Integrated Water Cycle Management Strategy

LOGOS Kemps Creek Logistics Project

Achieving new levels of Water and Environmental Sustainability

Estate Layout Plan prepared by *Axis architectural*

Report prepared for LOGOS Property
by Aquacell Pty Ltd with input from

- Woodlots and Wetlands Pty Ltd
- Bucken Lysenko Consulting

23rd June 2011

Overview

The LOGOS Kemps Creek Logistics Project, located in western Sydney, aims to set a new standard for environmental innovation and water management of industrial warehousing/distribution developments. The site when developed, will be almost totally self reliant for its water/wastewater needs, and therefore will not require any connection into Sydney Water's external infrastructure beyond a single domestic household sized potable water tap. The very high level of water sustainability will be achieved by employing such strategies as harvesting and treating roof water for potable supply (including drinking water), treating and recycling sewage with an advanced on-site treatment plant, and managing storm water run-off through constructed bio-retention ponds.

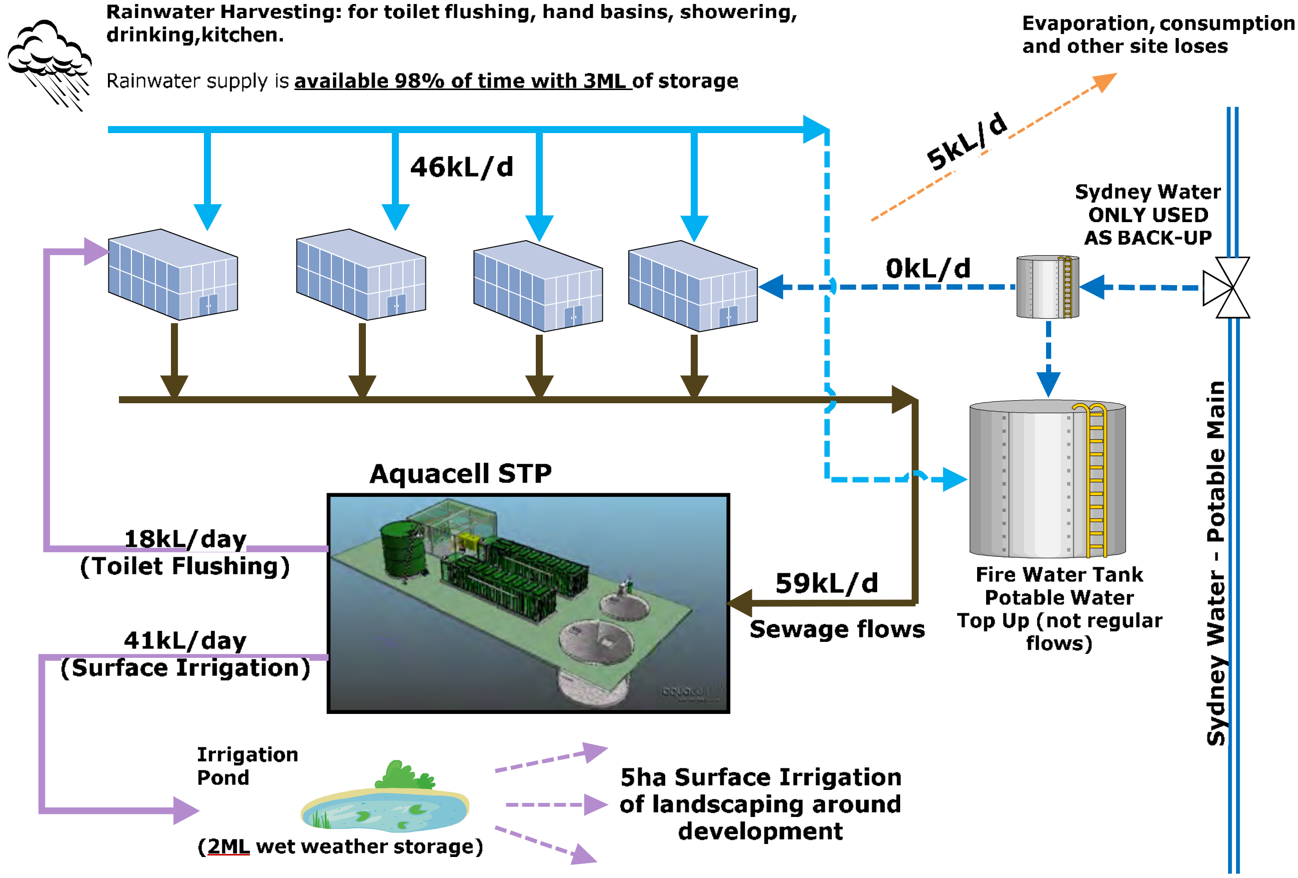
The detailed independent modelling that was undertaken to analyse the site's sustainability measures, demonstrated that with the provision of 3ML of rainwater storage, potable water supplies can be fully satisfied by internal sources 98% of the time. In the 2% of time that rainwater can't meet all potable needs (e.g. during periods of drought years), a single 20mm domestic connection into the property from Sydney Water will be sufficient to meet the necessary requirements. The net amount of water needed from Sydney Water to supplement the rainwater harvesting during these times will only be 322 kL per year, which is an equivalent to that used per year by a single household with moderately sized gardens, and 2 adults plus 3 children in residence. That is, the entire development has a similar annual demand to that of a single dwelling.

The site demand under the completed development will not increase from the current status.

All sewage from the site will be collected and treated by an on-site treatment plant, which will be totally independent of any Sydney Water sewerage infrastructure. The treatment process will produce recycled water with a very high quality so that it can be safely reused on site for surface irrigation of the development's landscaping and also for flushing toilets – thereby further lowering the site's net water demand.

The stormwater management system is designed to reduce peak outflows to rates less than predevelopment conditions, while the expected pollutant yield in the stormwater is less than 40% of that from a conventional industrial development.

A summary of the water/wastewater balance results for the LOGOS site is schematically shown on the following page.



LOGOS Kemps Creek Logistics Water Balance - Summary

Roof water supplies all in building reuse, except toilet flushing (supplied by treated effluent)

The sites sustainability measures also extend to the fire service infrastructure. The 2 x 650m^3 sprinkler tanks and 2 x 216m^3 hydrant tanks will be filled from the internal 3ML potable water supply which will meet all authority requirements. Calculations have shown that there are sufficient pressure/flows available to meet the fire service requirements.

Details of the sustainability measures proposed for the LOGOS Kemps Creek Logistics Project have been compiled with input from various experts to ensure that the water/wastewater management strategy is based on a thorough and robust design basis. The calculations and assumptions that form the foundations of the integrated water cycle management strategy are detailed in three key appendices.

- **Appendix A - Water and Wastewater Management Strategy** – Aquacell Pty Ltd is the company that will responsible for establishing and operating the proposed sewage treatment Plant. This report describes the regulatory requirements, detailed health based risk analysis, and process description of the proposed treatment plant.

- **Appendix B - Water Cycle Investigations** – Dr Peter Bacon (Woodlots and Wetlands Pty Ltd): water use, agronomy and rainfall analysis for LOGOS site.

- **Appendix C - Stormwater Management Plan** – prepared by Buckton Lysenko Consulting

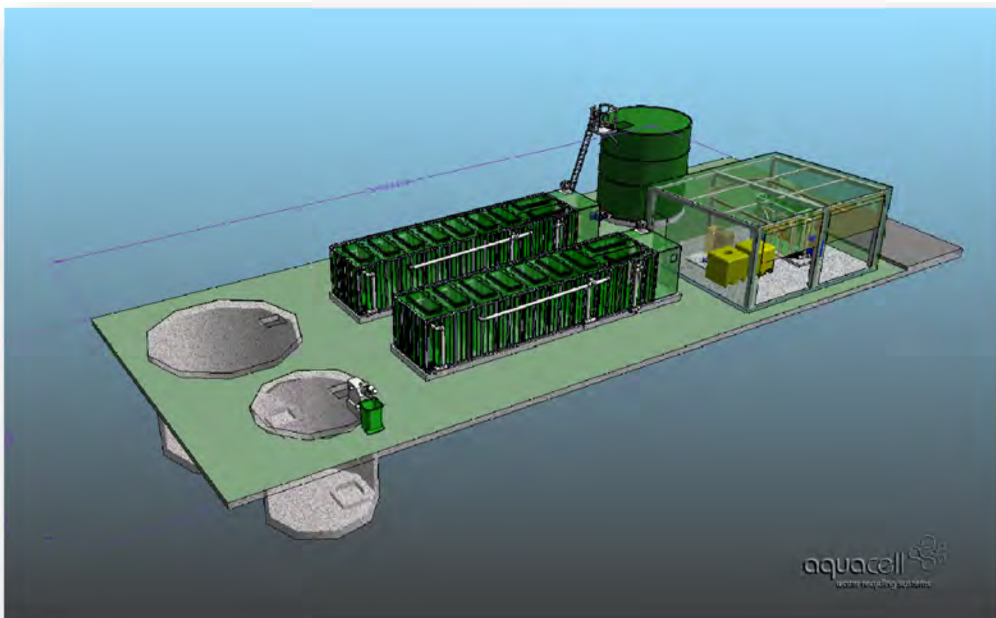
Appendix A – Water and Wastewater Management Strategy

Aquacell Pty Ltd

aquacell
water recycling solutions

Water and Wastewater Management Strategy

LOGOS KEMPS CREEK LOGISTICS PROJECT



Developer: Logos Property

Location: Kemps Creek, NSW

Date: 23rd June 2011

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1 Executive Summary

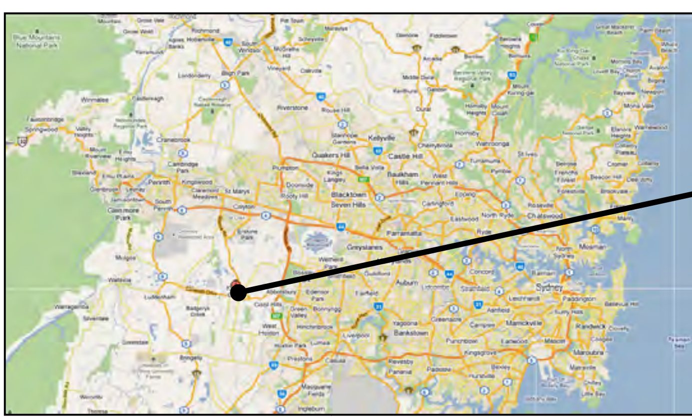
Aquacell was commissioned in May 2011 to support Logos Property investigate the strategic infrastructure that is required to sustainably manage water/wastewater from the Logos Kemps Creek Logistic project without reliance on Sydney Water's sewerage system or potable supply. The Logos site is located at Kemps Creek, NSW (see regional map below) and has an area of approximately 50ha. It is expected that the development will predominantly comprise warehousing and distribution offices/facilities, and may eventually have up to 1600 persons on site per day.

Wastewater generated from the site will be treated by an Aquacell decentralised sewage treatment plant. It will produce recycled water of a very high quality that will be suitable to safely irrigate common landscaping with sprinklers and to be reused in buildings to flush toilets. During rain periods, the recycled water will be held in a 2ML storage pond rather than be irrigated The size of this "wet weather" storage pond was designed so that environmental discharge into local watercourses will not occur more frequently than 1 in 2 years, which is in line with the *Environmental Guidelines: Use of Effluent by Irrigation* (2004) NSW DEC.

The potable water supply to Logos Kemps Creek Logistic project will be sourced from rainwater harvesting. All rainwater will be treated with a separate ultra-filtration / UV disinfection unit to ensure compliance with Australian drinking water standards and State legislation. Modelling has shown that if 3ML of storage is provided on site to capture and store rain runoff from all available roof area, then this will be sufficient to supply all potable water with 98% reliability. During the rare occasions that drought conditions limit supply, Sydney Water will be used as a backup, but this will not be the usual operational situation.

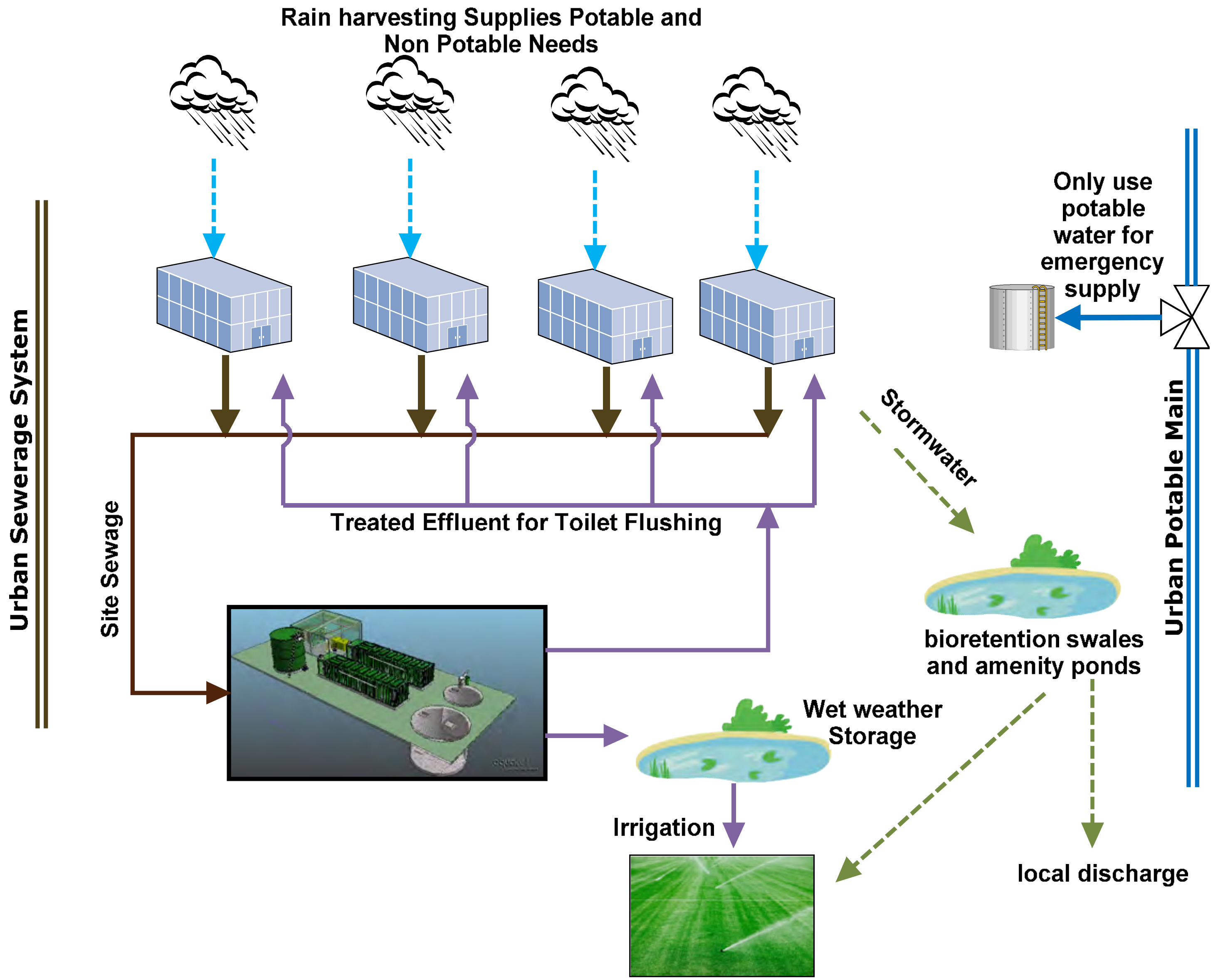
The data analysis in this Water Balance was prepared by an independent agronomist, Dr Peter Bacon of Woodlots and Wetlands Pty Ltd. His full report is provided in appendix B. The approach put forward for the LOGOS Kemps Creek Logistics Project will not require reliance on Sydney Water's infrastructure. A schematic of the water/wastewater flows are provided on the following page, however the general findings of this assessment concluded:

- The site's total water demand at full development is expected to be about 64 kL/day.
- 59kL/day of wastewater is produced from the site that would be treated by an Aquacell on-site Sewage Treatment Plant.
- The treated recycled water will be disposed of by irrigating 5ha of landscaped area of the development, with the option to also use it for toilet flushing at the facilities. The site's master plan shows that a total of 7.5ha of irrigation area is available, without considering stormwater management detention basins/ponds. Wet weather storage with a capacity of 2ML will ensure that environmental overflows only occurs in less than 50% of years, depending on the reuse strategy adopted.
- Rainwater will be harvested from all the available roof area, which will supply up to 46kL/day for potable water supplies. 3ML of rainwater storage will secure water availability from rainwater for 98% of the time.



Aerial View of LOGOS Kemps Creek Logistics Project Site – May 11 (Sourced from Nearmaps.com)

Regional Location of LOGOS Kemps Creek Logistics Project (Sourced from Google Maps)



Rain harvesting Supplies Potable and Non Potable Needs
Urban Sewerage System
Site Sewage
Treated Effluent for Toilet Flushing
Stormwater
Only use potable water for emergency supply
Urban Potable Main
bioretention swales and amenity ponds
Wet weather Storage
Irrigation
local discharge

Fire Service Needs for Sprinkler and Hydrants.

In addition to water/wastewater infrastructure requirements of the site, additional fire service infrastructure is also needed which will comprise:

- Sprinkler Service : Two storage tanks of 650 cubic meters will be require to meet the requirements for the storage of Class 1 to 4 goods in the warehouses.
- Hydrant Service: Two storage tanks of 216 cubic meters will meet the requirements for the hydrant system.

The sites sustainability measures also extend to the fire service infrastructure. The 2 x 650m^3 sprinkler tanks and 2 x 216m^3 hydrant tanks will be filled from the internal 3ML potable water supply which will meet all authority requirements. Calculations have shown that there are sufficient pressure/flows available to meet the fire service requirements.

2 Regulatory Background – Water and Wastewater Services

The NSW Water Industry Competition Act provides the regulatory framework to allow the private sector to deliver a decentralised water and wastewater treatment solution for the LOGOS Kemps Creek Logistics Project, independent of Sydney Water infrastructure and without having to obtain approval from Sydney Water.

2.1 Background of Act

The NSW Government introduced the Water Industry Competition Act 2006 (WICA) as part of its strategy for a sustainable water future to harness the innovation and investment potential of the private sector in the water and wastewater industries. At the same time, the Act establishes a licensing regime for private sector entrants to ensure the continued protection of public health, consumers and the environment. A corporation (other than a public water utility) must now obtain a licence under the Act to construct, maintain or operate any water industry infrastructure or to supply water (potable or non-potable) or provide sewerage services by means of any water industry infrastructure.

The LOGOS Kemps Creek Logistics Project Water and Wastewater infrastructure will require a WICA license to install and operate. This licence is required before any sewerage or water infrastructure commences construction on site, which includes all pipework associated with the treatment Plant, not just the treatment Plant equipment.

2.2 Who should Apply for a licence

The applicant must satisfy IPART/Minister of Primary Industries (responsible for the Office of Water), that they have the technical, financial and organisation capacity to be granted a licence. The Logos project will engage Aquacell, who already have secured previous a WICA licence, to establish, operate and manage the regulatory compliance associated with the decentralised scheme.

2.3 What Aspects will be Assessed with a WICA operators and retail licence.

(comments paraphrased from IPART's Combined How to Apply Guide - Network Operator and Retail Supplier - http://www.ipart.nsw.gov.au/water/private-sector-licensing/scheme-documents.asp)

IPART will conduct a detailed assessment of the licence application. Broadly, licence applications will be assessed against the following requirements, in accordance with section 10(4) of the WIC Act:

- that the applicant has, and will continue to have, the capacity (including technical, financial and organisational capacity) to carry out the activities that the licence (if granted) would authorise
- that the applicant has the capacity to carry out those activities in a manner that does not present a risk to public health;
- that the applicant has made, and will continue to maintain, appropriate arrangements with respect to insurance;
- in the case of an application for a licence to supply water (ie, a Retail Supplier's Licence) that, if such a licence is granted, sufficient quantities of the water supplied by the licensee will have been obtained from a source other than a public water utility;
- that the applicant has the capacity to carry out the activities that the licence (if granted) would authorise in a manner that does not present a significant risk of harm to the environment; and
- such other matters as the Minister considers relevant, having regard to the public interest.

In considering the licence application, IPART will also have regard to the following licensing principles, in accordance with section 7 of the WIC Act:

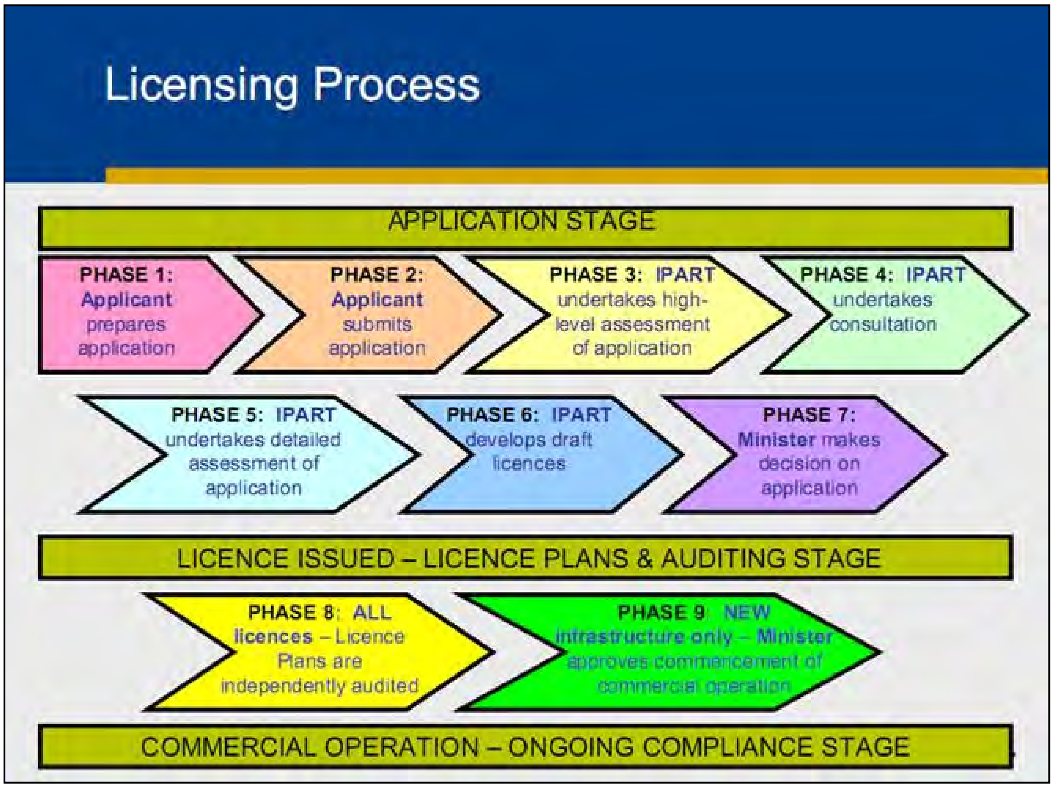
- the protection of public health, the environment, public safety and consumers
- the encouragement of competition in the supply of water and the provision of sewerage services
- the ensuring of sustainability of water resources, and
- the promotion of production and use of recycled water.

2.4 Application Process

A schematic summarising the application process is given on the following page. Key things to note:

- Application preparation by Aquacell (documentation) ~2months, based on past experience of pulling together the information that is required to satisfy IPART.
- Once submitted, the application goes out to consultation (Phase 4). This includes ministerial request for comment from several departments, plus public comment.
- After a licence is issued, installation can then take place.
- Prior to operation, an independent audit of the Plant must be undertaken (Phase 8), after which the licence goes back for ministerial sign off before reuse can occur.

Total Approval Process timeframe – ~2months to prepare the application; 6-8months to assess licence; probably about another 3months post operation to get final sign off before commercial reuse can commence. Because a license will take 8-12months to secure a licence before installation can commence on site (STP /associated Pipework), it is important to start the application process ASAP in the project cycle so that it does not hold up other construction activities on site. The WICA licence process can be done in parallel to or prior to finalising DA arrangements.



There is often a concern raised about private companies providing essential infra-structure, particularly in regards to what happens to the infrastructure/service if the private company can no longer deliver services. Firstly it must be understood that there are thousands of case examples around the world of private sector companies successfully delivering essential water/wastewater services from the small development through to large municipal schemes. What is being proposed for the LOGOS Kemps Creek Logistics Project is therefore not new. Under the Water Industry Competition Act, private companies are independently assessed not only for their technical capability, but also on their financial capability to operate a scheme in the long term. The financial viability of a scheme and a company's ability to deliver it, forms a core part of the criteria to whether or not a WICA licence is granted. Although there is never 100% guarantees of what the future holds, the independent government financial assessment undertaken with a WICA licence, gives developers and planning regulators a high level of confidence that the scheme will be set up with a safe pair of hands. Of course, the question is always asked about "what if...". If a company is granted a license and at some point in the future is no longer able to deliver the water/wastewater essential services, there is provision under the WIC Act for the Minister (Office of Water) to declare an operator of last resort to take of over the operation. In the unlikely scenario that this eventuates, it is reasonable to assume that one of the other WICA licensees will eagerly step in to fill the role; in a similar manner as what would happen with other private schemes around Australia and the world.

2.5 Protection of the Environment Operations (POEO) Act 1997

Activities that are deemed to be "scheduled" will require an environmental licence under the POEO Act. Sewage Treatment systems are required to have an Environmental Protection Licence where they processes more than 2,500EP per day (schedule 1, clause 36 (2)) or where the capacity of the Plant exceeds 750kL/day (schedule 1, clause 36 (3)). The STP at the Logos Kemps Creek Logistics project will have a capacity of approximately 60kL/day, which is therefore well below the prescribed limit requiring an EP licence.

3 Aquacell Experience

Aquacell is a company that specialises in decentralised blackwater and greywater schemes for commercial developments. We have a range of experience in different types of developments including Aged Care Facilities, Resorts, commercial offices, sports clubs, universities, and multi-dwelling apartments.

Specific projects that highlight our experience in operating Blackwater reuse Plants include:

- **Blacktown Workers Club**, **Sydney** –The Blacktown Workers Sports Club is located on the Harold Laybutt Sporting Complex and features the club, two soccer fields, two rugby league fields/cricket ovals, two bowling greens, five all-weather tennis courts and a baseball diamond as well as a 120-room hotel. The sporting complex is host to over 7,000 sports players. We have had a 100kL/day blackwater reuse Plant servicing this facility since 2006, when it was the first private sector on-site blackwater recycling operation in NSW. The Aquacell Plant treats blackwater from the Sports club (restaurant, gaming venue, conference centre), to a level that allows it to be used to surface irrigate the sports fields at the club. The project was initially instigated due to Sydney Water not provide sufficient water for them to sustain the upkeep of their sports grounds, which it has not had issues with since commencing blackwater ruse.

- **Liverpool Catholic Club & Mecure Inn**, **Sydney -** The Liverpool Catholic Club located in Sydney's south west includes a licensed club, café, bistro and restaurant, hotel, gymnasium, ice-skating rink, mini-golf, BMX track, hairdresser, butcher and a Mecure Hotel. 100kL/day of blackwater and greywater from the complex is treated to irrigate two football fields, a cricket pitch and be used in the Mecure Hotel for toilet flushing.

- **Canberra Airport, ACT -** Canberra Airport is the site of some of Australia's newest and most ecologically sustainable buildings and winner of the Australian Airports Association 'Capital City Airport of the Year 2007'. Aquacell worked with the airport to develop a scheme for recycled blackwater. The result is a 50,000 l/day blackwater recycling plant that currently delivers recycled water to the commercial building for toilet flushing.

- **RMIT, VIC –** Aquacell has recently installed a 6kL/day blackwater reuse system at RMIT, Melbourne. The treated water will be used in a fountain on campus, and possibly for irrigation in the future. We expect to have full approval to commence reuse activities in the next couple of months, in which Aquacell will become one of the first private schemes to gain full EPA approval to operate a blackwater reuse Plant in Victoria (there are some government based reuse schemes, but very few if any private schemes).

In addition to these blackwater reuse projects, Aquacell has also been awarded a 130kL/day sewer mining project for Dexus' 6 star building at 1 Bligh St. For this project we have secured a NSW Water Industry Competition Act (WICA) operators and retail licence for this project which will allow us to provide a long term operational contract to the client. Aquacell is one of the few companies with a WICA approval – see NSW IPART Web site - http://www.ipart.nsw.gov.au/water/private-sector-licensing/licence-applicants-holders.asp?view=holders. The Bligh St project is currently practically completed (i.e. installed and potable water commissioned) and is now waiting for regulatory approval to operate later in 2011.

Another recent high profile project that we have been awarded is for ANU in Canberra, which requires a 90kL/day blackwater reuse Plant. The ANU project is also scheduled to be completed mid 2011.

These projects highlight Aquacell's specific experience in delivering turn-key solutions for commercial blackwater reuse projects.

In addition to the blackwater experience already mentioned, Aquacell's experience in commercial grey water treatment makes us one of the leading companies in Australia for delivering greywater solutions.   We have a number of Greywater Plants in various stages of construction, approval and operation around Australia. The Table below lists our current contracts.

K2	G10	Windsor (Melbourne), VIC	Public Housing – Residential apartments
Birrigai	G5	Tidbinbilla, ACT	School outdoor education centre
Pinctada	G20	Broome, WA	Resort
Lot 6, Prince Henry at Little Bay Development	G10	Sydney, NSW	Green star, residential apartment block
Lot 7, Prince Henry at Little Bay Development	G10	Sydney, NSW	Green star, residential apartment block
Lot 11, Prince Henry at Little Bay Development	G20	Sydney, NSW	Green star, residential apartment block
Lot 13, Prince Henry at Little Bay Development	G20	Sydney, NSW	Green star, residential apartment block
Lot 18, Prince Henry at Little Bay Development	G10	Sydney, NSW	Green star, residential apartment block
Childers Square	G5	ACT	Commercial Offices
City West	G20	ACT	Commercial Offices
40 Mount St (ARK)	G10	North Sydney, NSW	Commercial Offices
RSL Care	G20	Rockhampton, QLD	Aged Care
King George Central	G10	Brisbane, QLD	Commercial Offices
Star City Casino	G100	Sydney, NSW	Casino
111 Eagle St	G10	Brisbane, QLD	Commercial Offices
Hamilton Harbour	G20	Brisbane, QLD	Residential, Commercial development

Note G5~5kL/day; G10~10kL/day; G20~20kL/day.

4 Wastewater Treatment Infrastructure

It is predicted that approximately 59kL/day of sewage would be produced if the development eventually reaches a 1600 person per day capacity. An Aquacell sewage treatment plant will be established to treat all of the effluent to a very high level so that it can be safely reused on-site. The resulting recycled water from the treatment plant will be pumped to: either of the two recycled water storage lagoons (with a total capacity of 2ML); or delivered into the buildings for toilet flushing. Up to 5ha of landscaped area will be irrigated with the treated recycled water that is taken from the on-site storage lagoons. Sizing the recycled water storage lagoons with a capacity of 2ML will provide sufficient buffering volume to ensure that environmental overflow do not occur more than 50% of years. A fifty percentile allowable run off has been adopted by the *Environmental Guidelines: Use of Effluent by Irrigation* (2004), Department of Environment and Conservation (NSW) – p39, which states:

> *"As a general guide, for low strength effluents, uncontrolled releases may be permitted in 50 percent of years."*

In the rare occasions that the storage ponds completely fill during prolonged rain events, the treated recycled water will overflow to the stormwater detention basins. Storage volumes are designed so that overflow to storm water detention basins does not occur more frequently than once every 2 years.

During the early stages of the development, the sewage flows are expected to be much less than the long term predictions (59kL/day). Lower wastewater production will also reduce the area required to dispose the recycled water. The Aquacell STP solution proposed has the flexibility to handle low flows during the initial years of development.

No significant trade waste or industrial wastewater production will be generated from the Logos project because the development is expected to only comprise warehousing and distribution activities. Any small quantities of trade waste wastewater generated for the development or the STP operation (e.g. sludge removal from the STP) will be removed by a licensed waste contractor from the site, rather than be processed by the on-site sewage facility.

4.1 Approach

Aquacell's design philosophy is based on the Australian *Guidelines for Water Recycling: Managing Health and Environmental Risks (2006)*. These guidelines provide a framework to guide recycle projects from concept to delivery so that they are executed in a manner that protects public health and the environment. The AGWR is based on a risk management approach which involves actively identifying and managing risks step by step. The AGWR is referenced in various State Government legislation throughout Australia, including the NSW Water Industry Competition Act.

4.2 HAZOP/HACCP

About 80-90% of the way through the design process, Aquacell will arrange a HAZOP/HACCP workshop to assess project design and operation risks, prior to finalising design. The client, client representatives will be invited to contribute to this workshop so as to ensure that thorough due diligence has been employed in the design phase.

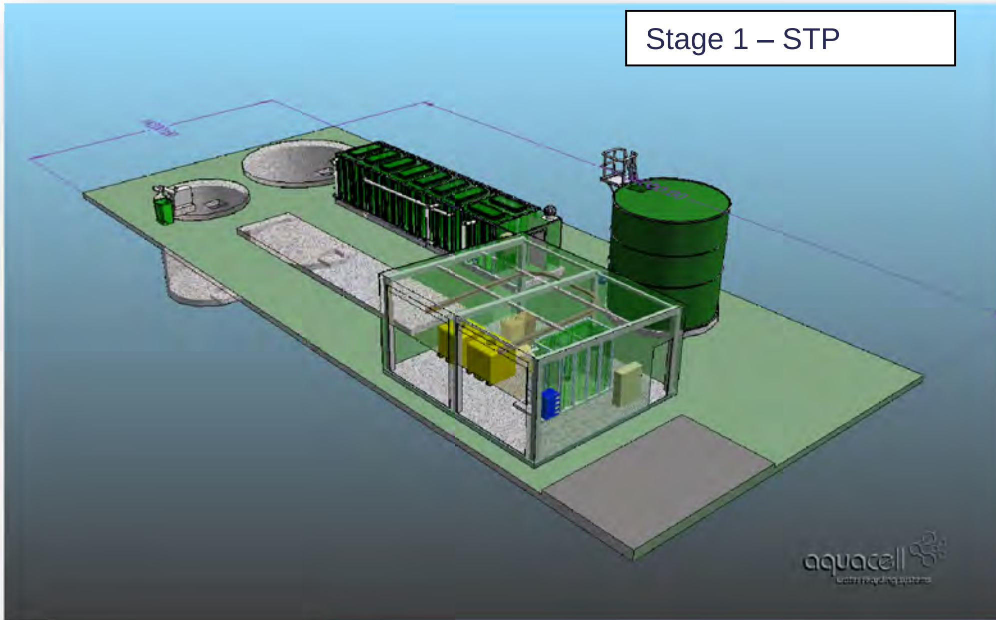
4.3 Treatment Plant Overview

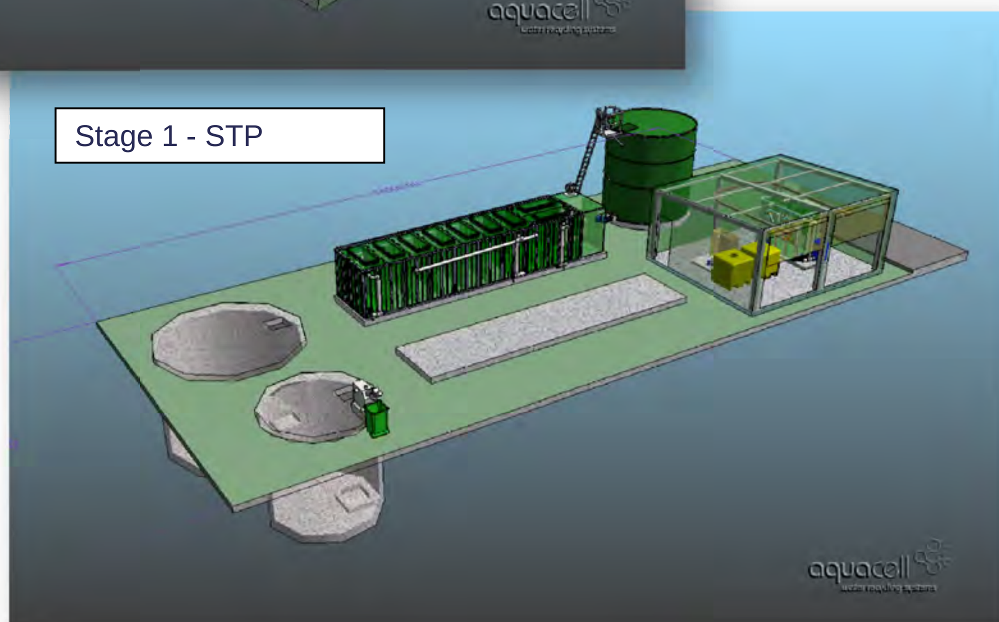
The STP treatment Plant proposed for the LOGOS Kemps Creek Logistics Project will comprise two modular Membrane Bioreactor (MBR) stages, each with a capacity of approximately 40kL-50kL/day. The staged approach delivers the maximum amount of flexibility to allow the STP to grow to meet the developments needs.

The treatment process proposed will consist of the following components:

1. Mechanical screening, screening compaction and encapsulation
2. Anoxic equilisation/buffer tank with peak overflow tank
3. Membrane Bioreactor with Ultrafiltration membranes
4. UV & chlorine Disinfection
5. Blue dye addition to the recycled water that is reused for toilet flushing – cross connection protection

A concept design of the proposed Stage 1 and Stage 2 STP is given on the following page, with a more detailed explanation of the equipment provided after this. Dimensions of the Plant are shown in Appendix B.


