROLS ARE INDICATIVE AND CAN BE ADAPTED TO SUIT SPECIFIC REQUIREMENTS
2. THE LOCATION OF VARIOUS CONTROLS IS INCLUDED AS A GUIDE AND MAY BE ADJUSTED TO EACH CREEK CROSSING
3. SPECIFIC SIZING AND CONFIGURATION OF THE CONTROLS WOULD BE CONDUCTED DURING FURTHER DESIGN IN ACCORDANCE WITH THE BLUE BOOK
4. THE PRACTICED AND CONTROLS ARE BASED ON THE PRACTICES DESCRIBED IN THE FOLLOW GUIDELINES:
 - MANAGING STORMWATER: URBAN SOILS AND CONSTRUCTION VOL 1 - LANDCOM, 2004
 - MANAGING STORMWATER: URBAN SOILS AND CONSTRUCTION VOL 2A - INSTALLATION OF SERVICES - DECC, 2008B

NOT TO SCALE

REV	DATE	REVISIONS	BOB	CKM	ARCHITECT:	DATE	PROJECT MANAGER	DATE	FOR APPROVAL	DRAWING NUMBER	REV
A	25/01/2012	CONCEPT DESIGN	BO	NME	© Cardno (NSW) Pty Ltd All Rights Reserved. Copyright in the whole and every part of this drawing belongs to Cardno and shall remain the property of Cardno (NSW) Pty Ltd. No part of this drawing is to be reproduced in whole or in part in any manner or form or on any media, in any form or by any means, without the prior written consent of Cardno (NSW) Pty Ltd.				ORANGE COUNCIL	W4916-1	B
B	29/04/2012	FINAL ISSUE	BO	NME	This document is prepared by Cardno (NSW) Pty Ltd under the name of Cardno (NSW) Pty Ltd. Cardno (NSW) Pty Ltd is not responsible for the use of this drawing in any way. Cardno (NSW) Pty Ltd does not and shall not assume any liability for any loss or damage, whether direct or indirect, arising from the use of this drawing in any way.	TO BE PRINTED AT 1:3	DESIGNED	CHECKED	MACQUARIE ORANGE PIPELINE DETAILS		
					APPROVED	REVIEWED	DATE	DATE	SEDIMENT & EROSION CONTROL DETAILS		



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 Email: info@cardno.com.au www.cardno.com.au



PROJECT	ORANGE PIPELINE OFFTAKE
PROJECT NO.	W4916
Designed	NE
Date	02/02/12
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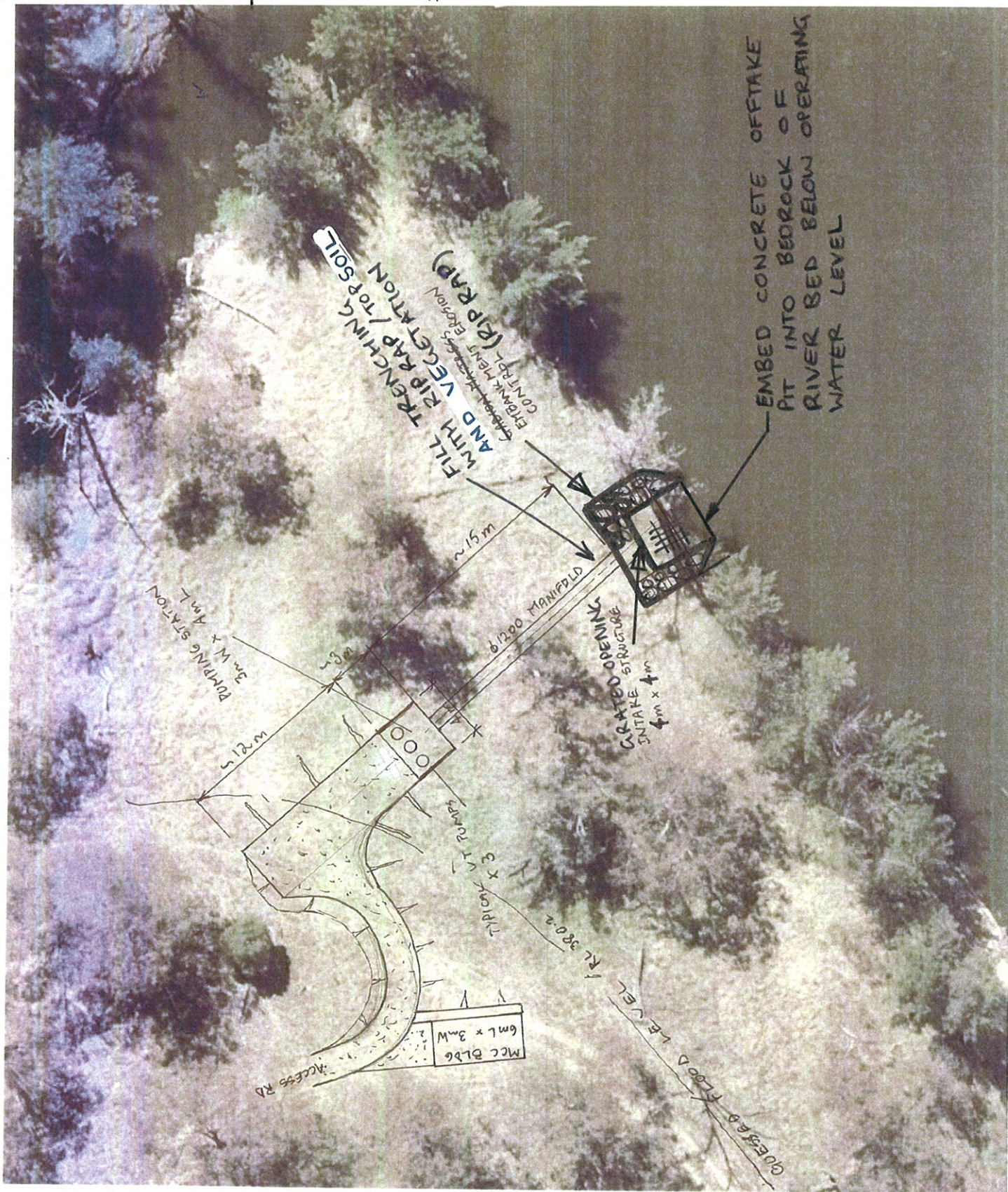
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FOR INFORMATION ONLY.
3/2/12.

CARDNO UPDATE

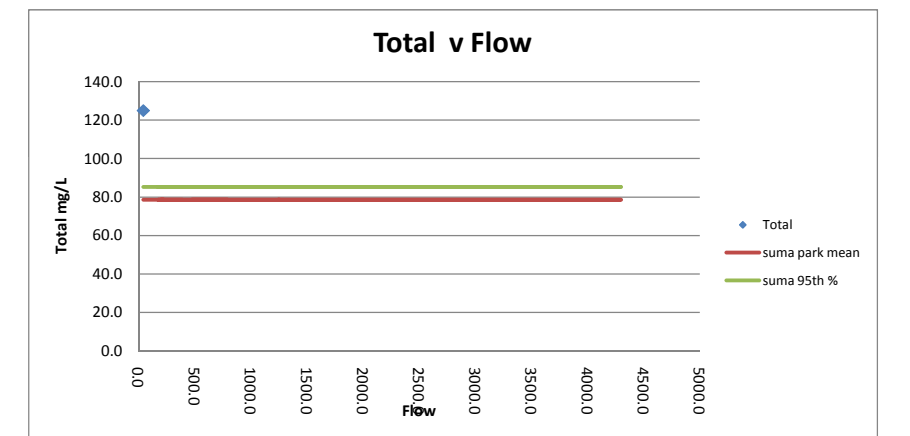
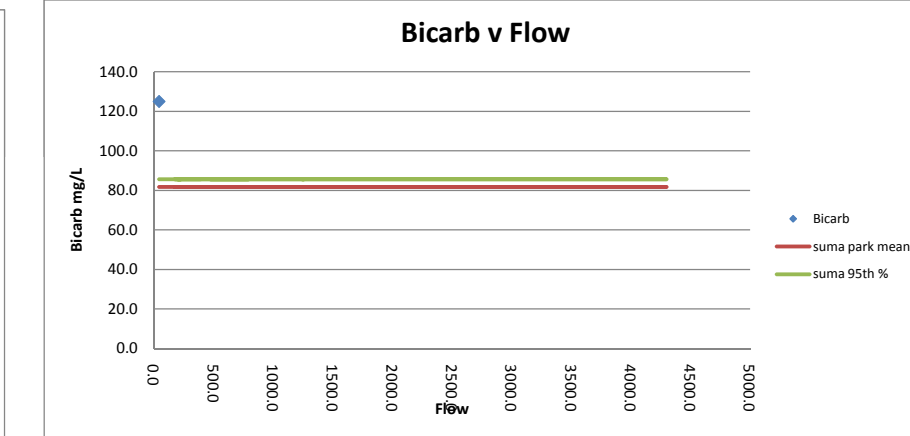
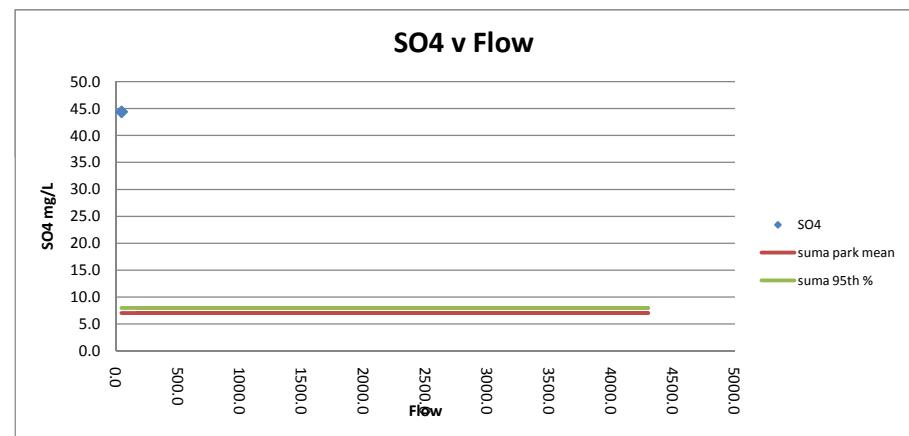
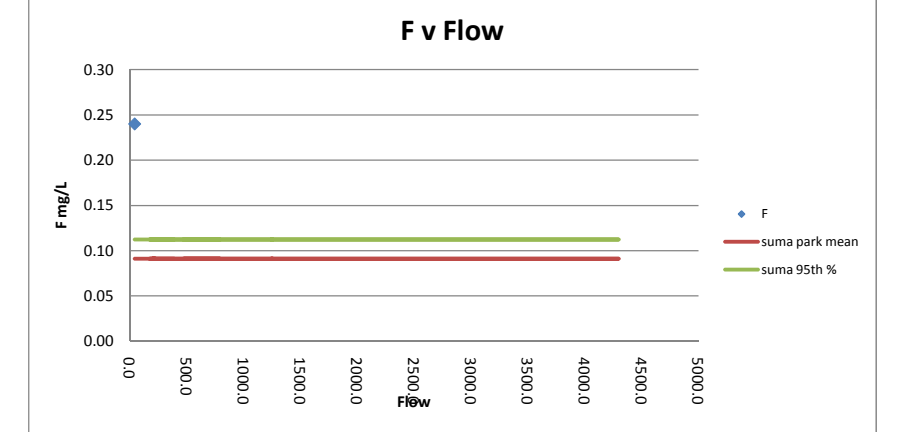
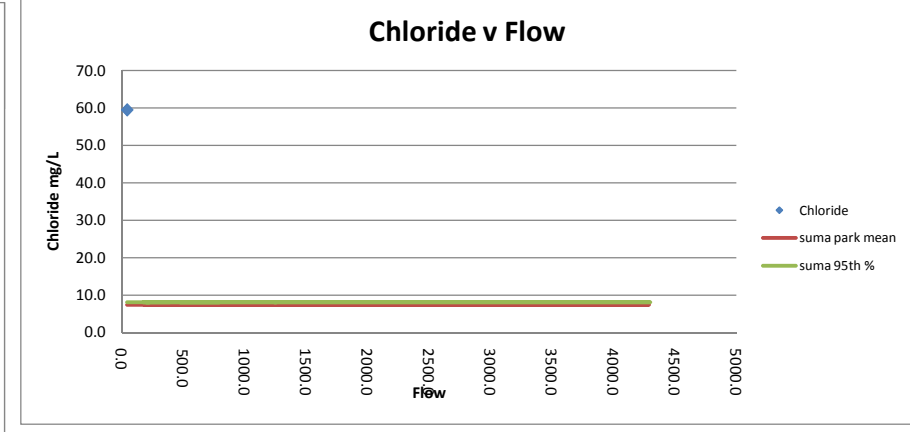
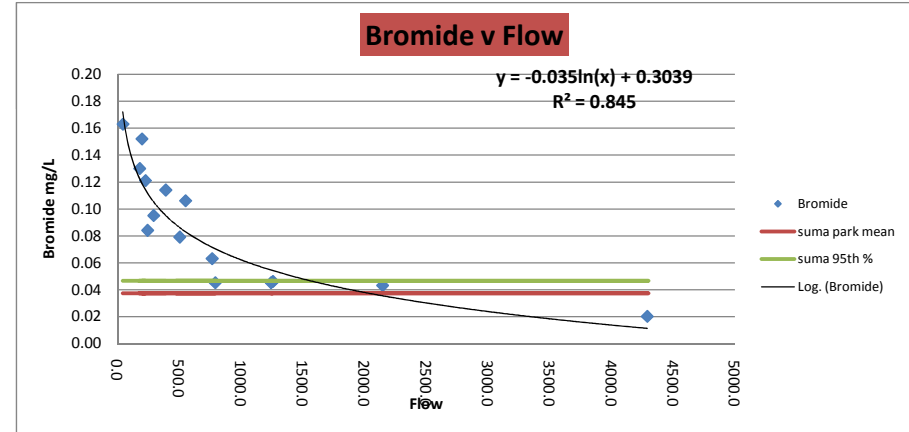
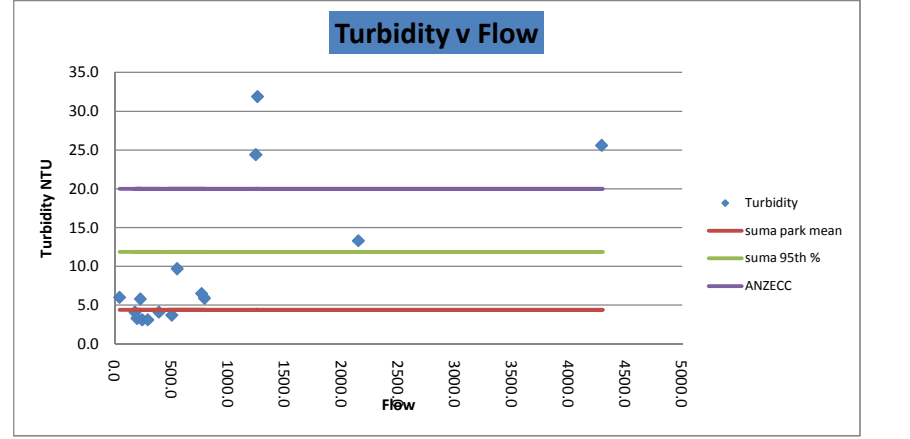
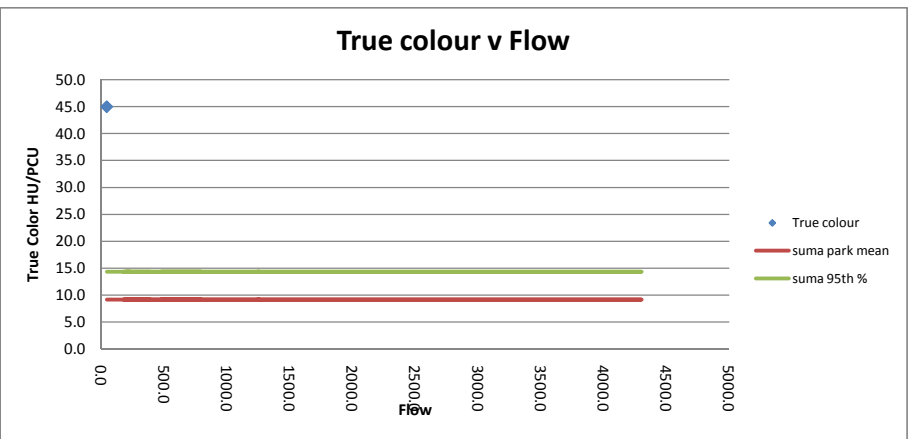
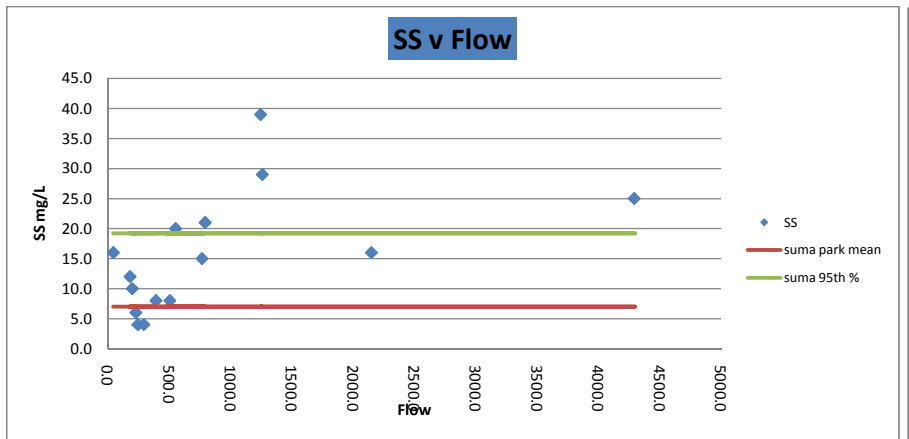
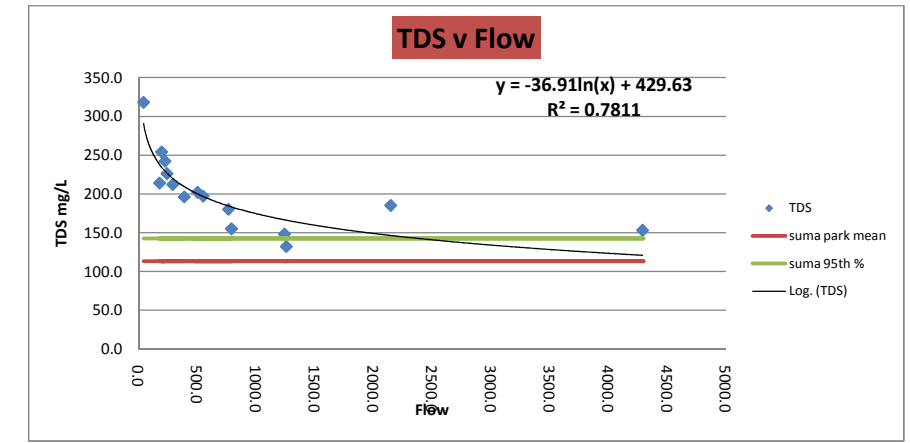
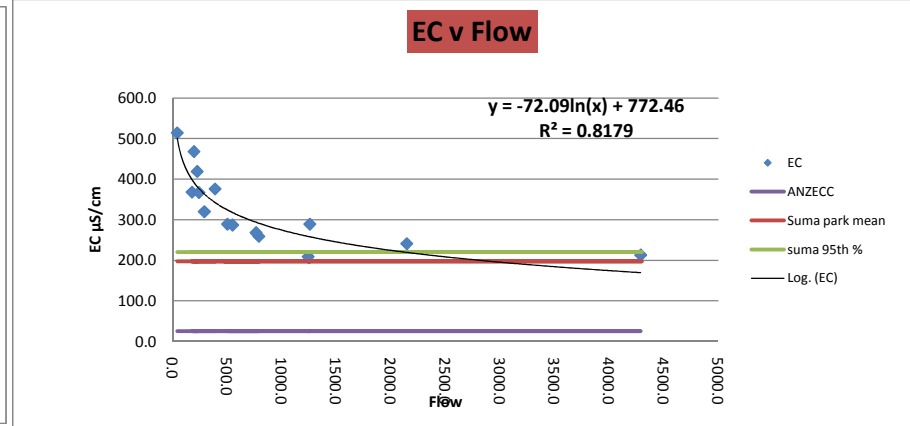
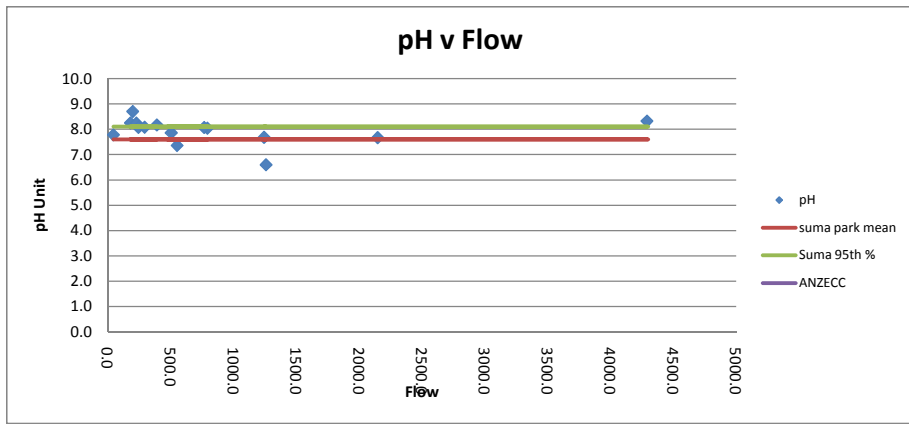
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- * 16/03/12
- * SEE SECTION SKETCH FOR DETAILS