Stage 1 – STP
aquacell


Stage 1 - STP
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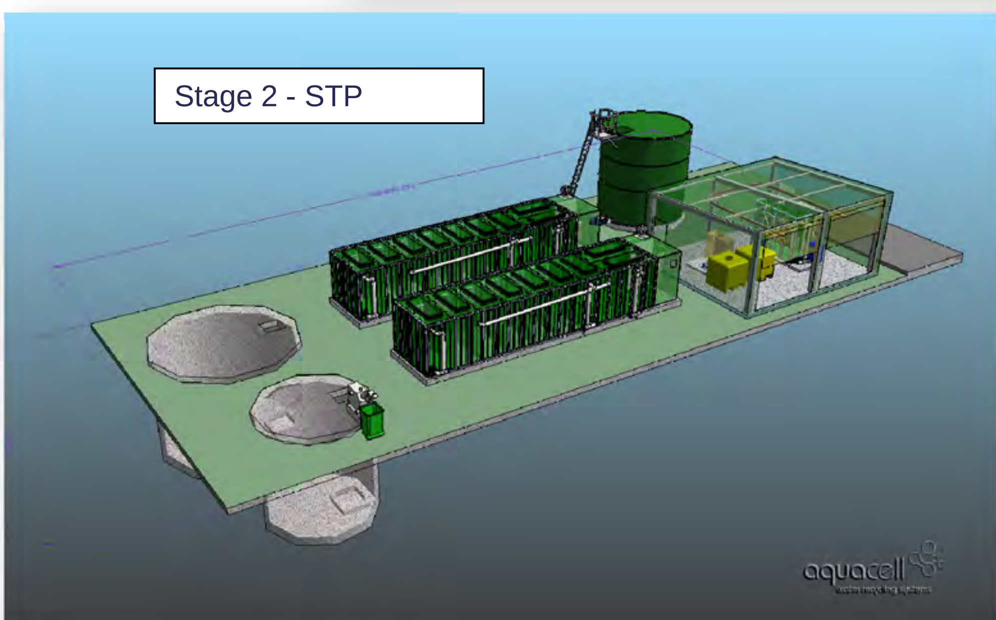
Stage 2 - STP
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4.4 Wastewater Treatment Process Risk Assessment

4.4.1 Introduction

The aim of the risk assessment is to assess the risks associated with reusing the treated recycled water for surface irrigation and in-building toilet flushing, and then to make sure that an appropriate treatment process is put in place to manage the risk. The approach is formalised in a number of discrete risk assessment steps.

1. Assess the potential human health risk that may be caused by reusing blackwater at the LOGOS Kemps Creek Logistics Project . The information in this report is based on assessing the risk for surface irrigation of development parks/landscaped areas and toilet flushing.
2. Show how the proposed treatment process meets the calculated “risk” associated with the treatment and reuse scheme. Each treatment component will reduce the virus/bacteria/protozoa by a certain amount, which is technically referred to as “log credits”. A log credit is the order of magnitude that a treatment process can remove a particular pathogen. For example, a 2 log credit for virus, will remove the virus in the effluent by 99%. A 4 log credit for virus will remove virus in the effluent by 99.99%. It is assumed that a 2log removal process, followed by a 4 log removal process will have a total impact of removing 6 log virus (i.e. 99.9999%) from the effluent.
3. Assess the Environmental Risks associated with the scheme
4. Demonstrate how the proposed treatment process meets the 12 elements of the Australian Guidelines of Water Recycling risk assessment.

Please note that the risk assessment is based on the Australian Guidelines for Water Recycling (AGWR) framework.

4.4.2 Human health risk assessment

Microbial quality Summary

Microbial hazards for human health include enteric bacteria, viruses and protozoa. The total log reduction required for this scheme was determined using the approach described in Section 3.7.2 of the AGWR and is shown below.

Table 1: Microbial health-based performance targets

Use	Ingestion L	Frequency/yr	% Population	Weighted L	Weighted total L	Log Reduction		
						Protozoa	Virus	Bacteria
Municipal irrigation	0.001[1]	50[1]	50	0.025	0.025	**3.50**	**4.91**	**3.67**
Toilet Flushing	0.00001	600	100	0.006	0.006	**2.88**	**4.29**	**3.09**

1. AGWR table 3.3 Intended uses and associated exposures for recycled water.

What Table 1 means

Ingestions: is the amount of recycled water in litres (L) that a person ingests with each exposure event

Frequency: is the number of events per year that a person is exposed to a particular situation.

% Population: is how much of the population is affected by the exposure event. E.g. 50% of the population at the LOGOS Kemps Creek Logistics Project is exposed to spray irrigation of the gardens.

Weighted L: is simply the multiplication of the amount ingested (L) by the frequency by the population percent. i.e. how much recycled water is ingested on average per person per year.

Log Reductions: this is the calculated amount of pathogens/micro-organisms (Protozoa, virus, bacteria), that has to be removed from the effluent, to ensure that a person has negligible exposure risk. The treatment process therefore needs to demonstrate that it can operate at a higher level of pathogen removal performance than what is shown here, to ensure there is a negligible exposure risk.

Basis of Microbial Risk Calculations – Log Reductions in Table 1

The calculation of Log Reductions shown in Table 1 is based on Appendix 2 of AGWR, where

- Log reduction = log (concentration in source water x exposure (L) x N /DALYd)
- Concentration in source water (*Table A2.1 Potential risks from irrigation of lettuce using treated sewage* of AGWR)
- Cryptosporidium (Protazoa) is 2000 - Organisms per litre in source water (N) (95^{th} Percentile)[a]
- Rotavirus is 8000 (Virus)- Organisms per litre in source water (N) (95^{th} Percentile)[a]
- Campylobacter (Bacteria) is 7000 - Organisms per litre in source water (N) (95^{th} Percentile)[a]
- a – Hazard concentrations in raw sewage (95^{th} percentile from Australian and international data). Numbers of adenoviruses have been used as an indication of numbers of rotaviruses, because of the lack of enumeration methods for rotaviruses. Adenoviruses were used because these were the most numerous of the viruses detected in Australian monitoring of sewage (data from Virginia Pipeline Scheme in South Australia).
- N is the number of exposures per year and DALYd is the dose equivalent to a DALY of 10^{-6} (1.6×10^{-2} Cryptosporidium, 2.5×10^{-3} rotavirus, 3.8×10^{-2} Campylobacter). DALYd includes consideration of dosed response and ratio of infection to illness.
- Exposure and N data could be found in *Table 3.3 Intended uses and associated exposures for recycled water* of AGWR.
- The log reduction values calculated are as following:

Irrigation

- Protozoa Log reduction = log ($2000 \times 0.025/1.6 \times 10^{-2}$) =3.50
- Virus Log reduction = log ($8000 \times 0.025/2.5 \times 10^{-3}$) = 4.91
- Bacteria Log reduction = log ($7000 \times 0.025/3.8 \times 10^{-2}$) = 3.67

Toilet flushing

- Protozoa Log reduction = log ($2000 \times 0.006/1.6 \times 10^{-2}$) =2.88
- Virus Log reduction = log ($8000 \times 0.006/2.5 \times 10^{-3}$) = 4.29
- Bacteria Log reduction = log ($7000 \times 0.006/3.8 \times 10^{-2}$) = 3.05

Operational Microbial log reduction targets

Based on the exposure risk calculations, we have therefore designed the sewage treatment process for the LOGOS Kemps Creek Logistics Project to achieve a log reduction of 5 log removal virus and 4 log removal protozoa. A conservative and comfortable “safety margin” is provided on the basis of these calculations. We don’t specifically focus on bacteria removal because it is deemed that if a process can remove virus to the necessary levels, it will also remove bacteria (which are larger and less resistant than virus). This approach is accepted by the regulator.

4.4.3 System Process Train

Specific Process Treatment Equipment proposed for the LOGOS Kemps Creek Logistics Project

The proposed process train will comprise:

1. 3mm Mechanical Screening
2. Membrane Bioreactor with flat sheet Ultra-filtration Membranes.
3. UV photo-oxidation disinfection
4. Chlorination disinfection

The stream that is recycled for in-building reuse (11kL/day) will include an additional treatment processes, involving

1. Blue dye addition to protect against cross connections.

How does the treatment process meet the required log removal criteria

Surface Irrigation– How Process Addresses Health Risk

Treatment plant performance objectives are as follows:

Table 2: Treatment plant performance objectives - Irrigation

Organisms	Operation /design Log Reduction Objectives	Calculated Critical Log Reduction Value (from Table 1)	Process Equipment Log Reduction Contributions	
			UV	Chlorine
Virus	5	4.91	1	4
Protozoa	4	3.50	4	0

Note: Operational design values have been set to higher level than the theoretical minimum critical log reduction requirements.

NOTE: whilst the above desktop demonstrates the proposed process will be able to confidently achieve the required level of pathogen removal, the actual pathogen removal is expected to be many orders of magnitude higher than what is theoretically shown here. The reasons being:

1. No pathogen removal credits have been claimed for the flat sheet ultra-filtration that will be used in the membrane bioreactor. Some regulatory authorities in Australia have not accepted desktop validation of submerged ultra-filtration membranes because there has been no international validation protocol developed. Membrane integrity is measured indirectly through on-line turbidity monitoring, which is acceptable to certain authorities around Australia and many others internationally, however we have taken a conservative approach to assume that no log credit will be recognised for flat sheet membranes.
2. A maximum of 4 log credits are attributed to one disinfection barrier, even if a higher effect occurs in reality.

Toilet Flushing – How Process Addresses Health Risk

Table 3: Treatment plant performance objectives – Toilet Flushing

Organisms	Operation /design Log Reduction Objectives	Calculated Critical Log Reduction Value (from Table 1)	Process Equipment Log Reduction Contributions	
			UV	Chlorine
Virus	5	4.29	0.5	4
Protozoa	4	2.88	4	0

Note: Operational design values have been set to higher level than the theoretical minimum critical log reduction requirements.

Chemical quality

Exposure of chemicals in recycled water is considered too low to represent a health risk.

Preventive measures

Preventative measures include ultra-filtration, ultraviolet (UV), and chlorine disinfection. Onsite control measures are also applied (see Element 3 of the table below).

4.4.4 Environmental risk assessment

Microbial quality

Microbial quality of the recycled water is not considered an environmental issue given the high levels of treatment required to minimise risks to human health. No preventive measures are required. The table below gives the e.coli levels expected in the treated recycled water, which will be lower than background environmental flows.

Parameter	Recycled Water Quality
E coli	<10 cfu/100mL (max) <1 cfu/100mL (95 percentile)

Chemical quality

A risk assessment will be carried out during the detailed design stage of the project and submitted as part of the application for Approval to Operate. The tables below provide information about the expected recycled water quality that will be produced from the Aquacell STP, assuming that the influent quality are within the parameters given.

Blackwater Influent Quality Specifications

Parameter	Blackwater Influent Water quality
Biochemical Oxygen demand (BOD), mg/l	300-500mg/L
Suspended solids, mg/l	200-400
pH	6.5-8.5
Oil and grease	<50mg/l
Total Nitrogen, mg/l	<85mg/l
Total phosphorous	<20mg/l
TDS	<1000mg/L

Blackwater Recycled water Specification

Parameter	Recycled Water Quality
Biochemical Oxygen demand (BOD), mg/l	<5mg/L (typically <1mg/L)
Suspended solids, mg/l	<2mg/L
pH	6.5-8.5
Oil and grease	<1mg/l
Total Nitrogen, mg/l *	<15mg/l
Total phosphorous *	<10mg/l

*Lower levels can be delivered if required with slight modification to the Plant

Preventive measures

A range of on-site preventive measures is to be applied (see Element 3 in the table below).

4.4.5 Risk Management Plan

The table below lists the 12 elements of the framework for managing recycled water quality and use (as per the AGWR) and shows how the scheme meets the various elements.

Table 3: Risk Management Plan

Framework element	Activity
Element 1: Commitment to responsible use and management of recycled water quality	
Components: *Responsible use of recycled water* *Recycled water policy* *Regulatory and formal requirements* *Engaging stakeholders*	• The owner of the facility will engage a suitable contractor to operate and maintain the treatment process and provide support. The wastewater facility is part of a range of features to achieve sustainability within this development. There is a commitment to ensure correct design installation and management. • Approval is to be sought from IPART regarding the

	installation and operation of the recycled water system. • The existence of wastewater recycling is a feature of advertising and promotion of the development. Customers will be provided with an education kit. Plumbers and relevant contractors are to be provided with information.
Element 2: Assessment of the recycled water system	
Components: *Identify intended uses and source of recycled water*	• Landscape surface irrigation
Recycled water system	• The plant receives wastewater from the LOGOS Kemps Creek Logistics Project industrial site. Water is subject to treatment through a membrane bioreactor, ultraviolet (UV) disinfection and chlorination. • The treated wastewater is piped to storage ponds, where it will be pumped from to irrigate landscape gardens.
Assessment of water quality data	• Raw wastewater was characterised is deemed to be similar to standard sewage.
Hazard identification and risk assessment	**Human health** Hazard identification and risk assessment for human health found that microbial hazards for humans include enteric bacteria, viruses and protozoa. **Environmental performance** Hazard identification and risk assessment for the environment found the following: • Phase 1 of the risk assessment (preliminary screening) used conservative literature values for wastewater and identified the hazards boron, cadmium, hydraulic load, nitrogen and phosphorous, salinity and sodium, as moderate to high risks.
Element 3: Preventative measures for recycled water management	
Components: *Preventative measures and multiple barriers*	**Human health** Preventative measures to manage risks to human health include: • Membrane filtration, UV disinfection and chlorine disinfection; • Pipe work (purple and/or with text) and signage at site of use indicating that recycled water is being used; • Educational material to contractors and residents about avoidance of inappropriate disposal of wastes; • Signage at site to alert public to recycled water system and co-ordination of contractors through the owner; • Backflow prevention and cross-connection control; Additional of blue dye to identify if cross connection occurs. • Drinking water system maintained at higher pressure than recycled water supply. **Environmental performance** Preventative measures to manage risks to the environment include: • Education programme for guests promoting use of environmentally friendly detergents in the bathroom/laundry and avoidance of disposal of household and garden chemicals; • A list of detergents considered appropriate for use in the retail areas made available to all retail operators and updated annually;
Critical control points	Critical control points were identified as: • Membrane filtration; • UV disinfection; • Chlorination.
Element 4: Operational procedures and process control	
Components: *Operational procedures*	• Operational procedures identified for all processes and activities associated with the system, including operation of treatment processes and auditing procedures for cross-

	connections. • Documented procedures must be available to operations personnel and for inspection at any time.
Operational monitoring	Monitoring includes: • Feed pH (continuous) • Dissolved oxygen (continuous) • Turbidity of filtered water (continuous) – *critical limits set;* • UV lamp, power and lamp failure (continuous) – *critical limits set;* • Chlorination (continuous) – *critical limits set;* • Recycled water pH (continuous) • On-site auditing of controls (signage, backflow prevention, etc); • On-site auditing and inspection of irrigation system

Corrective action	Corrective actions include the following:
	• Noncompliance with critical limits results in the system being stopped and replaced by mains water flow to the storage tank; that is, irrigation is paused if
	  o Turbidity limits of 2.0 nephelometric turbidity units (NTU) exceeded for >1 minute;
	  o UV system alarm is registered;
	  o Free chlorine residual is outside the range of 0.2 to 2.5;
	  o Recycled water pH is outside the range of 6.5 to 8.5
	• If cross-connections detected, irrigation stopped until repairs completed;

Equipment capability and maintenance	• Treatment plant and disinfection systems of standard and reliable design. Maintained by qualified supplier.
Element 5: Verification of recycled water quality	

Components:
Recycled water quality monitoring (specifically designed for individual systems, taking into account source of water, end uses and receiving environments)
	Human health
	In relation to human health, monitoring includes:
	• Monitoring of
	  o *E. coli* (monthly);
	  o Bacteriophage in membrane permeate (monthly);
	  o Chlorine residual in distribution system;
	• In-system monitoring for aesthetic parameters – turbidity;
	• Customer satisfaction, monitored by the operator; complaints are investigated particularly if clusters of complaints are received.

Application and discharge site monitoring	**Environmental performance** In relation to the environment, monitoring includes: • Visual assessment of irrigation area for function, ponding, soil compaction
Short-term evaluation of results	• Results are provided on an annual basis to regulator.
Corrective responses	• Corrective action depends on the exceedence. As a minimum, it involves investigation of plant performance records to confirm normal operation, and additional testing to confirm the exceedence and identify the source. • If target criteria for environmental parameters are exceeded, preventative measures need to be reassessed and corrective action taken to ensure environmental performance is improved.
Element 6: Management of incidents and emergencies	
Components: *Communication* *Incident and emergency response protocols*	• Noncompliance with approval conditions to be reported immediately to regulator.
Element 7: Operator, contractor and end user awareness and training	
Components: *Operator, contractor and end user*	• Operator of treatment plant to be sufficiently skilled to run the plant and investigate any faults;

awareness and involvement *Operator, contractor and end user training*	• Operator to be aware of approval conditions and instructed on occupational health and safety requirements; • Grounds keeper responsible for irrigation area maintenance is to be trained in the use of recycled water and preventive measures required.
Element 8: Community involvement and awareness	
Components: *Community consultation, communication and education*	• The existence of wastewater recycling is indicated to prospective tenants. All tenants are to be provided with an education kit.
Element 9: Validation research and development	
Components: *Validation of processes* *Design of equipment*	• Ongoing investigations into wastewater quality and treatment plant performance to refine assessments. This may enable less conservative critical control points to be adopted or treatment requirements reduced.
Element 10: Documentation and reporting	
Components: *Management of documentation and records* *Reporting*	• Design of treatment plant and irrigation system documented; • Operating procedures documented; • All results to be recorded and stored; • Results to be reported on an annual basis to the regulatory authority.
Element 11: Evaluation and audit	
Components: *Long-term evaluation of results* *Audit of recycled water quality management*	• Annual report on compliance with approval conditions, including test results audited by regulator; • Independent audit of compliance by a third party commissioned following the second year of operation.
Element 12: Review and continual improvement	
Components: *Review by senior managers*	• Performance of treatment plant, customer complaints/satisfaction and condition of irrigated areas reviewed by operator.

4.5 Process Treatment Component Explanation

4.5.1 Mechanical Screening

It is imperative that suitable screening is provided at the front end of the blackwater treatment process.

Aquacell are the Australian distributors for screening and grit removal equipment for the German company Noggerath. In the last 15 years, we have delivered over 60 units to various projects across Australia, many which are package inlet works for small municipal sewage treatment plants. A list of projects can be provided upon request.

We will utilise this experience to include a dedicated mechanical screening system, which will has screenings wash (to removal organics) and compaction. The compacted screenings fall into a hygienic bagging system which will be periodically removed from site. For a site the size the Logos Kemps Creek Logistics Project, we expect only about 20L-50L of washed compacted screenings to be produced per week. Under the DECCW *Waste Classifications Guidelines* (2009), grit or screenings from sewage treatment systems that have been dewatered so that the grit or screenings do not contain free liquids, is classified as General Solid Waste (putrescible). The waste will be periodically chemically assessed to confirm that it meets the guideline's General Solid Waste chemical criteria before being appropriately disposed to a waste management facility (landfill). It is likely that the waste will be removed by a waste contractor and disposed of to the Eastern Creek Waste Management Centre (landfill), which is approximately 9km away.

The screening unit proposed for the LOGOS Kemps Creek Logistics Project is a NOGGERATH NSI-B 200/S spiral sieve in-tank version. It will be located on top of the in-ground balance tank.

It will consist:

- Capacity – 10 l/sec
- 3mm perforated screens
- Tank with hinged cover and air exhaust connection DN 80
- 316SS screen and housing material
- Spiral sieve with perforated basket, fully integrated
- Screenings compactor, discharge chute
- Nylon spiral brush
- DN 100 inlet and outlet pipe connections
- Spraying system (screenings washing) above sieve basket equipped with solenoid valve
- Level control
- Hygienic encapsulation of compacted screening (70m tube style bag)

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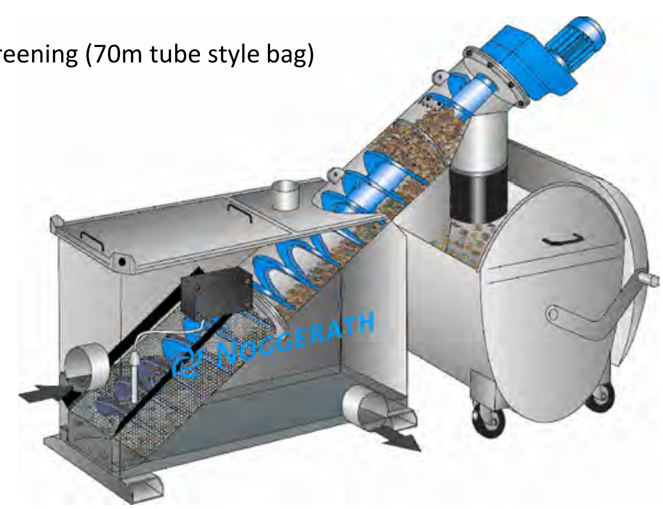
Example of Noggerath hygienic screenings encapsulation



4.5.2 Balance Tank / Peak Overflow Tank

The STP will use a 50kL balance tank to attenuate the peaks and troughs in flow rates throughout the day. The 50kL balance tank will also act as an anoxic reactor to enhance nitrification.

The operational balance tank will have an internal overflow to a separate 150kL tank that provides extra storage capacity during peak flows and will also deliver contingency storage in case there is a temporary reduction in treatment capacity (e.g. maintenance downtime). See detailed site arrangements at end of document. The combined volume of these tanks will provide approximately 3.5 days DWF storage capacity. If the overflow tank begins to fill, then level switches will remotely trigger alarms to be SMS / emailed to Aquacell operational staff. Once notified of an alarm in the overflow tank, a mitigation strategy will be implemented, either to fix the problem that is causing flows to back up or to arrange a pump out. The specific documentation of this procedure will be prepared as part of the IPART licence application and HACCP workshop.

The 50kL balance tank will have a submersible mixer installed (similar to the model shown above) to prevent solids from settling in the tank and to ensure an even mixing of wastewater. A lifting rig will be fixed into the tank to raise and lower the mixers to an operable height that will provide adequate mixing without aeration. Typically, the water level in the balance tank will be controlled to have a standard operational level of about 0.5m-1.5m so as to minimise aeration from the mixers. The lifting rig will be designed in conjunction with Aquacell's mixing specialist sub-contractor.

We have proposed that the balance tank and overflow tanks are delivered as in-ground concrete structures, but this may change during detailed design.

4.5.3 Biological Reactor

Air is diffused into the wastewater to maintain oxygenated conditions to support the growth of aerobic bacteria. These bacteria efficiently break down the organic matter in the effluent. Dissolved oxygen probes ensure that a consistent environment is maintained in the tank to optimise microbial activity and to minimise odour production.

The bioreactor of a MBR Plant operates at a much higher bacterial concentration than conventional treatment (10-14,000mg/L instead of 2-3,000mg/l). MBR's are more shock resistant, produce less sludge, require less of a footprint and is able to achieve nitrification of wastewater at much lower oxygen levels than what is required in conventional wastewater Plants.

4.5.4 MBR Membrane Modules

Effluent is circulated between the bioreactor and an ultrafiltration membrane tank module.

Aquacell systems use German made Biocel membranes. These are made from Polyether Sulfone (PES) with a nominal pore size of 0.04um. Since bacteria are ~1-2 micron, the membranes therefore provide an effective physical barrier to separate bacteria and other pathogens from the treated recycled water. After many years of operating blackwater reuse plants, Aquacell has found that Biocel membranes deliver a robust and reliable product compared to many of the other membrane competitors in the marketplace. One of the reasons is that Biocel flat sheet membranes are attached to flexible plate structures that aid in dislodging any sludge build up in the base of the membrane module, as can often happens with ridge membrane plate structures. The longer term performance of membranes is a very significant consideration when implementing a successful blackwater reuse scheme. The Biocel flat sheet membranes will deliver the long term performance that this project needs.

Biocel Membranes

4.5.5 UV Disinfection

The filtered recycled water will go through an Ultra-Violet Disinfection system as a first disinfection barrier. The UV system used will be validated against a recognised international protocol. E.g. USEPA.

4.5.6 Chlorination

Chlorine Disinfection provides a second disinfection barrier for the recycled water, and is the main disinfectant responsive to virus. It also has the added advantage of delivering a residual disinfection that will help to protect the treated recycled water until it reaches the irrigation storage ponds.

Aquacell stoichemetrically doses chlorine into the recycled water based on flow rates, however this is then further adjusted with a feedback response from a free chlorine probe situated in the recycled water holding tank to make sure that the recycled water leaving the STP site has a free chlorine residual of between 0.5-1mg/L.

4.5.7 Additional treatment required for In-Building Reuse

It is also proposed that treated recycled water be used for in-building reuse (e.g. toilet flushing). Reusing treated recycled water for in-building toilet flushing adds an additional risk for future cross connection; and also presents some challenges of slight colouration (from soluble organics) of the recycled water being noted in white toilet bowls.

The proposed treatment system will address this risk and colouration issue by adding a biodegradable blue dye to the water that is used for toilet flushing. The blue dye will add additional protection against future cross connections with potable water. If a plumbing mistake occurs in the future and a cross connection results, the "blue" recycled water will immediately be seen in the potable water supply and the error can be immediately rectified. The other advantage of blue dye addition is that people are have less adverse reactions to seeing a blue colour in their toilet bowls than a weak brown tea like colour – so it will also address some potential aesthetic concerns.

4.5.8 Recycled water Storage

The treated recycled water will be pumped to several storage ponds built across the site that will hold 2ML of storage capacity. Surface (sprinkler) irrigation of the landscape areas will be partially sourced from the treated recycled water in the ponds.

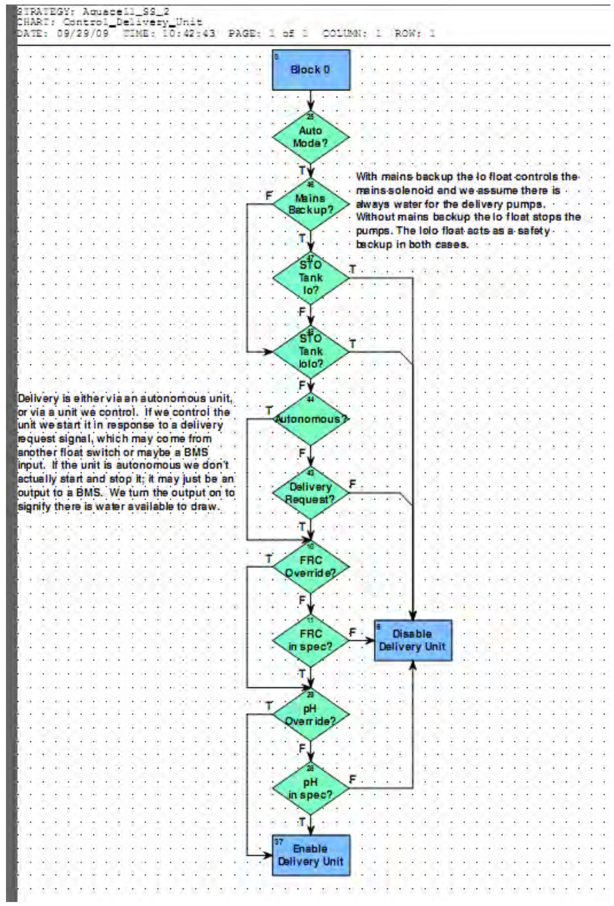
A 30-50kL intermediate holding tank will be built at the central STP site to collect the treated recycled water, before it is pumped to the storage pond and directly to the buildings for toilet flushing.

4.5.9 Instrumentation and Control

Control

Aquacell uses the SNAP-PAC industrial control system from Opto22. It provides robust, state-of-the-art hardware with integrated graphical programming, operator display and data acquisition with built-in support for industry-standard protocols such as Ethernet, TCP/IP, and OPC.

The hardware and software architecture is more sophisticated than a PLC, and is termed PAC (Programmable Automation Controller). PAC Control logic is written using an intuitive graphical flowchart language that is easy to understand by the technical and non-technical alike. The controls of Aquacell are made up of numerous intuitive easy-to-use flowchart-based control programming charts similar to what is shown below. This makes it simple to add new control procedures and change existing ones.



Aquacell has previously used PLC based programming control systems for its earlier Aquacell Plants, but has moved to Opto22 PAC control system in recent years because it offers a superior, easier to understand control platform to operate. It also offers seamless integration with communications equipment and the flexibility to connect to a range of comms options.

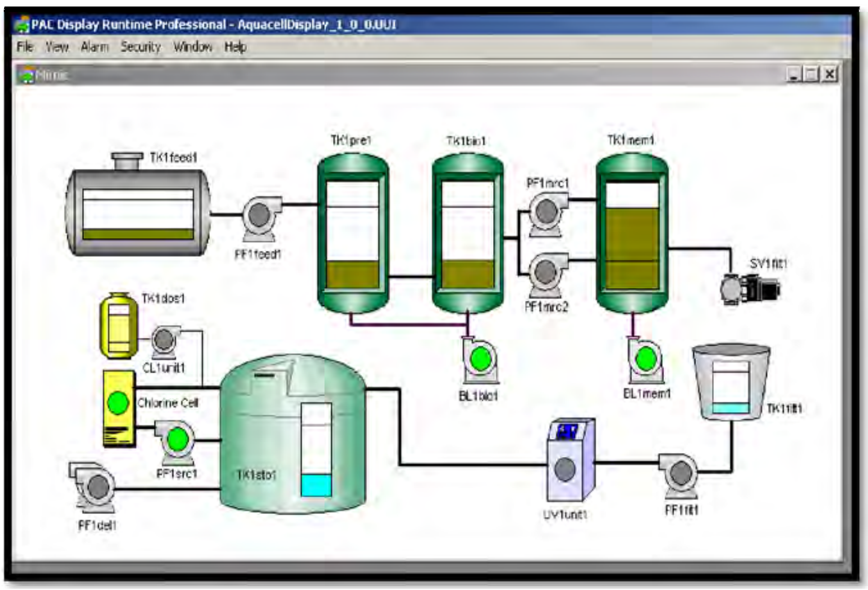
Software

Interoperability between the SCADA Terminal and other SCADA systems is made simple via the built-in OPC server. OPC is the industry-recognised open protocol for high-level process control interfacing and is supported by all reputable SCADA vendors. Any other SCADA system wishing to extract data from the SCADA Terminal simply needs to access it via OPC.

4.5.10 Telemetry/remote system control and capability and alarms

All telemetry and remote access to the Plant is provided via broadband internet, either by fixed-line or 3G cellular network. Because standard internet protocols are used, any internet-enabled network layer can be used. Standard internet security protocols such as IPsec and PPTP allow for secure remote access at all times.

Aquacell systems have been specifically designed to run in environments with little immediate technical expertise at hand. A screen shot from one of our MBR systems is shown below to demonstrate our remote monitoring and operation interface.



The plant will monitor parameters which include (but are not limited to) those listed below, and will use controls to ensure reliable and safe recycled water supply.

Parameter	Monitoring & Control
Level	• **MBR Tank levels**
	• **Recycled water storage tank level**
	• **High level Alarms**
Status or Condition	• **Flow**
	• **Level Sensors**
	• **Pumps on/off**
	• **Blowers on/off**
	• **Filtration**
	• **Aeration cycle**
UV	• **UV Lamp on/off**
Dissolved Oxygen	• **Online Dox monitoring**
Turbidity	• **Online turbidity monitoring**
pH	• **Online pH monitoring**
Chlorine	• **Online chlorine monitoring**

If a monitored parameter fails, an alarm will be raised to initiate a mitigation strategy. For example, if the turbidity value exceeds 2 NTU (as monitored by the online turbidity meter), perhaps due to membrane rupture or plant malfunction, recycled water supply from that stream will be immediately diverted, and an alarm will be raised and directed to the plant custodian via email and SMS. The Recycled Water Quality Management Plan that is established for the STP will establish the necessary protocols to be implemented if alarms are triggered.

4.5.11 Standard Operating and Maintenance Procedures

An operation and maintenance manual for the blackwater plant will be developed and provided as part of the contract.

a. The operation and maintenance manual will include:
   - i. Operator responsibilities and duties
   - ii. Records system
   - iii. Sampling and testing
   - iv. Occupational health and safety
   - v. Utilities details
   - vi. Electrical systems
   - vii. Process description, operation and control
   - viii. Residuals management
   - ix. Maintenance - service visits, frequency and tasks.
   - X. Phone assistance and support.

4.5.12 Occupational Health and Safety

a. Operational Health and Safety requirements will be included in the Operation and Maintenance Manual in the design of the system, and will also be identified in the risk assessment processes. These requirements include:
   i. Obligations and responsibilities of the proponent, owner, service provider and others
   ii. Prevention of illnesses and injuries
   iii. Confined spaces
   iv. Odour control and proper ventilation
   v. Noise control
   vi. Chemical control, including storage, MSDS and procedures for use.
   vii. Control of the generation of dangerous gases such as methane and hydrogen sulphide by wastewater (less of a risk for greywater)
   viii. Procedures for system failure
   ix. Provision of personal protective equipment (PPE)
   x. Ongoing training
b. Safe Work Method Statements will be prepared
c. All persons involved in the operation and maintenance of the recycled water system will be inducted into the Occupational Health and Safety aspects of the system

5 Water Treatment Infrastructure

The proposed water/wastewater strategy will harvest rainwater from the building roofs to supply all in-building water demands.   The inclusion of a 3 ML of rainwater storage connected to 26 ha of roof area (i.e. all available roof area is harvested) will significantly reduce stormwater runoff from the site. This is less than the storage capacity allowed for a 50 ha site under the Water Management Act 2000.

The Woodlots and Wetlands report (Appendix B) modelled 60 years rainfall data to determine the reliability of rainwater harvesting to supply potable water. The results are summarised in the table below.

Total Storage Volume (ML) provided for Rainwater Harvesting [1]	Reliability of Water Supply if rainwater supplies 64kL/day in-building demand (no blackwater reuse for toilet flushing).	Reliability of Water Supply if rainwater supplies 46kL/day in-building demand (blackwater is reused for toilet flushing).
3	95%	98%

1 – total storage volumes listed. These could be made up with several tanks. E.g. 3ML rainwater storage could be delivered with 3 x 1000kL rainwater tanks.

Although rainwater is a relatively clean source, it will still require treatment to be safely used – especially if harvested as a drinking water supply.

Many of these contaminants would mostly be removed with a first flush system installed, however additional protection is still needed because the rainwater will be the main commercial potable water supply.   We propose to install a treatment process based on hollow fibre (ultra-filtration) - described in sect 5.1, and UV disinfection similar to what is described for the wastewater treatment equipment. Such as system will afford a combined pathogen barrier of >5log for virus, bacteria and protozoa, which is more than adequate to address the risks associated with sourcing water from rainwater, whilst confidently meet the Australian Drinking Water guidelines.

The logical set up for the water treatment arrangement is to co-locate the treatment Plant and storage.

5.1 Hollow Fibre Membrane (USEPA Validated)

A Hollow Fibre membrane is included in the process train primarily to meet the NSW regulators stringent attitude towards continuous verification of water supply schemes. The Hollow Fibre system proposed with have fully automated, integrated membrane integrity testing to satisfy NSW regulators. The system we propose to use will be a VIREX PRO from the German company SECCUA (of equivalent)

The Virex Pro (hollow fiber unit) detects membrane damages smaller than the size of pathogens. Together with its ability to monitor the signal of a turbidity meter in the filtrate line of the system, it performs a continuous, indirect integrity test, triggering the integrated, direct membrane-test.

The tested pathogen removal performance of the Virex Pro system is as follows (measured against USEP Standards for Ultrafiltration systems used on surface water filtration on a new membrane):

- Virus (MS2 Phage) – full removal (>4.7 log tested)
- Bacteria (B.Subtilis, E-Coli) – full removal (>4.9 log tested)
- Parasites (Crypto) – full removal (>4.7 log tested)

As part of the VirexPro routine operation, a Cleaning-In-Place (CIP) cleansing of the membranes is periodically performed. Once the system detects a need for cleaning, it can apply different combinations of cleaning techniques, including pre- and post-flushing, internal backwash or backwash powered by an exteneral pump, and it is even able to automatically perform chemically-enhanced Cleaning-In-Place (CIP).

6 Irrigation Management

6.1 Guideline Overview

The principal NSW guidelines that are referenced for Effluent Irrigation are the *Environmental Guidelines: Use of Effluent by Irrigation* (2004) Department of Environment and Conservation (NSW). Below are selected excerpts from the guideline to explain the purpose of this framework.

The reuse of effluent by irrigation can make a significant contribution to the integrated management of our water resources. When the water and nutrients in effluent are beneficially utilised through irrigation some of the water extracted from rivers can be replaced and the amount of pollutants discharged into our waterways can be reduced.

This Guideline is educational and advisory in nature. It is not a mandatory or regulatory tool and it does not introduce new environmental requirements. The emphasis is on best management practices related to the management of effluent by irrigation, to be used to design and operate effluent irrigation systems, with the goal of reducing risks to the environment, public health and agricultural productivity.

In relation to effluent quality, effluent contains valuable resources (water, organic matter and nutrients). However, in excessive amounts these can be detrimental to soils or plant growth. Effluent can also contain chemical contaminants, salts and pathogens that can pose a risk to the wider environment, public health or may cause pollution. These risks can be minimised by applying the criteria and information provided in the Guideline to during site selection, design and operation phases of an effluent irrigation system.

Water and nutrient balances are used to calculate the amount of water and nutrients that should be applied, and at what times, to meet the crop requirements while ensuring increases in runoff and percolation are minimised. The water balance is calculated to determine the maximum volume of effluent that can be sustainably used. The elements to be considered in a water balance are rainfall, evapotranspiration, runoff and percolation. For some effluents, the loading rates of nutrients such as nitrogen and phosphorus can limit the quantity of effluent to be used for irrigation in a given area. In a nutrient balance the amount of the specific nutrient, (e.g. nitrogen or phosphorus) assumed to be applied in a year is compared with the amount taken up by the biological or physical processes of the crop-soil system. Pre-irrigation soil nutrient status is also considered.

The work undertaken in this report (particularly Water Cycle Management Investigations - Appendix A) uses this framework as a basis for developing a sustainable irrigation practice.

6.2 Irrigation Strategy

A detailed irrigation design will be developed as part of the design phase of the project. The agronomy calculations have concluded that 5ha of irrigation area is required to manage the treated recycled water generated from the site, which is conservatively based on 1600 people working at the site at full development. It should be appreciated that during the initial years when significantly less wastewater is produced, a much smaller area of irrigation will be needed (due to the lower flows). Depending on the way the development progresses, it may never reach the 5ha required.