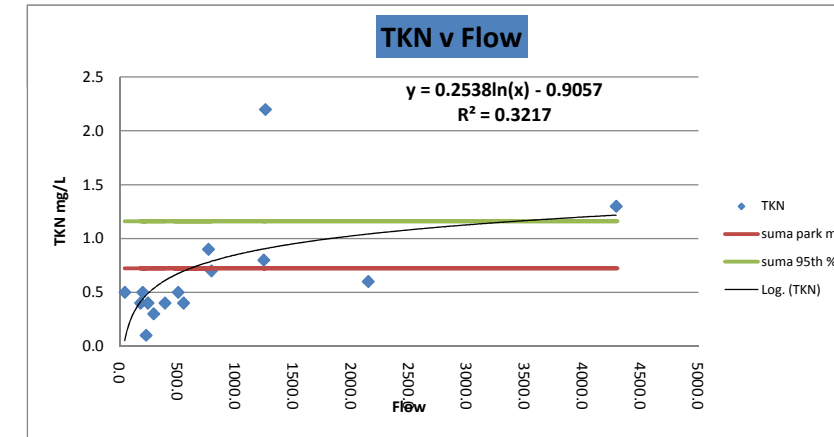
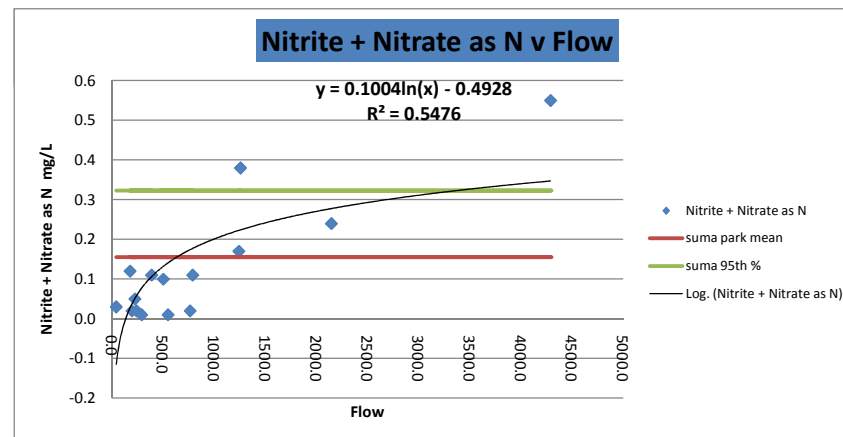
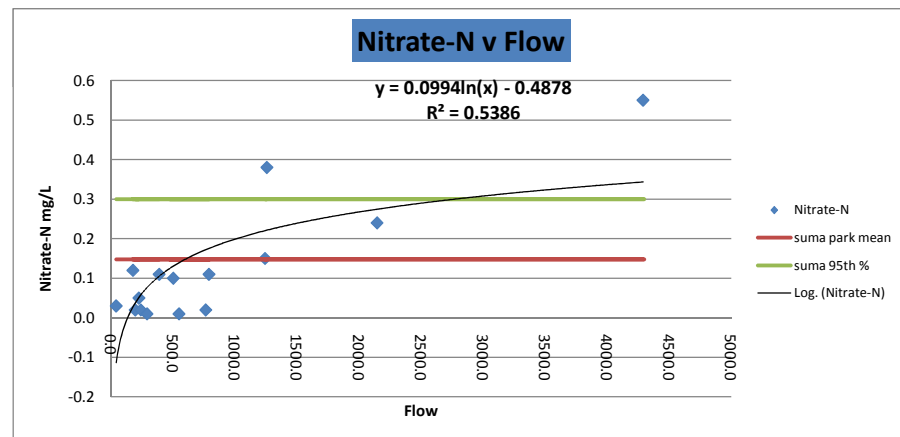
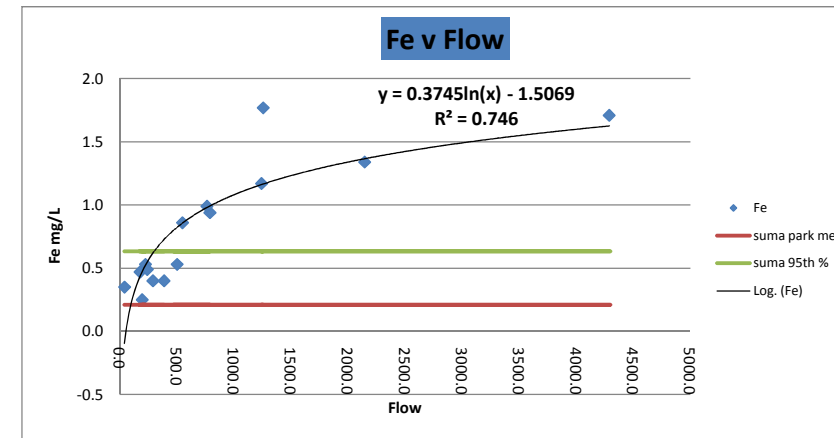
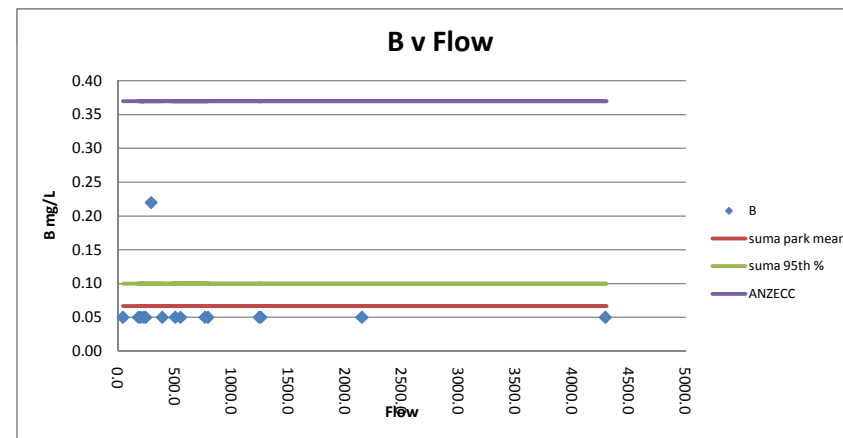
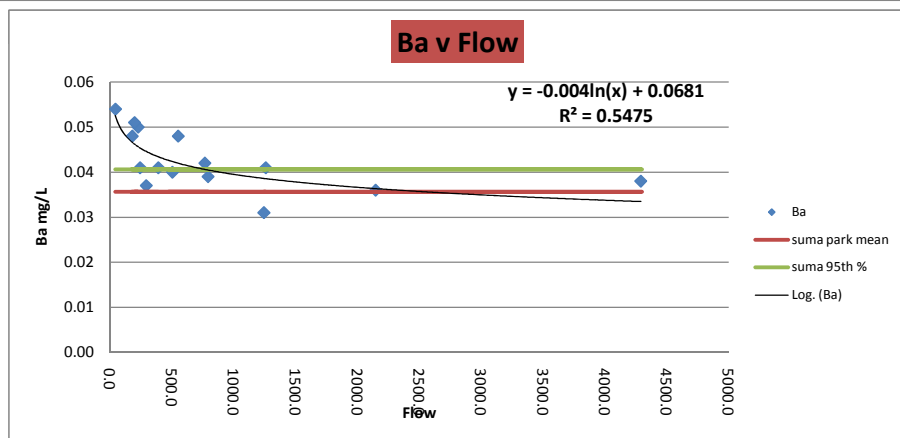
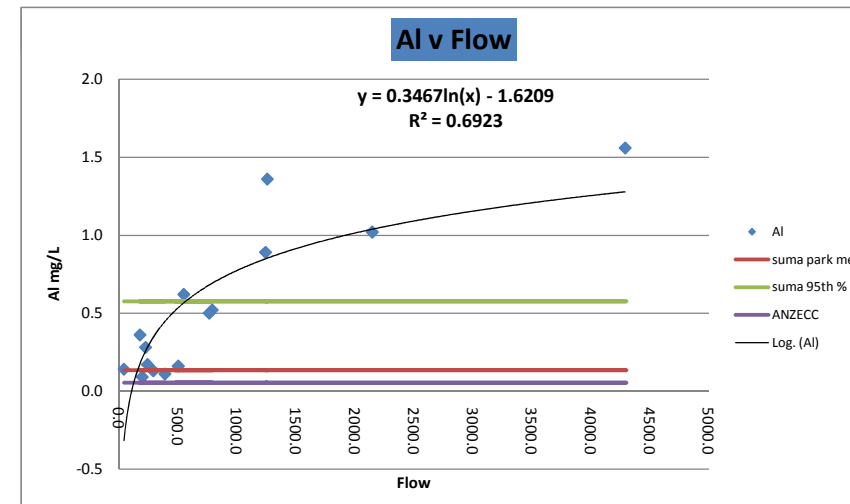
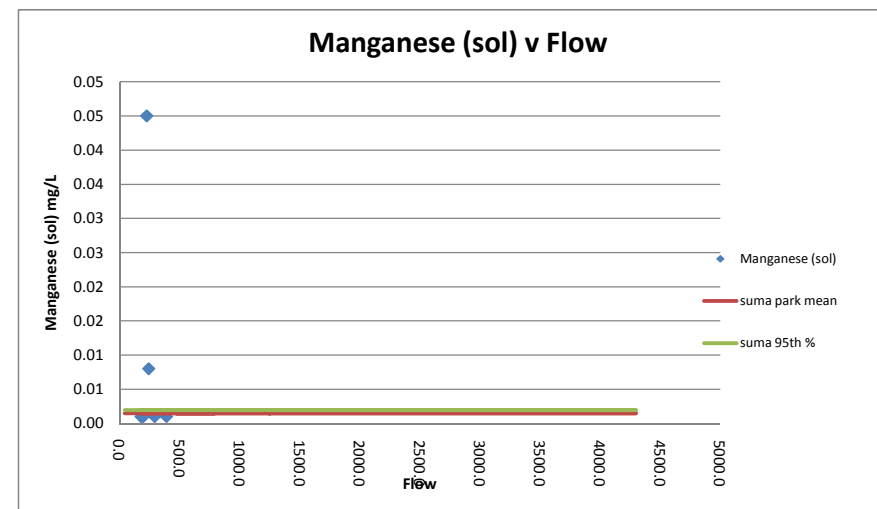
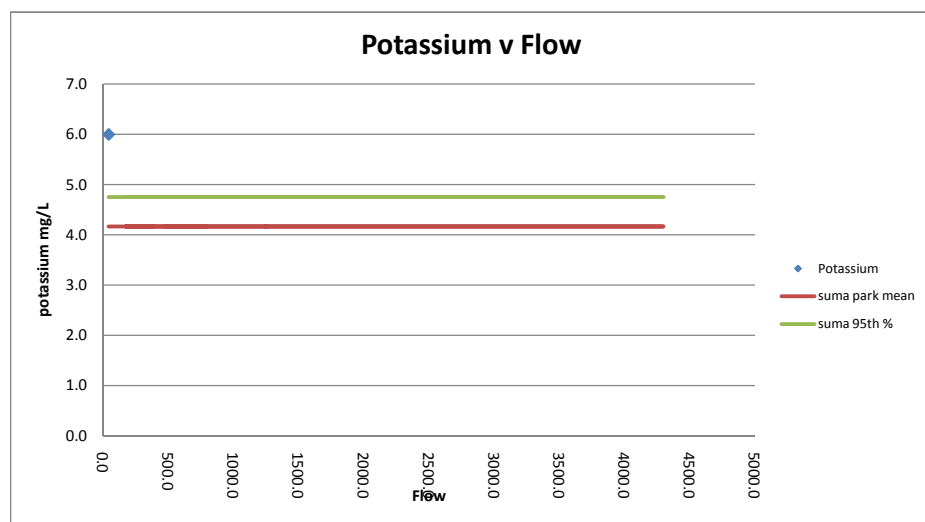
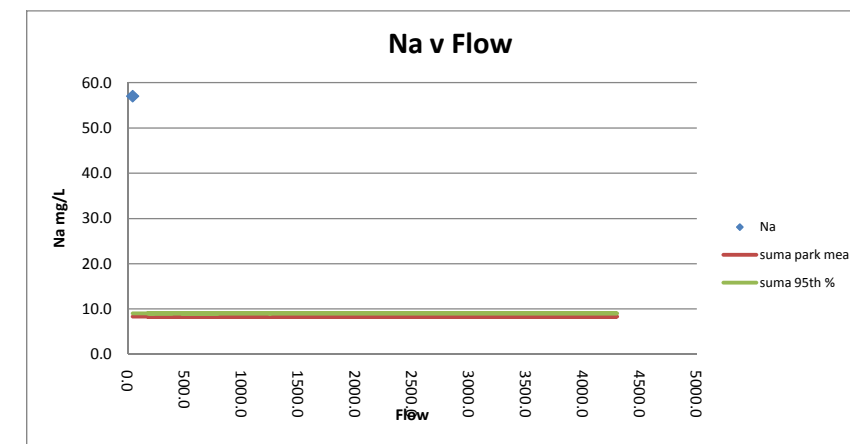
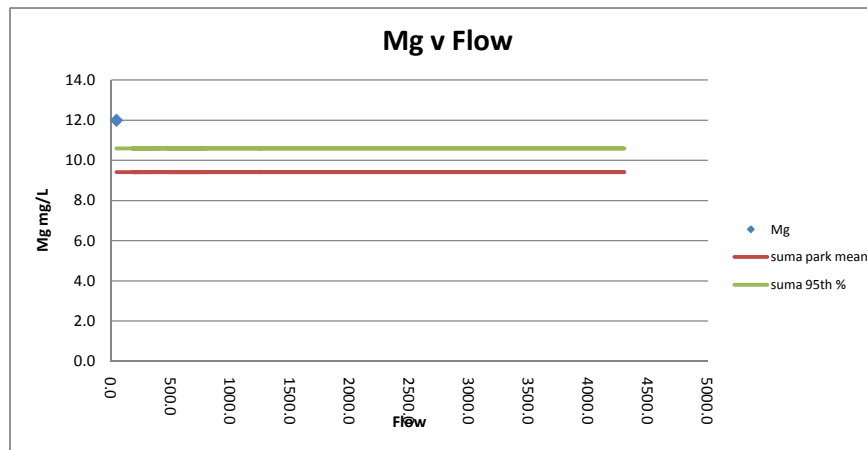