Even if the full 5ha of land is eventually needed, approximately 7.5ha is available on the site.

Much of the irrigated area comprises Cumberland Plain Woodland landscaping. Dr Peter Bacon (agronomist advising Aquacell for this project) has advised that this vegetation will vigorously respond to treated recycled water irrigation. Dr Bacon has also advised Aquacell that he has been involved with previous projects where Cumberland Plain Woodland have been irrigated with recycled water without adverse impacts to the vegetation.

The treated recycled water produced at the Logos Kemps Creek Project will be of a very high water quality that will be considered by regulators as being classified as a low strength effluent.

Aquacell Treated Recycled water Quality Specification

Parameter	Recycled Water Quality
Biochemical Oxygen demand (BOD), mg/l	<5mg/L (typically <1mg/L)
Suspended solids, mg/l	<2mg/L
pH	6.5-8.5
Oil and grease	<1mg/l
Total Nitrogen, mg/l *	<15mg/l
Total phosphorous *	<10mg/l

*Lower levels can be delivered if required with slight modification to the Plant

Criteria for Effluent Strength (DEC Environmental Guidelines 2004)

Table 3.1: Classification of effluent for environmental management

	Strength (average concentration mg/L)[1]		
Constituent	**Low[2]**	**Medium**	**High**
Total nitrogen	<50	50–100	>100
Total phosphorus	<10	10–20	>20
BOD_5	<40	40–1,500	>1,500
TDS[3]	<600	600–1,000	>1,000–2,500
Other pollutants (e.g. metals, pesticides)	Effluent with more than five times[4] the ANZECC and ARMCANZ (2000) long-term water quality trigger values for irrigation waters must be considered high strength for the purpose of establishing a strength class for runoff and discharge controls and will require close examination to ensure soil is not contaminated.		
Grease and oil	Effluent with more than 1,500 mg/L of grease and oil must be considered high strength and irrigation rates and practices must be managed to ensure soil and vegetation is not damaged.		

Notes: 1. Average concentrations established from a minimum of 12 representative samples, collected at regular intervals over a year.

2. Effluent generated by municipal sewage treatment plants with secondary treatment will generally be considered to be low strength.

Issues such as tail water management of irrigation run off are not relevant to the scheme proposed for Logos Kemps Creek project because irrigation does not occur during rainfall events and is applied at a rate so that run-off does not occur. i.e. there is no tail water produced.

Section 5.4 “Tailwater and stormwater runoff control” - DEC Environmental Guidelines 2004, states:

> *For low strength effluents these risks may be managed without the need for runoff diversion and collection systems provided suitable soils and topographic sites are selected, there is a buffer zone between the irrigation area and the water resource and a deficit irrigation regime is used. By leaving a small soil moisture deficit after each irrigation event, small rainfall events will not generate runoff and the runoff from large rainfall events is more likely to be of acceptable quality.*

A 2ML wet weather storage pond is included in the irrigation scheme to minimise runoff during wet weather. This pond capacity has been modelled to ensure that run-off of treated recycled water from the site does not occur in 50 percent of years – based on p39 in the *Guidelines: Use of Effluent by Irrigation* (2004) document.

7 Storm water Management

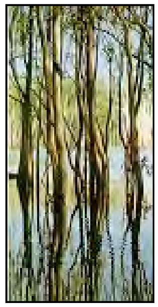
Excess storm water will be detained and treated via a combination of swales and storages prior to discharge from the development. As discussed previously in this document, discharge from the site resulting from recycled water will only occur in 50% of years – based on the *Environmental Guidelines: Use of Effluent by Irrigation* (2004), Department of Environment and Conservation (NSW).

A more detailed Stormwater management Plan and hydrological assessment of the site is provided in Appendix C.

Appendix B - Water Cycle Investigations

Woodlots and Wetlands Pty Ltd

Water Cycle Management Investigations
for
LOGOS Kemps Creek Logistics Project
Mamre Road, Kemps Creek



Report prepared for
Aquacell Pty Ltd
as part of a site wide
Integrated Water Cycle
Management Strategy for the
LOGOS Property

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Document Registration

Client	LOGOS Property
Date Issued	23rd June 2011
Document File name	Water Cycle Investigations
Document Title	Water Cycle Management at Kemps Creek logistics Project Mamre Road, Kemps Creek for LOGOS Property
Document Registered By	Peter Bacon signature

This report has been prepared for the express benefit of LOGOS in relation to the proposed Kemps Creek Logistics Project.

It is time and site specific and must not be used for any other purpose.

The input of team members is gratefully acknowledged.

Table of Contents

1 Introduction and project objectives

This section provides the background information. It identifies the subject site, describes the development proposal, states the report purpose and outlines the scope of works.

1.1 Background to Study

The purpose of this investigation is to demonstrate to the determining authorities that the water and waste water management needs of the development will be adequately taken into account as part of the site management.

The proposed development aims to minimise impact on the environment, including the call on external water resources and centralised sewerage systems.

The lack of a centralised sewerage system and relative scarcity of mains water supplies in the area creates an opportunity to reduce demand for potable water by:

1) The capture and use roof runoff as a non-potable[1] water source for fire water systems, cleaning, washdown and toilet flushing.
2) Depending on the extent of treatment rainfall could also be collected and used as potable water.
3) The recycling of suitably treated wastewater to meet non-potable demands such as landscape irrigation, toilet flushing and washdown.

We note the 'competition' between stormwater and treated recycled water for irrigatible lands and other reuse opportunities. The decision to use different proportions of sewage and stormwater is largely a matter of government regulations, capital and operating costs and opportunities.

Figures 1.1 and 1.2 show the differences between traditional systems and an integrated water cycle system.

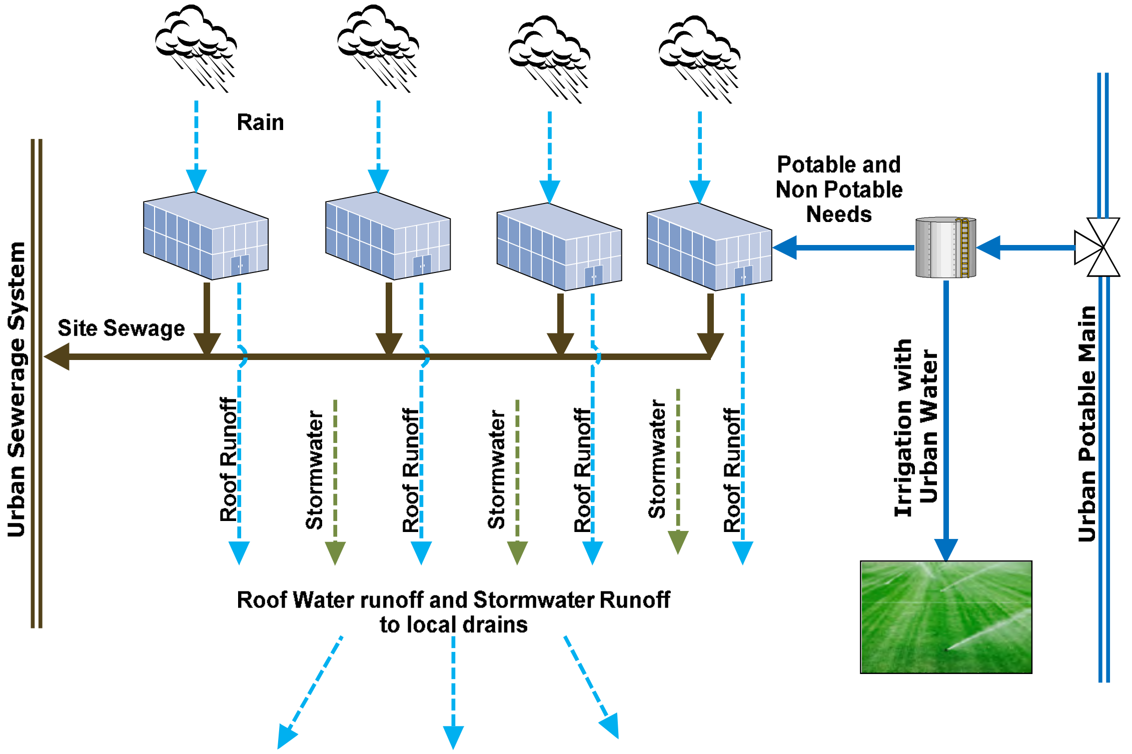
The key differences are:

- Minimal reliance on Sydney Water supplies
- Own sewage treatment system designed to recover and productively reuse water
- Capture and reuse of roof runoff for internal use
- Reduction in the peak stormwater outflow from the development to pre development flows

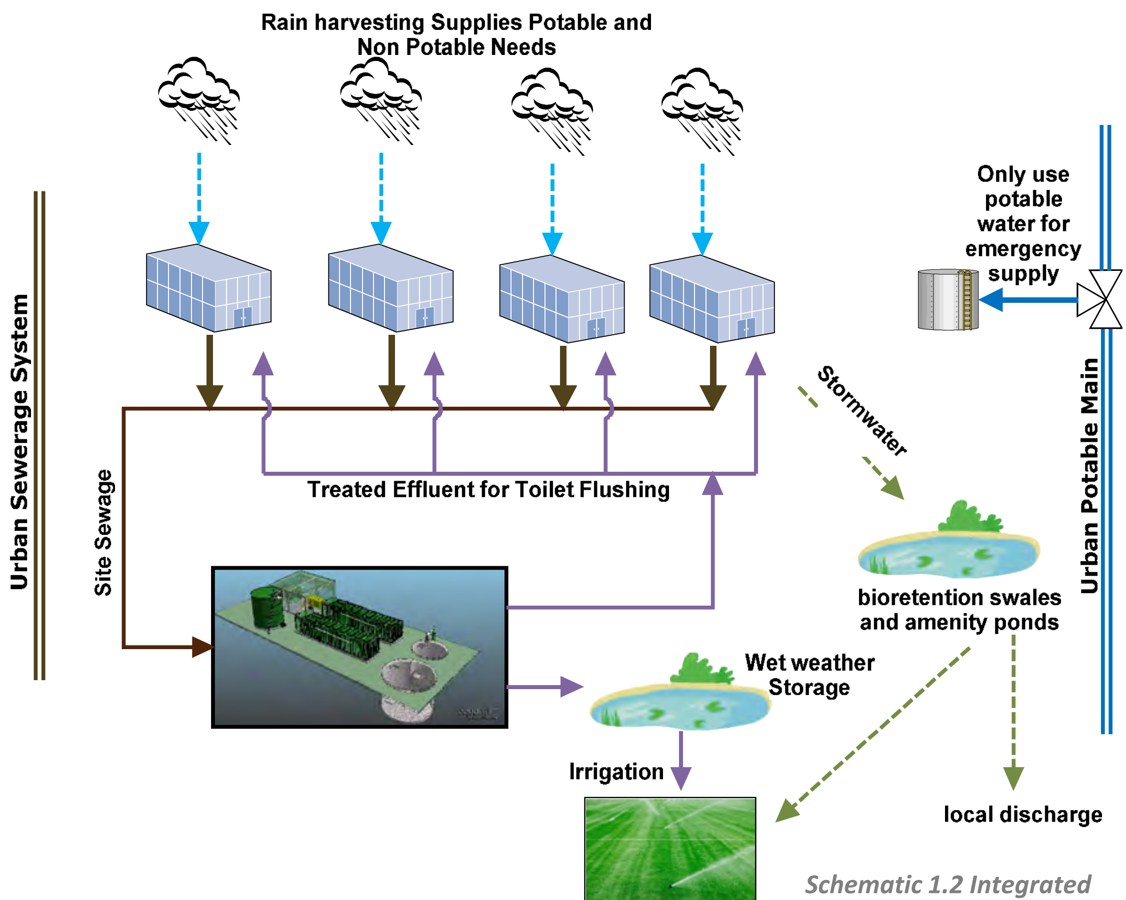
There are 4 basic questions that need to be answered when considering opportunities for implementing an integrated water cycle management system:

- What the likely needs for potable and non potable water?
- How much wastewater is likely to be produced?
- How can the stormwater be managed so that there is no increase in peak flows?
- How can the stormwater and recycled water water supplies be integrated to optimise the site from economic, environmental and regulatory viewpoints?

[1] Potable water is defined as water meeting the Australian Drinking Water Guidelines (2004). It is noted that potable criteria include both health and aesthetic criteria.



Schematic 1.1 Traditional water management system



Schematic 1.2 Integrated water management system

1.2 The Australian Drinking Water Guidelines

The Australian Drinking Water Guidelines (ADWG) are published by the National Health and Medical Research Council and the Natural Resource Management Ministerial Council. In 2007 the publishers began a rolling review of the fact sheets on which the guidelines are based. These fact sheets report on attributes that could impact on the suitability of water for drinking.

Table 1.1 shows the attributes that may impact on the 'potability' of roof runoff at Kemps Creek.

Table 1.1. Australian Drinking Water Guideline (2004) criteria for attributes that could be an issue at Kemps Creek.

Characteristic	Guideline values		Comments
	Health	Aesthetic	
E. coli	Zero in 100 mL of water		The ADWG recommend testing for *E. coli* to indicate the presence of faecal contamination. *Escherichia coli* (*E. coli*) should not be detected in any 100 mL sample of drinking water.
Turbidity	<1 NTU	<5 NTU	Higher turbidity can indicate potential to protect pathogens against disinfection. Low turbidity is especially important if disinfection is via VU radiation.
Hardness (as $CaCO_3$)	Not necessary	200	Caused by calcium and magnesium salts. Hard water is difficult to lather. <60 mg/L $CaCO_3$ – soft but possibly corrosive. 60-200 mg/L $CaCO_3$ – good quality. 200-500 mg/L $CaCO_3$ – increasing scaling problems. >500 mg/L $CaCO_3$ – severe scaling. Aesthetic guideline
Chloride		250	From natural mineral salts, effluent contamination. High concentrations more common in groundwater and certain catchments. Aesthetic guideline
Sodium	Not necessary	180	Natural component of water. Guideline value is taste threshold.
Total dissolved solids	Not necessary		Based on taste: <600 mg/L is regarded as good quality drinking water. 600-900 mg/L is regarded as fair quality 900-1200 mg/L is regarded as poor quality >1200 mg/L is regarded as unacceptable.

1.3 Current Health Recommendations for water sources

NSW Health supports the use of rainwater tanks in urban areas for non-drinking uses. These uses include toilet flushing, washing clothes or in water heating systems. It also supports tank water use in activities such as garden watering, car washing, filling swimming pools, spas and ornamental ponds, and fire fighting (NSW Health, 2007).

NSW Health recommends that people use the mains water supply for drinking and cooking.

However the national guidelines (Enhealth, 2004) make the point that the heating processes for hot water mean there is likely to be severe inactivation of microflor present in the roof runoff. Additionally, the volume of water consumed during showering is typically less than 100 mL/person, so the contamiant load is likely to be less than the infective dose. Also, using rainwater in urns to provide boiling water for tea, coffee, etc will kill off the vast majority of pathogens.

These comments suggest that use of rainwater into the hotwater services is, in effect, providing potable water. The hot water thermostat needs to be set at 65 to 70^{0}C. and operate as an off peak system.

1.3.1 Reasons for Using Rainwater

Substitution of mains water with the tank water reduces the demand for mains water. It also reduces the runoff rate from urban areas by diverting flows to sewers and treatment ponds. Reduction in runoff can reduce the extent of downstream erosion during storms. It also reduces the contaminant load being delivered to receiving water by the stormwater.

1.3.2 Water quality

Tank rainwater can contain organisms referred to as opportunistic pathogens such as *Aeromonas spp.* and *Pseudomonas aeruginosa*. However, except for severely immuno-compromised persons, these organisms are not considered to represent a significant risk through normal uses of drinking water supplies (WHO 2004).

Microbial contamination is normally measured by testing for *Escherichia coli (E. coli*), or alternatively thermotolerant coliforms. Thermotolerant coliforms or *E. coli* have been commonly identified in domestic tanks. This implies that enteric pathogens could often be present in rainwater tanks. However, when specific pathogens do occur, the number is usually extremely low and below the infective dose number (Australian Government, 2004).

There is no evidence in Australia to show that use of rainwater increases disease (Heyworth et al. 1999). In fact, Hayworth at al, (2001), found evidence that the health of children in homes using rainwater tanks was better than those in homes reliant on town water supplies. This occurred even when the tank maintenance level were poor. The likely reason why there is little evidence of health impacts from drinking rainwater captured off roofs with contamination such as bird faeces present is that the microflora in bird faeces are non infective to humans (Australian Government, 2004). This suggests that rainwater is generally safe for non consumptive usage. It is also likely to be safe for consumptive use.

Dead animals, especially large ones such as possums and cats, will definitely impact on tank water quality. It is essential that tanks be screened to prevent animal entry to the tank. Similarly, mosquitoes can be adequately addressed by suitable screening of the tank.
Chemical contamination of roofs and rainwater has been examined in several highly urbanised areas (Australian Government, 2004). Testing of rainwater from household tanks near industrial precincts was undertaken as part of investigations into impacts of lead, manganese, nickel, zinc and hydrocarbon concentrations in rainwater samples. The concentrations were consistently less than the values cited in the Australian drinking water guidelines (South Australian Department of Human Services, unpublished results 1999–2002).

At Kemps Creek, the roofs will be new and unlikely to have toxicants in the runoff. The National guidelines indicates that material such as tiles, Colourbond, zinc based roofing ,slate and fibreglass sheeting are all suitable for roof water capture (NRMMC, EPHC and NRMMC, 2009).

1.4 Sewage management options

The potential for safe recycling of treated sewerage has been enhanced by the development of membrane technology. This technology enables microfiltration of sewage thereby creating a 5 to 6 log reduction in indicator microorganisms (Pettigrew et al, 2010). This reduction in microflora numbers plus later chlorination is sufficient to enable the treated recycled water to meet the Australian Guidelines for water recycling targets (NRMMC/EPHC/AHMC, 2006).

The treated recycled water can therefore be safely used for toilet flushing, washdown and irrigation. The volume of recycled water that can be used for landscape irrigation is a function of the site conditions such as climate, soil type and separation distances to streams, boundaries, etc. It could even be used in cooling towers, however this is not proposed for the current project.

Additionally the proposed Sewage Treatment Plant (STP) can remove a high proportion of nutrients. This means that even in the unlikely event that recycled water was to reach ground or surface waters, it would have minimal impact on the nutrient balance. The benefit of this nutrient removal will depend on the risk of contaminating surface waters. For example, there should be more emphasis on nutrient removal if the irrigation area were relatively close to a drainage line.

An independent sewerage system requires an assessment of the site and the soil to determine its suitability for irrigation. This will need to be done if the proposal to install an onsite, centralised sewage system proceeds.

1.5 Management options for excess stormwater

There is a general need for development to not increase the peak outflow rate of stormwater compared with pre development conditions (See Penrith City Council water management DCP C3 2010). Additionally Penrith City Council requires a contamiant removal rate from stormwater exiting the site. In the current proposal these peak flow and contamiant removal requirements are achieved by a combination of collection and use of roof runoff and treatment of hardstand runoff in infiltration basins.

1.6 Objectives for sewage management strategy

1) Assess the site climate to determine a suitable irrigation management strategy.
2) Determine the soil and landscape attributes to determine opportunities and constraints to stormwater collection and recycled water reuse.
3) Assess the site requirements for potable and non potable water to determine the minimum satisfactory irrigation area needed to utilise the volume of wastewater which is not recycled within the development.

1.7 Reference documentation

In 2004 the then Department of Environment and Conservation published

‘ENVIRONMENTAL GUIDELINES’: USE OF EFFLUENT BY IRRIGATION.

Page 39 of these guidelines state that *“As a general guide, for low strength effluents, uncontrolled releases may be permitted in 50% of years”.* This is an important statement as the proposed system will produce low strength effluent.

The 2006 National Guidelines for Water Recycling provide comment on the risk management and the degree of disinfection needed to enable safe use of treated wastewater (NRMMC, EPHC, AHMC, 2006).

The 2009 Australian Guidelines for recycling stormwater (NRMMC, EPHC and NRMMC, (2009), where used as a guide for assessing health risks from using this water source.

These sources of information were used to develop a site water balance.

1.8 Methodology

The assessment sequence was as follows:

1) Estimate the likely demands for potable and non potable water
2) Estimate the likely volume of wastewater produced
3) Estimate the likely volume of rain water that runs off the roof.
4) Estimate the volume of roof water and recycled water that could be recycled
5) Assess the site climate to determine maximum irrigation application rates
6) Develop an integrated water balance for the site
7) Estimate the pre development peak runoff rate
8) Design the stormwater system to keep peak flow similar to or less than the predevelopment peak flow
9) Design the stormwater management system to reduce contamination loads to the targets in Penrith City Council's DCP.

Figure 1.1 shows the development area within a regional context. Figure 1.2 shows the potential irrigation areas within the site. Figures 1.3 shows the master plan of the site.

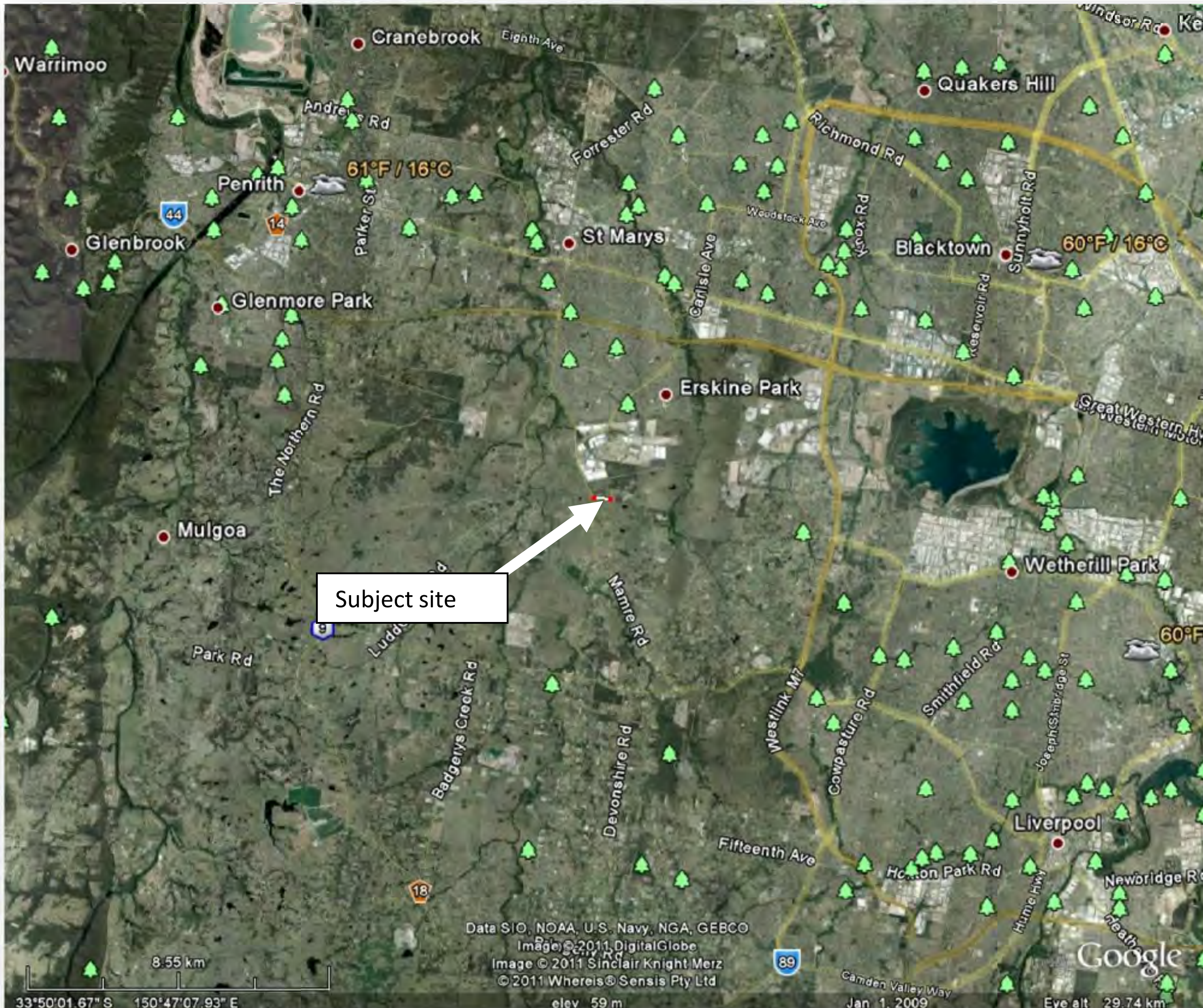


Figure 1.1. The locality within the western Sydney region

Figure 1.2. Detail of the site on Jan 1 2009

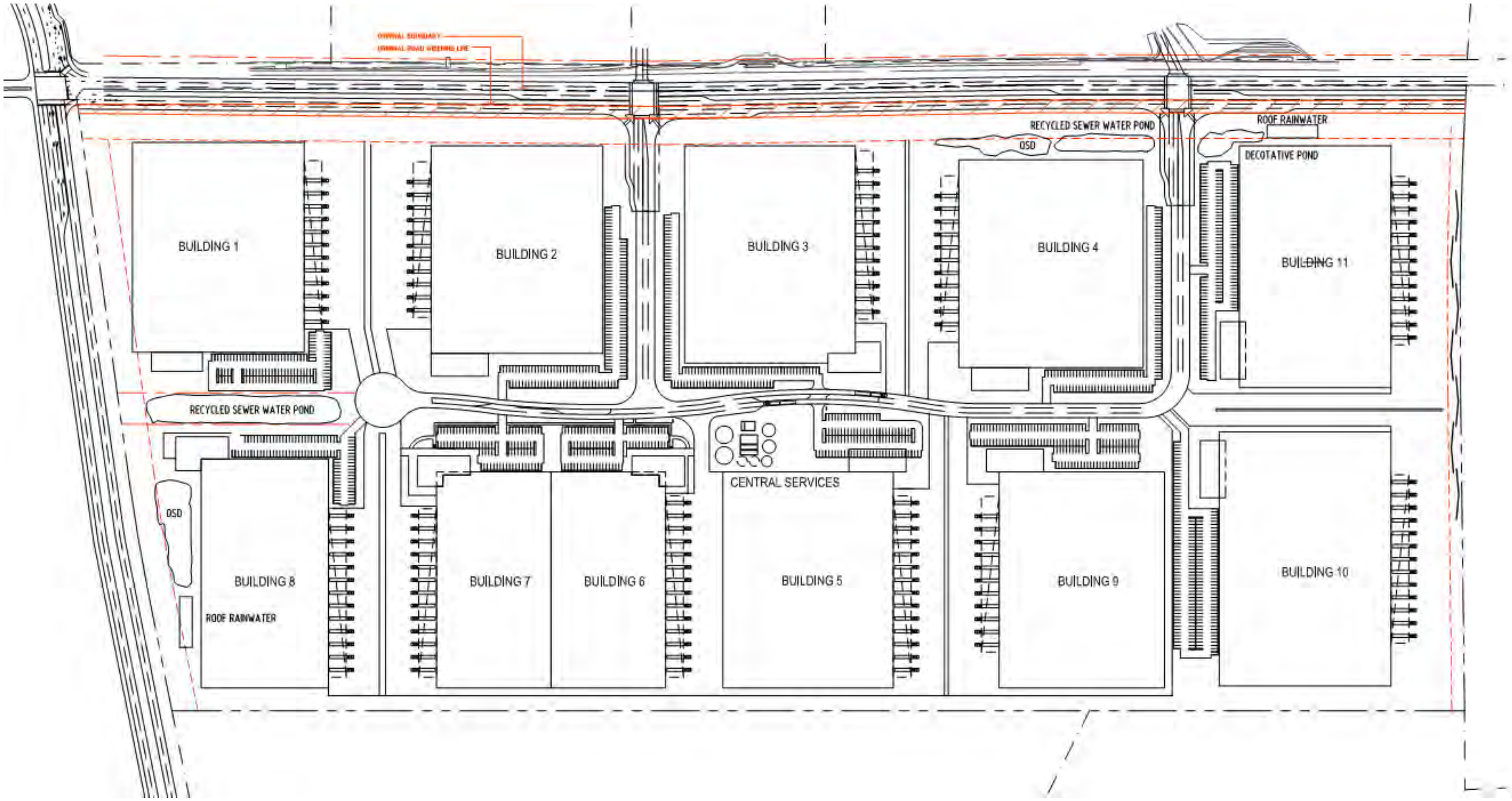


Figure 1.3. Masterplan showing indicative layout.

2 Site water balance and recycled water production

2.1 Assumptions and Modelled Scenarios

Two water balance scenarios were modelled as part of the investigations.

1) Rainwater harvested for all potable and non-potable water supplies; treated sewage only used for landscape irrigation.
2) Rainwater harvested for all potable and non-potable water supplies (except toilet flushing); sewage used for irrigation AND reused for toilet flushing

These scenarios assume a water demand of 40L/person/shift (due to use of more efficient water systems).

Water needs for the development are a function of the number of employees, the type of work undertaken and the need for operational water for processes. It is expected that the buildings will be used for bulky goods storage. If large quantities of process water are needed then the water supply system will need to be redesigned. However, it is understood that the project application only seeks approval for warehousing and distribution, and that any 'manufacturing' uses would require a separate approval.

2.2 Scenario 1 Rainwater harvested for all potable and non-potable water supplies; treated sewage only used for irrigation.

Table 2.1 shows the water demands when all water including toilet flushing is acquired from roof runoff. Additionally 4 star toilet flushing systems have been included as an extra conservation measure.

The total demand per shift is 39.8L, So, for 1600 shifts/day, there will be a need for 64 cubic m of roof water.

There will be some 60 cubic m of sewage generated/day.

2.3 Scenario 2 - Rainwater harvested for all potable and non-potable water supplies (except toilet flushing); Treated sewage used for irrigation AND reused for toilet flushing

Table 2.2 shows the water demands when all water except toilet flushing is acquired from roof runoff. Additionally 4 star toilet flushing systems have been included as an extra conservation measure.

Some 18.3 cubic m/day will be used for toilet flushing.

The total demand per shift is 39.8L. Some 28.5 L/ shift of roof water will be required. So, for 1600 shifts/day, there will be a need for 46 cubic m of roof water/day. A further 18 cubic m of water will be reclaimed from the sewage treatment system and reused for toilet flushing each day.

2.4 Reclaimed sewage use

Depending on the final design, the reclaimed wastewater will be used for a combination of landscape irrigation and toilet flushing.

The water quality criteria used to minimise risk are specified in
NRMMC, EPHC and NRMMC, (2006). National Guidelines for Water Recycling. Managing Health and Environmental Risks. Canberra ACT. The effluent will be treated to the extent recommended in these national guidelines.

There will be some 60 cubic m of sewage generated each day. Table 2.2 shows that approximately 1/3 of this volume will be treated and then recycled to flush toilets.

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Table 2.1. Estimated demand for water based on an average of 40L/employee/shift and 1600 employees. Roof runoff is disinfected and used for all water supplies. A 4 star toilet water conservation system is used.

End Use (Water Demand)	Assumptions	Percentage of demand	Total demand/ person/shift	Total rainwater demand (L/day)	Sewage volume (L/day)
Toilet and Urinal Flushing	Based on '4-star' toilet and urinal fittings.	28%	11.3	18,133	18,133
Hand Basin Washing	Based on 4 uses of the hand-basin per person/day for 15 seconds each time using a 3-star tap fitting (8.5 L/min). (75% hotwater)	21%	8.5	13,600	13,600
Showering	20% of staff have showers each day for 8 minutes each time using a 3-star shower head (8L/min). 50% of shower water is from the hot water system, based on roof runoff.	32%	12.8	20,480	20,480
Drinking	Personal consumption	5%	2.0	3,200	
Kitchen (washing & drinking)	Cooking, dishwashing 4 L / EP/ day (75% hot water)	10%	4.0	6,400	6,400
Leaking Water Devices and unaccounted for water	The water consumption attributed to leaking water devices was assumed negligible.	1%	0.4	640	0
Internal Cleaning	Based on the assumption that internal cleaning involves toilet flushing (12 toilet flushes- 36L) and mopping (5 buckets each 10 L). Hot water only. 12 premises*86L/premises. 50% return to sewer	2%	0.6	1,032	516
External Cleaning	Assuming each bucket of water requiring for mopping contains 10 L, Assumed that two buckets of non potable water will be required each day for washing external surfaces. 12 premises. 25% return	0%	0.2	240	60
Total		100%	39.8	63,725	59,189

Table 2.2. Estimated demand for water based on an average of 40L/employee/shift and 1600 employees. Roof runoff is disinfected and used for all water supplies except toilet flushing. Recycled water is used for toilet flushing. A 4 star toilet water conservation system is used.

End Use (Water Demand)	Assumptions	Percentage of demand	Total demand/person/ shift	Recycled sewage demand/person/ shift	Total rain water demand (L/day)	Sewage volume (L/day)
Toilet and Urinal Flushing	Based on '4-star' toilet and urinal fittings.	0%	0.0	11.3	0	18,133
Hand Basin Washing	Based on 4 uses of the hand-basin per person/day for 15 seconds each time using a 3-star tap fitting (8.5 L/min). (75% hotwater)	30%	8.5		13,600	13,600
Showering	20% of staff have showers each day for 8 minutes each time using a 3-star shower head (8L/min). 50% of shower water is from the hot water system, based on roof runoff.	45%	12.8		20,480	20,480
Drinking	Personal consumption	7%	2.0		3,200	
Kitchen (washing & drinking)	Cooking, dishwashing 4 L / EP/ day (75% hot water)	14%	4.0		6,400	6,400
Leaking Water Devices and unaccounted for water	The water consumption attributed to leaking water devices was assumed negligible.	1%	0.4		640	0
Internal Cleaning	Based on the assumption that internal cleaning involves toilet flushing (12 toilet flushes- 36L) and mopping (5 buckets each 10 L). Hot water only. 12 premises*86L/premises. 50% return to sewer	2%	0.6		1,032	516
External Cleaning	Assuming each bucket of water requiring for mopping contains 10 L, Assumed that two buckets of non potable water will be required each day for washing external surfaces. 12 premises. 25% return	1%	0.2		240	60
Total		100%	28.5	11.3	45,592	59,189

2.5 Fire services supply

Roof runoff will be stored for fire services. The volume will be as per the local fire code.

Sprinkler Service: Two storage tanks of 650 m^3 will be needed to meet the requirements for the storage of Class 1 to 4 goods in the warehouses.
Hydrant Service: Two storage tanks of 216 m^3 will meet the requirements for the hydrant system.

It is suggested that the tanks be either covered or have an auto top-up float, with the top up system connected to the rain water tank system.

2.6 Emergency supply

It is recommended that Sydney Water Corporation be asked to supply as a minimum a 20mm water tap to the entry point of the development. As per SWC specifications the minimum pressure should be 40 metres.

The rainwater collection tanks should have automatic top up points designed to cut in when the volume in storage falls below 10 days supply (i. e <460,000 L for the scenario shown in table 2.4). An emergency alarm should be activated at this time and alternative potable water supplied be obtained. For example, individual warehouses could install drinking water fountains.

3 Supply and management of roof runoff

3.1 Roof runoff model

Sixty years of daily rainfall data for the area were used to construct a water balance model. Roof runoff capture was assumed to occur when daily rainfall exceeded 2mm. Efficiency was set at 80%, to allow for some first flush diversion. The total roof area for the site is 26 ha. Maximising the sufficiency of roof runoff is critical when Sydney Water is not being routinely used. Therefore the full roof area of 26 ha was used. Table 3.1 sets out the model components.

Table 3.1. Components used to model scenarios with a range of roof areas, storage capacities and daily demand for roof water.

Roof area: 26 ha.
Rainwater storage capacities tested: 1 ML 2 ML 3 ML 4 ML 5 ML
Daily demand: 64 cubic m or 46 cubic m (from tables 2.1 and 2.2)

3.2 Surface water runoff model

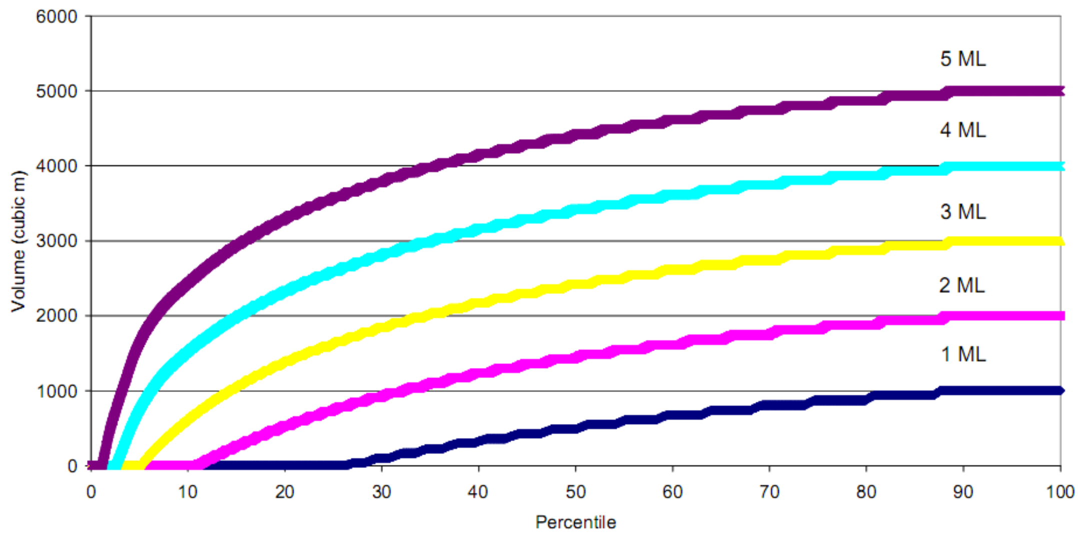
It is expected that regulatory authorities will require the peak runoff from the site to not exceed pre development flows. Capturing roof runoff and using it within the development as per table 2.2 will assist in reducing peak runoff. Infiltration basins will be used to further reduce peak outflow rates. These water cycle components are discussed in Section 4 below.

3.3 Adequacy of roof stormwater capture and reuse systems

The results of the 10 scenarios are shown as graphs of percentile of time for the volume of water in storage in figures 3.1 and 3.2.

Figure 3.1 shows that when the demand is 64 cubic m/day, there will be occasional periods when the rainwater tanks will be empty, even with 26 ha of roof catchment and 5 ML of storage. Tank capacities less than 4 ML will be empty for at least 11 days in the average year.

Figure 3.1. Roof runoff volume in storage as a percentile of time for 1 to 5 ML storage, 26 ha of roof catchment and 64 cubic m/day demand for roof water.



Relying on recycled water for toilet flushing reduces the demand for rainwater to 46 cubic m/day. Figure 3.2 shows that under these conditions, 3 ML of storage in conjunction with 26 ha of roof area will meet water demand in 98% of time. Increasing tank volume to an effective 4 ML will ensure that full water demand can be met in all but 1 day in the average year.

Figure 3.2. Roof runoff volume in storage as a percentile of time for 1 to 5 ML storage, 26 ha of roof catchment and 46 cubic m/day demand for roof water.

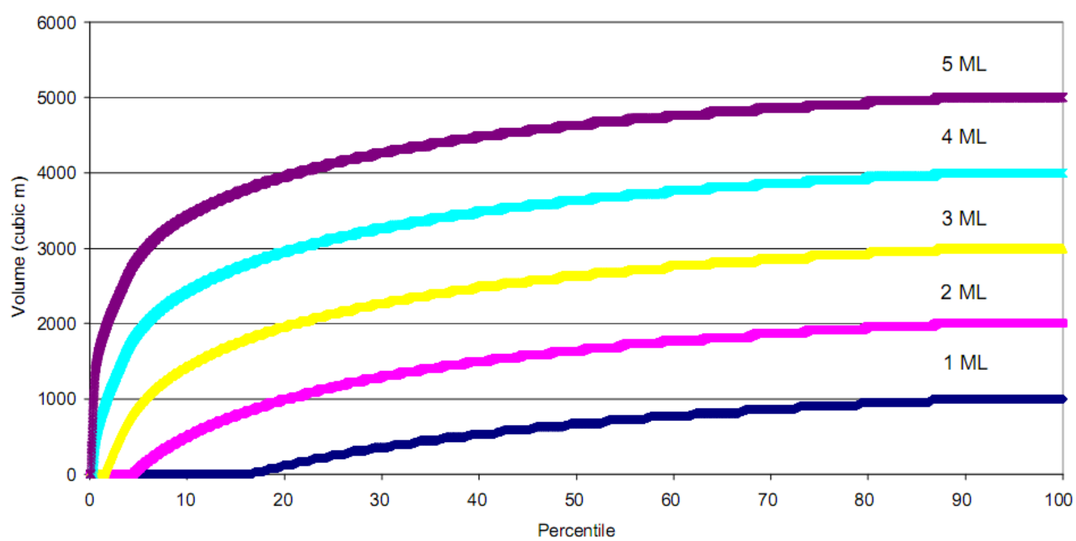


Table 3.2 sets out the percentage of time the various combinations of roof catchment and tank capacities would be unable to supply the non potable demand.

Table 3.2. The percentage of time that various storage tank sizes would be empty for demands of 64 and 46 cubic m/day. Assumes a roof catchment of 26 ha.

Storage volume	Demand for rainfall runoff	% of time that the tanks would be empty
1 ML	64 cubic m/day	29
2 ML		12
3 ML		5
4 ML		3
5 ML		1
1 ML	46 cubic m/day	18
2 ML		5
3 ML		2
4 ML		0.4
5 ML		0.1

Relying on roof runoff to supply all water needs except irrigation creates a demand of 64 cubic m/day. A 5 ML storage capacity is needed to ensure water is available in 99% of time.

A combination of reclaimed water for toilet flushing plus runoff from 26 ha of roof area for all other water needs under ‘normal’ conditions will require at least 3 ML of storage in order to achieve >98% reliability of supply. The assumed consumption of roof water is 46 cubic m/day.

Assuming the storage capacity was spread evenly among the buildings, average storage requirement would be approximately 0.35 ML/bulding for a demand of 46 cubic m/day.

3.4 Impact of capturing and using stormwater on runoff

The volume of stormwater storage/ ha can be based on the Water Management Act 2000. According to the provisions of this Act, approximately 10% of the average yearly runoff can be retained (DLWC, 2000). In the Kemps Creek area this is 0.084 of rainfall. The average annual rainfall since 1951 is 785 mm. 0.084 * 785 is 65.94 mm. Based on a 52 ha site, the maximum dam capacity would be 65.94*52*10000/1000 cubic m or 34 ML. The proposed storage capacity is up to 3 ML or 9% of the permissible maximum under the Water Management Act (2000). That is, the proposed rainwater harvesting is well within the 10% harvestable rights allowed under the Water Management Act.

4 Management of excess stormwater runoff

Section 3 above identified the potential for capturing and reuse of roof runoff as a substitute for potable water. The recommended scheme involved a minimum of 26 ha of roof area connected to a minimum of 3 ML of storage. The system would supply 46 cubic m/day in over 98% of time. That is, it would reduce roof runoff volume by 16.5 ML/year.

Table 4.1 sets out the site components.

The total site area is 52 ha. The RTA requires a 20m set back on the 1.5 km frontage so the development site is 49.8 ha. There are 26 ha of roof, 16.3 ha of hard stand and 7.5 ha of space for water storage, treatment and irrigated landscaping.

The site is divided into 2 subcatchments, with 42% of the development area in the eastern catchment and 58% in the west. Table 4.1 shows the anticipated land uses within the catchments.

Table 4.1 Land use components within each catchment of the site.

Component	Roof (ha)	Hardstand (ha)	Landscaping (ha)
Total site	26.00	16.30	7.50
East catchment	10.92	6.85	3.15
West catchment	15.08	9.45	4.35

MUSIC modelling was used to identify the extent to which the site hydrology and contamiant export changed because of stormwater treatment and reuse.

4.1 Current conditions

The site is covered with unimproved pasture. The soil was Luddenham Soil Landscape (Bannerman and Hazelton, 1990). This soil has a loam top soil some 9 cm thick. The subsoil is a clay loam.

4.2 Model inputs

The default values in MUSIC were used for agricultural and urban landuses. Use of urban default values for the roofs is likely to exaggerate the contamination yield. However the hard stand areas may have greater contamination, e.g from heavy trucks, than may occur in 'normal' urban areas. It was therefore decided to use default values.

In order to use the longest available data set it was decided to use that from Parramatta (met stn 066046). This data set has over 23 years of pluviograph information. Parramatta, with 921 mm average annual rainfall, has higher rainfall than Kemps Creek (784 mm). However the pattern is similar. Additionally designing for slightly higher rainfall allows for possible climate change impacts.

4.3 Model components

A range of different stormwater treatment devices and configurations were 'tested' in MUSIC to establish a treatment sequence that meets Penrith City Council's Water Management DCP. The final configuration is shown in figure 4.1.

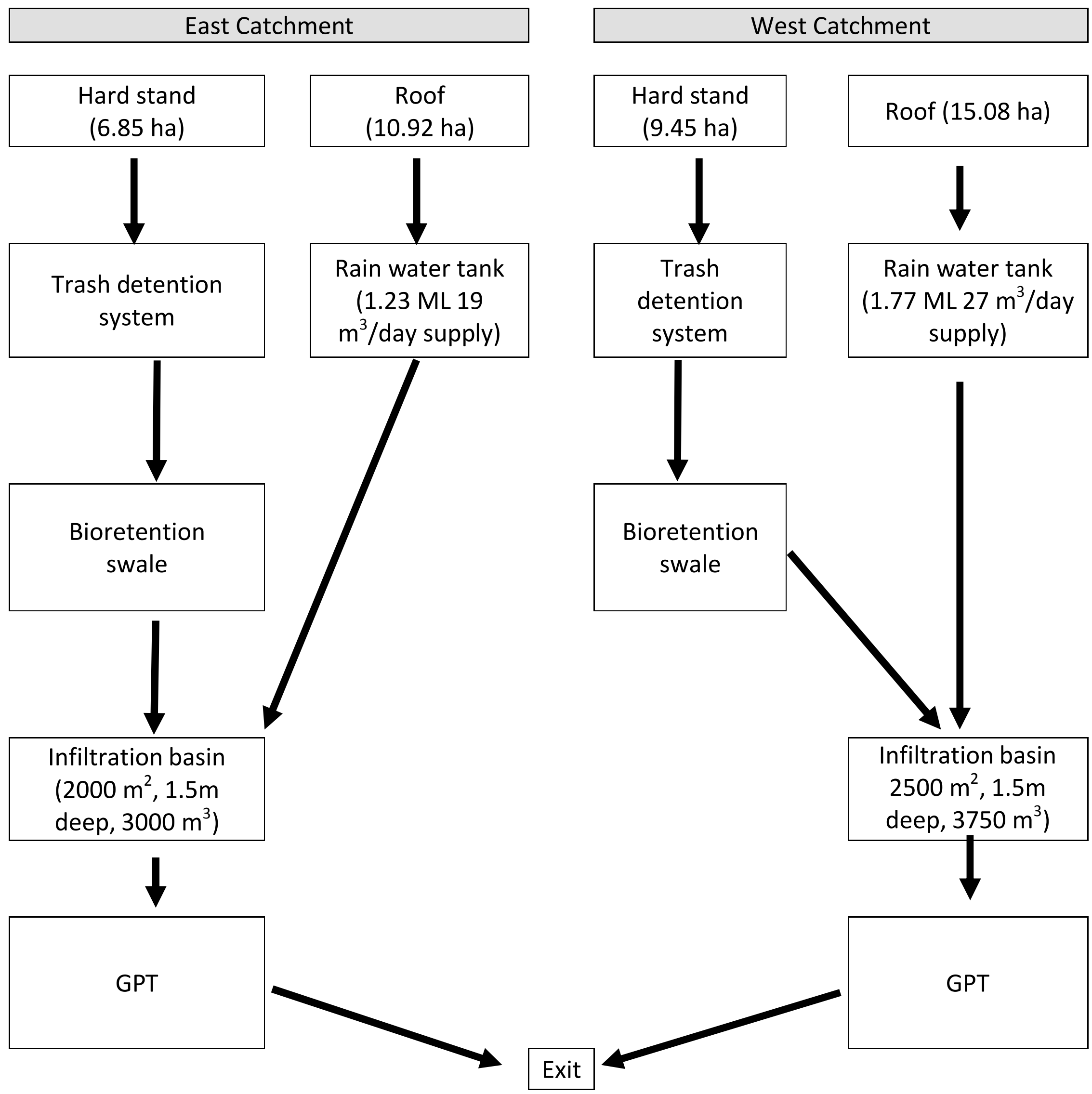


Figure 4.1. Schematic of stormwater management configuration.

The system will have 3 ML of roof runoff tanks and 6.75 ML of infiltration basins (providing On Site Detention (OSD)).
Area requirements are:

- Bioretention swale system 1150 m long, 1m wide base, 3m wide in total
- 2 rainwater tanks 4m high covering some 400 msq each
- 2 infiltration basins (OSD) east side 2000 m^2, west side 2500 m^2
- A 2000 m^3, 1700 m^2 wet weather storage pond for the on site sewage treatment and irrigation system.

4.4 Results

Pluviograph data was used in MUSIC was combined with the approach in Australian Rainfall and Runoff (1998) to identify peak flows for a range of significant storm events. These are shown in table 4.2.

Table 4.2 Pre and post development peak flows based on 30 minute time steps.

Average Recurrence interval (ARI)	Pre development (m3/sec)	Post development (m3/sec)
1 year	5.32	4.96
2 years	6.53	6.09
5 years	8.34	6.31
10 years	9.33	8.70
20 years	11.87	10.08
50 years	12.13	11.31
100 years	13.65	12.73

The results indicate that the stormwater treatment sequence shown in figure 4.1 has resulted in slightly lower peak flows than the current peak outflows from the development area.

Table 4.3 compares the stormwater volumes and contaminant load from the current site and the developed site with and without the proposed stormwater management inputs.

Table 4.3. Effectiveness of the proposed stormwater management devices in achieving Penrith City Council's water management guideline targets.

Component	Units	Pre development	Post development without stormwater management	Post development with stormwater management	% change	Penrith City Council's guideline	Compliant
Runoff volume	ML/y	125	330	185	-44%		Yes, see table 4.2.
Gross pollutants	kg/y	857	8710	0	-100%	-70%	Yes
Total suspended solids	kg/y	19900	66100	17200	-74%	-70%	Yes
Phosphorus	kg/y	58	137	52	-62%	-45%	Yes
Nitrogen	kg/y	449	951	470	-51%	-45%	Yes

The results in table 4.3 show that the proposed system complies with Penrith City Council's water management guideline DCP.

4.5 Conclusions

The proposed system integrates the water cycle management for the site. It is virtually independent of Sydney Water for potable supplies, and will have its own sewage treatment and recycling system.

Peak stormwater outflow rates and the contaminant load exports will be similar to predevelopment conditions.

5 Recycled water management and site irrigation demand

Total volume of sewage to be treated is estimated in tables 2.1 and 2.2 to be 59.2 cubic m/day, assuming 1600 shifts/day. Assuming workers excrete 1L/shift of liquid the total sewage flow sill be 60. cubic m/day.

In table 2.2 it was assumed that, following treatment, 18.1 cubic m of effluent was returned for toilet flushing. Therefore there was an excess of 60.5 cubic m-18.1 cubic m or 42.2 cubic m of excess recycled water produced each day.

The next section examines the effects of irrigation area on the site water balances.

5.1 Water balance under natural pasture conditions

A daily water balance was constructed using rainfall and evaporation for the past 60 years (Jan 1951 to May 2011).

A water balance was then constructed for the zero irrigation scenario. The components are shown in table 5.1

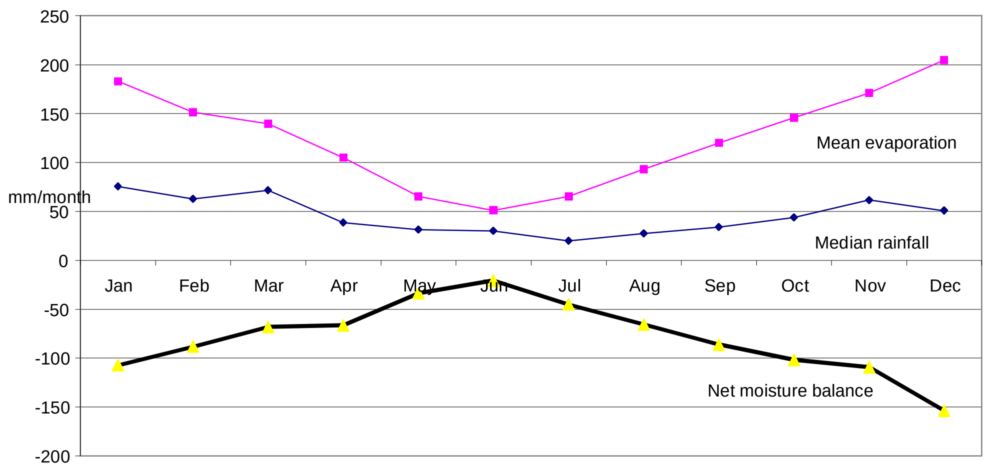
Table 5.1. Water balance for zero irrigation at Kemps Creek from Jan 1951 to May 2011(Figures derived from BoM data and FAO based modelling). (The percentages do not add exactly to 100 as there is some rounding of data).

Component	Daily average (mm)	Annual average (mm)	Percentage of rainfall
Rainfall	2.15	786	
Pan evaporation	4.03	1470	
Potential evapotranspiration	3.35	1221	
Rainfall runoff	0.24	86	11% of the rainfall
Infiltration into the soil	1.91	698	89% of the rainfall
Actual evapotranspiration (no irrigation)	1.53	560	71% of the rainfall
Percolation below the root zone	0.35	128	16% of the rainfall

The figures above provide a base line for establishing the viability of the proposed irrigation system. For example the potential evapotranspiration is 1.5 times the rainfall. This suggests that there is potentially a significant ‘avenue’ for removal of excess water generated on the site.

The figure below shows the annual rainfall, evaporation and net soil moisture balance.

Figure 5.1. Median monthly rainfall, mean monthly pan evaporation and difference between rainfall and evaporation each month in the average year (from BoM).



It is obvious that there is a strong seasonal trend. In winter there may be a need to retain excess water, whilst in summer there may not be enough to maximise plant growth (and attractiveness).

The issue are:

1) How much irrigation area is needed?
2) What size of wet weather storage is required?

There is a general relationship between irrigation area and storage requirements. This is illustrated in Figure 5.2.

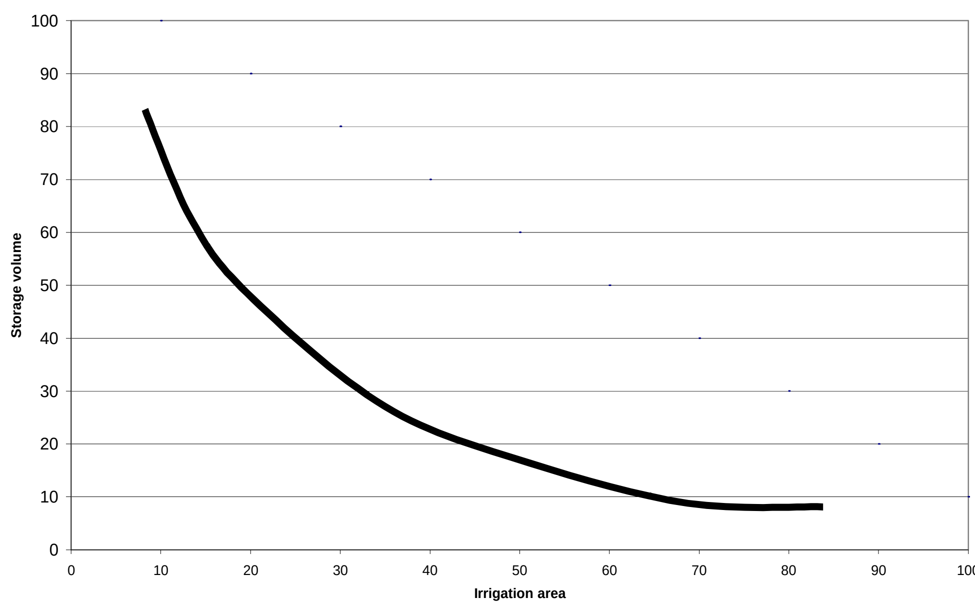


Figure 5.2. Generalised relationship between irrigation area and wet weather storage requirement.

In order to assess this relation for the Kemps Creek site a range of irrigation areas and a range of storage capacities were examined.

The aim was to assess the volume of recycled water that could be irrigated each day without increasing runoff from the site.

The average sewage flow was set at 42.2 cubic m (15.4 ML/y).

5.2 Effect of recycling reclaimed water for toilet flushing

Recycling water through the toilets has minimal impact on sewage flows. It is assumed each worker adds the equivalent of 1L/day or 1600 L when the site is fully developed. Without recycling the net outflow is 64 cubic m/day as table 2.1 shows. With recycling for toilet flushing the net demand is reduced to 42.2 cubic m/day, including the 1.6 cubic m/day of liquid excreted by the workforce. So the wet weather storage and irrigation system needs to accommodate 42.2 cubic m/day.

Table 5.2 shows the effect on overflow frequency of varying irrigation area and the irrigation quantity. The wet weather storage is set at 2000 cubic m. This is equivalent to 47 days flow.

Table 5.2. Change in frequency of overtopping with change in irrigation area and irrigation strategy. Sewage production of 64 cubic m/day, 18 cubic m is returned as flush water, net outflow is 42.2 cubic m/day.

Water balance component	Units	3 ha, 12.5 mm Irr	5 ha, 12.5 mm Irr	7 ha, 12.5 mm Irr	7 ha, 6.25 mm Irr
Percentage of years with overflow events	%	72	47	50[2]	43

Based on 42.2 cubic m/ day outflow and 12.5 mm irrigation, a combination of 5 ha of irrigation is needed if the wet weather storage is 2000 cubic m.

This combination is recommended for the system if reclaimed water is used for toilet flushing.

5.3 Hydrological and nutrient loading

Applying 15.4 ML to 5 ha is equivalent to applying 308 mm of irrigation each year.

The Aquacell sewage treatment plant is designed to deliver recycled water Nitrogen concentrations of<15 mg/L and recycled water Phosphorus concentrations of <10 mg/L. So the irrigation system is designed to deliver <15*3.08 kg of Nitrogen/ha/y (or 46 kg/ha/y) and <10* 3.08 kg of Phosphorus/ha/y (or 31 kg/ha/y). Indicative uptake by plants is around 100 kg/ha/y of Nitrogen and 20 kg/ha/y of Phosphorus. Nitrogen supply is less than potential demand, so there is minimal risk of Nitrogen loss, at least in the short to medium term. Phosphorus application rate

[2] The 7 ha of irrigation area is too large for the wet weather storage, so it is rare that the storage has sufficient volume (900 cubic m) to allow irrigation. If 7 ha of irrigation were developed the irrigation rate should be reduced to 6.5 mm.

exceeds likely demand so some of the Phosphorus will be retained in the soil. The ability of the soil to retain this excess Phosphorus is a function of the soil's P sorption capacity and the depth of the soil (DEC, 2004). The site's soils are derived from Wianamatta Shales. These have over 12,000 kg of P sorption capacity/ ha (DEC, 2004), so even if there was no uptake by plants the surface 1 metre of soil would take almost 400 years before it was saturated.

Finally, the nutrient concentration in the recycled water can be adjusted if necessary to reduce nutrient concentration in the recycled water. However at this stage this is not needed.

6 Conclusions

The solution that that will be implemented for the site will mean that the site will operate with no reliance on Sydney Water infrastructure 98% of the time for an average year. This will be achieved by collecting all water from roof runoff and stored in 3ML of tanks. Assuming the storage capacity was spread evenly among the buildings, average storage requirement would be around 0.3 ML/building for the calculated demand of 46 cubic m/day. Blackwater generated from the site will be re-used for toilet flushing and landscape irrigation.

In the 2% event that water will be required from Sydney Water, a total volume of 322 cubic m will be needed in the average year. This is similar to that used/year by a single household with moderately sized gardens, and 2 adults plus 3 children in residence. That is, the entire development has a similar annual demand to that of a single dwelling.

The site currently has a domestic supply of this size connected to the existing house.

The strategy for water and wastewater autonomy will be is achieved at no cost to Sydney Water or Government.

Storage volume	Demand for rainfall runoff	Percentage of time that Sydney Water will be needed	Days in the average year	Volume required from Sydney Water in the average year (cubic m)
3 ML	46 cubic m/day	2 %	7	322

A combination of diverting roof runoff for consumption, pollutant traps and infiltration basins reduces the post development peak stormwater outflow to rates less than those of predevelopment flows. Contamiant yield reduction was sufficient to meet targets set by Penrith City Council.

Recycling treated wastewater to flush toilets reduced net effluent production to 42.2 cubic m/day. A combination of a 2000 cubic m of wet weather storage and 5 ha of irrigation is sufficient to ensure there is no recycled water overflow in the 50%ile wet year. The system therefore achieves the DEC (2004) guidelines for out flow in less than 50% of years.

7 References

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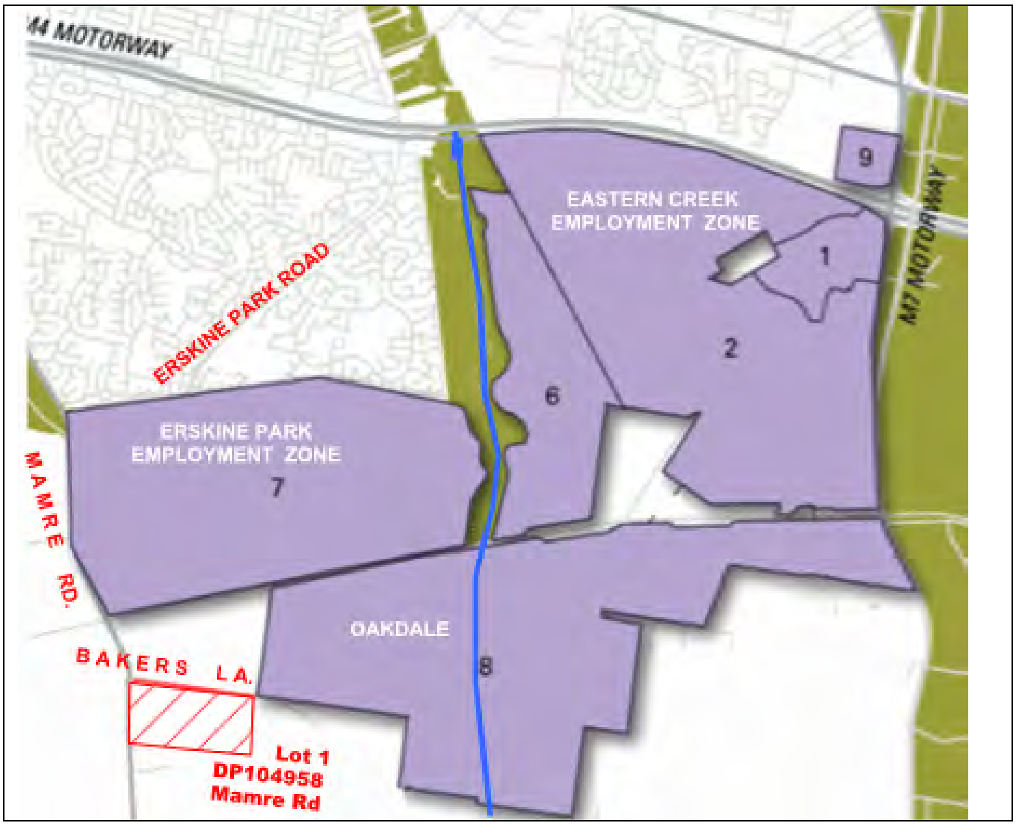
Appendix C – Storm Water Management Plan

Buckton Lysenko Consulting

STORMWATER MANAGEMENT PLAN
LOGOS Kemps Creek Logistics Project
Mamre Rd, Kemps Creek

Prepared for LOGOS Property Group



Prepared by:
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Suite 407, Henry Lawson Business Centre
Roseby Street
DRUMMOYNE NSW 2047

Dated: 24June, 2011 v10

TABLE OF CONTENTS

Annexure

Tables & Figures

A1 INTRODUCTION

Buckton Lysenko has been engaged by Logos Property to prepare a Stormwater Management Plan in support the proposed development to accommodate a warehousing distribution center.

The site has an area of 50 hectares and measures approximately 1000m by 500m and is predominately rural. It is bounded by Mamre Road, Bakers Lane and private properties to the east and south.

A ridge line splits the site so it slopes gently the North East and South West. The western portion of the site drains under Mamre Road, and into South Creek. The eastern portion of the site drains into a culvert under Bakers Lane and into a tributary of South Creek.

There are no visible signs of land degradation such as erosion.

This Stormwater Management Plan supersedes the August, 2010 submission to Planning. This submission includes environmentally friendly initiatives and was done in conjunction with Dr. Peter Bacon of Woodlots & Wetlands. The Buckton Lysenko portion of this report covers the hydraulic design for:-

- Site storm and roof water drainage
- Gross pollutant traps
- Rainwater harvesting tanks,
- Grassed and Bio-retention swales plus overland flow paths

.

The drainage performance requirements for the above elements were set by Dr. Peter Bacon after determining the impact of rainwater harvesting and reuse on this site.

A2 PLANNING POLICIES

Council's Stormwater Quality Control Policy (Penrith DCP 2006) sets the water quality discharge standards for new developments and methodology for demonstrating that the standards are met. Tables 1, 2 and 3 have been extracted from the DCP

Table 1 - Modeling Water Quality Impacts of New Developments

Total Development Area	Modeling Approach	Description
Small (5 ha to 10 ha)	Level 1 Average Annual Storm Load	*This prediction level estimates the average annual pollution loads for stormwater, commonly expressed in kilograms of pollutant exported per year. These relatively simple modeling techniques, which may relate to land use, annual rainfall, catchment runoff characteristics and average pollutant concentrations to estimate the actual pollutant load.*
Medium (10 ha to 50 ha)	Level 2 Actual Event Load	*This level assesses the pollutant loads from a storm event or on a daily basis. These models use daily or event runoff, which is then used to calculate pollutant loads.*
Large (> 50 ha)	Level 2 or 3 Actual Distribution of Concentrations & Load within Events. (On-site calibration)	*This level estimates actual pollutant concentrations and loads, as a function of time, within each storm event. This form of modeling uses relatively short duration rainfall data (e.g., 5-60 mins) and complex modeling of runoff characteristics from pervious and impervious areas to generate pollutographs, which indicate variations in pollutant concentration over time.*

Table 2 – Pollutant Retention Criteria

Pollutant	Description	Retention Criteria
Litter	All anthropogenic material (cans, bottles, wrapping etc)	70% of material ≥ 5 mm diameter
Coarse Sediment	Course sand (≥0.5mm)	80% of the load for particles ≤ 0.5 mm dia.
Nutrients	Total Phosphorus &* Total Nitrogen	45% retention of the load for each
Fine Particulates	fine sand (<0.5mm)	50% of the load for particles ≤ 0.1mm dia.
Free Oil & Grease	Free floating viscous liquids ≥ 150 μm that do not emulsify in aqueous solutions	90% of the load with no visible discharges
Free Oil & Grease	Free floating viscous liquids ≥ 150 μm that do not emulsify in aqueous solutions	90% of the load with no visible discharges

Table 3 – Average Annual Pollutant Loading Rates (Suitable for Use in Western Sydney in the Absence of Site Specific Information)

Land Use	Runoff Coeff (CV)	Course Sediment (KGS/HA/AN)	Fine Particulates (KGS/HA/ AN)	Total Phosphorus (KGS/HA/ AN)	Total Nitrogen (KGS/ HA/AN)	Organic Matter (M3/HA/AN)	Litter (M3/HA/AN
Natural	0.15	15	-	0.03	0.54	0.09	-
Pre-Development	0.2	90	-	0.16	1.26	0.05	0.01
Residential	0.35	500	45	0.8	4.8	0.25	0.05
Commercial	0.5	900	100	1.6	8.1	0.2	0.45
Industrial	0.52	950	110	1.7	9.5	0.2	0.35

A3 POLLUTANT GENERATION, WATER QUALITY and QUANTITY CONTROL

Extracts of the treatment train and controls proposed by Dr. P. Bacon in Section 4 of the Woodlands & Wetlands Report and incorporated in our design are outlined below.:-

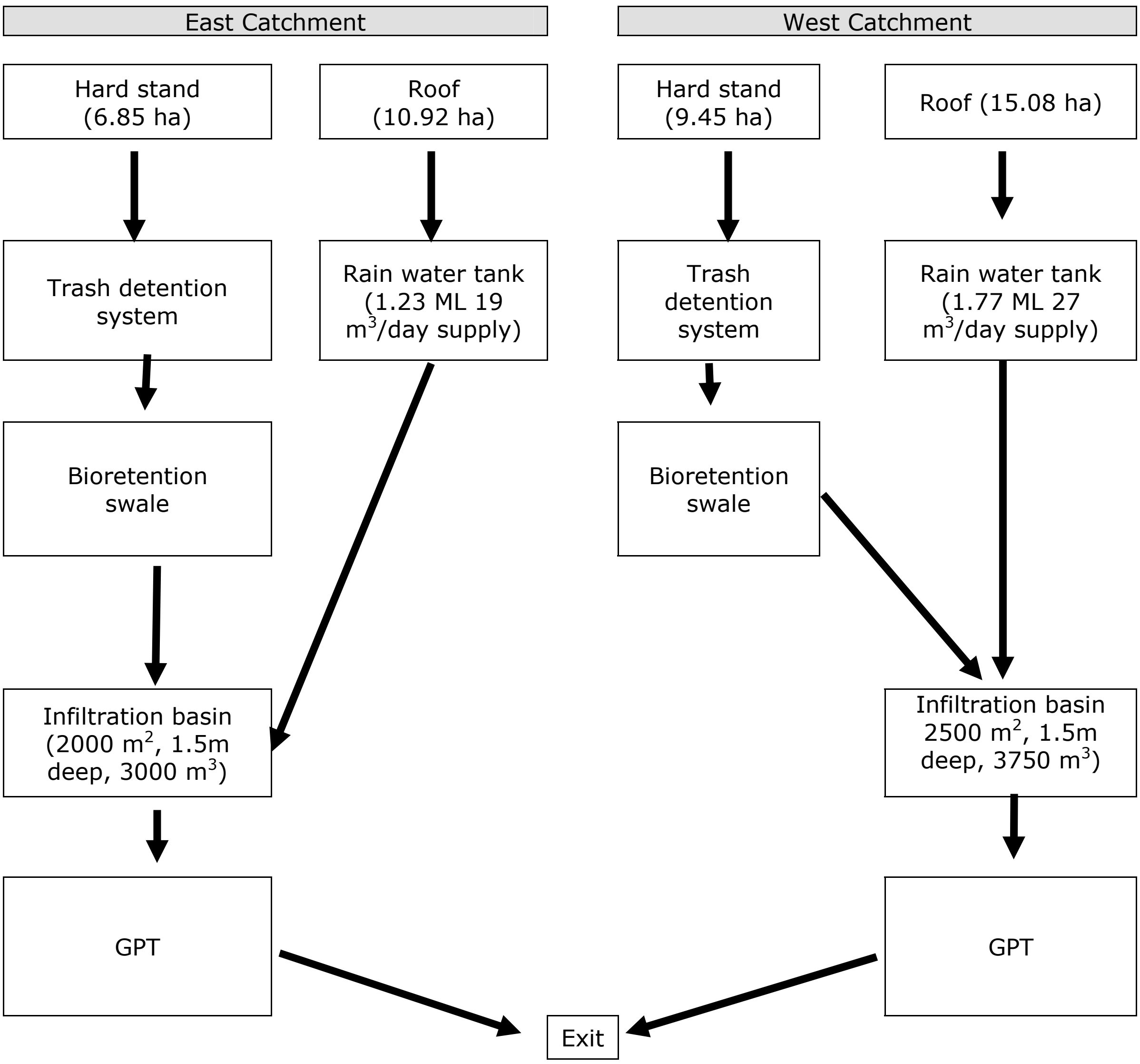


Figure .1. Schematic of stormwater management configuration (copied from Woodlots and Wetlands, 2011).

System components:

The system will have

- 3 ML of roof runoff storage capacity
- 6.75 ML of infiltration basins (providing On Site Detention (OSD)).
- Bioretention swale system 1150 m long, 1m wide base, 3m wide in total
- 2 infiltration basins (OSD) east side 2000 m^2, west side 2500 m^2
- A 2000 m3, 1700 m2 recycled non-potable water storage and irrigation system.
- Sprinkler Service: Two storage tanks of 650 m3 will be needed to meet the requirements for the storage of Class 1 to 4 goods in the warehouses.
- Hydrant Service: Two storage tanks of 216 m3 will meet the requirements for the hydrant system.

Pluviograph data was used in MUSIC modelling and was combined with the approach in Australian Rainfall and Runoff (1998) to identify peak flows for a range of significant storm events. These are shown in table 4.

Table 4 Pre and post development peak flows based on 30 minute time steps (copied from Woodlots and Wetlands, 2011).

Average Recurrence interval (ARI)	Pre development (m3/sec)	Post development (m3/sec)
1 year	5.32	4.96
2 years	6.53	6.09
5 years	8.34	6.31
10 years	9.33	8.70
20 years	11.87	10.08
50 years	12.13	11.31
100 years	13.65	12.73

The results indicate that the stormwater treatment sequence shown in figure 1 has resulted in slightly lower peak flows than the current peak outflows from the development area.

Table 5 compares the stormwater volumes and contamiant load from the current site and the developed site with and without the proposed stormwater management inputs.

Table 5. Effectiveness of the proposed stormwater management devices in achieving Penrith City Council's water management guideline targets (copied from Woodlots and Wetlands, 2011).

Component	Units	Pre development	Post development without stormwater management	Post development with stormwater management	% change	Penrith City Council's guideline	Compliant
Runoff volume	ML/y	125	330	185	-44%		Yes, see table 4
Gross pollutants	kg/y	857	8710	0	-100%	-70%	Yes
Total suspended solids	kg/y	19900	66100	17200	-74%	-70%	Yes
Phosphorus	kg/y	58	137	52	-62%	-45%	Yes
Nitrogen	kg/y	449	951	470	-51%	-45%	Yes

The results in table 5, above, show that the proposed system complies with Penrith City Council's water management guideline DCP.

The Music model with long term local meteorological data was used above by Peter Bacon of Woodlots and Wetlands to confirm the performance and impact of the:-

- Water quality elements.
- Water balance for the site.
- Rain water harvesting on the performance of the OSD system.

Buckton Lysenko's original pre-development flow estimates determined with RAFTS (see Table 7 Section A3) were consistent with the above Music results. The minor differences in the answers are due to the different approaches in the hydrology modules of Music and Rafts software. Music uses long term local meteorological data from local gauging stations where Rafts uses standard storm patterns prescribed in Australian Rainfall & Runoff (EIA, 1998). The reduced flows generated by Music are due to rainwater harvesting, and justify a reduction in OSD volumes of 20%.

A3.1 STORMWATER HARVESTING & REUSE

Roof water is captured and stored in two tanks. This water is treated to a potable standard and reticulated around the site.

The additional benefit of rainwater reuse is the reduction of peak flows and volumes from the site which brings the discharge closer to the natural state.

A3.2 GROSS POLLUTANT TRAPS

It is proposed to install an Ecosol unit in the stormwater system in each catchment. These are required to help remove 80 % of the Total Suspended Solids (TSS) from the annual discharge. The GPTs also remove the solid litter and oils and nutrients within litter that may be flushed into the stormwater pipe network.