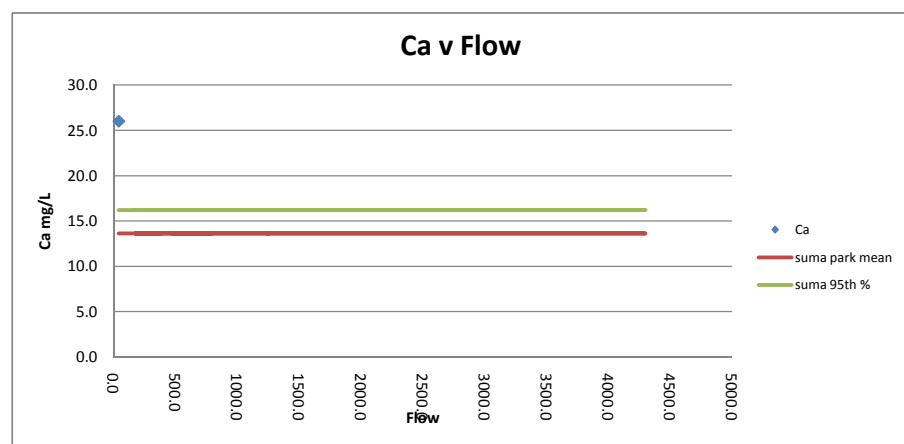
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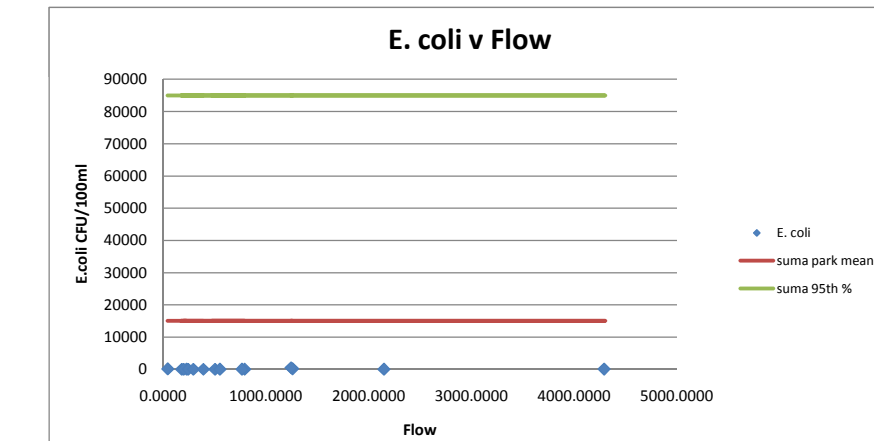
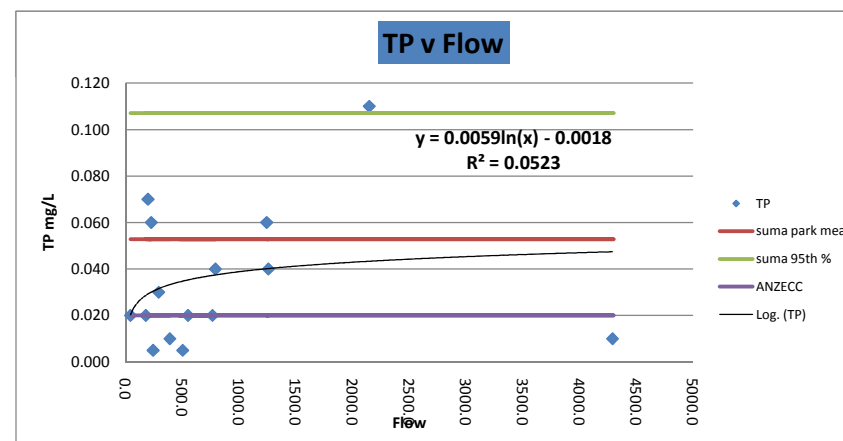
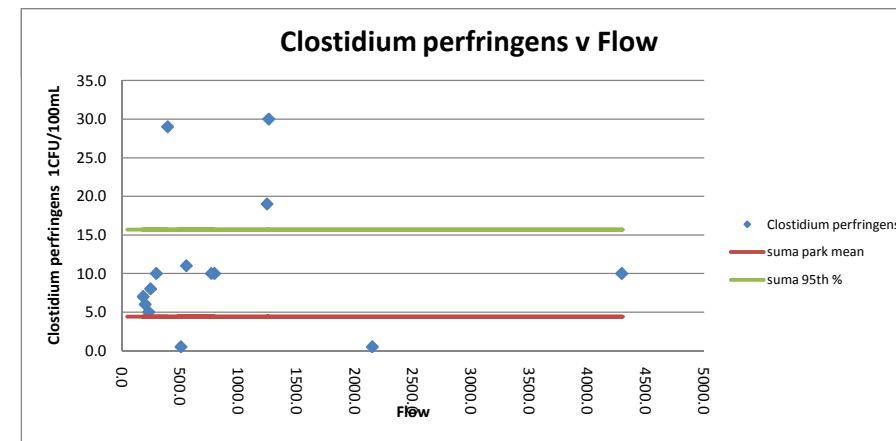
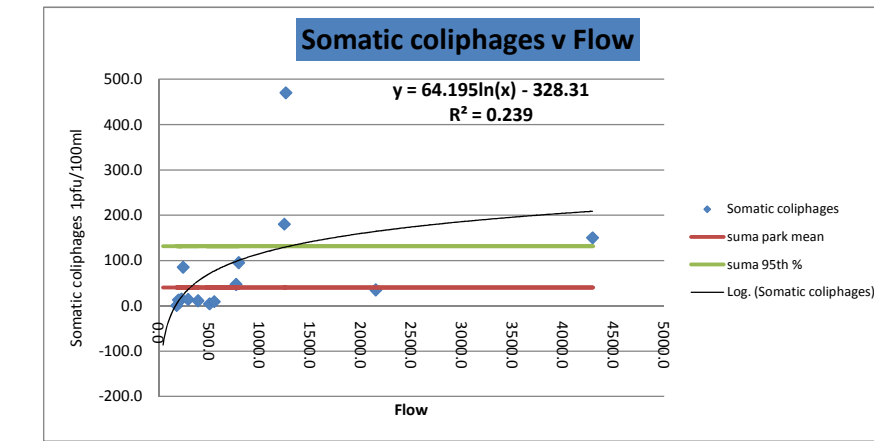
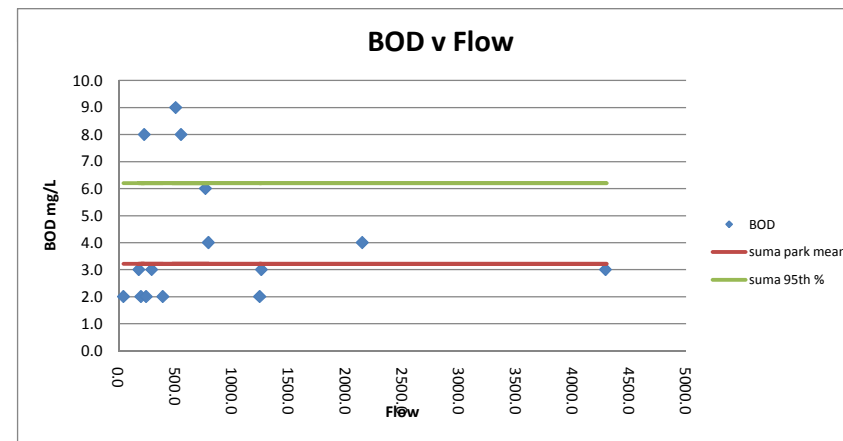
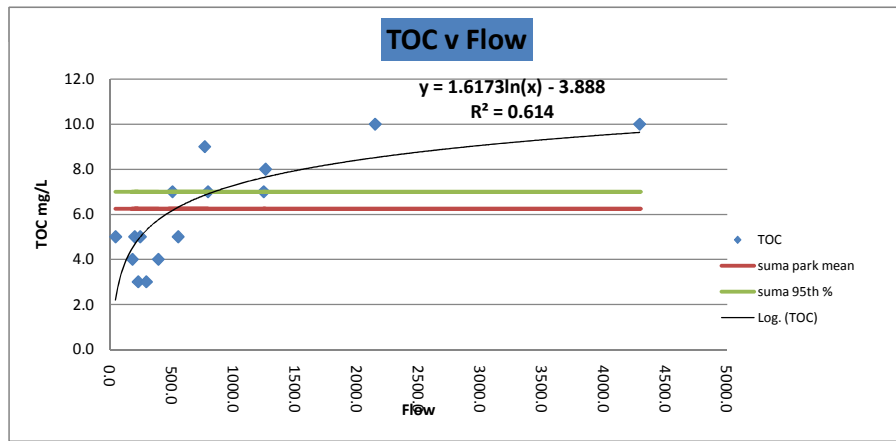
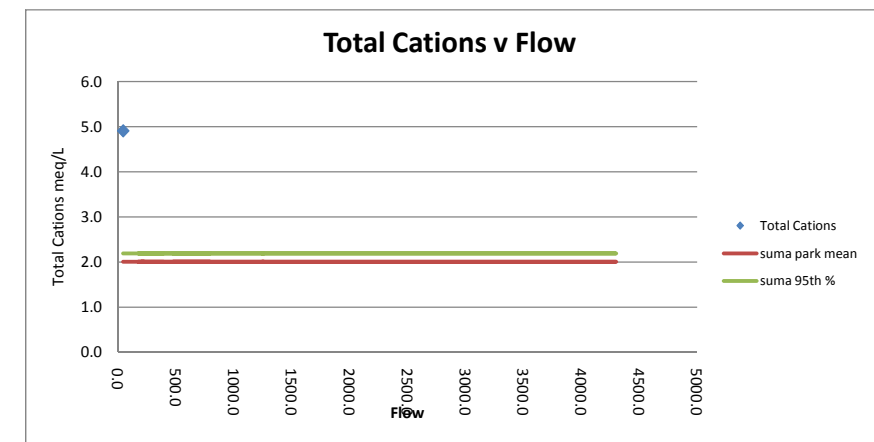
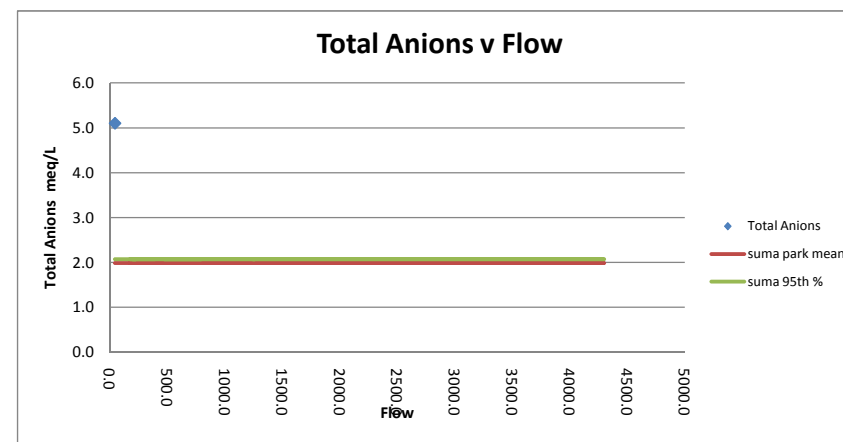
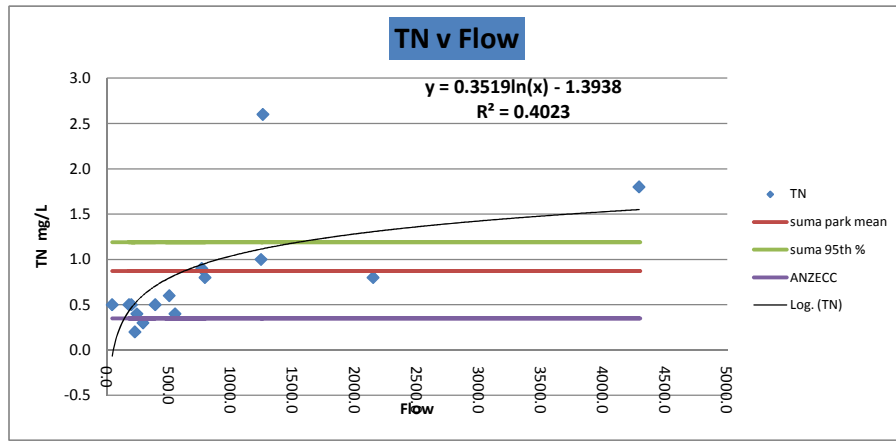