A3.3 BIO-RETENTION FILTER

These pollutant filter facilities consist of permeable soil, sand and gravel layers some 1010 mm in overall depth which trap sediments and the attached nutrients, metals and other soluble pollutants as they seep through the layers to underlying subsoil drainage lines located at the bottom of the filter media containing trenches. The bio-retention filter is primarily targeting flows up to the 3 month discharge; however runoff up to approximately the 1 year event is to be routed through the facility.

A4 ANALYSIS OF UPSTREAM CATCHMENTS

The site is located towards the top of a ridge line within the South Creek catchments. Under existing conditions some of the runoff from adjacent areas would pass through the site. The minor upstream catchment has been intercepted and diverted around the development. (Refer Annexure "C" (PRE- DEVELOPMENT CATCHMENT PLAN)

Surface flows from the minor upstream catchment converge near the North Eastern corner of the site. These flows are intercepted and conveyed via a pipe to the north-eastern corner, then allowed to flow in an open swale to the existing site discharge point on Bakers Lane. This pipe/swale system will convey the 100 year storm flows around the new development.

Development of the site in the manner proposed within this report is expected to meet and generally exceed Penrith City Council's objectives and performance criteria for stormwater.

The proposed design makes use of Best Management Practices as well as high quality proprietary equipment. The treatment train proposal reduces peak flows while improving water quality. The proposed design is sympathetic to the industrial nature of the overall development area and should lend itself to relatively minimal maintenance requirements.

A5 STORMWATER DRAINAGE SYSTEM

Generally stormwater runoff generated from the roof and surface areas is collected via a pit and pipe system which has been designed to a minimum 1 in 20 year ARI standard. The site pavement grading allows for runoff in excess of the pipe capacity or pipe blockage to be directed to the OSD in the low points at Bakers Lane and Mamre Road.

Pavement runoff generally sheets onto a Bio-filtration swale then it is conveyed to a GPT which discharges to the Bio-filtration system within the OSD ponds. The two OSD storages have been designed such that the post development discharges do not exceed natural flows.

Pre-development flows were determined for all recurrence intervals up to 100 years after determining the natural flow paths and time of concentration (Refer Annexure C and B). The calculated flows were:-

Table - 6: Pre-Development Flows & Critical Storm Durations

ARI (yrs)	Critical Storm (hrs)	East Catchment (m^3/s)	Critical Storm (hrs)	West Catchment (m^3/s)	**Total Flow (m^3/s)**
5	2	3.82	2	3.44	**7.26**
10	2	4.45	2	4.25	**8.70**
20	2	5.29	1	5.37	**10.66**
50	1	6.12	1	6.42	**12.54**
100	1	7.01	1	7.51	**14.52**

The reduction of storm flows due to water harvesting was considered in the design of piping.

The internal drainage design meets and in some areas exceeds the flows generated by the 20 year storm. Detail DRAINS calculations are contained in Annexure D and the resultant element sizes in Annexure E

Road drainage in Bakers Lane and Mamre Road was designed for a 1 in 20 year ARI. To meet current standards the two existing culverts in Mamre Road are to be replaced with a 600 and 1500 diameter pipes and the one in Bakers Lane will be replaced with an 1800 diameter pipe.

As this site is located at the top of the catchment it is not subject to flooding.

There are no adverse drainage impacts from this development on the neighboring properties as relative to the current state there is up to 15% reduction in stormwater flows.

ANNEXURE "A"

SITE LAYOUT PLAN

david@axisarchitects.com.au

LOGOS Property

LOGOS Kemps Creek Logistics Project

MAMRE ROAD & BAKERS LANE, KEMPS CREEK. NSW

AXIS architectural
2 / 107 Cronulla Street, Cronulla NSW 2230
p + 02 9523 7858 e +
nominated architect - David McDonald NSW ARB -7997

ESTATE LAYOUT PLAN
LOT 1 & 2

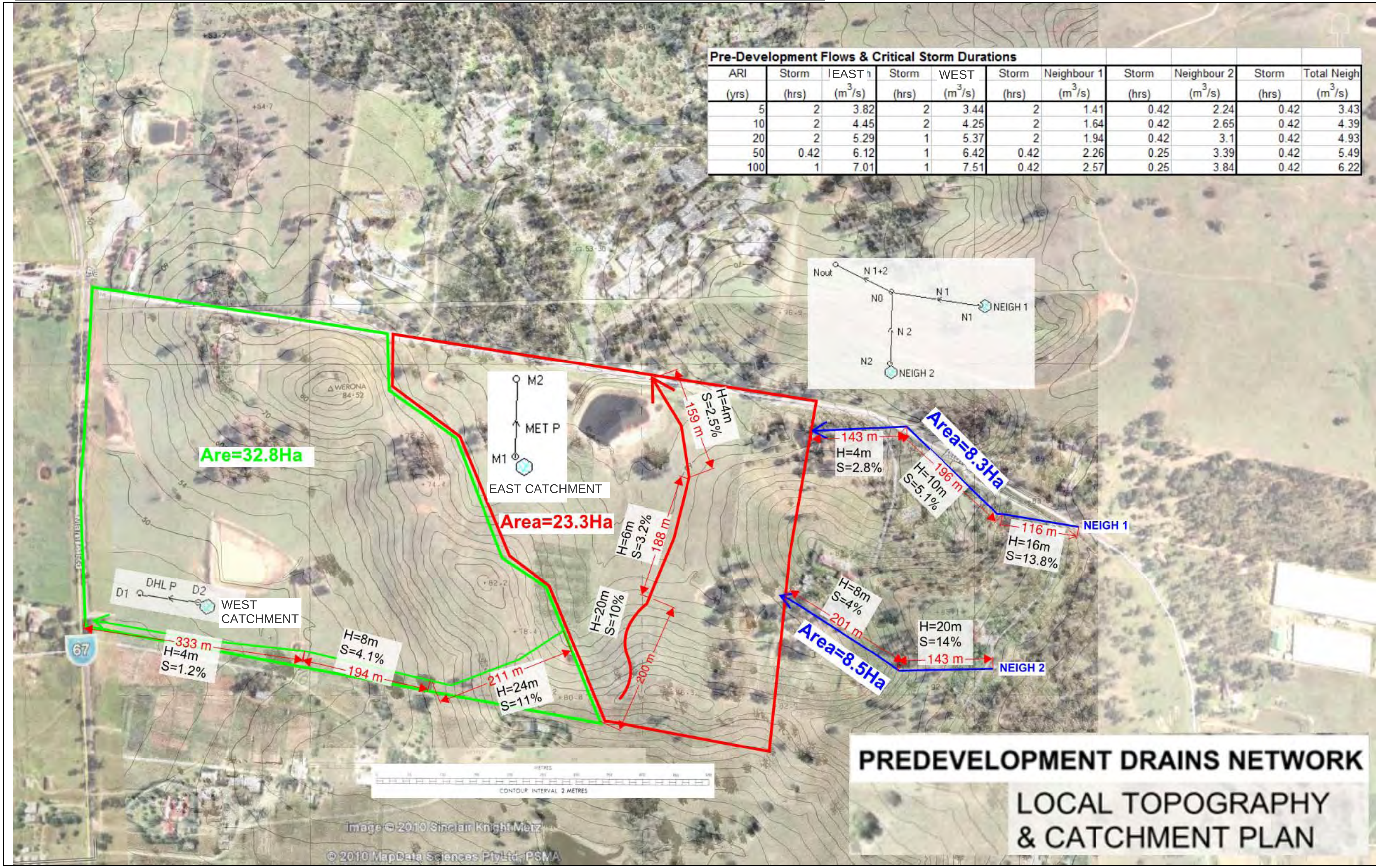
August 2010
1:3000 scale

100501/ LP-EP-DA

A 101 / E

ANNEXURE "B"

Pre-Development Catchment Plan

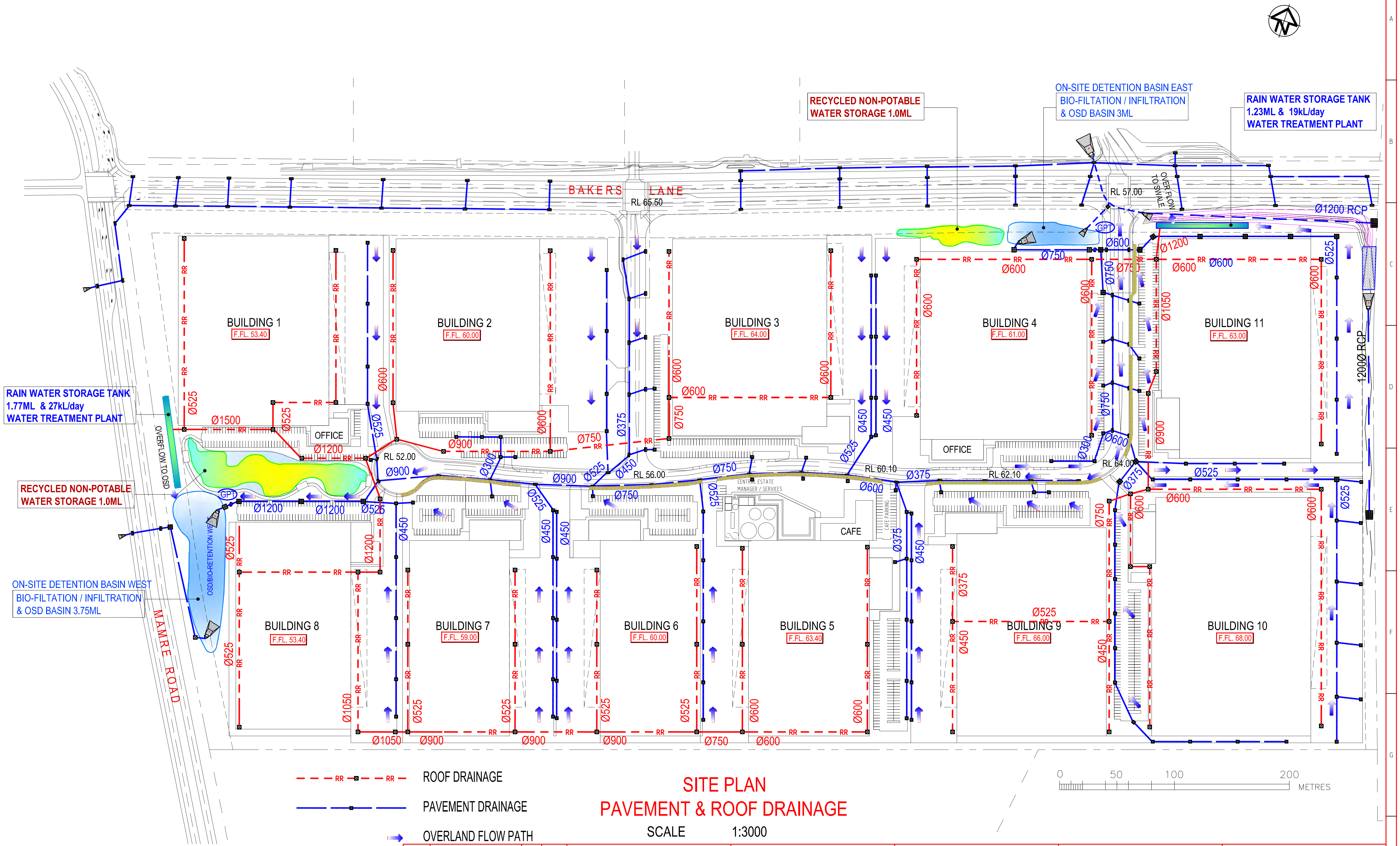


Pre-Development Flows & Critical Storm Durations

ARI (yrs)	Storm (hrs)	EAST (m³/s)	Storm (hrs)	WEST (m³/s)	Storm (hrs)	Neighbour 1 (m³/s)	Storm (hrs)	Neighbour 2 (m³/s)	Storm (hrs)	Total Neigh (m³/s)
5	2	3.82	2	3.44	2	1.41	0.42	2.24	0.42	3.43
10	2	4.45	2	4.25	2	1.64	0.42	2.65	0.42	4.39
20	2	5.29	1	5.37	2	1.94	0.42	3.1	0.42	4.93
50	0.42	6.12	1	6.42	0.42	2.26	0.25	3.39	0.42	5.49
100	1	7.01	1	7.51	0.42	2.57	0.25	3.84	0.42	6.22

ANNEXURE "C"

DRAINS MODELS



— — RR — — RR	ROOF DRAINAGE
— — — —	PAVEMENT DRAINAGE
→	OVERLAND FLOW PATH

SITE PLAN
PAVEMENT & ROOF DRAINAGE

SCALE 1:3000

PHASE/REVISION	DESCRIPTION	BY	DATE
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ARCHITECT: AXIS

CLIENT: LOGOS Property

CONSULTANT: BUCKTON LYSENKO CONSULTING ENGINEERS

PROJECT: BAKERS LANE KEMPS CREEK

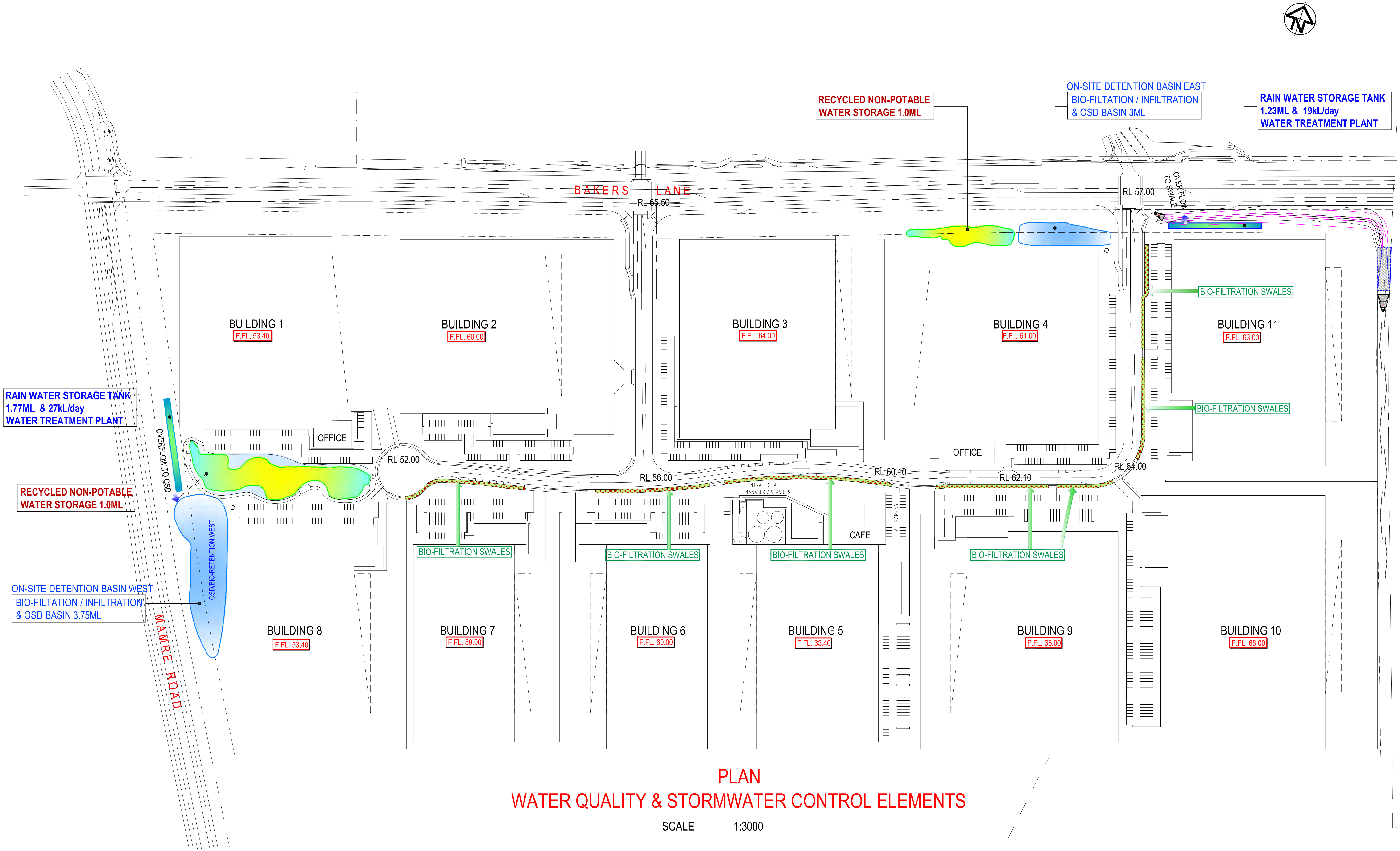
DRAWING TITLE: CIVIL STORMWATER
STORMWATER CONCEPT
SITE PLAN
SHEET 1

DRAWN	SCALE	CAD FILE	
RW	AS SHOWN		
PROJECT	PHASE	REVISION	DRWG. No.
24991	0	2	CP1

LOGOS Property

LOGOS Kemps Creek Logistics Project

MAMRE ROAD & BAKERS LANE, KEMPS CREEK. NSW



PLAN
WATER QUALITY & STORMWATER CONTROL ELEMENTS

SCALE 1:3000

LOGOS Property

LOGOS Kemps Creek Logistics Project

MAMRE ROAD & BAKERS LANE, KEMPS CREEK. NSW

PHASE/ REVISION	DESCRIPTION	BY	DATE
2	NOTATION	BL	24.06.11

ARCHITECT: AXIS

CLIENT: LOGOS Property

CONSULTANT: BUCKTON LYSENKO Consulting Engineers
Suite 407, Henry Lawson Business Centre
Birkenhead Point
Roseby Street, Drummoyne NSW 2047
Telephone: (02) 9719 3700
Facsimile: (02) 9719 3711
E-Mail: email@bucktonlysenko.com.au

PROJECT: BAKERS LANE KEMPS CREEK

DRAWING TITLE: CIVIL STORMWATER QUALITY & CONTROL ELEMENTS

DRAWN	SCALE	CAD FILE	
RW	AS SHOWN		
PROJECT	PHASE	REVISION	DRWG. No.
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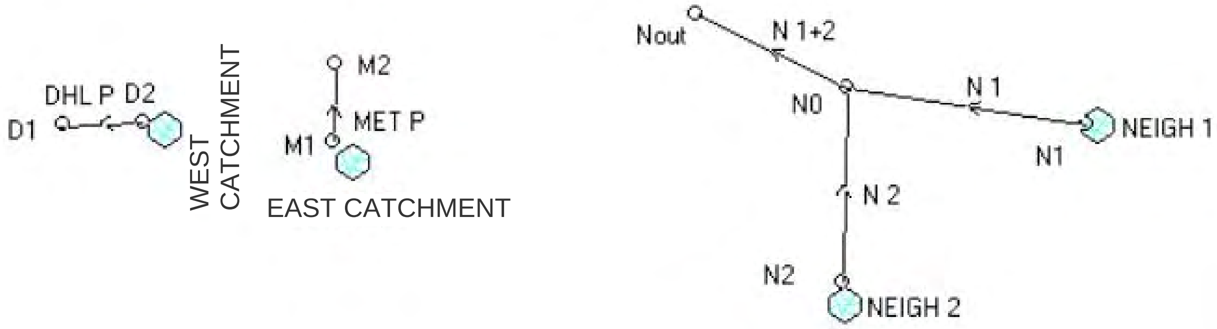


DATA FILE

PIT / NODE DETAILS   Version 9

Name	Type	Family	Size	Ponding Volume (cu.m)	Pressure Change Coeff. Ku	Surface Elev (m)	Max Pond Depth (m)	Base Inflow (cu.m/s)	Blocking Factor	x	y	Bolt-down lid	id	Part Full Shock Loss
N2	Node					10		0		-1419.507	11677.2		941277	
N0	Node					5		0		-1417.196	11782.46		941172	
Nout	Node					2		0		-1499.436	11822.64		941267	
N1	Node					7		0		-1287.561	11762.53		941278	
M1	Node					8		0		-1697.473	11753.63		964401	
M2	Node					5		0		-1696.856	11795.63		941175	
D2	Node					8		0		-1801.231	11763.52		964414	
D1	Node					5		0		-1844.229	11762.53		964410	

DETENTION BASIN DETAILS

Name	Elev	Surf. Area	Init Vol. (cu	Outlet Type	K	Dia(mm)	Centre RL	Pit Family	Pit Type	x	y	HED	Crest RL	Crest Leng	id

SUB-CATCHMENT DETAILS

Name	Pit or Node	Total Area (ha)	Paved Area %	Grass Area %	Supp Area %	Paved Time (min)	Grass Time (min)	Supp Time (min)	Paved Length (m)	Grass Length (m)	Supp Length (m)	Paved Slope(%) %	Grass Slope %	Supp Slope %	Paved Rough	Grass Rough	Supp Rough	Lag Time or Factor	Gutter Length (m)	Gutter Slope %
NEIGH 2	N2	8.74	0	100	0	0	6	0										0		
NEIGH 1	N1	8.2	0	100	0	0	14	0										0		
METCASH	M1	23.3	0	100	0	0	15	0										0		
DHL	D2	32.8	0	100	0	0	28	0										0		

PIPE DETAILS

Name	From	To	Length (m)	U/S IL (m)	D/S IL (m)	Slope (%)	Type	Dia (mm)	I.D. (mm)	Rough	Pipe Is	No. Pipes	Chg From	At Chg	Chg (m)	RI (m)	Chg (m)	RL (m)	etc (m)
N 2	N2	N0	250	1	0.98	0.01	Concrete, un	1500	1524	0.06	New	1	N2	0					
N 1+2	N0	Nout	10	2	1.999	0.01	Concrete, un	2700	2700	0.06	New	1	N0	0					
N 1	N1	N0	10	1	0.999	0.01	Concrete, un	1500	1524	0.06	New	1	N1	0					
MET P	M1	M2	10	4.002	4	0.02	Concrete, un	2700	2700	0.06	New	1	M1	0					
DHL P	D2	D1	10	5	4.998	0.02	Concrete, un	2700	2700	0.06	New	1	D2	0					

DETAILS of SERVICES CROSSING PIPES

Pipe	Chg (m)	Bottom Elev (m)	Height of S (m)	Chg (m)	Bottom Elev (m)	Height of Ser (m)	Chg (m)	Bottom Elev (m)	Height of Ser (m)	etc etc

CHANNEL DETAILS

Name	From	To	Type	Length (m)	U/S IL (m)	D/S IL (m)	Slope (%)	Base Width (m)	L.B. Slope (1:?)	R.B. Slope (1:?)	Manning n	Depth (m)	Roofed

DRAINS results prepared 20 August, 2010 from Version 2010.08

PIT / NODE DETAILS   Version 8

Name	Max HGL	Max Pond HGL	Max Surfa Flow Arrivi (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
N2	3.31		3.102				
N0	3.04		0				
Nout	2.98		0				
N1	3.04		1.943				
M1	5.08		5.292				
M2	5.02		0				
D2	6.08		5.377				
D1	6.02		0				

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
NEIGH 2	3.102	0	3.102	0	6	0	AR&R 20 year, 25 minutes storm, average 82 mm/h, Zone 1
NEIGH 1	1.943	0	1.943	0	14	0	AR&R 20 year, 2 hours storm, average 33.5 mm/h, Zone 1
WEST (	5.292	0	5.292	0	15	0	AR&R 20 year, 2 hours storm, average 33.5 mm/h, Zone 1
EAST	5.377	0	5.377	0	28	0	AR&R 20 year, 1 hour storm, average 51 mm/h, Zone 1

Outflow Volumes for Total Catchment (0.00 impervious + 73.0 pervious = 73.0 total ha)

Storm	Total Rainf cu.m	Total Runo cu.m (Runo	Impervious cu.m (Runo	Pervious Runoff cu.m (Runoff %)
AR&R 20 y	19355.6	10484.44 (	0.00 (0.0%	10484.44 (54.2%)
AR&R 20 y	24955.33	14323.16 (	0.00 (0.0%	14323.16 (57.4%)
AR&R 20 y	37250.4	21772.72 (	0.00 (0.0%	21772.72 (58.4%)
AR&R 20 y	48936.8	27949.08 (	0.00 (0.0%	27949.08 (57.1%)

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
N 2	3.102	1.7	3.313	3.039	AR&R 20 year, 25 minutes storm, average 82 mm/h, Zone 1
N 1+2	4.931	2.6	3.039	2.979	AR&R 20 year, 25 minutes storm, average 82 mm/h, Zone 1
N 1	1.943	1.1	3.043	3.039	AR&R 20 year, 2 hours storm, average 33.5 mm/h, Zone 1
WEST '	5.292	2.7	5.075	5.016	AR&R 20 year, 2 hours storm, average 33.5 mm/h, Zone 1
EAST '	5.377	2.7	6.082	6.022	AR&R 20 year, 1 hour storm, average 51 mm/h, Zone 1

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level

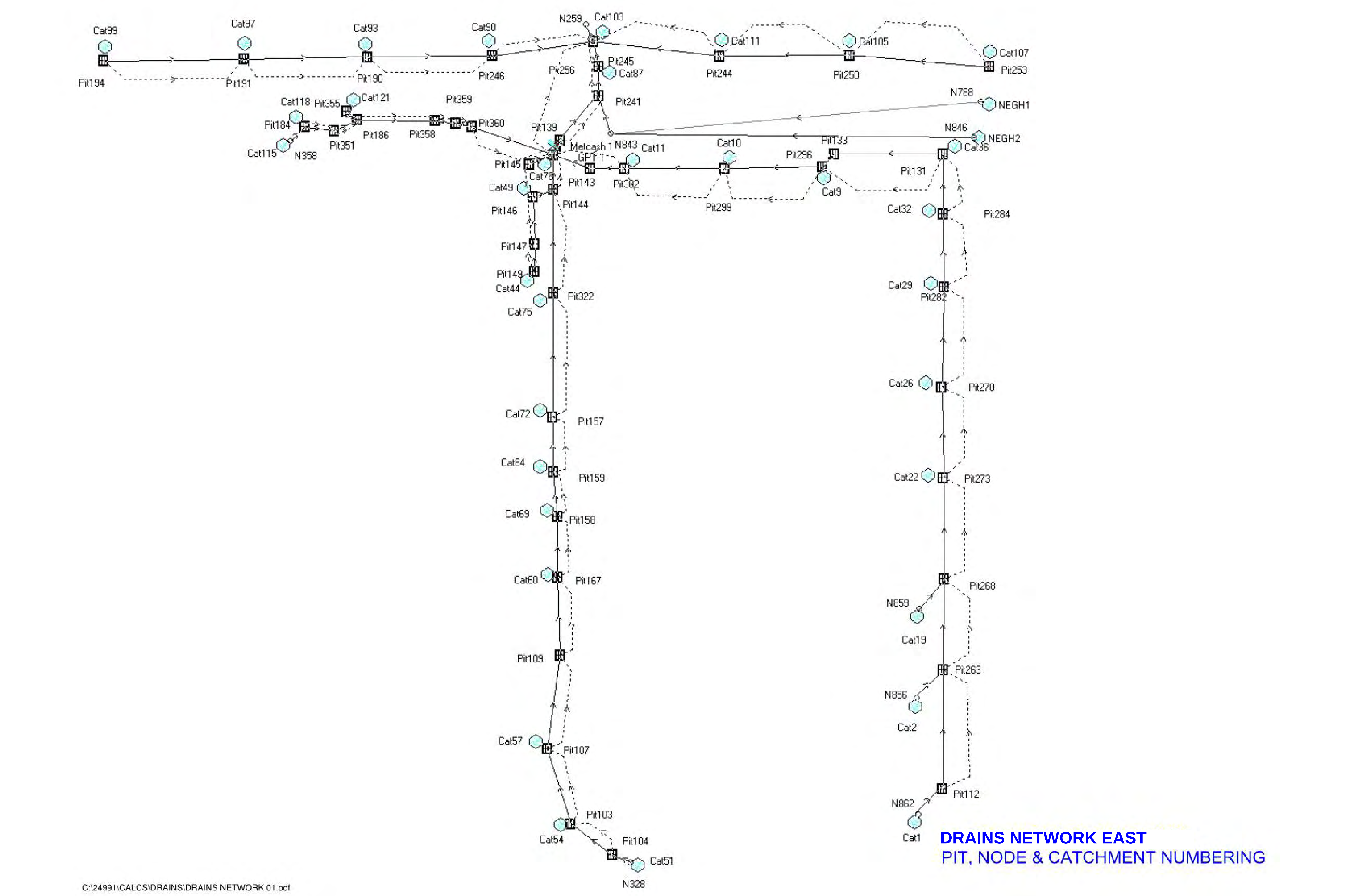
CONTINUITY CHECK for AR&R 20 year, 2 hours storm, average 33.5 mm/h, Zone 1

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Ch (cu.m)	Difference %
N2	3366.37	3366.37	0	0
N0	6511.49	6511.04	0	0
Nout	6511.04	6511.04	0	0
N1	3145.12	3145.12	0	0
M1	8932.86	8932.86	0	0
M2	8932.86	8932.86	0	0
D2	12504.73	12504.73	0	0
D1	12504.73	12504.73	0	0

Pre-Development Flows & Critical Storm Durations

ARI (yrs)	Storm (hrs)	EAST (m^3/s)	Storm (hrs)	WEST (m^3/s)	Storm (hrs)	Neighbour 1 (m^3/s)	Storm (hrs)	Neighbour 2 (m^3/s)	Storm (hrs)	Total Neigh (m^3/s)
5	2	3.82	2	3.44	2	1.41	0.42	2.24	0.42	3.43
10	2	4.45	2	4.25	2	1.64	0.42	2.65	0.42	4.39
20	2	5.29	1	5.37	2	1.94	0.42	3.1	0.42	4.93
50	0.42	6.12	1	6.42	0.42	2.26	0.25	3.39	0.42	5.49
100	1	7.01	1	7.51	0.42	2.57	0.25	3.84	0.42	6.22

PREDEVELOPMENT MODEL & FLOWS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Pit194
Cat97
Pit191
Cat93
Pit190
Cat90
Pit246
N259
Cat103
Pit256
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Cat111
Pit244
Cat105
Pit250
Cat107
Pit253
N788
NEGH1
N846
NEGH2
Cat36
Pit131
Pit133
Pit296
Cat9
Cat10
Pit299
Cat11
N843
Pit302
Metcash 1
GPT 1
Pit139
Pit145
Cat76
Pit143
Pit144
Cat49
Pit146
Pit147
Pit149
Cat44
Cat75
Pit322
Cat118
Pit355
Cat121
Pit359
Pit184
Pit351
Pit186
Pit358
Pit360
Cat115
N358
Cat72
Pit157
Cat64
Pit159
Cat69
Pit158
Cat60
Pit167
Pit109
Cat57
Pit107
Pit103
Cat54
Pit104
Cat51
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Cat32
Pit284
Cat29
Pit282
Cat26
Pit278
Cat22
Pit273
Pit268
N859
Cat19
Pit263
N856
Cat2
Pit112
N862
Cat1
DRAINS NETWORK EAST
PIT, NODE & CATCHMENT NUMBERING
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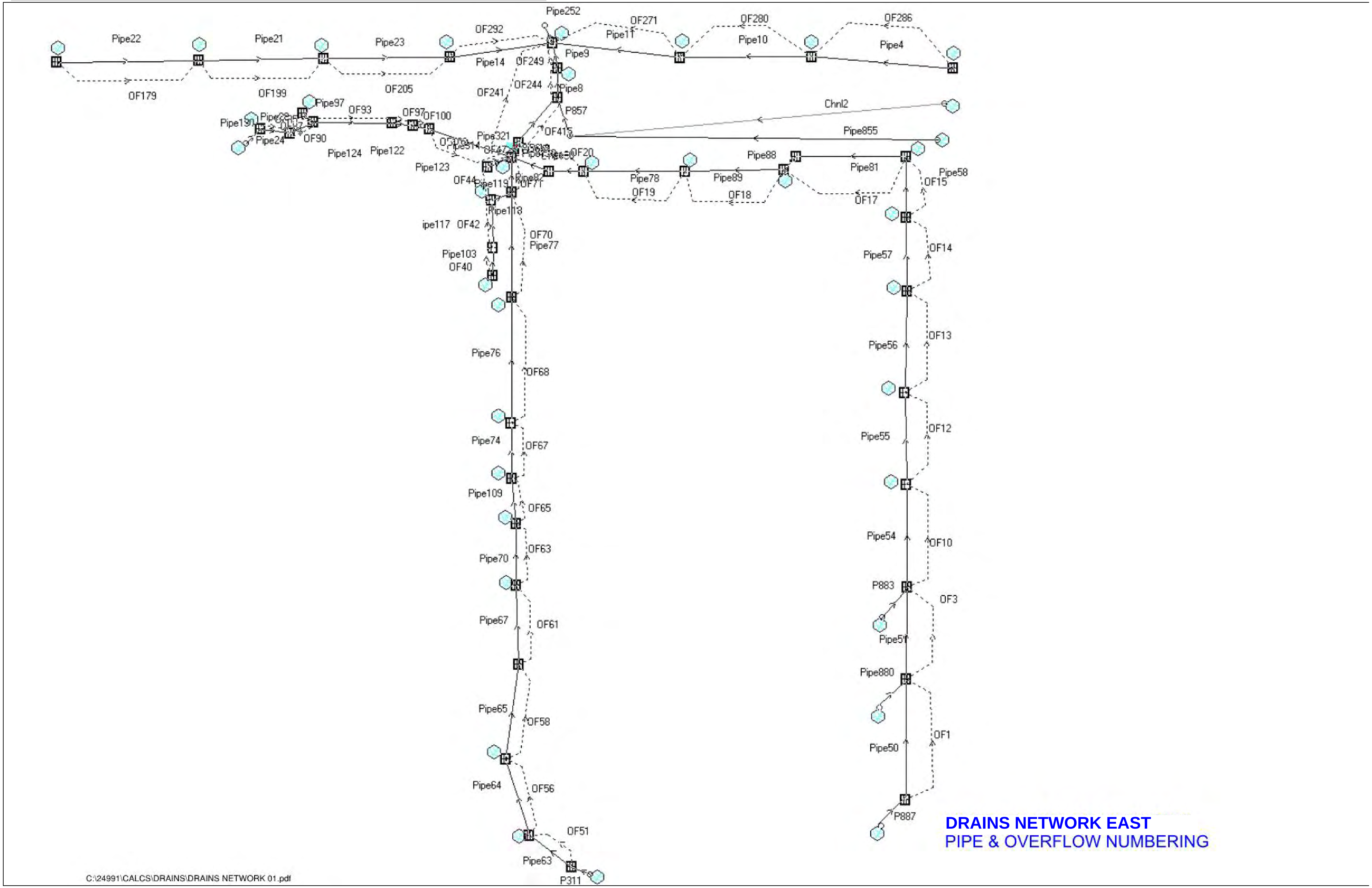

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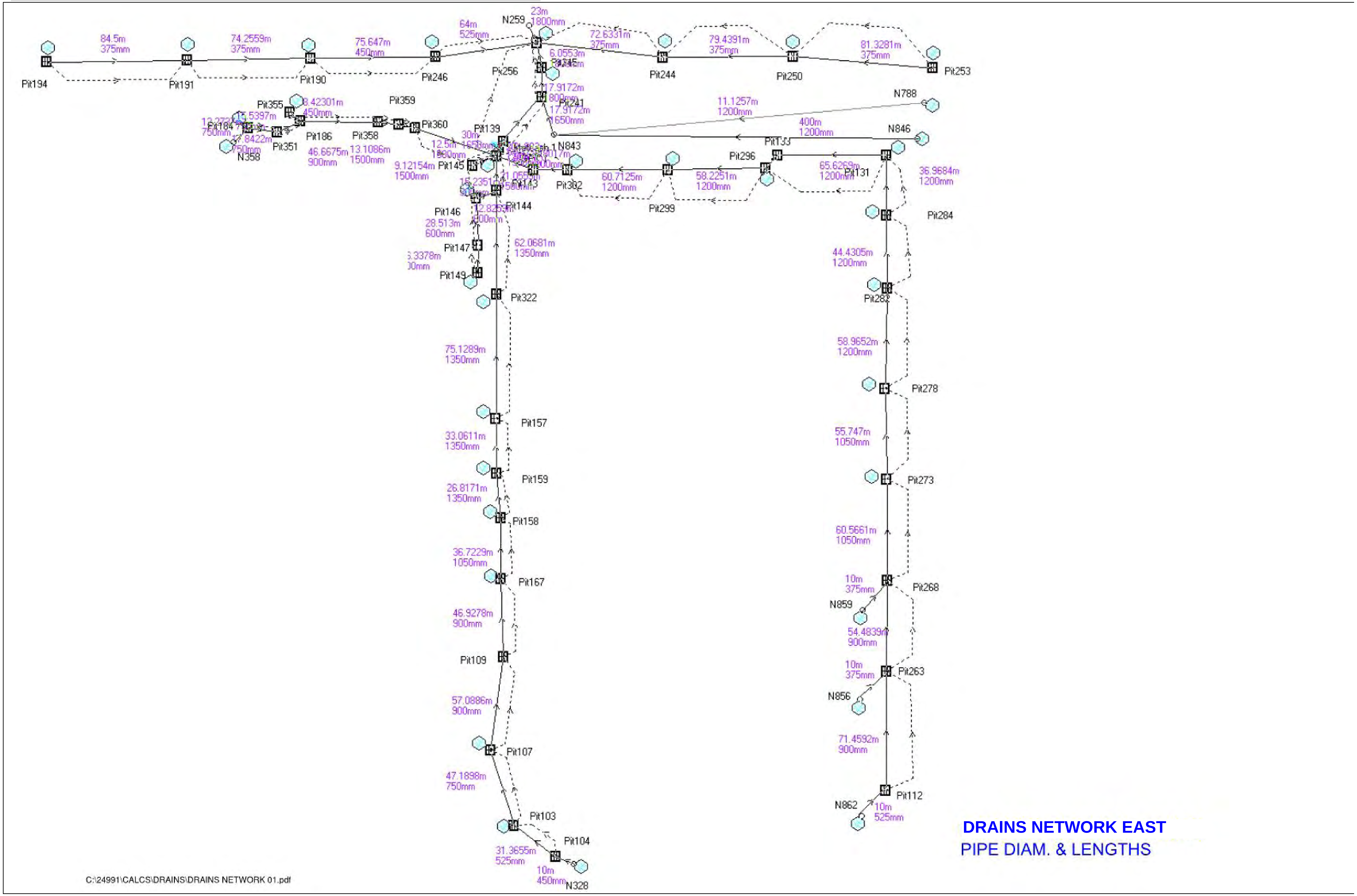
PIPE & OVERFLOW NUMBERING