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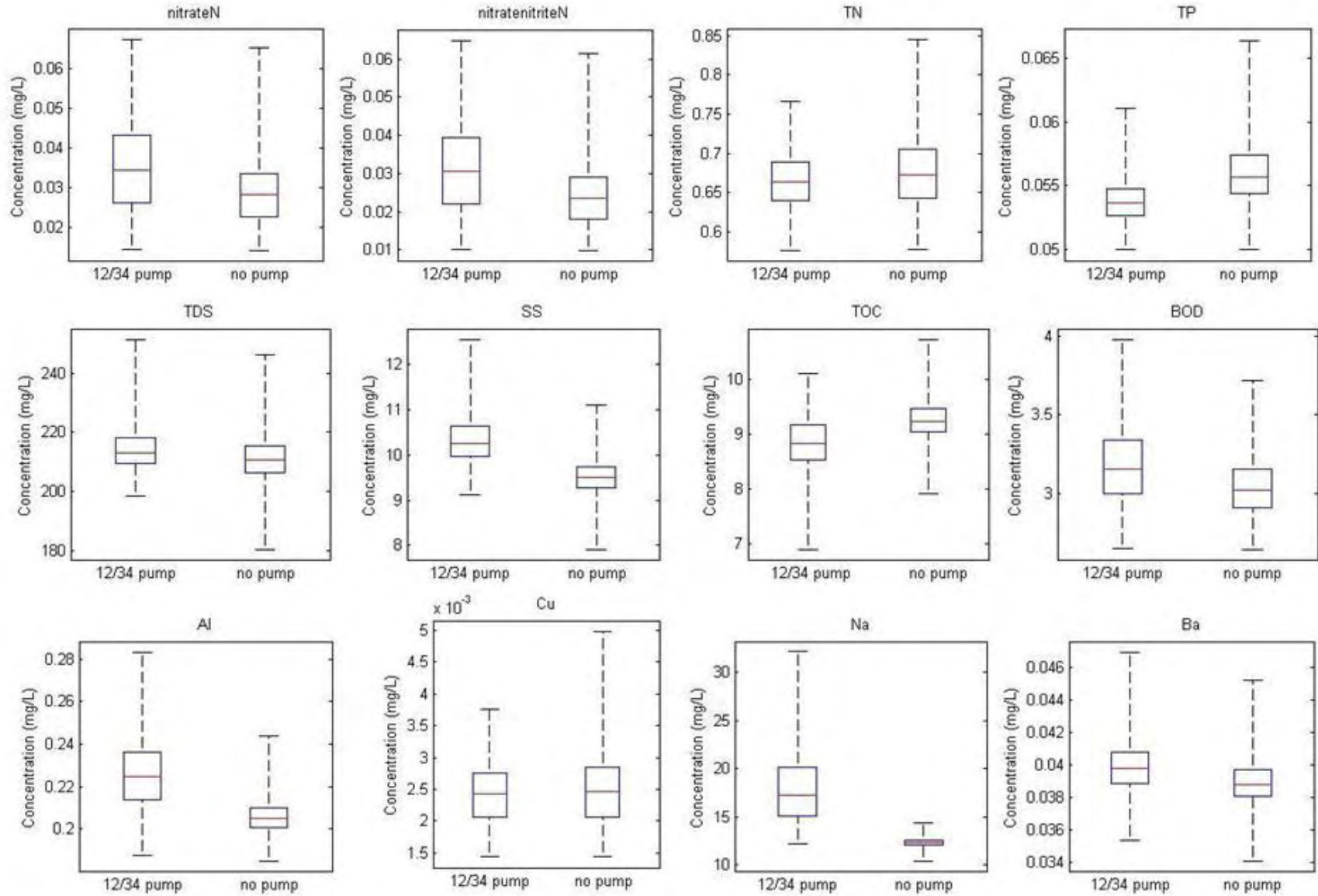
Water Quality Analysis Figures







Decrease in Flow (red arrow pointing left)
Increase in Flow (blue arrow pointing right)



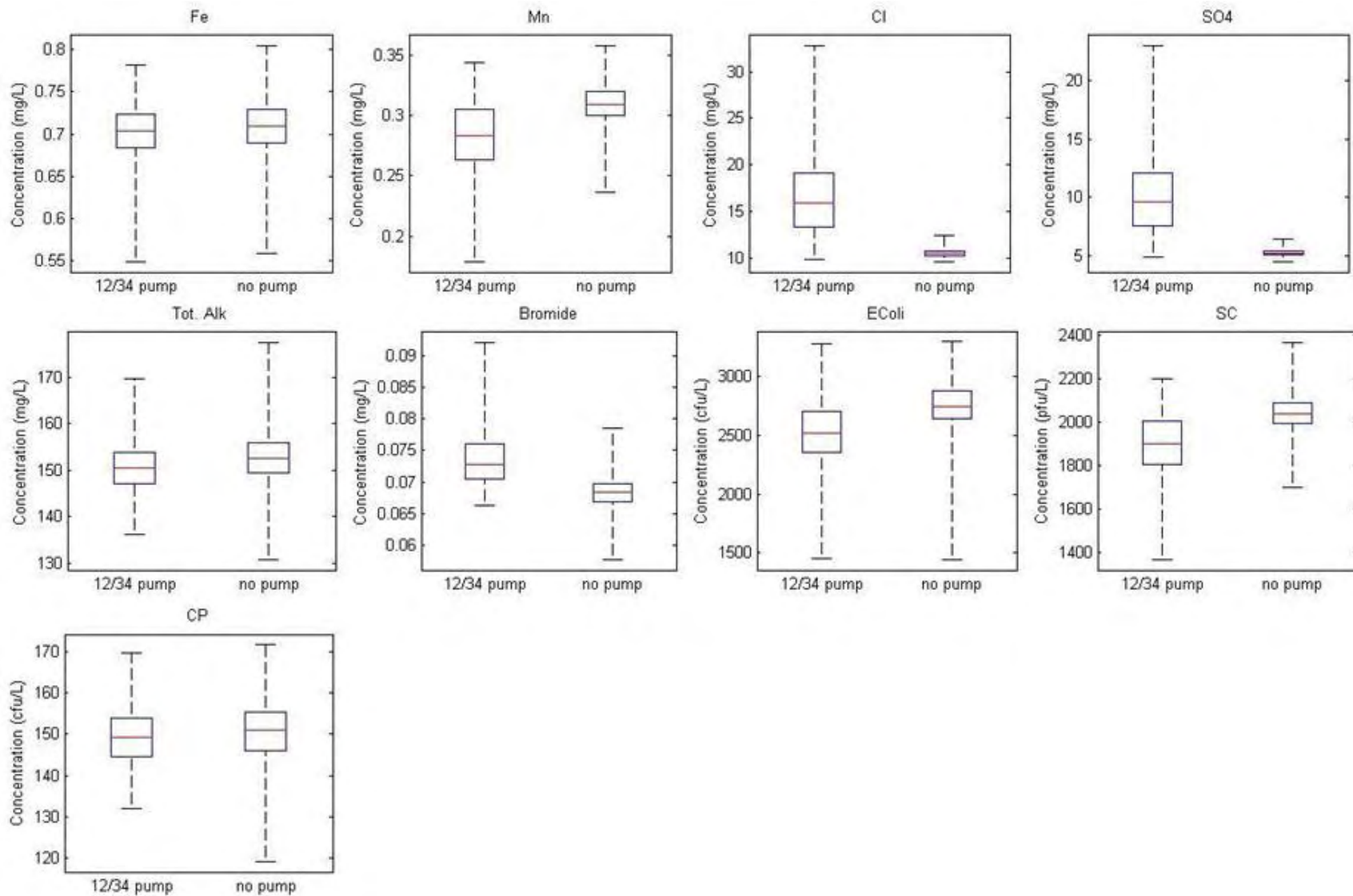
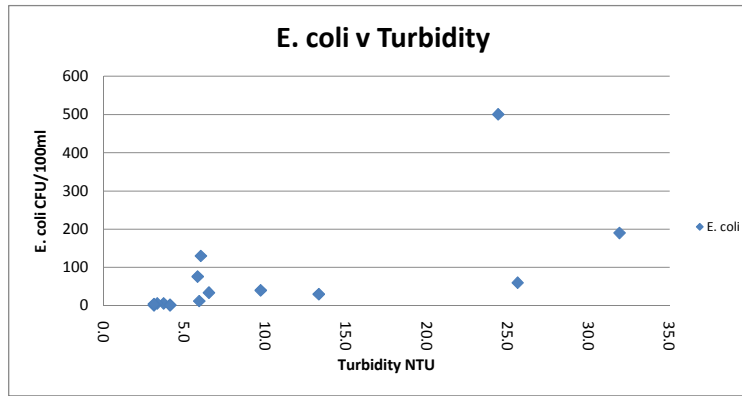
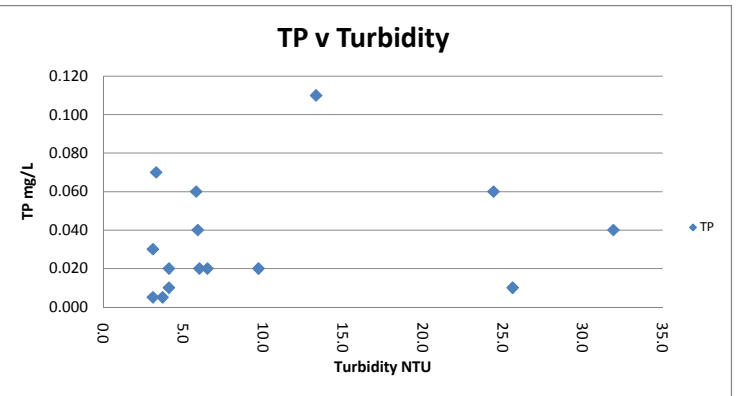
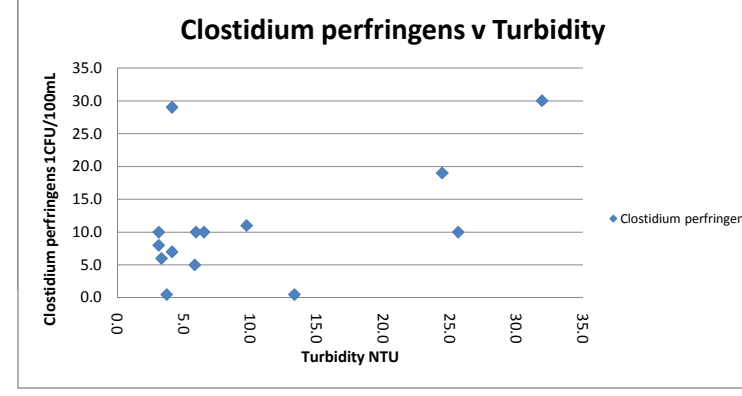
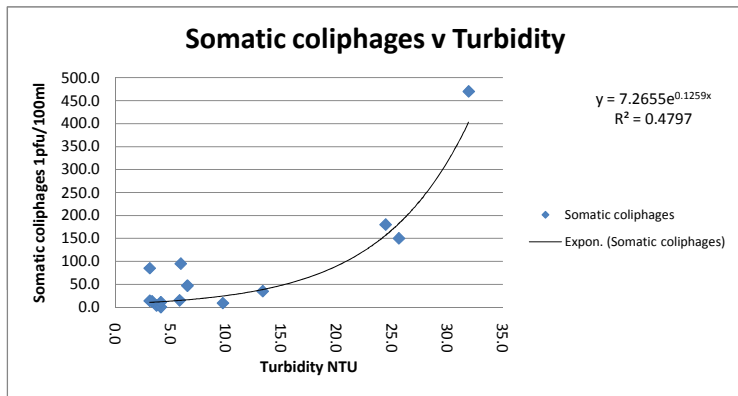
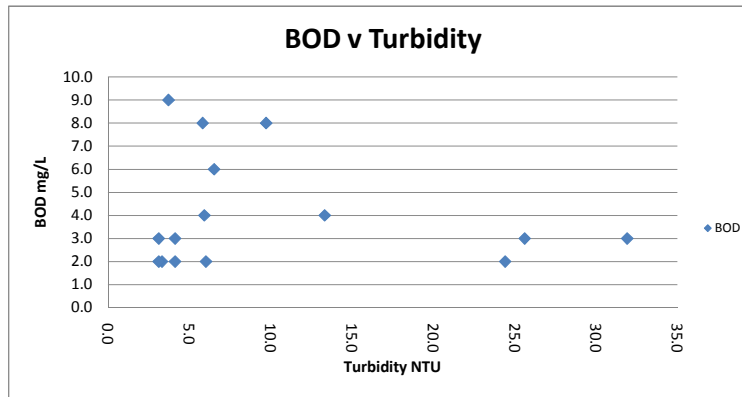
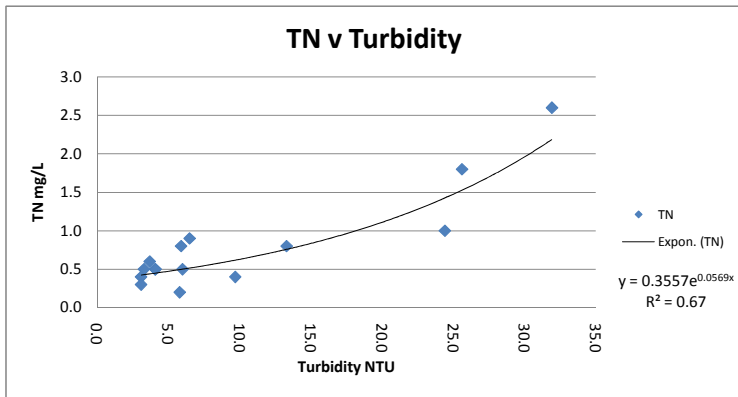


Figure. Boxplots showing the distribution of concentration for parameters outlined in Section 6.1.1 for the existing scenario and pumping scenario. The red line indicates the median and the whiskers extend to the minimum and maximum of the data.



Appendix C

Pells Consulting Groundwater Report

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Our Ref: L120523
23rd May 2012

Rhys Thompson
Cardno (NSW/ACT) Pty Ltd
Level 3, 910 Pacific Highway
GORDON NSW 2072

Dear Rhys

**GROUNDWATER ISSUES - WATER QUALITY AND GEOMORPHOLOGY IMPACTS
REPORT, MACQUARIE ORANGE PIPELINE PROJECT**

Please find attached a letter report providing advice on groundwater issues relevant to the preparation of a Water Quality and Geomorphology impacts report, Macquarie Orange Pipeline Project.

This letter incorporates comments received on the report by Council. This letter supersedes our previous letters by the same title.

Yours sincerely,

STEVEN PELLIS
BE(Civil) MEngSc

1 INTRODUCTION

1.1 Purpose of this report

Orange City Council proposes to undertake the Macquarie Orange Pipeline Project (referred to in this report as 'the project'). This report has been prepared to provide assistance to Cardno on groundwater issues to be addressed in their preparation of a Water Quality and Geomorphology impacts (WQ&G) report, as an input to the environmental assessment (EA) of the project. The EA is being prepared in accordance with the requirements of Part 3A of the NSW Environmental Planning and Assessment Act 1979 (EP&A Act).

1.2 Project overview

The project involves construction and operation of infrastructure required to transfer approximately 12 ML/day of water a distance of approximately 37 km from the Macquarie River to the Suma Park Dam at Orange.

The infrastructure required to transfer the water includes an intake and pump stations, an underground pipeline (approximately 37 km in length), an discharge structure, and ancillary infrastructure (power supply).

In summary, the project would involve construction and operation of the following infrastructure:

- ▶ 37 km of 375 mm diameter water rising main between the Macquarie River and Suma Park Dam
- ▶ an proposed offtake and pump station located at the upper Macquarie River
- ▶ two booster pump stations and break tanks along the pipeline route
- ▶ power supply to pumps and other infrastructure
- ▶ telemetry controls to enable remote operation of the infrastructure including pumps and valves etc
- ▶ a discharge structure at the Suma Park Dam.

1.3 The location of the project

The proposed off-take point would be located north of Long Point on the upper Macquarie River.

The proposed route for the pipeline, shown on Figure 1, includes road reserves, including Ophir Rd and Long Point Rd. In some areas the pipeline would need to be constructed on private land. It is proposed that the majority of the pipeline would be underground and would not impact on farming or other land uses.

The majority of the pipeline would be located in the Cabonne local government area (LGA).

The pipeline would discharge to via a structure located at the north of the Suma Park Dam.

1.4 Scope and structure of report

1.4.1 Scope of report

The scope and intent of this letter is to provide a broad-level review. based on a field reconnaissance and review of publically available data, of:

- potential impacts to groundwater resources over the pipeline route, and;
- potential impacts to groundwater resources adjacent to the Macquarie River between the proposed offtake location and Lake Burrendong.

The groundwater issues raised in the job briefing sheet for the Water Quality and Geomorphology impacts (WQ&G) report are:

1. The potential risks to groundwater quality during construction and operation activities (including the proposed off take, pump infrastructure and pipeline maintenance activities)
2. Demonstrate that the project can be designed and managed consistent with the principle of a neutral or beneficial effect on water quality in the water catchment
3. Include a framework for the mitigation, management and monitoring of groundwater quality impacts during construction and operation including reference to the Managing urban stormwater soils and construction volume 1 and volume 2.

This letter report therefore provides advice to Cardno on the groundwater issues raised in the DGR's (and associated departmental letters) which are relevant to this WQ&G scope.

1.4.1.1 Exclusions

The letter report does not address all of the groundwater issues raised in the Director General's Requirements (DGR's), only those relevant to the scope of the WQ&G report. The detail of investigation is constrained by the scope of works agreed between Pells Consulting and Cardno.

1.4.2 Where Director-General's requirements are addressed in report

Groundwater issues raised in the DGR's (and associated departmental letters) which are relevant to scope of the WQ&G report are summarised in Table 1, together with a reference to where they are addressed in this letter.

1.4.3 Report Structure

While the DGR summary document (reference 6) broadly discussed groundwater issues, it is noted that groundwater issues are elucidated primarily in the letter from the NSW Office of Water (2011, reference 9), in which was provided a "general list of environmental assessment requirements to be addressed in the EA". For groundwater, this is summarised as comprising four key issues, which are discussed in this letter in turn:

1. Characterisation of groundwater resources Section 2
2. Identification of impacts to groundwater resources Section 3
3. Groundwater mitigation, monitoring and contingency requirements – Section 4
4. Ensure that relevant groundwater guidelines and policies are addressed – Section 5

1.4.4 Information sources used for this report

A field reconnaissance was undertaken by Mr Steven Pells and Dr Philip Pells of Pells Consulting on the 18th September 2011. This comprised driving adjacent to the pipeline route and undertaking a visual inspection of the land and hydrologic features.

Documents viewed and / or referred to in preparation of this report are listed in the references section at the end of this report. In addition, public domain geological and hydrogeological data were also used, such as geological sheets and the NSW Groundwater Database.

Table 1 Director General's Requirements, Groundwater Aspects of the Water quality and geomorphology impacts report.

Assessment requirements	Where addressed in report
<ul style="list-style-type: none"> ▶ Ecological Impacts (DGR, DoP 24/3/11, pg 2) groundwater dependent communities 	Not addressed. See 1.4.1.1 above.
<ul style="list-style-type: none"> ▶ Groundwater Characterisation (NoW, 23/3/2011, pg 5) 	Section 2
<ul style="list-style-type: none"> ▶ Groundwater Impacts <ul style="list-style-type: none"> ▪ assess the potential risks to surface and groundwater quality during construction and operation activities demonstrating that the project can be designed and managed consistent with the principle of a neutral or beneficial effect on water quality in the water catchment (DGR, DoP 24/3/11, pg 3); ▪ include an assessment of potential impacts on other groundwater and surface water users, and the environment under different climatic conditions with details of how existing water access rights will be protected, including with respect to availability, quantity and quality of water in the Macquarie Catchment (DGR, DoP 24/3/11, pg 3); ▪ requirement to intercept groundwater (NoW, 23/3/2011, pg 2); ▪ impacts to Groundwater Dependent Ecosystems (NoW, 23/3/2011, pg 2); (NoW, 23/3/2011, pg 6). ▪ impacts to groundwater users (NoW, 23/3/2011, pg 2): ▪ predicted dewatering volumes, time period of dewatering, water quality and disposal/retention methods. 	<p>Section 3</p> <p>Section 3.1</p> <p>Section 3.2</p>
<ul style="list-style-type: none"> ▶ Groundwater Impact Mitigation <ul style="list-style-type: none"> ▪ include a framework for the mitigation, management and monitoring of surface and groundwater quality impacts during construction and operation including reference to the Managing urban stormwater soils and construction volume 1 and volume 2 (DGR, DoP 24/3/11, pg 3). ▪ Adequate mitigating, monitoring and contingency 	Section 4

<p>requirements to address surface and groundwater impacts (NoW, 23/3/2011, pg 2)</p>	
<p>▶ Groundwater Policy and Guidelines (NoW, 23/3/2011, pg 4)</p> <p>The assessment is required to take into account the following NSW Government policies:</p> <ul style="list-style-type: none"> ▪ NSW Groundwater Policy Framework Document- General (August 2007) ▪ NSW Groundwater Quantity Management Policy ▪ NSW Groundwater Quality Protection Policy (1998) ▪ NSW State Groundwater Dependent Ecosystem Policy (2002) ▪ NSW Inland Groundwater Shortage Zones Embargo Order 1 and 2 (December 2008) <p>The assessment is required to take into account the following NOW Guidelines for Controlled Activities (August 2010):</p> <ul style="list-style-type: none"> ▪ Riparian corridors (and associated Vegetation Management Plans) ▪ Watercourse crossings ▪ Laying pipes and cables in watercourses 	<p>Section 5</p>



Figure 1 – Proposed route to Macquarie River

2 GROUNDWATER RESOURCE CHARACTERISATION

2.1 Geological Setting

The pipeline is set within the geological region known as the Lachlan Fold Belt. This is a geological region with a complex history (Branagan and Packham, 2000) and associated complex formations. In the study area, the geology typically comprises:

- Devonian metasedimentary slates, siltstones and sandstones;
- Silurian volcanic tuffaceous mudstones, conglomerates and breccias, and;
- Ordovician volcanoclastic sandstones, siltstone, breccia and basalt.

Some younger Tertiary intrusions of basalt are found to outcrop at locations along the pipeline route. These are similar to the basalt formations found underneath Orange, and forming Mt Canobolas to the South-West of the town.

The geological formations encountered along the pipeline route are summarised in Table 2 below. Chainages are approximate, and are measured along the pipeline route starting from the river proposed offtake, as shown in Figure 4. Descriptions of each formation are provided in the notes below the table.