DRAINS NETWORK EAST
PIPE DIAM. & LENGTHS
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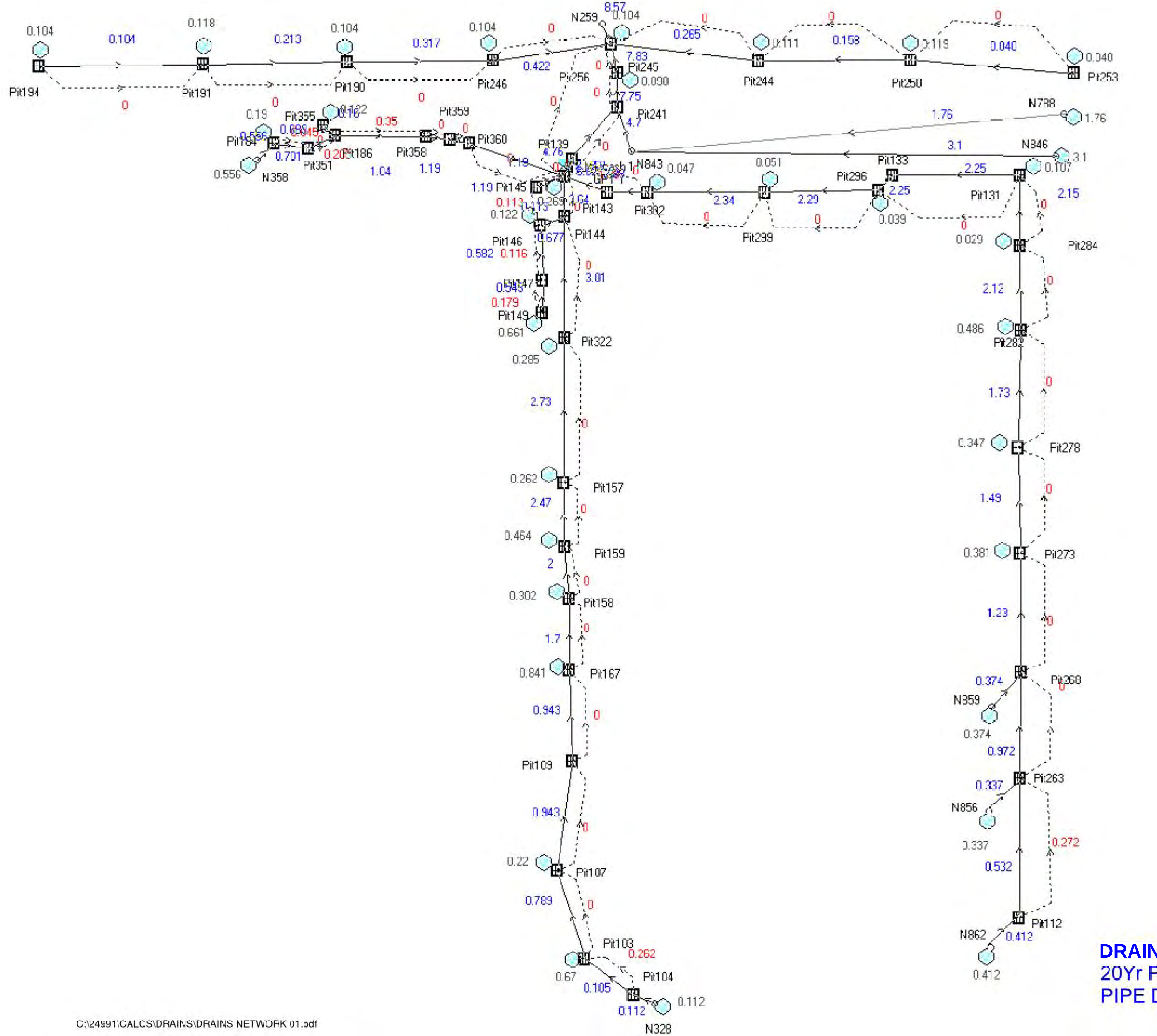

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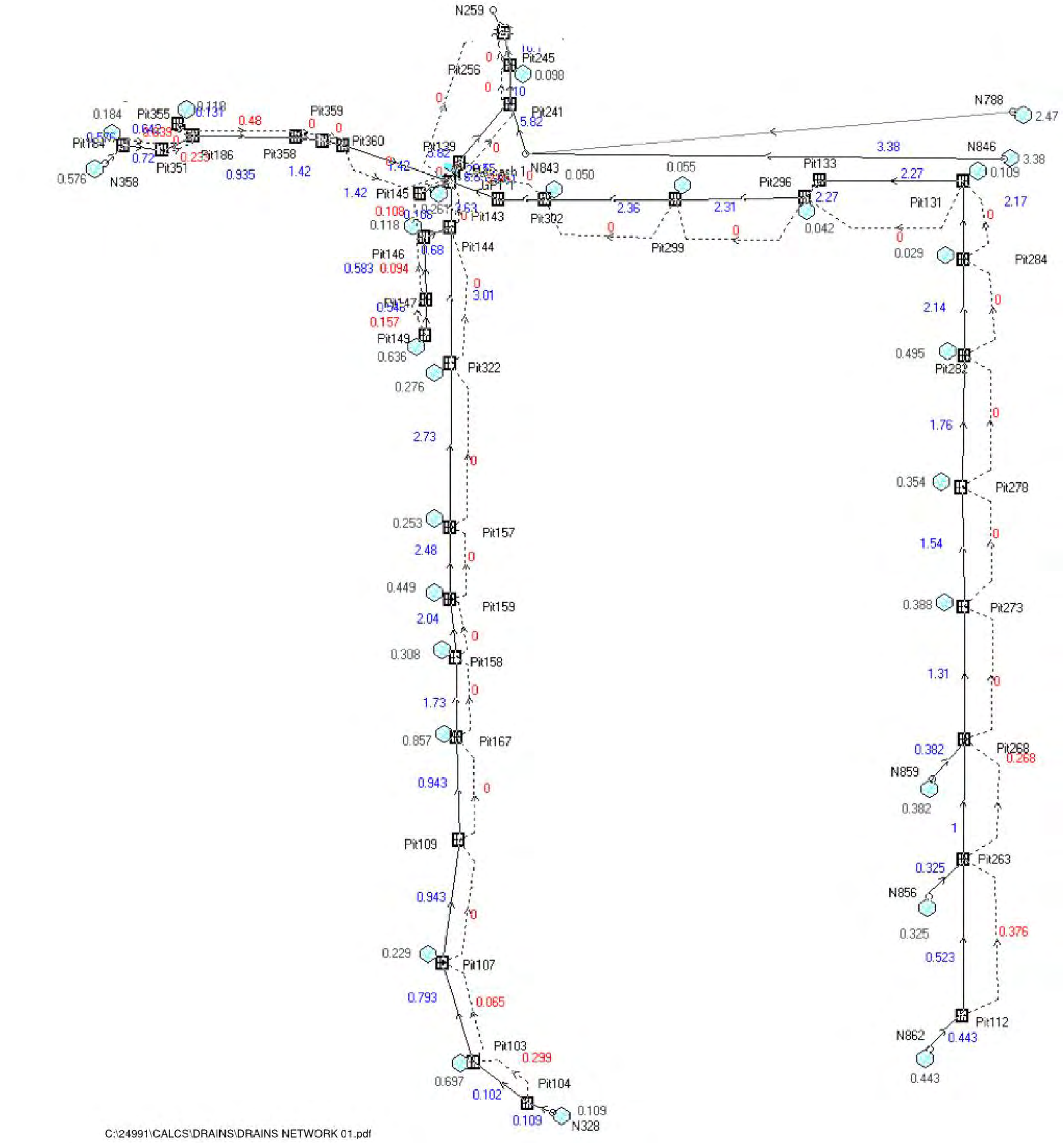
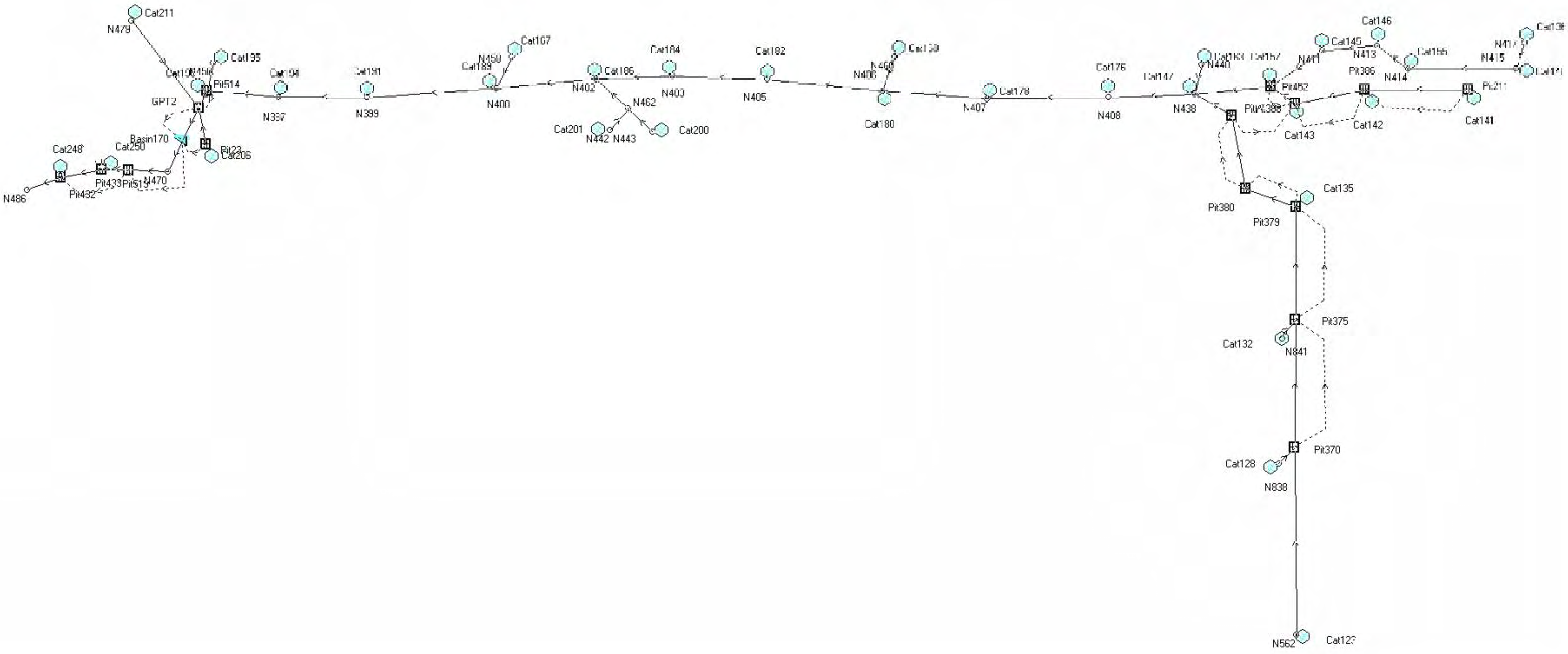
20Yr PEAK FLOWS FOR INTERNAL PIPE DESIGN



DRAINS NETWORK EAST
100Yr -1Hr STORM
PEAK FLOWS FOR INTERNAL BASIN DESIGN



DRAINS NETWORK WEST

PIT, NODE & CATCHMENT NUMBERING

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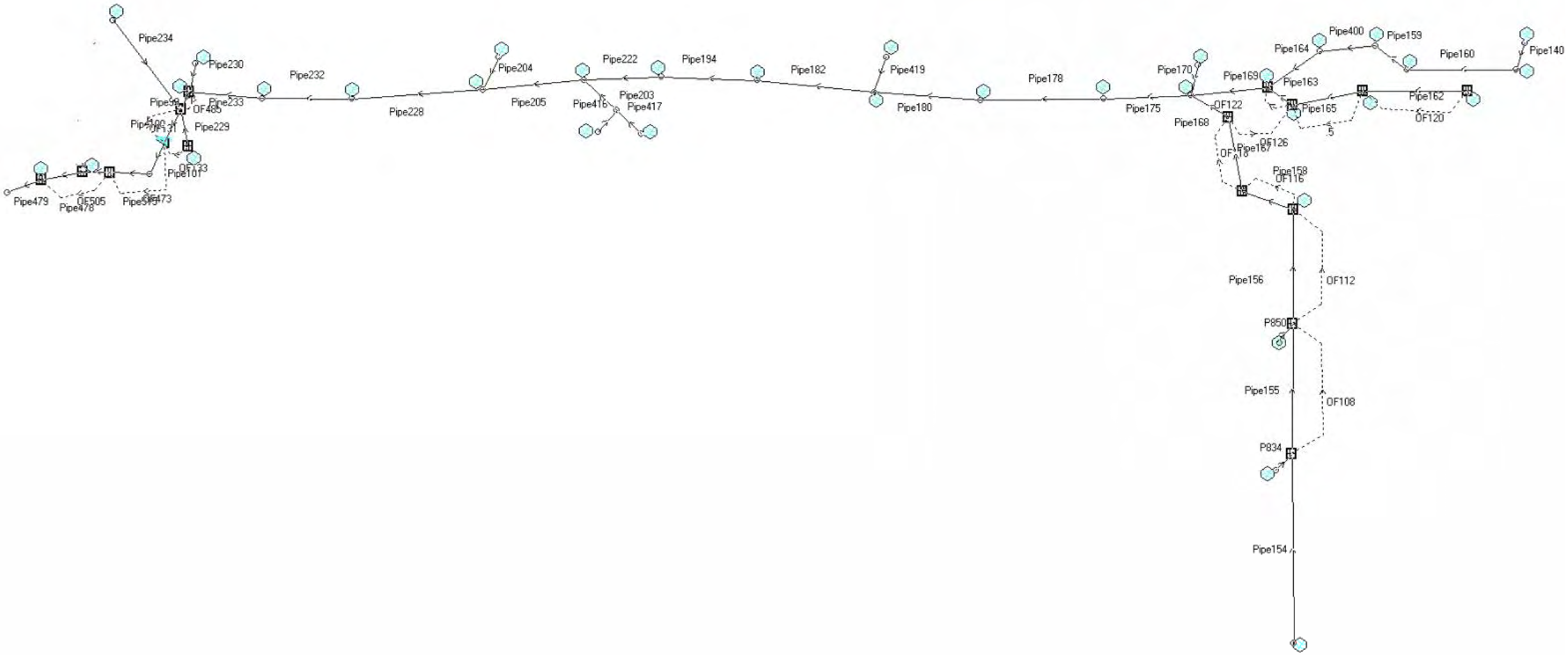

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PIPE & OVERFLOW NUMBERING

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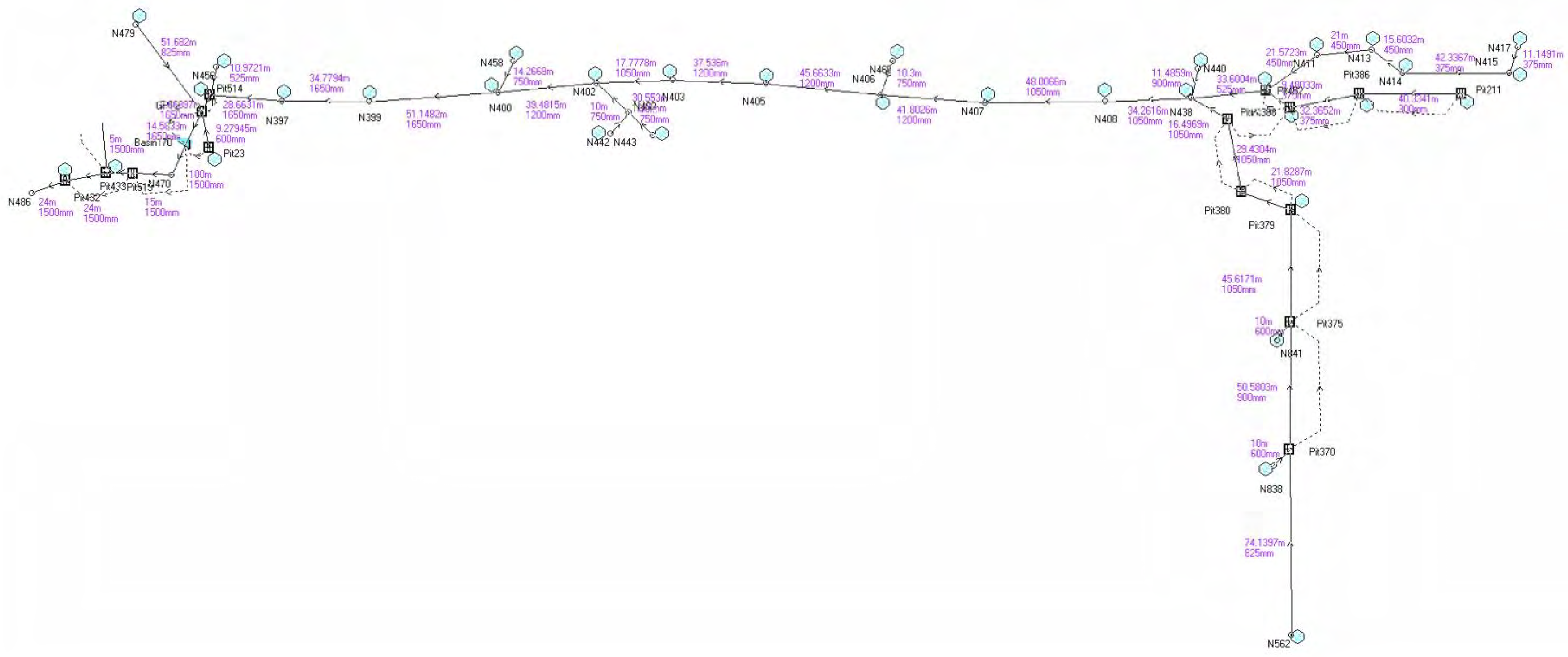

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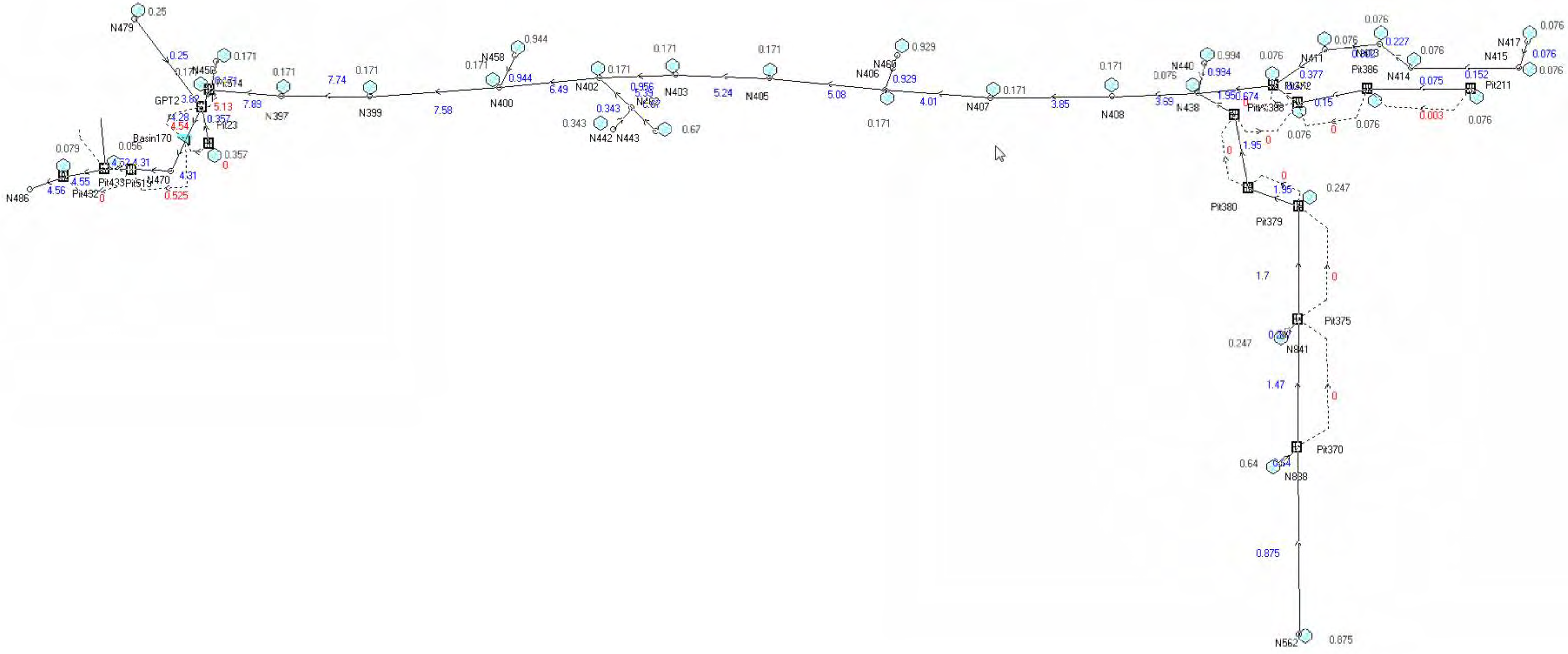
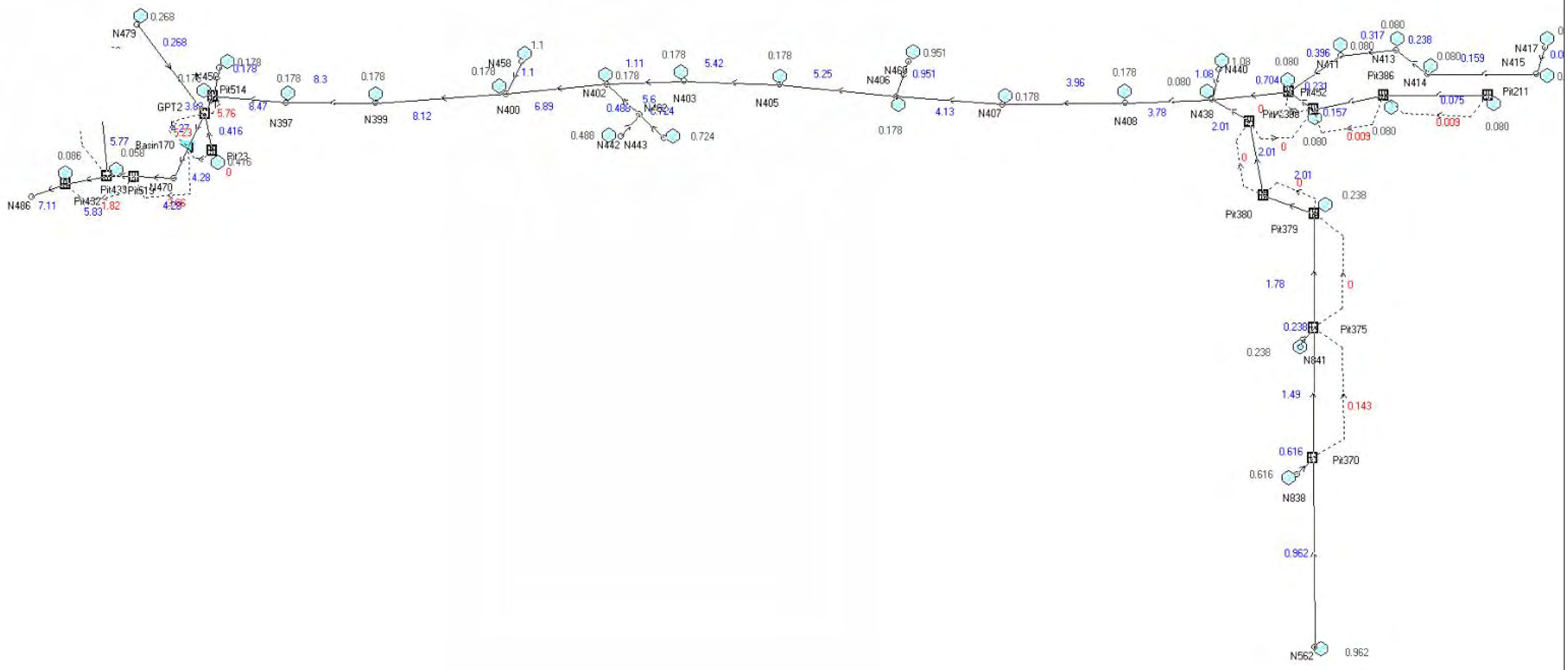
PIPE DIAM. & LENGTHS



DRAINS NETWORK EAST
20Yr -25min PEAK FLOWS FOR INTERNAL PIPE DESIGN



DRAINS NETWORK EAST

100Yr -1Hr STORM

PEAK FLOWS FOR INTERNAL BASIN DESIGN

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PIT / NODE DETAILS Version 9

Name	Type	Family	Size	Ponding Volume (cu.m)	Pressure Change Coeff. Ku	Surface Elev (m)	Max Pond Depth (m)	Base Inflow (cu.m/s)	Blocking Factor	x	y		Bolt-down lid	id	Part Full Shock Loss
Pit23	Sag	DUMMY	UNLIM	15	2.1	46	0.3	0	0	-1124.53	6196433		No	22	1 x Ku
GPT2	Sag	DUMMY	UNLIM	15	5.8	45	0.3	0	0	-1127.29	6196447		No	23	1 x Ku
N470	Node					45			0		-1139.66	6196421		1269	
Pit519	Sag	DUMMY	UNLIM	10	0.6	43	0.2		0	0	-1155.67	6196422	No	5.69E+08	1 x Ku
Pit433	OnGrade	DUMMY	UNLIM		0.5	43			0	0	-1166.26	6196422	No	1430	1 x Ku
Pit432	OnGrade	DUMMY	UNLIM		0.3	42.9			0	0	-1182.95	6196419	No	1429	1 x Ku
N486	Node					42.9			0		-1196.45	6196414		1303	
Pit145	OnGrade	Standard E	Grated 600 x 600		3.7	62.5			0	0.5	-395.857	6196663	No	144	1 x Ku
GPT 1	OnGrade	Standard E	Grated 1500 x 1500		1.9	62.4			0	0.5	-381.468	6196669	No	138	1 x Ku
Pit139	Sag	DUMMY	UNLIM	20	0	57	0.3		0	0	-376.873	6196677	No	139	QUDM
Pit241	Sag	DUMMY	UNLIM	15	1.3	57.25	0.2		0	0	-353.619	6196705	No	240	1 x Ku
Pit256	Sag	DUMMY	UNLIM	15	0.3	57.15	0.2		0	0	-353.642	6196723	No	255	1 x Ku
Pit245	Sag	DUMMY	UNLIM	15	0.8	57.1	0.5		0	0	-356.641	6196738	No	244	1 x Ku
N259	Node					55			0		-361.489	6196748		510	
Pit149	OnGrade	Standard E	Grated 900 x 900		2.7	62.7			0	0.5	-393.028	6196597	No	148	1 x Ku
Pit147	Sag	Standard E	Grated 60(	2	0.7	62.55	0.1		0	0.5	-392.71	6196614	No	146	1 x Ku
Pit146	Sag	Standard E	Grated 90(	2	1.9	62.55	0.1		0	0.5	-393.685	6196643	No	145	1 x Ku
Pit144	OnGrade	Standard E	Grated 900 x 900		0.5	62.5			0	0.5	-381.469	6196647	No	143	1 x Ku
Pit194	Sag	DUMMY	UNLIM	15	5.7	64.4	0.2		0	0	-657.303	6196726	No	193	1 x Ku
Pit191	Sag	DUMMY	UNLIM	15	3.5	62.4	0.2		0	0	-571.24	6196727	No	190	1 x Ku
Pit190	OnGrade	DUMMY	UNLIM		1.1	60.45			0	0	-495.612	6196729	No	189	1 x Ku
Pit246	Sag	DUMMY	UNLIM	15	0.9	58.35	0.2		0	0	-418.56	6196729	No	245	1 x Ku
Pit253	Sag	DUMMY	UNLIM	15	5.9	61.6	0.2		0	0	-113.612	6196723	No	252	1 x Ku
Pit250	Sag	DUMMY	UNLIM	15	2.2	58.8	0.2		0	0	-199.323	6196730	No	827	1 x Ku
Pit244	Sag	DUMMY	UNLIM	15	1.2	58.2	0.2		0	0	-279.482	6196729	No	243	1 x Ku
N328	Node					63.5			0		-333.916	6196234		798	
Pit104	OnGrade	Standard E	Grated 1200 x 1200		1	63.4			0	0.5	-345.102	6196239	No	103	1 x Ku
Pit103	Sag	DUMMY	UNLIM	10	2.6	63.22	0.3		0	0	-370.708	6196258	No	102	1 x Ku
Pit107	Sag	DUMMY	UNLIM	10	0.9	62.9	0.3		0	0	-385.104	6196304	No	106	1 x Ku
Pit109	Sag	DUMMY	UNLIM	10	0.3	62.7	0.2		0	0	-377.354	6196362	No	108	1 x Ku
Pit167	Sag	DUMMY	UNLIM	10	1.2	62.7	0.3		0	0	-378.791	6196409	No	166	1 x Ku
Pit158	Sag	DUMMY	UNLIM	15	0	62.75	0.3		0	0	-378.923	6196447	No	157	1 x Ku
Pit159	Sag	DUMMY	UNLIM	15	0.9	62.75	0.3		0	0	-381.582	6196474	No	158	1 x Ku
Pit157	Sag	DUMMY	UNLIM	15	0.7	62.75	0.3		0	0	-381.662	6196508	No	156	1 x Ku
Pit322	Sag	Standard E	Grated 12(	3	0.7	62.7	0.2		0	0	-381.362	6196584	No	760	1 x Ku
N358	Node					62.5			0		-542.571	6196677		918	
Pit184	Sag	Sutherland	Kerb inlet \	3	3	62	0.15		0	0.5	-533.912	6196686	No	183	1 x Ku
Pit351	Sag	DUMMY	UNLIM	15	3.2	60.95	0.3		0	0	-515.829	6196683	No	935	1 x Ku
Pit186	Sag	DUMMY	UNLIM	15	3.2	60.7	0.3		0	0	-501.543	6196690	No	185	1 x Ku
Pit358	Sag	DUMMY	UNLIM	15	0	60.7	0.3		0	0	-453.649	6196690	No	958	1 x Ku
Pit359	Sag	DUMMY	UNLIM	15	0.2	60.7	0.3		0	0	-441.095	6196688	No	959	1 x Ku
Pit360	Sag	DUMMY	UNLIM	15	0.3	60.7	0.3		0	0	-431.471	6196686	No	960	1 x Ku
Pit355	Sag	DUMMY	UNLIM	15	2.7	60.95	0.3		0	0	-508.27	6196696	No	941	1 x Ku
N410	Node								0		78.341	6195676		1054	
N417	Node					62.4			0		-593.317	6196474		1061	
N415	Node					62.38			0		-596.588	6196463		1059	
N414	Node					60.7			0		-640.094	6196463		1058	
N413	Node					60.4			0		-652.715	6196472		1057	
N411	Node					59.6			0		-674.659	6196470		1055	
Pit452	Sag	Standard E	Grated 90(	3	1.3	59	0.15		0	0	-695.364	6196456	No	1612	1 x Ku
N438	Node					58.1			0		-725.849	6196453		1137	
N408	Node					57.2			0		-760.681	6196451		1052	
N407	Node					55.8			0		-809.531	6196451		1051	
N406	Node					54.6			0		-851.925	6196454		1050	
N405	Node					53.3			0		-898.302	6196459		1049	
N403	Node					52.3			0		-936.446	6196460		1047	
N402	Node					51.2			0		-967.264	6196459		1046	
N400	Node					49.5			0		-1007.21	6196455		1044	
N399	Node					47.5			0		-1059.29	6196451		1042	
N397	Node					46			0		-1095.11	6196451		1040	
Pit514	Sag	DUMMY	UNLIM	15	0.9	45.1	0.3		0	0	-1123.91	6196454	No	4.97E+08	1 x Ku
Pit211	OnGrade	Standard E	Grated 900 x 900		4.1	60.2			0	0.5	-615.811	6196454	No	210	1 x Ku
Pit386	OnGrade	Standard E	Grated 900 x 900		2.7	59.7			0	0.5	-657.417	6196454	No	1118	1 x Ku
Pit388	Sag	Standard E	Grated 90(	15	1.3	59.1	0.15		0	0.5	-685.476	6196449	No	1120	1 x Ku
N440	Node					58.1			0		-723.095	6196465		1142	
N442	Node					52			0		-961.536	6196438		1150	
N462	Node					51.8			0		-954.14	6196447		1209	
N443	Node					52.2			0		-944.578	6196437		1151	
N456	Node					46.1			0		-1121.6	6196466		1167	
N458	Node					49.9			0		-1001.01	6196468		1170	
N460	Node					54.6			0		-846.979	6196468		1174	
N479	Node					43.8			0		-1154.36	6196483		1287	
Pit420	OnGrade	DUMMY	UNLIM		4.9	64.62			0	0	-821.141	6196701	No	1368	1 x Ku
Pit418	OnGrade	DUMMY	UNLIM		1.5	63.19			0	0	-895.211	6196702	No	1366	1 x Ku
Pit416	OnGrade	DUMMY	UNLIM		1.1	58.97			0	0	-968.671	6196702	No	1364	1 x Ku
Pit414	OnGrade	DUMMY	UNLIM		0.9	53.13			0	0	-1047.35	6196702	No	1362	1 x Ku
Pit412	OnGrade	DUMMY	UNLIM		0.3	49.68			0	0	-1103.31	6196701	No	1360	1 x Ku
Pit409	OnGrade	DUMMY	UNLIM		0.2	47.23			0	0	-1147.06	6196698	No	1357	1 x Ku
Pit408	Sag	DUMMY	UNLIM	10	3.8	45.09	0.2		0	0	-1188.44	6196699	No	1356	1 x Ku
Pit406	Sag	DUMMY	UNLIM	5	1.4	44.88	0.2		0	0	-1202.01	6196681	No	1354	1 x Ku
Pit404	OnGrade	DUMMY	UNLIM		1.4	44.78			0	0	-1196.2	6196632	No	1348	1 x Ku
Pit399	OnGrade	DUMMY	UNLIM		0.4	44.78			0	0.5	-1214.11	6196629	No	1295	1 x Ku
N483	Node					44.6			0		-1229.58	6196624		1297	
Pit438	OnGrade	DUMMY	UNLIM		5.9	44.42			0	0	-1185.39	6196549	No	1435	1 x Ku
Pit436	OnGrade	DUMMY	UNLIM		1.7	43.9			0	0	-1174.4	6196508	No	1433	1 x Ku
N562	Node					60			0		-684.99	6196235		19694831	
Pit370	Sag	DUMMY	UNLIM	15	2.8	59.3	0.3		0	0	-685.647	6196310	No	989	1 x Ku
Pit375	Sag	DUMMY	UNLIM	15	0.1	59.3	0.2		0	0.5	-685.364	6196362	No	1002	1 x Ku
Pit379	Sag	DUMMY	UNLIM	15	1.9	59.15	0.2		0	0.5	-685.129	6196407	No	1030	1 x Ku
Pit380	Sag	DUMMY	UNLIM	15	1.4	59.2	0.2		0	0.5	-705.478	6196415	No	1031	1 x Ku
Pit74	OnGrade	DUMMY	UNLIM		0.6	59.15			0	0.5	-711.093	6196444	No	73	1 x Ku
N788	Node					60			0		-118.702	6196701		4.21E+08	
N843	Node					57.4			0		-346.197	6196682		6.17E+08	
N838	Node					60			0		-692.25	6196304		6.12E+08	
N841	Node					60			0		-690.868	6196354		6.15E+08	
N846	Node					59.7			0		-123.003	6196679		6.17E+08	
N856	Node					64.2			0		-158.265	6196335		6.77E+08	
Pit263	Sag	Standard E	Grated 90(	4	1.2	64.15	0.2		0	0.5	-142.213	6196352	No	584	QUDM
Pit268	Sag	DUMMY	UNLIM	4	0	64.1	0.2		0	0	-141.54	6196408	No	589	QUDM
Pit273	Sag	DUMMY	UNLIM	10	0.8	64.1	0.2		0	0	-141.877	6196470	No	594	1 x Ku
Pit278	OnGrade	DUMMY	UNLIM		0.8	64.05			0	0.5	-142.887	6196526	No	602	1 x Ku
Pit282	Sag	DUMMY	UNLIM	4	1.2	64.05	0.2		0	0.5	-141.54	6196588	No	610	1 x Ku
Pit284	Sag	DUMMY	UNLIM	15	0.2	64.05	0.3		0	0.5	-142.082	6196632	No	620	1 x Ku
Pit131	Sag	Standard E	Grated 12(	3	1.7	63.95	0.2		0	0.5	-142.084	6196669	No	130	1 x Ku
Pit133	OnGrade	Standard E	Grated 1200 x 1200		0.7	63.55			0	0.5	-208.933	6196669	No	132	1 x Ku
Pit296	OnGrade	Standard E	Grated 1200 x 1200		0.7	63.55			0	0.5	-216.165	6196661	No	637	1 x Ku
Pit299	OnGrade	Standard E	Grated 1200 x 1200		0.3	63.1			0	0.5	-276.319	6196660	No	641	1 x Ku
Pit302	OnGrade	Standard E	Grated 1200 x 1200		0.3	63.1			0	0.5	-337.481	6196660	No	650	1 x Ku

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Pit143	OnGrade	Standard E	Grated 1200 x 1200		1.3	62.7		0	0.5	-358.711	6196660	No	142	1 x Ku		
N859	Node					64.2		0		-156.715	6196390		6.77E+08			
N862	Node					64.6		0		-157.49	6196264		6.78E+08			
Pit112	Sag	Standard E	Grated 90(	4	0	64.15	0.2	0	0.5	-142.319	6196279	No	111	QUDM		