Table 2 – Geological Formations En Route of Pipeline (See Figure 4)

Chainage	Formation
0-900	Cunningham Formation
900-2500	Mafic Volcanic Rocks
2500-7800	Cunningham Formation
7800-8300	Bay Formation
8300-15200	Barnaby Hills Shale
15200-19900	Mafic Volcanic Rocks
19900-22900	Mullions Range Volcanics
22900-23300	Barnaby Hills Shale / Mullions Range Volcanics / Mafic Volcanic Rocks
23300-30200	Mullions Range Volcanics
30200-32200	Oakdale Formation
32200-34300	Oakdale Formation / Ultramafic cumulates and lava
34300-36240	Oakdale Formation

Notes:

- Cunningham Formation: - *Devonian metasedimentary siliciclastic. Slate, laminated siltstone, feldspa-lithic- quartz- calcareous sandstone, phyllite, shale.*
- Mafic Volcanic Rocks - *Tertiary mafic volcanics: basalt, trachyte, rhyolite, tuff.*
- Bay Formation - *Devonian feldspathic sandstone, siltstone*
- Barnaby Hills Shale - *Silurian feldspathic micaceous and carbonaceous siltstone and shale, fine grained sandstone*
- Mullions Range Volcanics - *Silurian rhyolite, tuffaceous mudstone, rhyolite breccia, volcanic conglomerate, dacite, limestone*
- Oakdale Formation - *Ordovician mafic volcanoclastic sandstone, basalt, siltstone, black shale, chert, breccia, conglomerate*

The geological formations adjacent to the Macquarie River, downstream of the proposed offtake, are exclusively the Cunningham Formation, with some tertiary basalt intrusions approaching close to the river in one or two locations.

2.2 Aquifer Types and Characteristics

Aquifers within fractured rock formations along the alignment of the pipeline are generally low yielding and are expected to have salinity levels that are suitable only for limited irrigation and watering of some domestic stock (Green et al, 2011). In the *Hydrogeology Map of Australia* (Jacobson and Lau, 2000) the region adjacent to the pipeline is described as comprising “extensive fractured or fissured rock of low to moderate productivity”.

It is anticipated based on geological conditions that the groundwater depth in the fractured rock aquifers would be below the depth of pipe trenching. The depth to water in these fractured rock aquifers is reported in the Australian Natural Resource Atlas (ANRA) to be 40 m (for the Lachlan Fold Belt, NSW) (www.anra.gov.au). Groundwater vulnerability mapping (discussed below) for the area also infers deep groundwater resources in the region of the pipeline.

The tertiary basalt formations underneath and extending to the south west of Orange are known to provide good aquifers with high yields and fresh water found at some locations. While that particular formation is not intersected by the pipeline, similar tertiary basalt outcrops, albeit of lesser extent, may be expected to be located underneath the pipeline route at some locations (approximate chainages 900-2500 and 15200 to 19900 – see Figure 4). Fresh groundwater resources may be found at these locations, with capacity for productive yields, but perhaps with only minor total storage due to its relatively small extent. The depth to water in the Orange Basalts is reported as 20 m (ANRA). This is consistent with bores installed by this company in the basalts south-east of Orange.

Over 50% of the test pits constructed along the pipeline route encountered rock at the surface, based on records of test pits (MWH, 2011). In the remainder of pits soil generally 1 to 3 metres depth was encountered, with one case where a depth of 4 metres was reported. The test pits do not document the presence of water. Alluvium associated with streams are considered to be poor aquifers, being “*thin and low yielding, and the groundwater generally brackish or saline*” (*Groundwater in New South Wales* (1984) as cited in Green et al 2011, pg 15). Based on this data and available geological maps, it is considered that there are also no significant shallow or superficial aquifers in the soil formations along the route of the pipeline.

2.3 Groundwater Usage

The locations of existing groundwater bores are shown in Figures 3 and 4 (from the NSW Groundwater Database). There are generally few registered groundwater bores along the pipeline route, and no groundwater bores adjacent to the Macquarie River between the proposed offtake and Lake Burrendong, indicating low groundwater usage in the area. Some bores are recorded adjacent to the pipeline in the basalt intrusion regions and in the Mullions Range Volcanics (between chainages 23300 and 32200). It is anticipated that these bores, if active, would be used for irrigation purposes or stock watering. The majority of groundwater usage in the Macquarie Catchment is for irrigation purposes (Piscopo, 2001).

A significantly higher density of registered bores is associated with greater groundwater usage in the Orange region, accessing the higher yielding Orange basalt formations and carbonaceous siltstones, sandstones and limestones just to the north of the Suma Park reservoir. The pipeline does not pass through these more densely utilised aquifers.

2.4 Groundwater Management Zones and Vulnerability

Groundwater resources are defined and recognised by State and Territory agencies as Groundwater Management Units (GMU) or Unincorporated Areas.

A Groundwater Management Unit (GMU) is a hydraulically connected groundwater system that is recognised as a major aquifer with high production and high usage. The Australian Natural Resources Data Library (ANRDL) states that “*this definition allows for management of the groundwater resource at an appropriate scale at which resources issues and intensity of use can be incorporated into groundwater management practices*”. GMU’s may be grouped into provinces with respect to state or geological boundaries.

Unincorporated Areas are defined as those areas not included as a GMU.

The highly utilised basalt aquifers in the Orange region are recognised as the “Orange Basalt” GMU. In contrast, the pipeline passes through the “*Unincorporated Area – Lachlan Fold Belt Province, NSW*” (ANRA). The planned pipeline route does not pass through nationally significant aquifer units.

Groundwater zones within the Macquarie River catchment are shown in Figure 6 (reproduced from Green et al 2011), and the location of the pipeline is superimposed upon each figure.

Groundwater vulnerability mapping has also been completed for the region (Piscopo et al 2001). Vulnerability mapping takes into account general aquifer characteristics, depth to the watertable and recharge to characterise how vulnerable land areas are to groundwater contamination (*ibid*, pg 12). Groundwater vulnerability maps relevant to the study area are reproduced in Figure 7 below. It can be seen that within the region of the pipeline, a vulnerability designation of low to low-moderate applies, indicating that only a low level of assessment is required. The table reproduced below provides recommendations for groundwater assessments with respect to aquifer vulnerability (from Piscopo 2001).

Table 8. Groundwater assessment for developments that require consent

Vulnerability classification	Groundwater assessment requirements
Low	Groundwater contamination assessment report A desk study is required to identify the concerns and potential risk to groundwater or the environment, and the need for any further action to be presented in the development application. A standard format hydrogeological report would most likely result.
Low-moderate	Site investigation with monitoring A potential risk is indicated by the vulnerability map requiring site investigation and groundwater monitoring. The extent of work should involve a limited amount of site investigation, soil and water sampling and testing, definition of flow systems and reporting, in addition to a desk study.
Moderate	Detailed site investigation and monitoring For moderate vulnerability areas, or where the previous levels of investigation indicate a demonstrated risk to groundwater, a detailed groundwater site investigation is required. The work should include an ongoing monitoring program, details on the protection design factors, (natural attenuation, physical barriers, etc) in addition to the previous levels of investigation.
Moderately high	Demonstrated groundwater protection system The risk to groundwater, as demonstrated by the vulnerability map, is an area in which contamination to groundwater cannot be tolerated. The work should include a desk study, detailed site investigation, and implementation of an on-going monitoring program, as indicated above. In addition, the protection design system incorporating natural attenuation, hydraulic barriers, physical barriers etc, needs to be demonstrated, to be effective. The proposal will need to include a feasibility plan for a clean-up, in addition to a detailed monitoring and ongoing assessment program.
High	Demonstrated remedial action plan/prohibition This classification identifies the area as having a potential risk so great as to warrant a demonstrated remedial action plan. The work should include a desk study, site investigations, ongoing monitoring, plus a demonstrated remedial action plan for clean-up, which analyses the effectiveness of the remediation approach in achieving designated water quality criteria. The financial capacity of the responsible party to enact the plan should also be evaluated. In the event that the risk to groundwater is unacceptable, an activity may be banned by the responsible authority.

Source: Modified from the Australian Water Resources Council (AWRC), *Draft Guidelines for Groundwater Protection*, (1992).

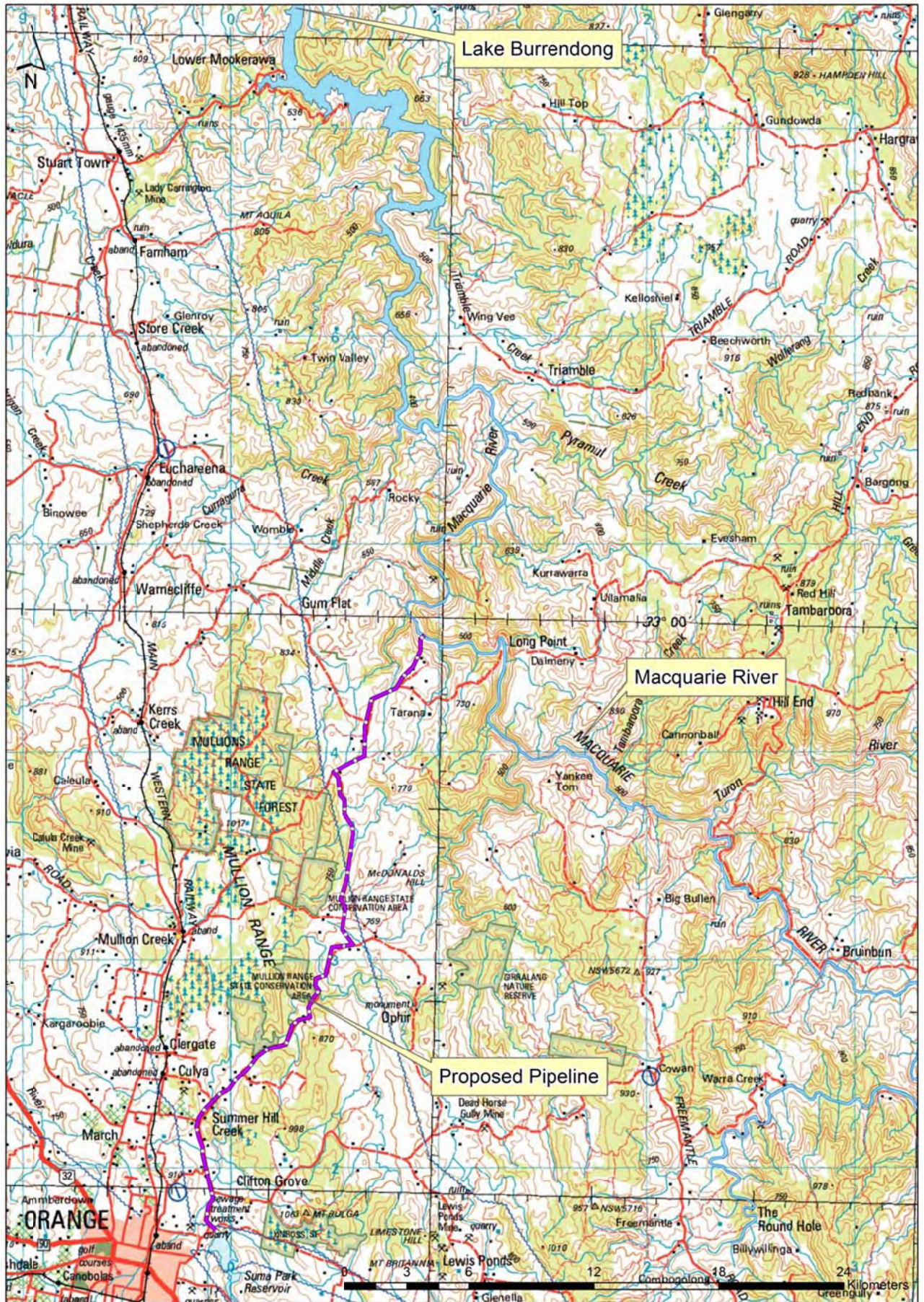


Figure 2 – Topographic Features over Proposed Route

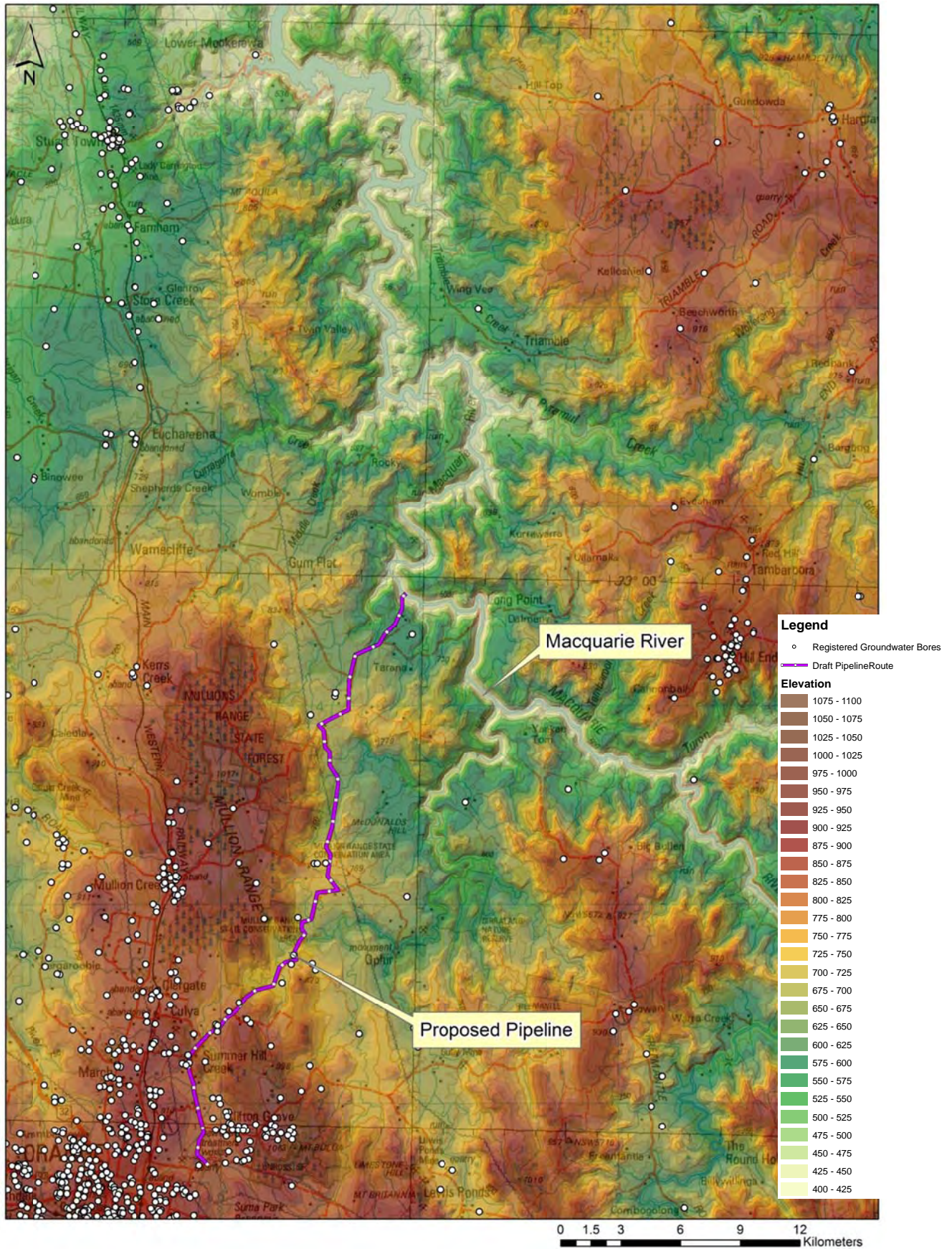


Figure 3 – Topographic conditions over proposed route, showing existing bores

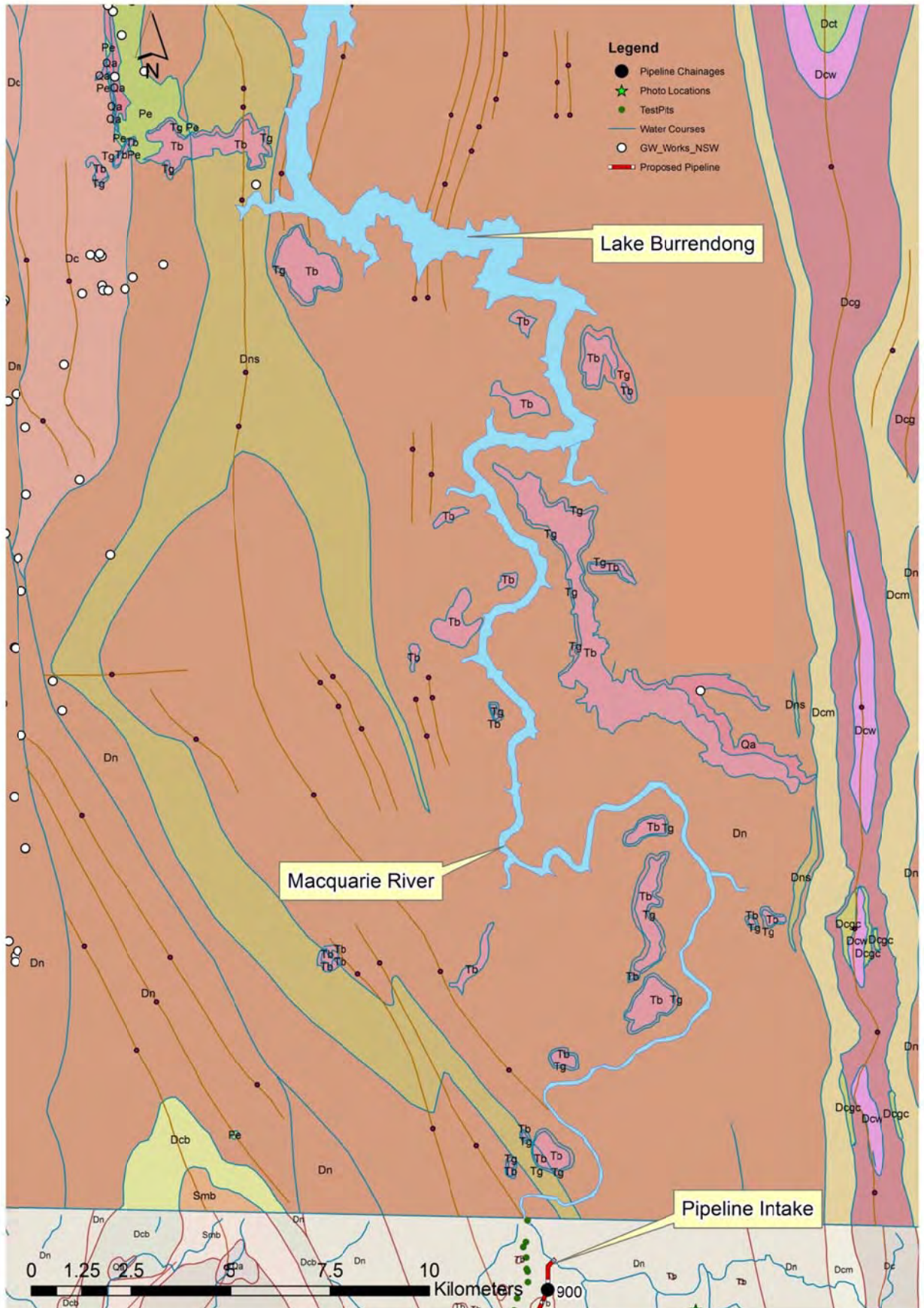
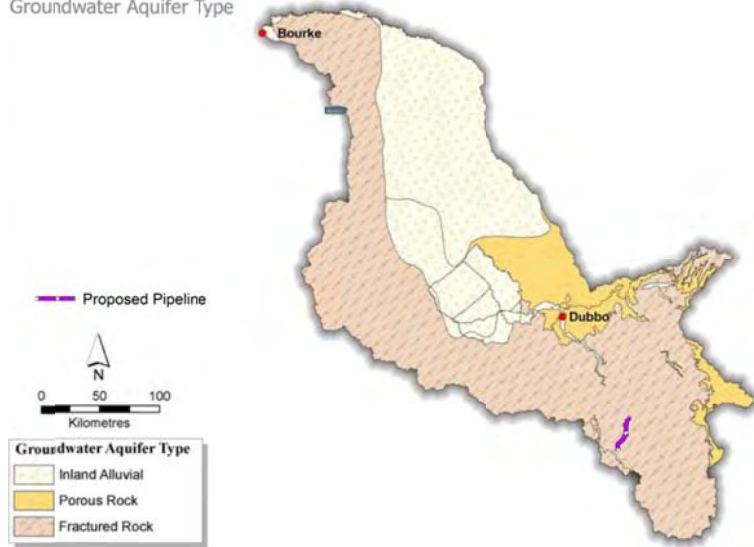
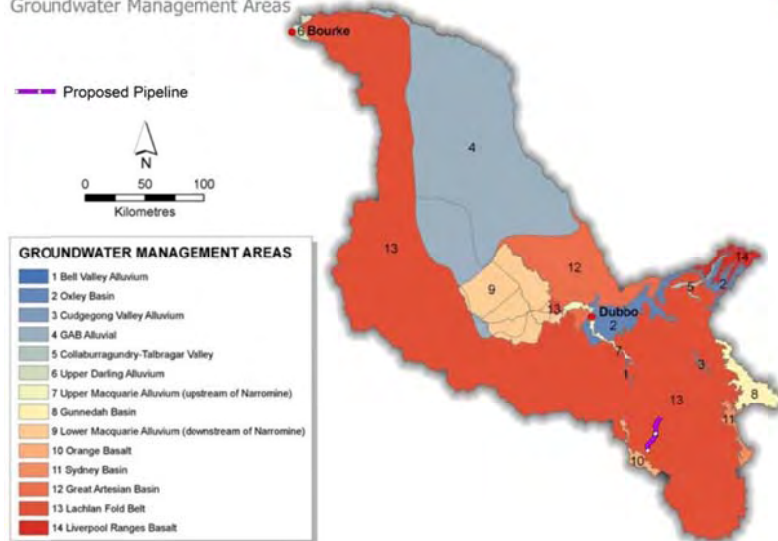


Figure 5 - Geological Conditions adjacent to Macquarie River between the Proposed offtake and Lake Burrendong, showing existing bores.

Macquarie-Bogan Catchment
Groundwater Aquifer Type



Macquarie-Bogan Catchment
Groundwater Management Areas



Macquarie-Bogan Catchment
Groundwater Suitability

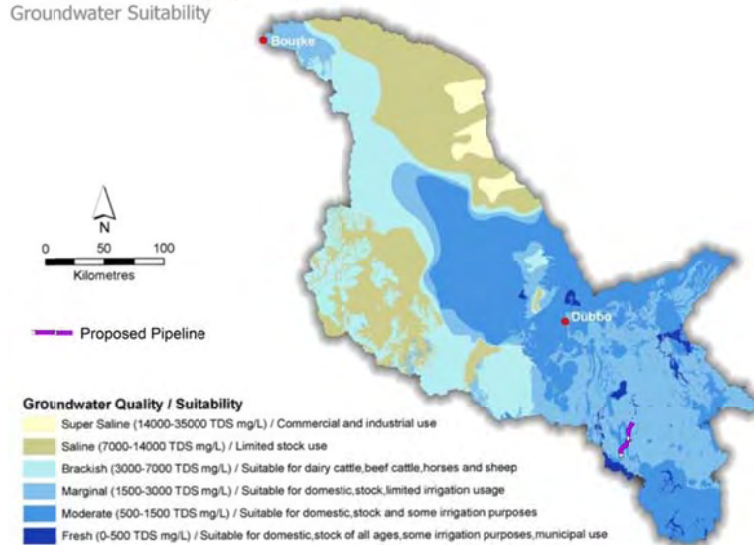


Figure 6 – Aquifers of the Macquarie Catchment (from Green et al, 2011)

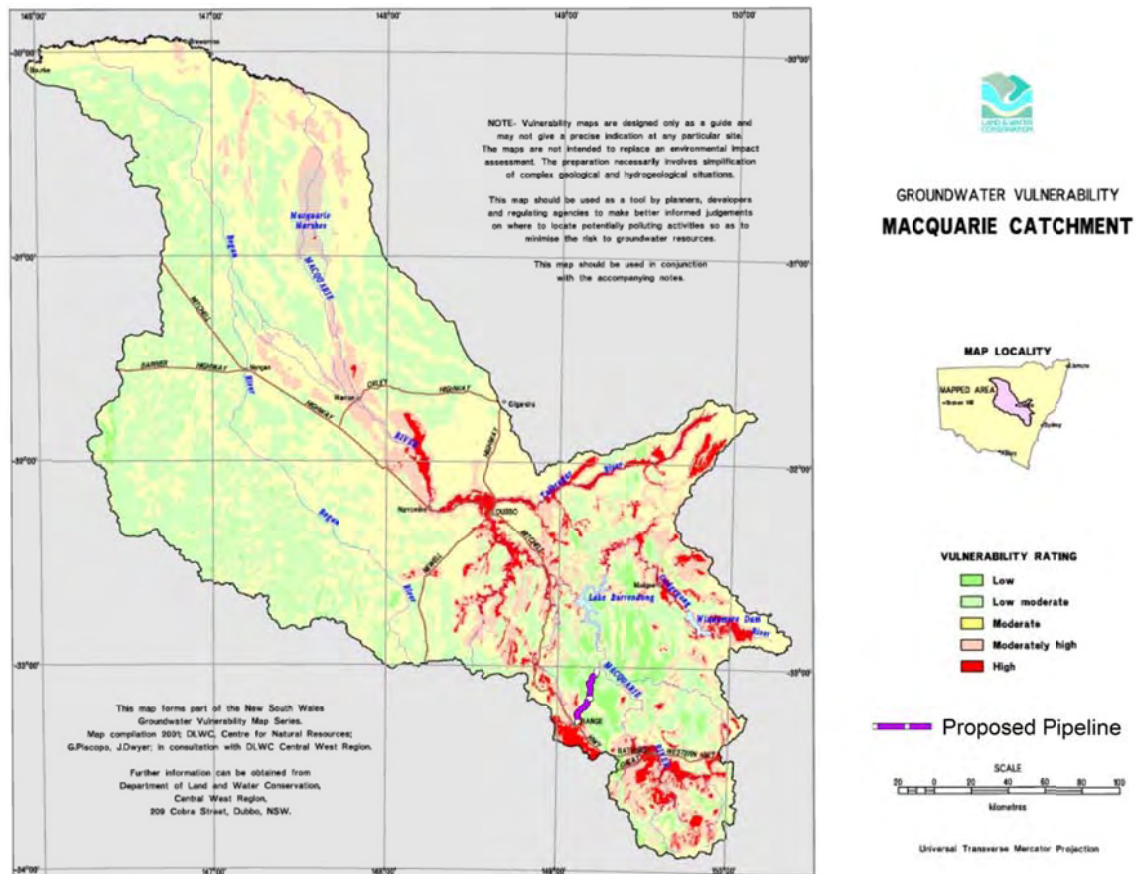


Figure 7 – Regional Groundwater Vulnerability Map

2.5 Groundwater Exchange with the Macquarie River

The nature of interactions between rivers and adjacent groundwater systems are depicted in Figure 8.

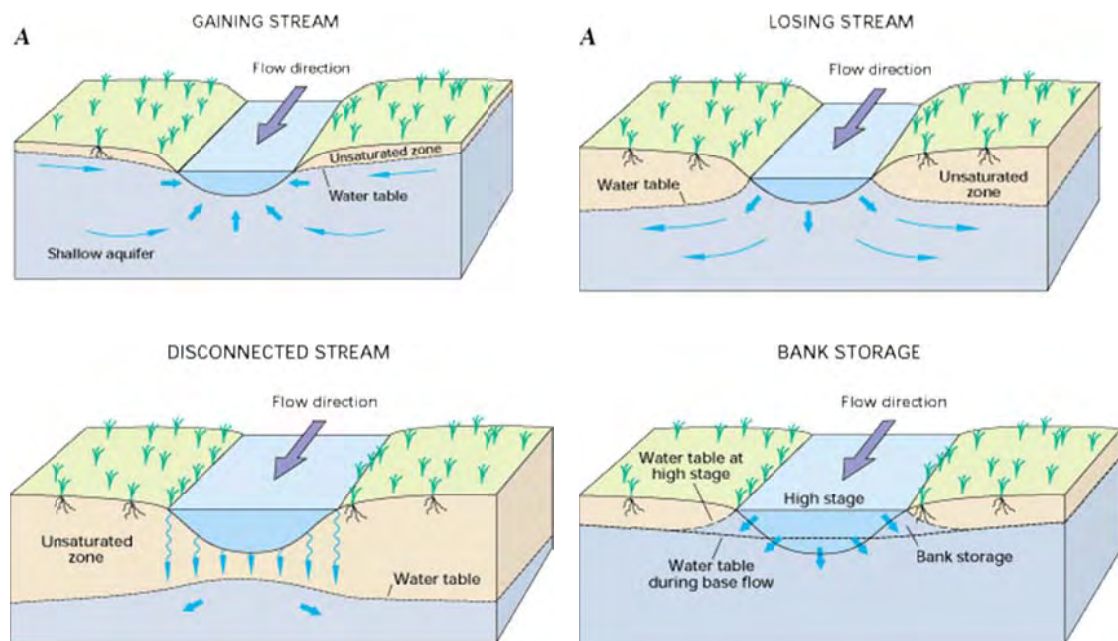


Figure 8 – Concepts of Interactions of a River and Adjacent Groundwater Systems (USGS, 1998)

Stream gauging data are current and available for the Macquarie River at the gauging site “Macquarie River at Bruinbun” approximately 33 km upstream of Long Point. A previous gauging station at “Macquarie at Dixon’s Long Point”, approximately 7 km upstream of Long Point, is no longer operational. The nearest gauging location downstream of the project is at Lake Burrendong, approximately 50 km downstream. A new gauge located approximately 4.6 km upstream of the proposed offtake was commissioned in June 2011 (Station 421192). This gauge will offer important information for ongoing management of the system.