DETENTION BASIN DETAILS

Name	Elev	Surf. Area	Init Vol. (cu	Outlet Type	K	Dia(mm)	Centre RL	Pit Family	Pit Type	x	y	HED	Crest RL	Crest Leng	id
Basin170	40.88	2	0	Culvert	0.5					-1134.02	6196434	No			4.51E+08
	41.1	6													
	41.5	6													
	42.4	6													
	42.5	3000													
	43	3000													
	43.5	3000													
	44	3000													
	44.5	3000													
Metcash 1	53.2	1	0	Culvert	0.5					-379.608	6196674	No			1.71E+08
	58	5													
	58.05	5													
	58.1	1500													
	58.8	1500													
	59.3	1500													
	59.5	1500													
	59.6	1500													

SUB-CATCHMENT DETAILS

Name	Pit or Node	Total Area (ha)	Paved Area %	Grass Area %	Supp Area %	Paved Time (min)	Grass Time (min)	Supp Time (min)	Paved Length (m)	Grass Length (m)	Supp Length (m)	Paved Slope(%) %	Grass Slope %	Supp Slope %	Paved Rough	Grass Rough	Supp Rough	Lag Time or Factor
Cat206	Pit23	1.138	95	5	0	15	5	0										0
Cat250	Pit433	0.15	80	20	0	0	0	0	90	90	-1	1	1	-1	0.013	0.2	-1	0
Cat248	Pit432	0.2063	80	20	0	0	0	0	90	90	-1	2.2	2.2	-1	0.013	0.2	-1	0
Cat78	GPT 1	0.7063	95	5	0	10	5	0										0
Cat87	Pit256	0.228	85	15	0	0	0	0	70	70	-1	1	1	-1	0.013	0.2	-1	0
Cat103	Pit245	0.263	85	15	0	0	0	0	90	90	-1	2.2	2.2	-1	0.013	0.2	-1	0
Cat44	Pit149	1.7462	95	5	0	0	0	0	200	200	-1	1	1	-1	0.013	0.1	-1	0
Cat49	Pit146	0.3192	95	5	0	10	5	0										0
Cat99	Pit194	0.263	85	15	0	0	0	0	90	90	-1	2.2	2.2	-1	0.013	0.2	-1	0
Cat97	Pit191	0.298	85	15	0	0	0	0	90	90	-1	2.2	2.2	-1	0.013	0.2	-1	0
Cat93	Pit190	0.263	85	15	0	0	0	0	90	90	-1	2.2	2.2	-1	0.013	0.2	-1	0
Cat90	Pit246	0.263	85	15	0	0	0	0	90	90	-1	2.2	2.2	-1	0.013	0.2	-1	0
Cat107	Pit253	0.1	85	15	0	0	0	0	90	90	-1	2.2	2.2	-1	0.013	0.2	-1	0
Cat105	Pit250	0.3	85	15	0	0	0	0	90	90	-1	2.2	2.2	-1	0.013	0.2	-1	0
Cat111	Pit244	0.28	85	15	0	0	0	0	90	90	-1	2.2	2.2	-1	0.013	0.2	-1	0
Cat51	N328	0.343	80	20	0	0	0	0	200	200	-1	1	1	-1	0.013	0.2	-1	0
Cat54	Pit103	1.6191	90	10	0	6	8	0										0
Cat57	Pit107	0.533	90	10	0	6	8	0										0
Cat60	Pit167	2.0667	95	5	0	7	5	0										0
Cat69	Pit158	0.7431	95	5	0	7	5	0										0
Cat64	Pit159	1.217	95	5	0	10	5	0										0
Cat72	Pit157	0.6866	95	5	0	10	5	0										0
Cat75	Pit322	0.7486	95	5	0	10	5	0										0
Cat115	N358	1.648	95	5	0	0	0	0	250	250	-1	0.5	1	-1	0.013	0.2	-1	0
Cat118	Pit184	0.4982	95	5	0	10	5	0										0
Cat121	Pit355	0.3192	95	5	0	10	5	0										0
Cat136	N417	0.181	95	5	0	6	5	0										0
Cat140	N415	0.181	95	5	0	6	5	0										0
Cat155	N414	0.181	95	5	0	6	5	0										0
Cat146	N413	0.181	95	5	0	6	5	0										0
Cat145	N411	0.181	95	5	0	6	5	0										0
Cat157	Pit452	0.181	95	5	0	6	5	0										0
Cat147	N438	0.181	95	5	0	6	5	0										0
Cat176	N408	0.406	95	5	0	6	5	0										0
Cat178	N407	0.406	95	5	0	6	5	0										0
Cat180	N406	0.406	95	5	0	6	5	0										0
Cat182	N405	0.406	95	5	0	6	5	0										0
Cat184	N403	0.406	95	5	0	6	5	0										0
Cat186	N402	0.406	95	5	0	6	5	0										0
Cat189	N400	0.406	95	5	0	6	5	0										0
Cat191	N399	0.406	95	5	0	6	5	0										0
Cat194	N397	0.406	95	5	0	6	5	0										0
Cat196	Pit514	0.406	95	5	0	6	5	0										0
Cat141	Pit211	0.181	95	5	0	6	5	0										0
Cat142	Pit386	0.181	95	5	0	6	5	0										0
Cat143	Pit388	0.181	95	5	0	6	5	0										0
Cat163	N440	3.0913	95	5	0	0	0	0	300	300	-1	0.5	1	-1	0.013	0.2	-1	0
Cat201	N442	1.796	95	5	0	15	0	0	290	290	-1	0.5	1	-1	0.013	0.2	-1	0
Cat200	N443	2.085	95	5	0	0	0	0	300	400	-1	0.5	1	-1	0.013	0.2	-1	0
Cat195	N456	0.406	95	5	0	6	5	0										0
Cat167	N458	3.0086	95	5	0	15	5	0										0
Cat168	N460	2.7218	95	5	0	0	0	0	240	240	-1	0.5	1	-1	0.013	0.2	-1	0
Cat211	N479	1.09	60	40	0	0	0	0	262	290	-1	0.5	1	-1	0.013	0.2	-1	0
Cat214	Pit420	0.3325	85	15	0	0	0	0	90	90	-1	2.2	2.2	-1	0.013	0.2	-1	0
Cat217	Pit418	0.2475	50	50	0	0	0	0	90	90	-1	2.2	2.2	-1	0.013	0.2	-1	0
Cat220	Pit416	0.2475	50	50	0	0	0	0	90	90	-1	2.2	2.2	-1	0.013	0.2	-1	0
Cat222	Pit414	0.264	50	50	0	0	0	0	90	90	-1	2.2	2.2	-1	0.013	0.2	-1	0
Cat230	Pit412	0.1815	60	40	0	0	0	0	90	90	-1	2.2	2.2	-1	0.013	0.2	-1	0
Cat227	Pit409	0.1575	60	40	0	0	0	0	90	90	-1	2.2	2.2	-1	0.013	0.2	-1	0
Cat233	Pit408	0.14	60	40	0	0	0	0	90	90	-1	1	1	-1	0.013	0.2	-1	0
Cat237	Pit406	0.075	80	20	0	0	0	0	90	90	-1	2.2	2.2	-1	0.013	0.2	-1	0
Cat242	Pit404	0.075	80	20	0	0	0	0	90	90	-1	1	1	-1	0.013	0.2	-1	0
Cat244	Pit399	0.075	80	20	0	0	0	0	90	90	-1	1	1	-1	0.013	0.2	-1	0
Cat246	Pit438	0.13	80	20	0	0	0	0	90	90	-1	1	1	-1	0.013	0.2	-1	0
Cat247	Pit436	0.075	80	20	0	0	0	0	90	90	-1	1	1	-1	0.013	0.2	-1	0
Cat123	N562	2.7519	95	5	0	5	0	0	368	250	0	3	3	0	0.013	0.2	0	0
Cat135	Pit379	0.6514	100	0	0	5	0	0	150	0	0	3	0	0	0.013	0	0	0
NEGH1	N788	8.2	0	100	0	0	14	0										0
Cat128	N838	1.6849	100	0	0	5	0	0	150	0	0	3	0	0	0.013	0	0	0
Cat132	N841	0.6514	100	0	0	5	0	0	150	0	0	3	0	0	0.013	0	0	0
NEGH2	N846	8.74	0	100	0	0	6	0										0
Cat2	N856	0.8899	95	5	0	0	0	0	140	100	-1	0.5	1	-1	0.013	0.2	-1	0
Cat22	Pit273	0.937	95	5	0	7	5	0										0
Cat26	Pit278	0.8537	95	5	0	7	5	0										0
Cat29	Pit282	1.1945	95	5	0	7	5	0										0
Cat32	Pit284	0.0706	95	5	0	7	5	0										0
Cat36	Pit131	0.2628	95	5	0	7	5	0										0
Cat9	Pit296	0.0874	100	0	0	5	0	0										0
Cat10	Pit299	0.1145	100	0	0	5	0	0										0
Cat11	Pit302	0.1051	100	0	0	5	0	0										0
Cat19	N859	0.9206	95	5	0	7	5	0										0
Cat1	N862	1.265	95	5	0	5	5	0	130	100	-1	0.5	1	-1	0.013	0.2	-1	0

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PIPE DETAILS

Name	From	To	Length (m)	U/S IL (m)	D/S IL (m)	Slope (%)	Type	Dia (mm)	I.D. (mm)	Rough	Pipe Is	No. Pipes	Chg From	At Chg	Chg (m)	RI (m)	Chg (m)	RL (m)
Pipe229	Pit23	GPT2	9.27945	42.66	42.567	1	Concrete,	600	600	0.015	New	1	Pit23	0				
Pipe100	GPT2	Basin170	14.5833	42.544	42.5	0.3	Concrete,	1650	1676	0.015	NewFixed	1	GPT2	0				
Pipe101	Basin170	N470	100	40.88	40.68	0.2	Concrete,	1500	1524	0.015	NewFixed	1	Basin170	0				
Pipe515	N470	Pit519	15	40.68	40.635	0.3	Concrete,	1500	1524	0.015	New	1	N470	0				
P784	Pit519	Pit433	5	40.635	40.62	0.3	Concrete,	1500	1524	0.015	New	1	Pit519	0				
Pipe478	Pit433	Pit432	24	40.62	40.548	0.3	Concrete,	1500	1524	0.015	New	1	Pit433	0				
Pipe479	Pit432	N486	24	40.548	40.5	0.2	Concrete,	1500	1524	0.015	New	1	Pit432	0				
Pipe119	Pit145	GPT 1	15.2351	61.52	60	9.98	Concrete,	300	300	0.015	New	1	Pit145	0				
Pipe120	GPT 1	Metcash 1	5.1329	58.126	58.1	0.51	Concrete,	1500	1524	0.015	NewFixed	1	GPT 1	0				
P661	Metcash 1	Pit139	30	53.3	53.15	0.5	Concrete,	900	900	0.015	NewFixed	1	Metcash 1	0				
Pipe321	Pit139	Pit241	30	53.155	53.005	0.5	Concrete,	1650	1676	0.015	New	1	Pit139	0				
Pipe8	Pit241	Pit256	17.9172	53.005	52.915	0.5	Concrete,	1800	1800	0.015	New	1	Pit241	0				
Pipe9	Pit256	Pit245	6.0553	52.915	52.885	0.5	Concrete,	1800	1800	0.015	NewFixed	1	Pit256	0				
Pipe252	Pit245	N259	23	53	52.885	0.5	Concrete,	1800	1800	0.015	NewFixed	1	Pit245	0				
Pipe103	Pit149	Pit147	16.3378	60.7	60.618	0.5	Concrete,	600	600	0.015	New	1	Pit149	0				
Pipe117	Pit147	Pit146	28.513	60.6	60.457	0.5	Concrete,	600	600	0.015	New	1	Pit147	0				
Pipe118	Pit146	Pit144	12.8259	60.44	60.376	0.5	Concrete,	600	600	0.015	New	1	Pit146	0				
Pipe82	Pit144	GPT 1	21.0559	58.74	58.635	0.5	Concrete,	1500	1524	0.015	New	1	Pit144	0				
Pipe22	Pit194	Pit191	84.5	63.4	61.4	2.37	Concrete,	375	375	0.015	New	1	Pit194	0				
Pipe21	Pit191	Pit190	74.2559	61.4	59.4	2.69	Concrete,	375	375	0.015	New	1	Pit191	0				
Pipe23	Pit190	Pit246	75.647	59.4	57.2	2.91	Concrete,	450	450	0.015	New	1	Pit190	0				
Pipe14	Pit246	Pit245	64	57.2	56	1.88	Concrete,	525	525	0.015	New	1	Pit246	0				
Pipe4	Pit253	Pit250	81.3281	60.2	57.09	3.82	Concrete,	375	375	0.015	New	1	Pit253	0				
Pipe10	Pit250	Pit244	79.4391	57.194	56.5	0.87	Concrete,	375	375	0.015	New	1	Pit250	0				
Pipe11	Pit244	Pit245	72.6331	56.426	55.7	1	Concrete,	375	375	0.015	New	1	Pit244	0				
P311	N328	Pit104	10	61.05	61	0.5	Concrete,	450	450	0.015	New	1	N328	0				
Pipe63	Pit104	Pit103	31.3655	61	60.843	0.5	Concrete,	525	525	0.015	New	1	Pit104	0				
Pipe64	Pit103	Pit107	47.1898	60.82	60.584	0.5	Concrete,	750	750	0.015	New	1	Pit103	0				
Pipe65	Pit107	Pit109	57.0886	60.56	60.275	0.5	Concrete,	900	900	0.015	New	1	Pit107	0				
Pipe67	Pit109	Pit167	46.9278	60.26	60.025	0.5	Concrete,	900	900	0.015	New	1	Pit109	0				
Pipe70	Pit167	Pit158	36.7229	60.01	59.826	0.5	Concrete,	1050	1070	0.015	New	1	Pit167	0				
Pipe109	Pit158	Pit159	26.8171	59.81	59.676	0.5	Concrete,	1350	1370	0.015	New	1	Pit158	0				
Pipe74	Pit159	Pit157	33.0611	59.66	59.495	0.5	Concrete,	1350	1370	0.015	New	1	Pit159	0				
Pipe76	Pit157	Pit322	75.1289	59.47	59.094	0.5	Concrete,	1350	1370	0.015	New	1	Pit157	0				
Pipe77	Pit322	Pit144	62.0681	59.07	58.76	0.5	Concrete,	1350	1370	0.015	New	1	Pit322	0				
Pipe130	N358	Pit184	12.2737	58.873	58.812	0.5	Concrete,	750	750	0.015	New	1	N358	0				
Pipe24	Pit184	Pit351	17.8422	58.812	58.723	0.5	Concrete,	750	750	0.015	New	1	Pit184	0				
Pipe98	Pit351	Pit186	15.5397	58.723	58.645	0.5	Concrete,	750	750	0.015	New	1	Pit351	0				
Pipe124	Pit186	Pit358	46.6675	58.645	58.412	0.5	Concrete,	900	900	0.015	New	1	Pit186	0				
Pipe122	Pit358	Pit359	13.1086	58.412	58.346	0.5	Concrete,	1500	1524	0.015	New	1	Pit358	0				
Pipe123	Pit359	Pit360	9.12154	58.346	58.3	0.5	Concrete,	1500	1524	0.015	New	1	Pit359	0				
Pipe314	Pit360	GPT 1	12.5	58.263	58.2	0.5	Concrete,	1500	1500	0.015	New	1	Pit360	0				
Pipe97	Pit355	Pit186	8.42301	59.55	59.508	0.5	Concrete,	450	450	0.015	New	1	Pit355	0				
Pipe140	N417	N415	11.1491	60.96	60.904	0.5	Concrete,	375	375	0.015	New	1	N417	0				
Pipe160	N415	N414	42.3367	60.904	59.333	3.71	Concrete,	375	375	0.015	New	1	N415	0				
Pipe159	N414	N413	15.6032	59.333	58.841	3.15	Concrete,	450	450	0.015	New	1	N414	0				
Pipe400	N413	N411	21	58.841	58.18	3.15	Concrete,	450	450	0.015	New	1	N413	0				
Pipe164	N411	Pit452	21.5723	58.18	57.5	3.15	Concrete,	450	450	0.015	New	1	N411	0				
Pipe169	Pit452	N438	33.6004	57.5	55.758	5.18	Concrete,	525	525	0.015	New	1	Pit452	0				
Pipe175	N438	N408	34.2616	55.758	54.836	2.69	Concrete,	1050	1070	0.015	New	1	N438	0				
Pipe178	N408	N407	48.0066	54.836	53.636	2.5	Concrete,	1050	1070	0.015	New	1	N408	0				
Pipe180	N407	N406	41.8026	53.636	52.8	2	Concrete,	1200	1200	0.015	New	1	N407	0				
Pipe182	N406	N405	45.6633	52.78	51	3.9	Concrete,	1200	1200	0.015	New	1	N406	0				
Pipe194	N405	N403	37.536	50.98	50.2	2.08	Concrete,	1200	1200	0.015	New	1	N405	0				
Pipe203	N403	N402	30.553	50.18	49.1	3.53	Concrete,	1200	1200	0.015	New	1	N403	0				
Pipe205	N402	N400	39.4815	49.08	47.4	4.26	Concrete,	1200	1200	0.015	New	1	N402	0				
Pipe228	N400	N399	51.1482	45.895	43.696	4.3	Concrete,	1650	1676	0.015	New	1	N400	0				
Pipe232	N399	N397	34.7794	43.696	42.653	3	Concrete,	1650	1676	0.015	New	1	N399	0				
Pipe233	N397	Pit514	28.6631	42.653	42.567	0.3	Concrete,	1650	1676	0.015	New	1	N397	0				
Pipe99	Pit514	GPT2	7.66897	42.567	42.544	0.3	Concrete,	1650	1676	0.015	New	1	Pit514	0				
Pipe162	Pit211	Pit386	40.3341	59.5	59.097	1	Concrete,	300	300	0.015	New	1	Pit211	0				
Pipe165	Pit386	Pit388	32.3652	58.324	58	1	Concrete,	375	375	0.015	New	1	Pit386	0				
Pipe163	Pit388	Pit452	9.48033	58	57.95	0.53	Concrete,	375	375	0.015	New	1	Pit388	0				
Pipe170	N440	N438	11.4859	56.6	56.485	1	Concrete,	900	900	0.015	New	1	N440	0				
Pipe416	N442	N462	10	49.6	49.5	1	Concrete,	750	750	0.015	New	1	N442	0				
Pipe222	N462	N402	17.7778	49.456	49.1	2	Concrete,	1050	1070	0.015	New	1	N462	0				
Pipe417	N443	N462	10	49.6	49.5	1	Concrete,	750	750	0.015	New	1	N443	0				
Pipe230	N456	Pit514	10.9721	42.622	42.567	0.5	Concrete,	525	525	0.015	New	1	N456	0				
Pipe204	N458	N400	14.2669	48.55	48.407	1	Concrete,	750	750	0.015	New	1	N458	0				
Pipe419	N460	N406	10.3	52.9	52.849	0.5	Concrete,	750	750	0.015	New	1	N460	0				
Pipe234	N479	GPT2	51.682	42.808	42.55	0.5	Concrete,	825	825	0.015	New	1	N479	0				
Pipe27	Pit420	Pit418	71.1531	63.6	62.2	1.97	Concrete,	375	375	0.015	New	1	Pit420	0				
Pipe29	Pit418	Pit416	71.8971	62	57.8	5.84	Concrete,	375	375	0.015	New	1	Pit418	0				
Pipe31	Pit416	Pit414	78.2448	57.78	52	7.39	Concrete,	375	375	0.015	New	1	Pit416	0				
Pipe38	Pit414	Pit412	53.4989	51.98	48.55	6.41	Concrete,	375	375	0.015	New	1	Pit414	0				
Pipe35	Pit412	Pit409	44.7028	48.5	46	5.59	Concrete,	450	450	0.015	New	1	Pit412	0				
Pipe36	Pit409	Pit408	39.3063	45.98	43.96	5.14	Concrete,	525	525	0.015	New	1	Pit409	0				
Pipe37	Pit408	Pit406	21.5137	43.94	43.75	0.88	Concrete,	600	600	0.015	New	1	Pit408	0				
Pipe236	Pit406	Pit404	48.9937	43.73	43.485	0.5	Concrete,	600	600	0.015	New	1	Pit406	0				
Pipe472	Pit404	Pit399	20	43.47	43.37	0.5	Concrete,	600	600	0.015	New	1	Pit404	0				
Pipe473	Pit399	N483	5	43.35	43.325	0.5	Concrete,	600	600	0.015	New	1	Pit399	0				
Pipe239	Pit438	Pit436	41.1301	42.911	42.5	1	Concrete,	375	375	0.015	New	1	Pit438	0				
Pipe474	Pit436	Pit433	97	42.499	41.5	1.03	Concrete,	375	375	0.015	New	1	Pit436	0				
Pipe154	N562	Pit370	74.1397	58	57.629	0.5	Concrete,	825	825	0.015	New	1	N562	0				
Pipe155	Pit370	Pit375	50.5803	56.66	56.407	0.5	Concrete,	900	900	0.015	New	1	Pit370	0				
Pipe156	Pit375	Pit379	45.6171	56.407	56.179	0.5	Concrete,	1050	1050	0.015	New	1	Pit375	0				
Pipe158	Pit379	Pit380	21.8287	56.179	56.07	0.5	Concrete,	1050	1050	0.015	New	1	Pit379	0				
Pipe167	Pit380	Pit74	29.4304	56.07	55.923	0.5	Concrete,	1050	1050	0.015	New	1	Pit380	0				
Pipe168	Pit74	N438	16.4969	55.923	55.758	1	Concrete,	1050	1070	0.015	New	1	Pit74	0				
P857	N843	Pit241	17.9172	53.095	53.005	0.5	Concrete,	1650	1676	0.015	New	1	N843	0				
P834	N838	Pit370	10	58	57.629	3.71	Concrete,	600	600	0.015	New	1	N838	0				
P850	N841	Pit375	10	58	57.629	3.71	Concrete,	600	600	0.015	New	1	N841	0				
Pipe855	N846	N843	400	55.095	53.095	0.5	Concrete,	1200	1200	0.015	New	1	N846	0				
Pipe880	N856	Pit263	10	60.55	60.5	0.5	Concrete,	375	375	0.015	New	1	N856	0				
Pipe51	Pit263	Pit268	54.4839	60.27	59.998	0.5	Concrete,	900	900	0.015	New	1	Pit263	0				
Pipe54	Pit268	Pit273	60.5661	59.98	59.677	0.5	Concrete,	1050	1070	0.015	New	1	Pit268	0				
Pipe55	Pit273	Pit278	55.747	59.66	59.381	0.5	Concrete,	1050	1070	0.015	New	1	Pit273	0				
Pipe56	Pit278	Pit282	58.9652	59.36	59.065	0.5	Concrete,	1200	1200	0.015	New	1	Pit278	0				
Pipe57	Pit282	Pit284	44.4305	59.04	58.929	0.25	Concrete,	1200	1200	0.015	New	1	Pit282	0				
Pipe58	Pit284	Pit131	36.9684	58.929	58.837	0.25	Concrete,	1200	1200	0.015	New	1	Pit284	0				
Pipe81	Pit131	Pit133	65.6269	58.837	58.673	0.25	Concrete,	1200	1200	0.015	New	1	Pit131	0				
Pipe88	Pit133	Pit296	11.1257	58.673	58.645	0.25	Concrete,	1200	1200	0.015	New	1	Pit133	0				
Pipe89	Pit296	Pit299	58.2251	58.645	58.499	0.25	Concrete,	1200	1200	0.015	New	1	Pit296	0				
Pipe78	Pit299	Pit302	60.7125	58.499	58.347	0.25	Concrete,	1200	1200	0.015	New	1	Pit299	0				
Pipe79	Pit302	Pit143	20.8883	58.347	58.295	0.25	Concrete,	1200	1200	0.015	New	1	Pit302	0				
Pipe80	Pit143	GPT 1	23.8017	58.295	58.235	0.25	Concrete,	1200	1200	0.015	New	1	Pit143	0				
P883	N859	Pit268	10	60.55	60.5	0.5	Concrete,	375	375	0.015	New	1	N859	0				
P887	N862	Pit112	10	60.55	60.5	0.5	Concrete,	525	525	0.015	New	1	N862	0				
Pipe50	Pit112	Pit263	71.4592	60.65	60.293	0.5	Concrete,	900	900	0.015	New	1	Pit112	0				

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DETAILS of SERVICES CROSSING PIPES

Pipe	Chg (m)	Bottom Elev (m)	Height of S (m)	Chg (m)	Bottom Elev (m)	Height of S (m)	Chg (m)	Bottom Elev (m)	Height of S (m)	etc etc

CHANNEL DETAILS

Name	From	To	Type	Length (m)	U/S IL (m)	D/S IL (m)	Slope (%)	Base Widtl (m)	L.B. Slope (1:?)	R.B. Slope (1:?)	Manning n	Depth (m)	Roofed
Chnl2	N788	N843	Prismatic	260	58.05	57.4	0.25	3.5	5	5	0.15	3.5	No

OVERFLOW ROUTE DETAILS

Name	From	To	Travel Time (min)	Spill Level (m)	Crest Length (m)	Weir Coeff. C	Cross Section	Safe Deptl Major Stor (m)	SafeDepth Minor Ston (m)	Safe DxV (sq.m/sec)	Bed Slope (%)	D/S Area Contributing %	id
OF133	Pit23	Basin170	2				Dummy us	0.2	0.05	0.6	1	0	1352
OF131	GPT2	Basin170	0.3				Dummy us	0.2	0.05	0.6	1	0	1350
OF473	Basin170	Pit519	0.2	43.25	6	1.7	Dummy us	0.2	0.05	0.6	1	0	4.52E+08
OF505	Pit519	Pit432	0.2				Dummy us	0.2	0.05	0.6	1	0	5.73E+08
OF47	Pit145	GPT 1	2				Dummy us	0.2	0.05	0.6	1	0	682
OF241	GPT 1	Pit245	0.502				Dummy us	0.2	0.05	0.6	1	0	1576
OF318	Metcash 1	Pit139	0.1	58.7	2	1.7	Dummy us	0.2	0.05	0.6	1	0	2.48E+08
OF415	Pit139	Pit241	1				Dummy us	0.2	0.05	0.6	1	0	4.14E+08
OF244	Pit241	Pit256	0.5				Dummy us	0.2	0.05	0.6	1	0	1579
OF249	Pit256	Pit245	0.5				Dummy us	0.2	0.05	0.6	1	0	1583
OF40	Pit149	Pit147	2				Dummy us	0.2	0.05	0.6	1	0	674
OF42	Pit147	Pit146	2				Dummy us	0.2	0.05	0.6	1	0	676
OF44	Pit146	Pit145	2				Dummy us	0.2	0.05	0.6	1	0	678
OF71	Pit144	GPT 1	2				Dummy us	0.2	0.05	0.6	1	0	743
OF179	Pit194	Pit191	1.5				Dummy us	0.2	0.05	0.6	1	0	1474
OF199	Pit191	Pit190	1.5				Dummy us	0.2	0.05	0.6	1	0	1494
OF205	Pit190	Pit246	1.5				Dummy us	0.2	0.05	0.6	1	0	1500
OF292	Pit246	Pit245	1.5				Dummy us	0.2	0.05	0.6	1	0	8519057
OF286	Pit253	Pit250	1				Dummy us	0.2	0.05	0.6	1	0	8519051
OF280	Pit250	Pit244	1				Dummy us	0.2	0.05	0.6	1	0	8519045
OF271	Pit244	Pit245	1				Dummy us	0.2	0.05	0.6	1	0	8519036
OF51	Pit104	Pit103	0.7				Dummy us	0.2	0.05	0.6	1	0	694
OF56	Pit103	Pit107	0.8				Dummy us	0.2	0.05	0.6	1	0	705
OF58	Pit107	Pit109	1				Dummy us	0.2	0.05	0.6	1	0	709
OF61	Pit109	Pit167	0.8				Dummy us	0.2	0.05	0.6	1	0	715
OF63	Pit167	Pit158	0.5				Dummy us	0.2	0.05	0.6	1	0	728
OF65	Pit158	Pit159	0.255				Dummy us	0.2	0.05	0.6	1	0	731
OF67	Pit159	Pit157	0.5				Dummy us	0.2	0.05	0.6	1	0	739
OF68	Pit157	Pit322	1.25				Dummy us	0.2	0.05	0.6	1	0	740
OF70	Pit322	Pit144	1				Dummy us	0.2	0.05	0.6	1	0	742
OF85	Pit184	Pit351	3				Dummy us	0.2	0.05	0.6	1	0	927
OF90	Pit351	Pit186	3				Dummy us	0.2	0.05	0.6	1	0	950
OF93	Pit186	Pit358	7				Dummy us	0.2	0.05	0.6	1	0	956
OF97	Pit358	Pit359	5				Dummy us	0.2	0.05	0.6	1	0	970
OF100	Pit359	Pit360	5				Dummy us	0.2	0.05	0.6	1	0	974
OF102	Pit360	Metcash 1	3				Dummy us	0.2	0.05	0.6	1	0	977
OF87	Pit355	Pit186	3				Dummy us	0.2	0.05	0.6	1	0	947
OF485	Pit514	GPT2	0.3				Dummy us	0.2	0.05	0.6	1	0	5.03E+08
OF120	Pit211	Pit386	0.6				Dummy us	0.2	0.05	0.6	1	0	1083
0.5	Pit386	Pit388	2				Dummy us	0.2	0.05	0.6	1	0	1084
OF122	Pit388	Pit452	2				Dummy us	0.2	0.05	0.6	1	0	1085
OF135	Pit420	Pit418	0.55				Dummy us	0.2	0.05	0.6	1	0	1381
OF138	Pit418	Pit416	0.5				Dummy us	0.2	0.05	0.6	1	0	1383
OF139	Pit416	Pit414	0.5				Dummy us	0.2	0.05	0.6	1	0	1384
OF140	Pit414	Pit412	0.5				Dummy us	0.2	0.05	0.6	1	0	1385
OF163	Pit412	Pit409	0.6				Dummy us	0.2	0.05	0.6	1	0	1415
OF150	Pit409	Pit408	0.6				Dummy us	0.2	0.05	0.6	1	0	1396
OF153	Pit408	Pit406	0.8				Dummy us	0.2	0.05	0.6	1	0	1399
OF155	Pit406	Pit404	1.5				Dummy us	0.2	0.05	0.6	1	0	1401
OF157	Pit404	Pit438	1.5				Dummy us	0.2	0.05	0.6	1	0	1403
OF168	Pit438	Pit436	0.8				Dummy us	0.2	0.05	0.6	1	0	1464
OF170	Pit436	Pit433	2				Dummy us	0.2	0.05	0.6	1	0	1466
OF108	Pit370	Pit375	0.5				Dummy us	0.2	0.05	0.6	1	0	998
OF112	Pit375	Pit379	5				Dummy us	0.2	0.05	0.6	1	0	1006
OF116	Pit379	Pit380	2				Dummy us	0.2	0.05	0.6	1	0	1018
OF118	Pit380	Pit74	0.5				Dummy us	0.2	0.05	0.6	1	0	1037
OF126	Pit74	Pit388	5				Dummy us	0.2	0.05	0.6	1	0	1089
OF3	Pit263	Pit268	1				Dummy us	0.2	0.05	0.6	1	0	515
OF10	Pit268	Pit273	1				Dummy us	0.2	0.05	0.6	1	0	523
OF12	Pit273	Pit278	1.2				Dummy us	0.2	0.05	0.6	1	0	525
OF13	Pit278	Pit282	0.6				Dummy us	0.2	0.05	0.6	1	0	526
OF14	Pit282	Pit284	0.6				Dummy us	0.2	0.05	0.6	1	0	527
OF15	Pit284	Pit131	0.6				Dummy us	0.2	0.05	0.6	1	0	528
OF17	Pit131	Pit296	1				Dummy us	0.2	0.05	0.6	1	0	530
OF18	Pit296	Pit299	1				Dummy us	0.2	0.05	0.6	1	0	531
OF19	Pit299	Pit302	1				Dummy us	0.2	0.05	0.6	1	0	532
OF20	Pit302	GPT 1	5				Dummy us	0.2	0.05	0.6	1	0	533
OF1	Pit112	Pit263	1.1				Dummy us	0.2	0.05	0.6	1	0	514

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DRAINS results prepared 25 August, 2010 from Version 2010.08

PIT / NODE DETAILS				Version 8			
Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
Pit23	45.6	46	0.416	0	0.4	0	None
GPT2	45.3	45.3	5.764	15	-0.3	5.232	Outlet System
N470	43.24		0				
Pit519	43.2	43.2	3.663	10	-0.2	1.823	Outlet System
Pit433	42.9		0.058		0.1		None
Pit432	42.53		1.862		0.37		None
N486	41.82		0				
Pit145	62.26		0.108		0.24	0	None
GPT 1	60.95		0.261		1.45	0	None
Pit139	57.25	57.05	2.855	1.8	-0.25	0	Outlet System
Pit241	57.17	57.25	0	0	0.08	0	None
Pit256	55.95	57.15	0.098	0	1.2	0	None
Pit245	55.69	57.1	0.114	0	1.41		None
N259	54.45		0				
Pit149	62.7		0.636		0	0.157	Outlet System
Pit147	62.19	62.65	0.157	2	0.36	0.094	None
Pit146	61.77	62.65	0.203	2	0.78	0.108	None
Pit144	61.12		0		1.38	0	None
Pit194	64.08	64.4	0.114	0	0.32	0	None
Pit191	62.46	62.46	0.129	2.5	-0.06	0	Outlet System
Pit190	60.08		0.114		0.37	0	None
Pit246	57.91	58.35	0.114	0	0.44	0	None
Pit253	60.54	61.6	0.043	0	1.06	0	None
Pit250	58.88	58.88	0.13	3.7	-0.08	0	Outlet System
Pit244	58.05	58.2	0.121	0	0.15	0	None
N328	63.42		0.109				
Pit104	63.4		0		0	0.299	Outlet System
Pit103	63.52	63.52	0.959	10	-0.3	0.065	Outlet System
Pit107	63	62.9	0.26	0	-0.1	0	Outlet System
Pit109	62.74	62.7	0	0	-0.04	0	Outlet System
Pit167	62.56	62.7	0.857	0	0.14	0	None
Pit158	62.15	62.75	0.308	0	0.6	0	None
Pit159	62.1	62.75	0.449	0	0.65	0	None
Pit157	61.88	62.75	0.253	0	0.87	0	None
Pit322	61.51	62.7	0.276	0	1.19	0	None
N358	61.81		0.576				
Pit184	61.77	62.15	0.184	3	0.23	0.039	None
Pit351	61.25	61.25	0.039	15	-0.3	0.233	Outlet System
Pit186	61	61	0.233	15	-0.3	0.48	Outlet System
Pit358	60.95	60.7	0.48	0	-0.25	0	Outlet System
Pit359	60.95	60.7	0	0	-0.25	0	Outlet System
Pit360	60.95	60.7	0	0	-0.25	0	Outlet System
Pit355	61.09	61.1	0.118	5.3	-0.14	0	Outlet System
N417	61.2		0.08				
N415	61.1		0.08				
N414	59.72		0.08				
N413	59.58		0.08				
N411	59.23		0.08				
Pit452	58.69	59.01	0.08	0.1	0.31		None
N438	56.69		0.08				
N408	55.91		0.178				
N407	54.51		0.178				
N406	53.58		0.178				
N405	52.36		0.178				
N403	51.06		0.178				
N402	50.05		0.178				
N400	46.71		0.178				
N399	46.06		0.178				
N397	45.71		0.178				
Pit514	45.4	45.4	0.178	15	-0.3	5.764	Outlet System
Pit211	60.2		0.08		0	0.009	Outlet System
Pit386	59.7		0.087		0	0.009	Outlet System
Pit388	59.15	59.19	0.08	6.2	-0.05	0	Outlet System
N440	57.14		1.076				
N442	50.05		0.488				
N462	50.05		0				
N443	50.08		0.724				
N456	45.44		0.178				
N458	49.26		1.099				
N460	53.7		0.951				
N479	45.34		0.268				
Pit420	64.4		0.144		0.22	0	None
Pit418	62.68		0.081		0.51	0	None
Pit416	58.57		0.081		0.4	0	None
Pit414	53.13		0.087		0	0.003	Outlet System
Pit412	49.04		0.065		0.64	0	None
Pit409	46.45		0.056		0.78	0	None

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Pit408	45.29	45.29	0.046	10	-0.2	0.262	Outlet System
Pit406	45.08	45.08	0.289	5	-0.2	0.039	Outlet System
Pit404	44.51		0.06		0.27	0	None
Pit399	44.06		0.029		0.72		None
N483	43.81		0				
Pit438	43.35		0.051		1.07	0	None
Pit436	42.98		0.029		0.92	0	None
N562	60.04		0.962				
Pit370	59.6	59.6	0	15	-0.3	0.143	Outlet System
Pit375	58.55	59.31	0.143	0.2	0.75	0	None
Pit379	58.29	59.16	0.238	0.3	0.86	0	None
Pit380	57.64	59.2	0	0	1.56	0	None
Pit74	57.08		0		2.07	0	None
N788	59.09		2.466				
N843	57.26		0				
N838	59.74		0.616				
N841	58.56		0.238				
N846	61.14		3.379				
N856	64.8		0.325				
Pit263	64.35	64.35	0.376	4	-0.2	0.268	Outlet System
Pit268	64.27	64.1	0.268	0	-0.17	0	Outlet System
Pit273	64.17	64.1	0.388	0	-0.07	0	Outlet System
Pit278	63.94		0.354		0.11	0	None
Pit282	63.72	64.05	0.495	0	0.33	0	None
Pit284	63.32	64.05	0.029	0.1	0.73	0	None
Pit131	63.13	63.96	0.109	0.1	0.82	0	None
Pit133	62.49		0		1.06		None
Pit296	62.3		0.042		1.25	0	None
Pit299	61.88		0.055		1.22	0	None
Pit302	61.53		0.05		1.57	0	None
Pit143	61.37		0		1.33		None
N859	64.87		0.382				
N862	64.49		0.443				
Pit112	64.35	64.35	0	4	-0.2	0.376	Outlet System