The gauging data from Macquarie River at Bruinbun, since 1955, was obtained. The Macquarie River at this location is perennial, and a baseflow separation analysis was undertaken showing a baseflow index of 0.44. As such, it is expected that groundwater makes a net contribution to flow in the Macquarie River in the vicinity of the project. This is indicative of the ‘gaining stream’ conceptualisation shown in Figure 8, although a ‘losing stream’ situation may prevail intermittently during periods of high flow.

3 GROUNDWATER IMPACTS

3.1 En route of Pipeline

The potential impacts to groundwater resources from construction of a trenched pipeline are considered to be minor to non-existent. The trenching will affect only the upper surface and will be shallow and superficial with respect to interference of aquifer flow systems. As the pipeline is a linear feature, it does not cover a large area and is not considered to provide a risk to altering the recharge or water balance of an aquifer system.

Specifically, and in response to assessment requirements in Table 1, in this region:

- There is expected to be no requirement to intercept groundwater – trenching 1 to 2 metres depth will not intercept fractured rock aquifers, and significant shallower aquifers are not believed to be present.
- There are expected to be insignificant impacts to groundwater flow systems and aquifer water balances. Consequently:
 - impacts to Groundwater Dependent Ecosystems are expected to be small to negligible (although such ecological determinations should be undertaken by qualified ecologists);
 - impacts to groundwater users will be negligible (additionally, there are very few groundwater users in the region affected by the pipeline)
 - there is anticipated to be neutral effect on the beneficial usage category of the aquifers (additionally, the existing aquifers are understood to be of 'marginal' salinity).
- There is expected to be no requirement for substantial dewatering. Any dewatering required is likely to be superficial, associated with management of local and recent precipitation at the worksite. Based on the available data, negligible groundwater flows will occur towards the trenching site works.

The risk of a spill or contamination event occurring during construction should be subject to construction planning and management controls. The likelihood of impacts to groundwater systems from such spills has been designated to be low to low-moderate, according to regional groundwater vulnerability mapping. As such, the primary responses to spill management, such as protection of surface water resources, are likely to control the required actions, and are likely to cover the requirements for groundwater protection.

The incidence of pipe failure during operation, and the consequent transfer of water from the Macquarie River to be released to a location along the pipeline route would similarly be covered by surface water management responses. Based on available water quality data, it is considered that foreign water that did reach the aquifer near the burst location would be of limited quantity and is likely to be of comparable or superior quality to the groundwater at that location.

3.2 Groundwater Exchange with the Macquarie River

It can be seen from Figure 8 that groundwater levels adjacent to a river are affected by the stage in the river. For example, an increase in the river stage during flood will cause an increase in the groundwater level adjacent to the river. The magnitude of the change in

groundwater level is less than the change in river stage, and decreases with distance away from the river. This is shown in Figure 9.

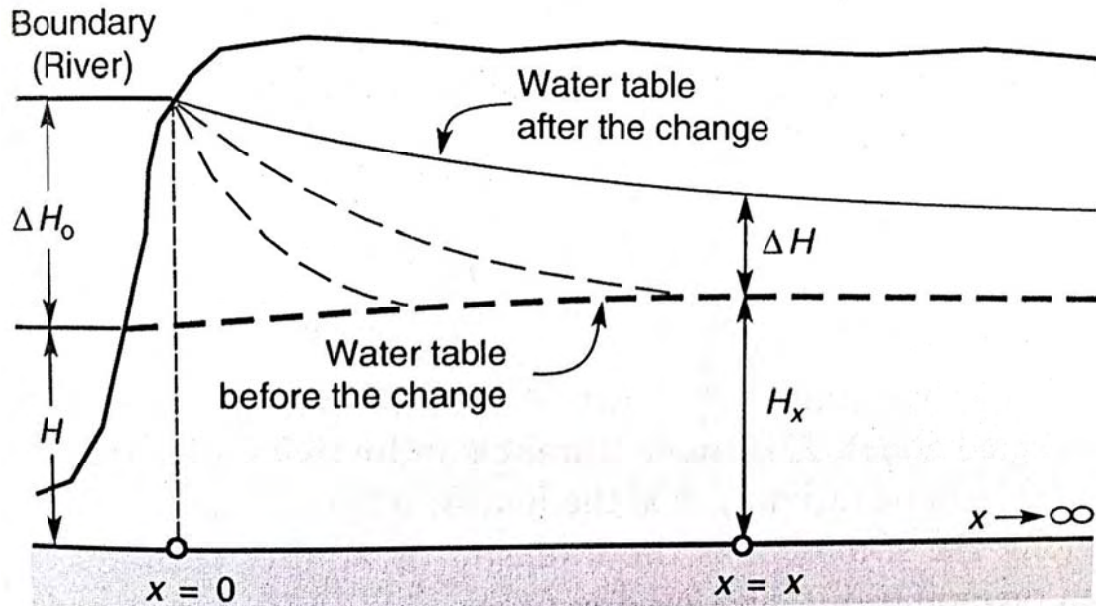


Figure 9 – Change in groundwater levels due to change in river stage (Kresic 2007)

Extraction of surface water at the proposed offtake will impact slightly on stage in the river at locations downstream of the proposed offtake. The project will not impact on surface-groundwater exchanges upstream of the proposed offtake as it will not reduce surface water discharges at locations upstream of the proposed offtake.

This decrease in stage will induce a decrease in the water table level in aquifers that are adjacent to the river. The change in the water table will be less than the change in river stage, and will diminish with distance.

It can be shown that the maximum change in river stage due to the abstractions will occur for abstractions taken during the lowest permissible river discharge. Specifically, the greatest change in stage in the Macquarie River will occur when abstractions of 12 ML a day are taken when river flows are at 34 ML/day.

The magnitude of the change in stage can be estimated using Manning's formula for open channel flow:

$$Q = \frac{S_o^{\frac{1}{2}}}{n} \cdot R_h^{\frac{2}{3}} \cdot A \quad (1)$$

Where:

Q	= discharge ($L^3 \cdot T^{-1}$)
S_o	= bed slope ($L \cdot L^{-1}$)
n	= Manning's roughness parameter (unitless)
A	= cross sectional flow area (L^2)
R_h	= the hydraulic radius (L)
	= A / wetted perimeter of flow

In model studies undertaken by Geolyse (2012), a slope of 0.0012 and roughness 'n' of 0.04 were used to represent the Macquarie River in the vicinity of the proposed offtake.

The change in river stage near the proposed offtake due to abstraction of 12 ML/day during low flows, for various assumed river widths, slopes and roughness parameters is plotted in Figure 10, which was developed using Equation (1).

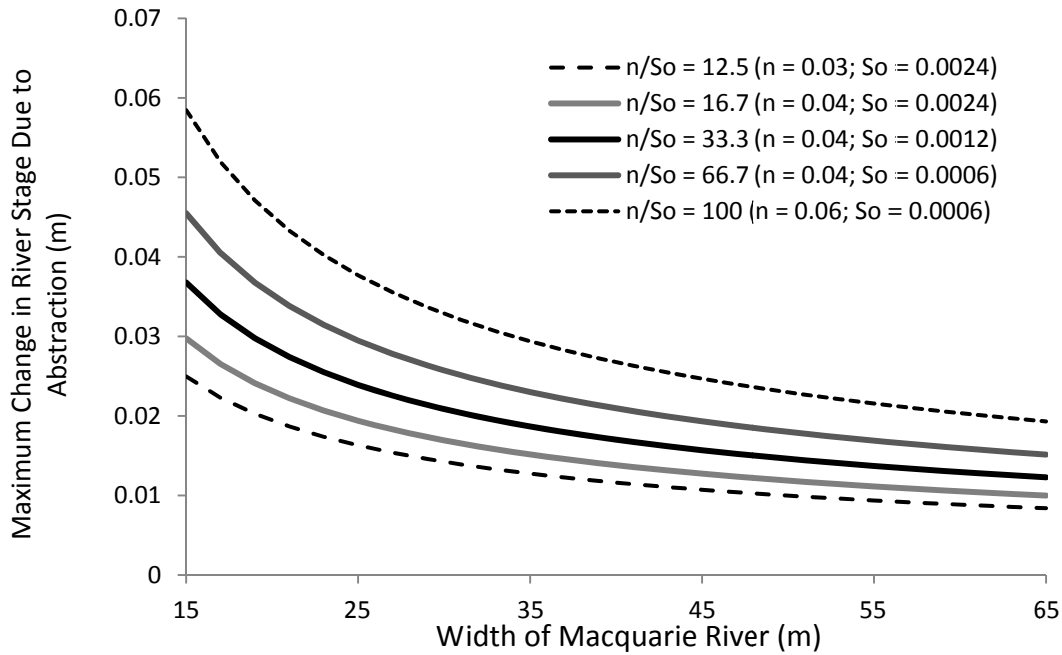


Figure 10 – Maximum Change in River Stage Due to Abstraction of 12 ML/day

It can be seen from Figure 10 that the maximum change in river stage due to abstractions of 12 ML/day is in the order of 10 to 50 mm, depending on the width of the river and roughness characteristics at any particular location. This is consistent with an estimate of 19 mm made by the consultancy Geolyse (as advised to Pells Consulting by Orange City Council). At other times (ie during higher flows) the change in stage would be less, and the changes would diminish with distance downstream until they become negligible at Lake Burrendong.

This small change in river stage would theoretically induce a small change in the groundwater levels adjacent to the river. The maximum magnitude of change in groundwater would be close to 30 to 50 mm adjacent to the river, but would diminish with distance from the river.

The transient propagation of change in groundwater levels due to a change in river stage can be estimated using Equation (2) (Kresic, 2007).

$$\Delta H_{z,t} = \Delta H_{b,t=0} \times \text{erfc}(\lambda) \quad (2)$$

Where: $\text{erfc}(\)$ is an error function
 $\lambda = \frac{z}{2\sqrt{\alpha t}}$
 z = the distance from the river (L)
 α = is the hydraulic diffusivity of the aquifer formation (L^2/T)
 t = time (T)

Equation (2) was used to examine the changes in groundwater levels due to abstractions. Based on an assumed hydraulic conductivity of $6 \times 10^{-3} \text{ m}^2/\text{s}$, the *maximum* predicted changes to groundwater level were estimated, as shown in Table 3.

Table 3 – Indicative Maximum Change in Groundwater Levels Adjacent to Macquarie River

Distance from River	20 m	50 m	100 m
Change in Groundwater Level	10 mm	2 mm	< 0.1 mm

4 GROUNDWATER IMPACT MONITORING AND MITIGATION

Based on the nature of aquifers, the nature of the project and the designation of low to low-moderate vulnerability, it is believed that groundwater monitoring along the route of the pipeline is not appropriate to support this project application.

Groundwater monitoring adjacent to the Macquarie River is not believed to be appropriate.

No special mitigation measures are considered appropriate or required for protection of groundwater resources adjacent to the pipeline route.

The only mitigation strategy that is recommended is, in the case of a major spill during construction or major pipeline breakage, a qualified hydrogeologist should be engaged to review the event, and to determine the nature of groundwater related responses that are required, if any.

5 RELEVANT STATUTORY POLICY AND GUIDELINES

The following policies are commented on with reference to the project.

5.1 Relevant Policy

The letter from NSW Office of Water (reference 11) provides reference to the NSW Groundwater Policy Framework Document - General (August 2007), but only a 1997 document by the same name was found on the web link provided.

This policy promotes sustainable resource usage, holistic assessments and adaptive management, and provides the over-riding policy for the documents below (Sections 5.1.1 and 5.1.2 below). It also states that management of a groundwater resource should be commensurate with the level of threat the groundwater system is subject to (pg 8.). Similarly, special protection should be provided to regions with significant environmental and/ or social values. The policy also promotes integrated management of surface and ground waters.

5.1.1 NSW Groundwater Quality Protection Policy (1998)

The principles items in this policy document which are considered relevant are discussed in turn:

Protection (or improvement) of the existing beneficial usage category of the existing groundwater resources.

It is considered that the proposed pipeline introduces very slight to negligible impacts on groundwater resources along the route of the pipeline. As such, the degree to which the existing beneficial usage category must be defined is considered to be low. Based on available data, the groundwater resources along the route of the pipeline are considered to be useful for limited irrigation and stock watering. It is considered that this beneficial usage category of aquifers en route of the pipeline will not be lessened by the proposed project.

Special protection to town water supplies

No town water groundwater supplies are accessed from aquifers en route of the pipeline. The town water supplies in the Orange basalts will not be affected by the pipeline construction.

Prevention of groundwater pollution

With respect to the consideration of aquifer vulnerability, the risk of groundwater pollution for aquifers en route of the pipeline is considered to be low. Controls of pollution risk activities will be imposed as part of the construction management plan, and no further special controls have been placed with consideration to groundwater.

Scale of groundwater protection to be commensurate with the risk a development proposes.

The assessment of groundwater protection has considered the risk, the groundwater vulnerability and the beneficial usage of the groundwater system. It is considered that the a