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
Cat206	0.416	0.392	0.024	15	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat250	0.058	0.054	0.006	5.68	29.29	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat248	0.086	0.079	0.01	4.48	23.12	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat78	0.261	0.246	0.015	10	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat87	0.098	0.093	0.008	4.89	25.19	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat103	0.114	0.107	0.01	4.48	23.12	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat44	0.636	0.624	0.018	9.17	31.2	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat49	0.118	0.111	0.007	10	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat99	0.114	0.107	0.01	4.48	23.12	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat97	0.129	0.121	0.011	4.48	23.12	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat93	0.114	0.107	0.01	4.48	23.12	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat90	0.114	0.107	0.01	4.48	23.12	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat107	0.043	0.041	0.004	4.48	23.12	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat105	0.13	0.122	0.011	4.48	23.12	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat111	0.121	0.114	0.01	4.48	23.12	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat51	0.109	0.103	0.01	9.17	47.29	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat54	0.697	0.642	0.055	6	8	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat57	0.229	0.211	0.018	6	8	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat60	0.857	0.813	0.044	7	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat69	0.308	0.292	0.016	7	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat64	0.449	0.424	0.026	10	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat72	0.253	0.239	0.015	10	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat75	0.276	0.26	0.016	10	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat115	0.576	0.569	0.011	12.91	54.07	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat118	0.184	0.173	0.011	10	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat121	0.118	0.111	0.007	10	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat136	0.08	0.076	0.004	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat140	0.08	0.076	0.004	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat155	0.08	0.076	0.004	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat146	0.08	0.076	0.004	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat145	0.08	0.076	0.004	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat157	0.08	0.076	0.004	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat147	0.08	0.076	0.004	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat176	0.178	0.17	0.009	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat178	0.178	0.17	0.009	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat180	0.178	0.17	0.009	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat182	0.178	0.17	0.009	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat184	0.178	0.17	0.009	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat186	0.178	0.17	0.009	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat189	0.178	0.17	0.009	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat191	0.178	0.17	0.009	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat194	0.178	0.17	0.009	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat196	0.178	0.17	0.009	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat141	0.08	0.076	0.004	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone

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Cat142	0.08	0.076	0.004	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat143	0.08	0.076	0.004	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat163	1.076	1.065	0.018	14.4	60.32	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat201	0.488	0.48	0.011	29.11	59.1	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat200	0.724	0.718	0.01	14.4	71.68	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat195	0.178	0.17	0.009	6	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat167	1.099	1.035	0.064	15	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat168	0.951	0.941	0.018	12.6	52.76	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat211	0.268	0.238	0.053	13.28	59.1	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat214	0.144	0.135	0.012	4.48	23.12	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat217	0.081	0.059	0.031	4.48	23.12	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat220	0.081	0.059	0.031	4.48	23.12	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat222	0.087	0.063	0.033	4.48	23.12	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat230	0.065	0.052	0.018	4.48	23.12	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat227	0.056	0.045	0.016	4.48	23.12	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat233	0.046	0.038	0.012	5.68	29.29	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat237	0.031	0.029	0.004	4.48	23.12	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat242	0.029	0.027	0.003	5.68	29.29	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat244	0.029	0.027	0.003	5.68	29.29	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat246	0.051	0.047	0.006	5.68	29.29	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat247	0.029	0.027	0.003	5.68	29.29	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat123	0.962	0.948	0.024	14.51	38.89	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat135	0.238	0.238	0	10.55	0	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
NEGH1	2.466	0	2.466	0	14	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat128	0.616	0.616	0	10.55	0	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat132	0.238	0.238	0	10.55	0	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
NEGH2	3.379	0	3.379	0	6	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat2	0.325	0.319	0.009	9.12	31.2	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat22	0.388	0.368	0.02	7	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat26	0.354	0.336	0.018	7	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat29	0.495	0.47	0.025	7	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat32	0.029	0.028	0.001	7	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat36	0.109	0.103	0.006	7	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat9	0.042	0.042	0	5	0	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat10	0.055	0.055	0	5	0	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat11	0.05	0.05	0	5	0	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat19	0.382	0.362	0.02	7	5	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone
Cat1	0.443	0.436	0.012	13.72	36.2	0	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone

Outflow Volumes for Total Catchment (47.6 impervious + 20.8 pervious = 68.4 total ha)

Storm	Total Rainf	Total Runo	Impervious	Pervious Runoff
	cu.m	cu.m (Run	cu.m (Run	cu.m (Runoff %)
AR&R 5 ye	26606.24	21412.67 (	18048.56 (	3364.11 (41.6%)
AR&R 10 y	30094.45	24865.15 (	20477.28 (	4387.87 (48.0%)
AR&R 20 y	34882.2	29613.43 (	23810.88 (	5802.54 (54.8%)
AR&R 50 y	40353.93	35009.33 (	27620.58 (	7388.75 (60.3%)
AR&R 100	45141.68	39781.22 (	30954.30 (	8826.91 (64.4%)

PIPE DETAILS

Name	Max Q	Max V	Max U/S	Max D/S	Due to Storm
	(cu.m/s)	(m/s)	HGL (m)	HGL (m)	
Pipe229	0.416	1.5	45.364	45.3	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe100	4.289	2.4	44.213	43.77	AR&R 20 year, 1 hour storm, average 51 mm/h, Zone 1
Pipe101	4.301	2.4	43.515	43.243	AR&R 20 year, 1 hour storm, average 51 mm/h, Zone 1
Pipe515	4.301	2.4	43.243	43.2	AR&R 20 year, 1 hour storm, average 51 mm/h, Zone 1
P784	5.772	3.2	42.935	42.903	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe478	5.825	3.2	42.688	42.528	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe479	7.105	4.2	42.319	41.825	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe119	0.108	3.6	61.654	60.949	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe120	6.626	3.6	59.677	59.602	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
P661	3.551	5.6	58.115	57.252	AR&R 20 year, 1 hour storm, average 51 mm/h, Zone 1
Pipe321	5.825	2.6	57.252	57.17	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe8	10.036	3.9	56.131	55.952	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe9	10.124	4	55.75	55.688	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe252	10.9	4.6	54.957	54.455	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe103	0.548	1.9	62.317	62.19	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe117	0.583	2.1	62.058	61.773	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe118	0.68	2.4	61.291	61.117	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe82	3.629	2	61.016	60.949	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe22	0.114	2.1	63.585	62.462	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe21	0.22	2	61.774	60.08	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe23	0.332	2.1	59.847	57.912	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe14	0.446	2.6	57.719	56.384	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe4	0.043	2.1	60.292	58.884	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe10	0.162	1.5	58.703	58.045	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe11	0.26	2.4	57.719	56.045	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
P311	0.109	0.7	63.421	63.4	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe63	0.102	0.5	63.402	63.52	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe64	0.793	1.8	63.223	63.003	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe65	0.943	1.5	62.919	62.738	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe67	0.943	1.5	62.706	62.558	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe70	1.732	1.9	62.325	62.149	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1

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Pipe109	2.036	1.4	62.149	62.101	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe74	2.48	1.7	61.969	61.882	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe76	2.731	1.9	61.753	61.512	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe77	3.008	2	61.357	61.117	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe130	0.576	1.3	61.814	61.771	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe24	0.72	1.6	61.364	61.25	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe98	0.688	1.6	61.052	61	AR&R 50 year, 1 hour storm, average 59 mm/h, Zone 1
Pipe124	0.951	1.5	60.969	60.95	AR&R 50 year, 1 hour storm, average 59 mm/h, Zone 1
Pipe122	1.415	0.8	60.95	60.95	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe123	1.415	0.8	60.95	60.95	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe314	1.415	0.8	60.949	60.949	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe97	0.153	1	61.028	61	AR&R 50 year, 1 hour storm, average 59 mm/h, Zone 1
Pipe140	0.08	1.3	61.199	61.109	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe160	0.159	2.7	61.1	59.722	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe159	0.238	1.6	59.722	59.578	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe400	0.317	2	59.578	59.235	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe164	0.396	2.5	59.235	58.685	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe169	0.704	3.3	58.022	56.69	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe175	3.78	4.5	56.69	55.912	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe178	3.957	4.5	55.912	54.649	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe180	4.132	4.7	54.506	53.67	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe182	5.248	6.5	53.585	52.362	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe194	5.424	4.9	52.362	51.346	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe203	5.6	6.3	51.065	50.054	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe205	6.886	7	50.054	48.374	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe228	8.124	7.6	46.709	46.065	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe232	8.299	3.8	46.065	45.713	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe233	8.474	3.8	45.713	45.4	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe99	3.869	1.8	45.338	45.3	AR&R 10 year, 1 hour storm, average 44 mm/h, Zone 1
Pipe162	0.075	1.1	59.988	59.7	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe165	0.157	1.4	59.453	59.147	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe163	0.231	2.1	58.885	58.685	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe170	1.076	2.7	57.141	57.026	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe416	0.488	1.7	50.054	50.054	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe222	1.114	2.2	50.054	50.054	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe417	0.724	2.4	50.084	50.054	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe230	0.178	0.8	45.435	45.4	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe204	1.099	2.8	49.262	49.042	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe419	0.951	2.2	53.699	53.585	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe234	0.268	0.5	45.335	45.3	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe27	0.144	2.1	63.823	62.685	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe29	0.225	3.6	62.209	58.572	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe31	0.306	4.1	58.02	53.13	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe38	0.39	3.5	52.577	49.043	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe35	0.455	4.1	48.8	46.453	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe36	0.512	4.2	46.271	45.29	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe37	0.404	1.4	45.137	45.08	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe236	0.488	1.7	44.892	44.514	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe472	0.529	1.9	44.257	44.061	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe473	0.55	2.2	43.978	43.809	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe239	0.051	1.2	43.061	42.981	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe474	0.08	0.7	42.969	42.903	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe154	0.962	1.8	60.044	59.6	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe155	1.488	2.3	58.929	58.545	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe156	1.777	2.1	58.535	58.291	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe158	2.007	2.3	57.788	57.639	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe167	2.007	2.3	57.283	57.082	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe168	2.007	2.4	56.93	56.69	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
P857	5.825	2.6	57.258	57.17	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
P834	0.616	2.2	59.736	59.6	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
P850	0.238	0.9	58.564	58.545	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe855	3.379	3	61.141	57.258	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe880	0.325	2.9	64.8	64.35	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe51	1.005	1.6	64.315	64.265	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe54	1.311	1.5	64.265	64.168	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe55	1.544	1.7	64.086	63.938	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe56	1.758	1.6	63.857	63.719	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe57	2.14	1.9	63.498	63.323	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe58	2.167	1.9	63.278	63.128	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe81	2.267	2	62.782	62.488	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe88	2.267	2	62.353	62.303	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe89	2.308	2	62.155	61.885	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe78	2.36	2.1	61.827	61.533	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe79	2.409	2.1	61.473	61.367	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe80	2.409	2.1	61.068	60.949	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
P883	0.382	3.5	64.866	64.265	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
P887	0.443	2	64.489	64.35	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
Pipe50	0.523	0.8	64.35	64.35	AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
CHANNEL DETAILS					
Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm
Chnl2	2.466	1.5			AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1

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Design Storms 5, 10, 20, 50 &100Yr ARI

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OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF133	0	0	0.362	0	0	0	0	
OF131	5.232	5.232	0.362	0.145	0.21	39.61	1.44	AR&R 100 year, 1 hour storm, average 66 m
OF473	3.663	3.663	0.362	0.124	0.16	36.76	1.29	AR&R 100 year, 1 hour storm, average 66 m
OF505	1.823	1.823	0.362	0.093	0.1	32.49	1.03	AR&R 100 year, 1 hour storm, average 66 m
OF47	0	0	0.362	0	0	0	0	
OF241	0	0	0.362	0	0	0	0	
OF318	2.855	2.855	0.362	0.111	0.13	34.98	1.2	AR&R 100 year, 1 hour storm, average 66 m
OF415	0	0	0.362	0	0	0	0	
OF244	0	0	0.362	0	0	0	0	
OF249	0	0	0.362	0	0	0	0	
OF40	0.157	0.157	0.362	0.036	0.02	15.74	0.52	AR&R 100 year, 1 hour storm, average 66 m
OF42	0.094	0.094	0.362	0.03	0.01	13.53	0.44	AR&R 100 year, 1 hour storm, average 66 m
OF44	0.108	0.108	0.362	0.031	0.01	14.16	0.46	AR&R 100 year, 1 hour storm, average 66 m
OF71	0	0	0.362	0	0	0	0	
OF179	0	0	0.362	0	0	0	0	
OF199	0	0	0.362	0	0	0	0	
OF205	0	0	0.362	0	0	0	0	
OF292	0	0	0.362	0	0	0	0	
OF286	0	0	0.362	0	0	0	0	
OF280	0	0	0.362	0	0	0	0	
OF271	0	0	0.362	0	0	0	0	
OF51	0.299	0.299	0.362	0.046	0.03	19.52	0.62	AR&R 100 year, 1 hour storm, average 66 m
OF56	0.065	0.065	0.362	0.025	0.01	11.96	0.41	AR&R 100 year, 1 hour storm, average 66 m
OF58	0	0	0.362	0	0	0	0	
OF61	0	0	0.362	0	0	0	0	
OF63	0	0	0.362	0	0	0	0	
OF65	0	0	0.362	0	0	0	0	
OF67	0	0	0.362	0	0	0	0	
OF68	0	0	0.362	0	0	0	0	
OF70	0	0	0.362	0	0	0	0	
OF85	0.039	0.039	0.362	0.021	0.01	10.38	0.35	AR&R 100 year, 1 hour storm, average 66 m
OF90	0.233	0.233	0.362	0.042	0.02	17.94	0.58	AR&R 100 year, 1 hour storm, average 66 m
OF93	0.48	0.48	0.362	0.056	0.04	23.3	0.68	AR&R 100 year, 1 hour storm, average 66 m
OF97	0	0	0.362	0	0	0	0	
OF100	0	0	0.362	0	0	0	0	
OF102	0	0	0.362	0	0	0	0	
OF87	0	0	0.362	0	0	0	0	
OF485	5.764	5.764	0.362	0.151	0.22	40.44	1.49	AR&R 100 year, 1 hour storm, average 66 m
OF120	0.009	0.009	0.362	0.012	0	5.8	0.25	AR&R 100 year, 1 hour storm, average 66 m
0.5	0.009	0.009	0.362	0.012	0	6.23	0.24	AR&R 100 year, 1 hour storm, average 66 m
OF122	0	0	0.362	0	0	0	0	
OF135	0	0	0.362	0	0	0	0	
OF138	0	0	0.362	0	0	0	0	
OF139	0	0	0.362	0	0	0	0	
OF140	0.003	0.003	0.362	0.007	0	3.65	0.2	AR&R 100 year, 1 hour storm, average 66 m
OF163	0	0	0.362	0	0	0	0	
OF150	0	0	0.362	0	0	0	0	
OF153	0.262	0.262	0.362	0.044	0.03	18.89	0.58	AR&R 100 year, 1 hour storm, average 66 m
OF155	0.039	0.039	0.362	0.021	0.01	10.38	0.36	AR&R 100 year, 1 hour storm, average 66 m
OF157	0	0	0.362	0	0	0	0	
OF168	0	0	0.362	0	0	0	0	
OF170	0	0	0.362	0	0	0	0	
OF108	0.143	0.143	0.362	0.035	0.02	15.42	0.5	AR&R 100 year, 1 hour storm, average 66 m
OF112	0	0	0.362	0	0	0	0	
OF116	0	0	0.362	0	0	0	0	
OF118	0	0	0.362	0	0	0	0	
OF126	0	0	0.362	0	0	0	0	
OF3	0.268	0.268	0.362	0.044	0.03	18.89	0.59	AR&R 100 year, 1 hour storm, average 66 m
OF10	0	0	0.362	0	0	0	0	
OF12	0	0	0.362	0	0	0	0	
OF13	0	0	0.362	0	0	0	0	
OF14	0	0	0.362	0	0	0	0	
OF15	0	0	0.362	0	0	0	0	
OF17	0	0	0.362	0	0	0	0	
OF18	0	0	0.362	0	0	0	0	
OF19	0	0	0.362	0	0	0	0	
OF20	0	0	0.362	0	0	0	0	
OF1	0.376	0.376	0.362	0.051	0.03	21.41	0.64	AR&R 100 year, 1 hour storm, average 66 m

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q	Max Q	Max Q
			Total	Low Level	High Level
Basin170	43.76	4006.6	7.964	4.301	3.663
Metcash 1	59.59	2334.4	6.406	3.551	2.855

CONTINUITY CHECK for AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1

Node	Inflow	Outflow	Storage Cl	Difference
	(cu.m)	(cu.m)	(cu.m)	%
Pit23	727.08	727.08	0	0

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GPT2	17150.08	17151.38	0	0							
Basin170	17151.37	17149.76	0.61	0							
N470	13590.09	13570.58	0	0.1							
Pit519	17130.24	17111.5	0	0.1							
Pit433	16588.38	16586.32	0	0							
Pit432	17448.38	17448.03	0	0							
N486	17448.03	17448.03	0	0							
Pit145	33.55	33.55	0	0							
GPT 1	12665.96	12663.67	0	0							
Metcash 1	12663.67	12662.15	0.97	0							
Pit139	12662.12	12683.18	0	-0.2							
Pit241	19898.26	19899.88	0	0							
Pit256	20040.22	20044.78	0	0							
Pit245	21294.57	21293.77	0	0							
N259	21293.77	21293.77	0	0							
Pit149	1114.72	1114.72	0	0							
Pit147	1114.72	1114.81	0	0							
Pit146	1318.77	1318.67	0	0							
Pit144	6316.3	6315.53	0	0							
Pit194	161.91	161.89	0	0							
Pit191	345.35	345.33	0	0							
Pit190	507.24	507.26	0	0							
Pit246	669.17	669.32	0	0							
Pit253	61.56	61.53	0	0.1							
Pit250	246.22	246.19	0	0							
Pit244	418.57	418.56	0	0							
N328	206.5	206.5	0	0							
Pit104	206.5	206.67	0	-0.1							
Pit103	1223	1223.23	0	0							
Pit107	1557.8	1556.7	0	0.1							
Pit109	1556.7	1555.28	0	0.1							
Pit167	2875.71	2874.33	0	0							
Pit158	3349.14	3345.98	0	0.1							
Pit159	4123.56	4120.05	0	0.1							
Pit157	4558.72	4555.56	0	0.1							
Pit322	5033.83	5031.18	0	0.1							
N358	1051.18	1051.18	0	0							
Pit184	1369.48	1369.71	0	0							
Pit351	1369.71	1369.96	0	0							
Pit186	1573.92	1574.7	0	0							
Pit358	1574.7	1575.94	0	-0.1							
Pit359	1575.94	1576.72	0	0							
Pit360	1576.72	1577.41	0	0							
Pit355	203.94	203.96	0	0							
N410	0	0	0	0							
N417	115.64	115.64	0	0							
N415	231.29	231.29	0	0							
N414	346.93	346.93	0	0							
N413	462.57	462.57	0	0							
N411	578.21	578.26	0	0							
Pit452	1040.74	1040.85	0	0							
N438	6837.28	6837.27	0	0							
N408	7096.67	7096.68	0	0							
N407	7356.08	7356.08	0	0							
N406	9351.66	9351.65	0	0							
N405	9611.05	9611.06	0	0							
N403	9870.46	9870.45	0	0							
N402	12604.24	12604.26	0	0							
N400	14785.86	14785.9	0	0							
N399	15045.29	15045.29	0	0							
N397	15304.67	15303.25	0	0							
Pit514	15822.03	15821.47	0	0							
Pit211	115.64	115.61	0	0							
Pit386	231.25	231.21	0	0							
Pit388	346.86	346.84	0	0							
N440	1971.34	1971.34	0	0							
N442	1145.37	1145.37	0	0							
N462	2474.42	2474.42	0	0							
N443	1329.05	1329.05	0	0							
N456	259.4	259.4	0	0							
N458	1922.23	1922.23	0	0							
N460	1736.18	1736.18	0	0							
N479	601.52	601.52	0	0							
Pit420	204.7	204.7	0	0							
Pit418	337.23	337.11	0	0							
Pit416	469.64	469.68	0	0							
Pit414	611.04	611.06	0	0							
Pit412	712.4	712.49	0	0							
Pit409	800.43	800.43	0	0							
Pit408	878.46	878.46	0	0							
Pit406	923.78	923.79	0	0							
Pit404	969.06	968.92	0	0							
Pit399	1014.2	1014.2	0	0							

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N483	1014.2	1014.2	0	0
Pit438	78.48	78.48	0	0
Pit436	123.75	123.75	0	0
N562	1756.26	1756.26	0	0
Pit370	2851.45	2851.66	0	0
Pit375	3275.07	3278.17	0	-0.1
Pit379	3701.58	3701.86	0	0
Pit380	3701.86	3704.69	0	-0.1
Pit74	3704.69	3709.45	0	-0.1
N788	3483.42	3483.42	0	0
N843	7222.82	7215.09	0	0.1
N838	1095.18	1095.18	0	0
N841	423.41	423.41	0	0
N846	3739.39	3739.39	0	0
N856	568.1	568.1	0	0
Pit263	1376.98	1378.39	0	-0.1
Pit268	1966.57	1967.94	0	-0.1
Pit273	2566.6	2567.57	0	0
Pit278	3113	3113.67	0	0
Pit282	3876.84	3876.88	0	0
Pit284	3921.96	3920.86	0	0
Pit131	4088.78	4087.96	0	0
Pit133	4087.96	4087.68	0	0
Pit296	4144.49	4144.5	0	0
Pit299	4218.93	4219.2	0	0
Pit302	4287.54	4287.8	0	0
Pit143	4287.8	4288.2	0	0
N859	588.18	588.18	0	0
N862	807.4	807.4	0	0
Pit112	807.4	808.88	0	-0.2

Run Log for PITT LOSS QUDM1 run at 07:02:11 on 25/8/2010

Upwelling occurred at Pit514, Pit408, Pit370, Pit351, Pit186, Pit112, Pit104, GPT2
Freeboard was inadequate at more than 20 pits.
The maximum flow exceeded the safe value in the following overflow routes: OF505, OF485, OF473, OF318, OF131, OF93, OF1

DRAINS OUTPUT EAST & WEST
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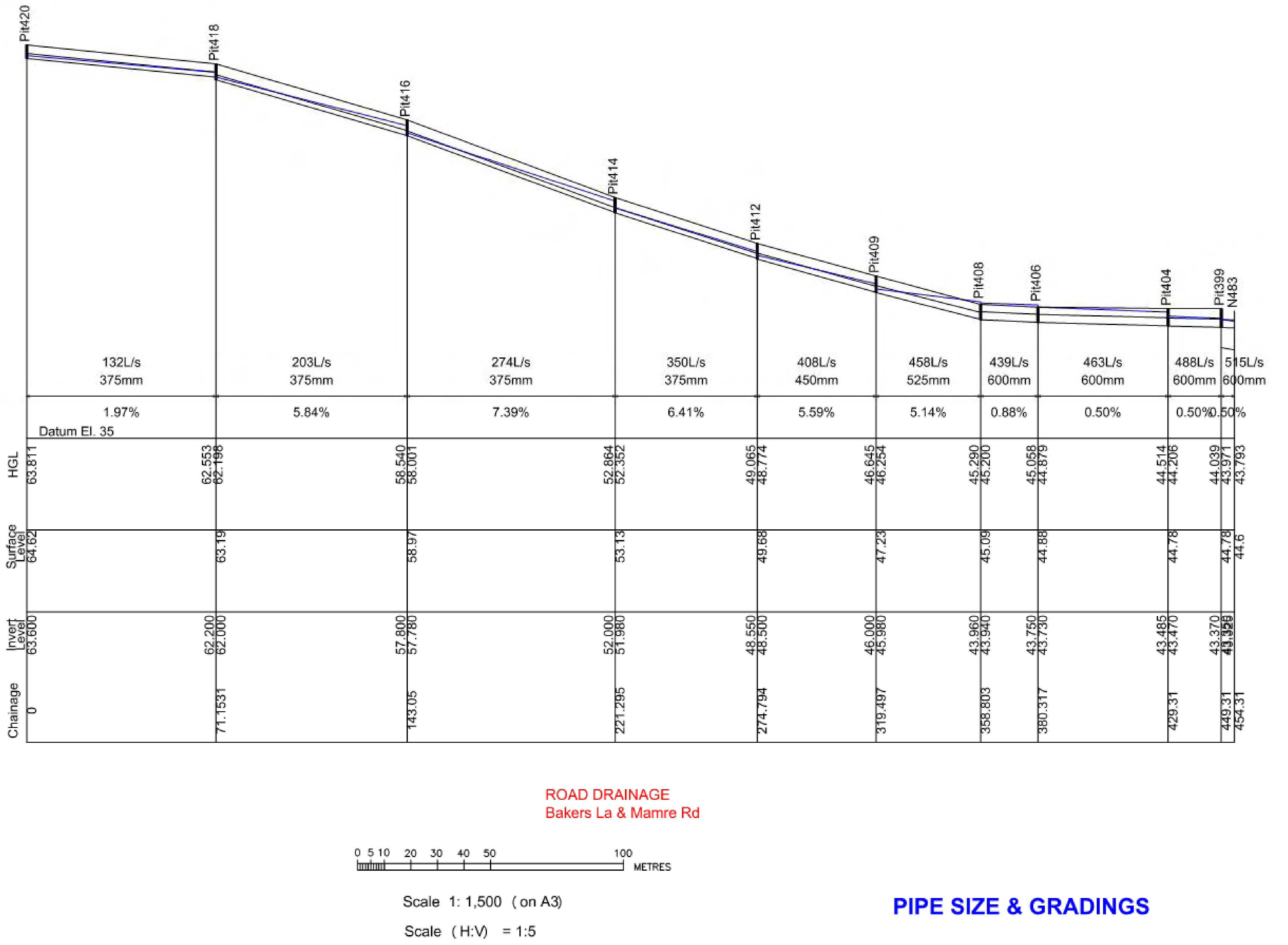
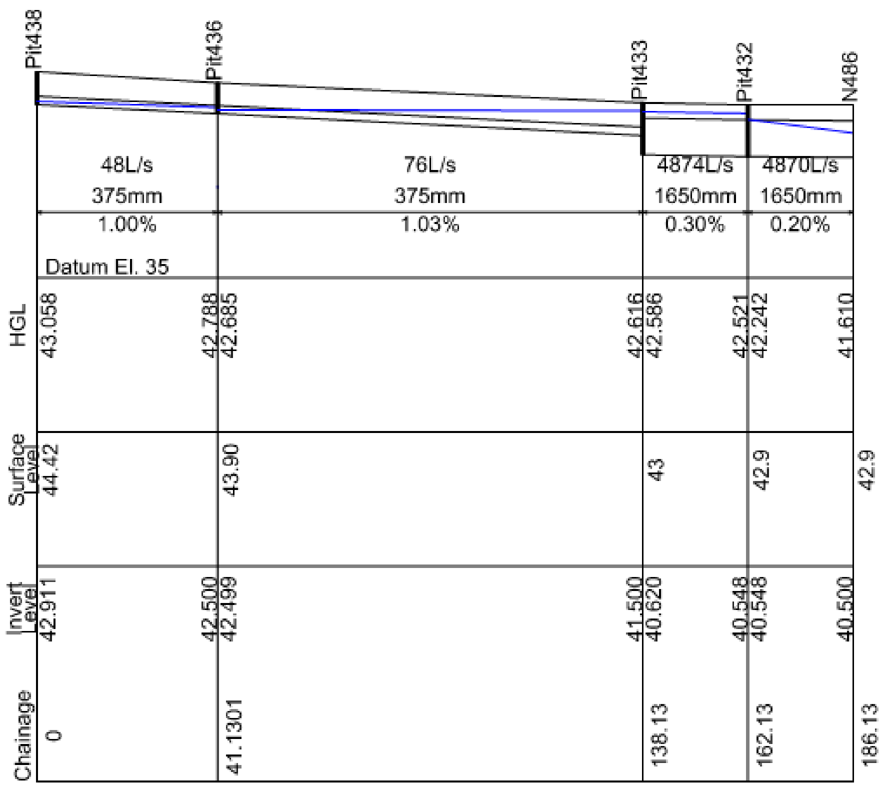
ANNEXURE "D"

DESIGN OUTCOME


Pit420
Pit418
Pit416
Pit414
Pit412
Pit409
Pit408
Pit406
Pit404
Pit399
N483
132L/s 375mm
203L/s 375mm
274L/s 375mm
350L/s 375mm
408L/s 450mm
458L/s 525mm
439L/s 600mm
463L/s 600mm
488L/s 600mm
515L/s 600mm
1.97%
5.84%
7.39%
6.41%
5.59%
5.14%
0.88%
0.50%
0.50%
0.50%
Datum El. 35
HGL
Surface Level
Invert Level
Chainage
ROAD DRAINAGE
Bakers La & Mamre Rd
0 5 10 20 30 40 50 100
METRES
Scale 1: 1,500 (on A3)
Scale (H:V) = 1:5
PIPE SIZE & GRADINGS



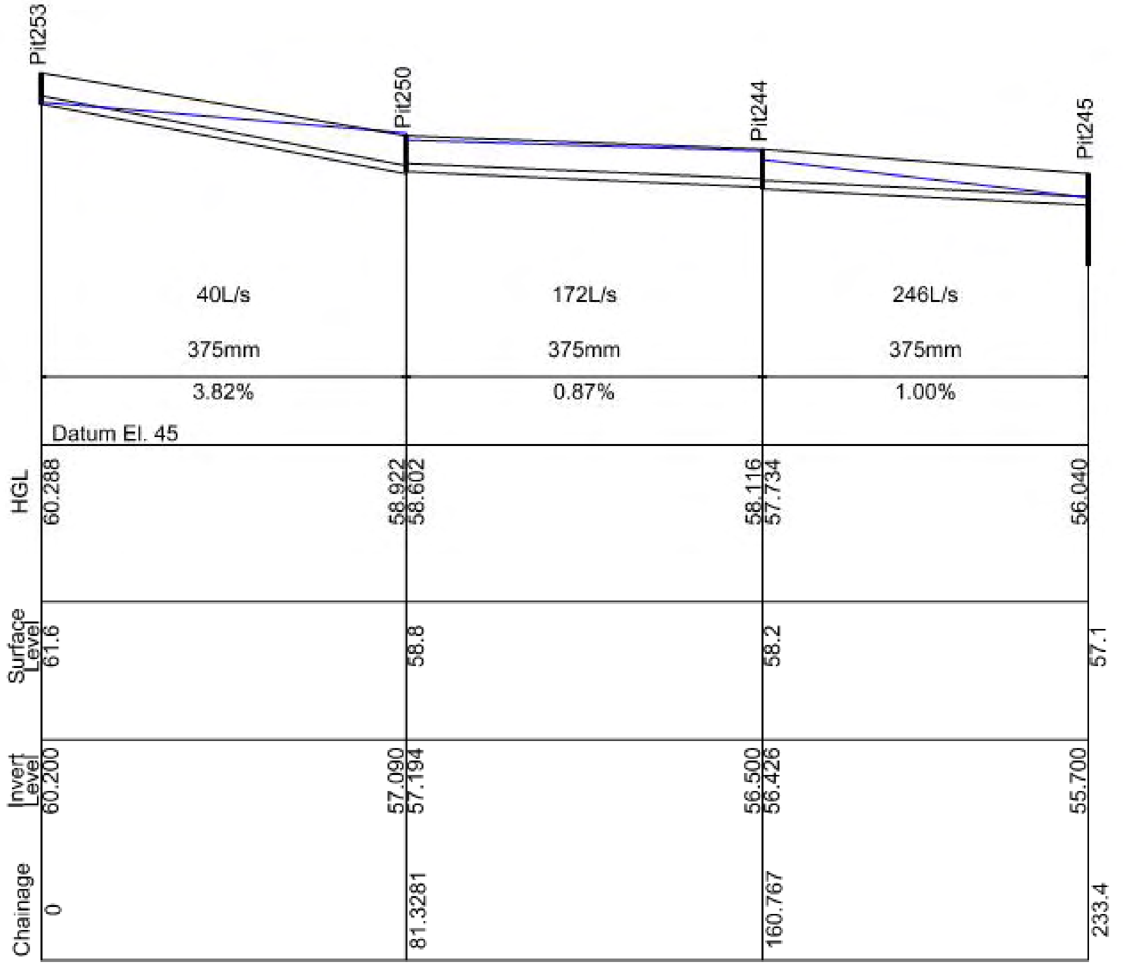
ROAD DRAINAGE
Mamre Rd

0 5 10 20 30 40 50 100 METRES

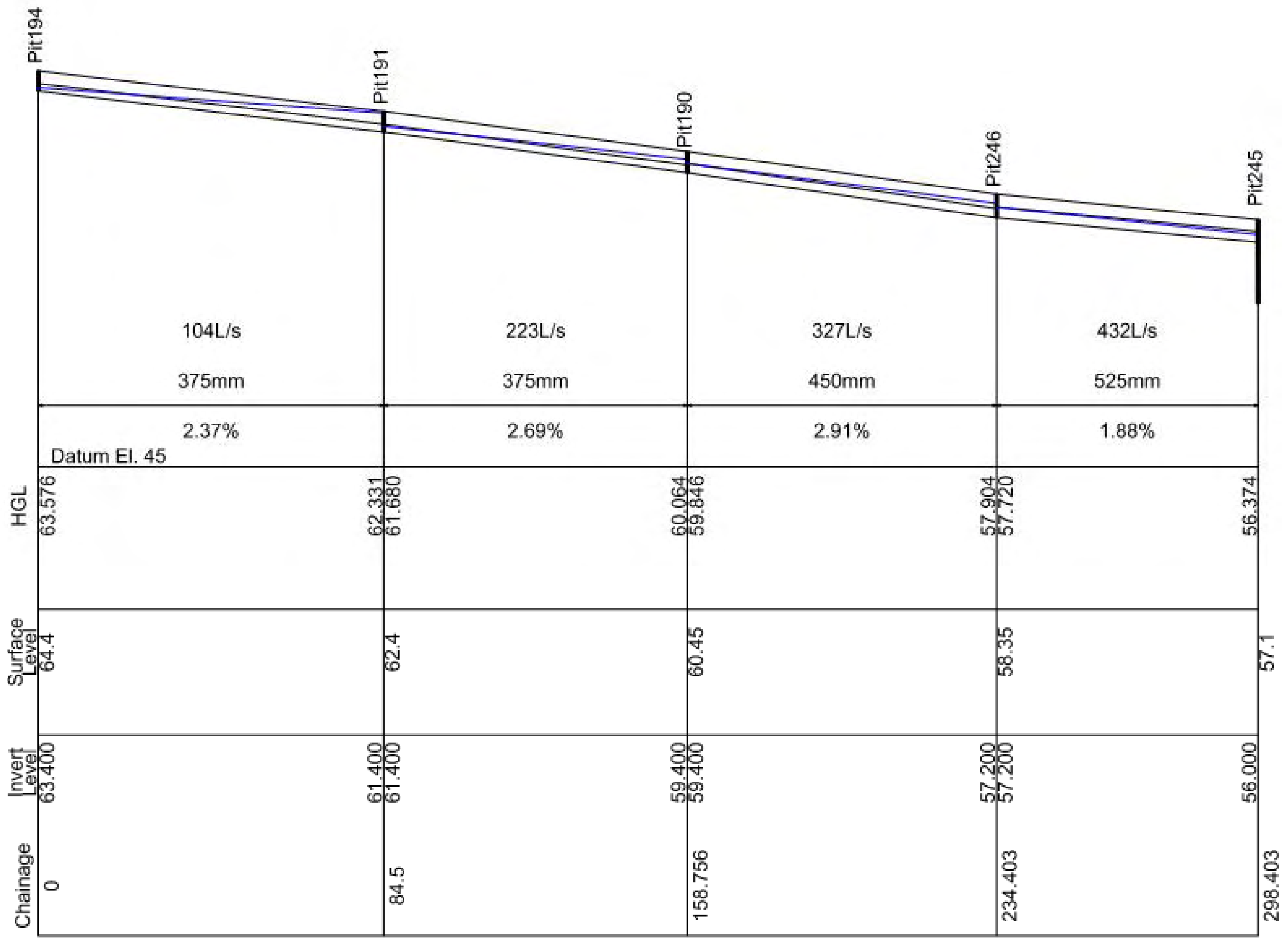
Scale 1: 1,500 (on A3)

Scale (H:V) = 1:5

PIPE SIZE & GRADINGS



ROAD DRAINAGE
Barkers La



ROAD DRAINAGE
Barkers La

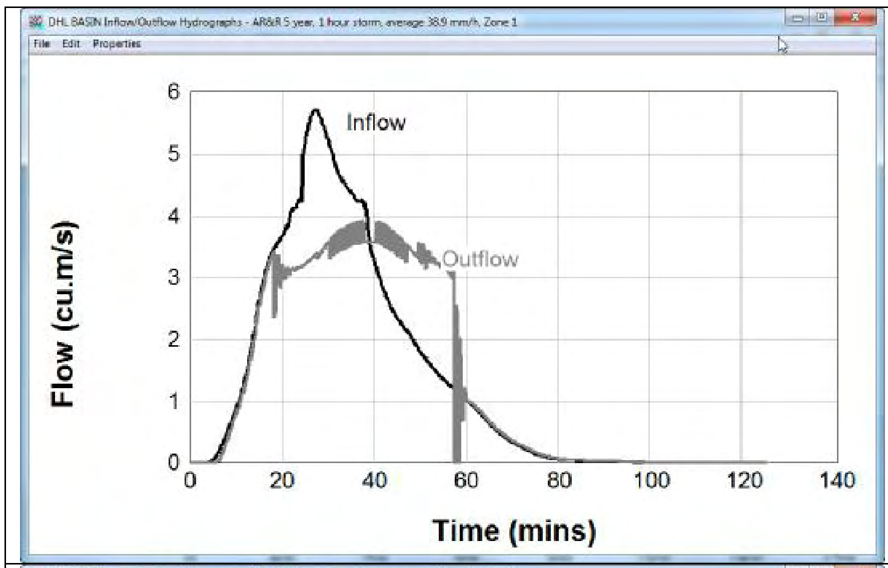
0 5 10 20 30 40 50 100 METRES

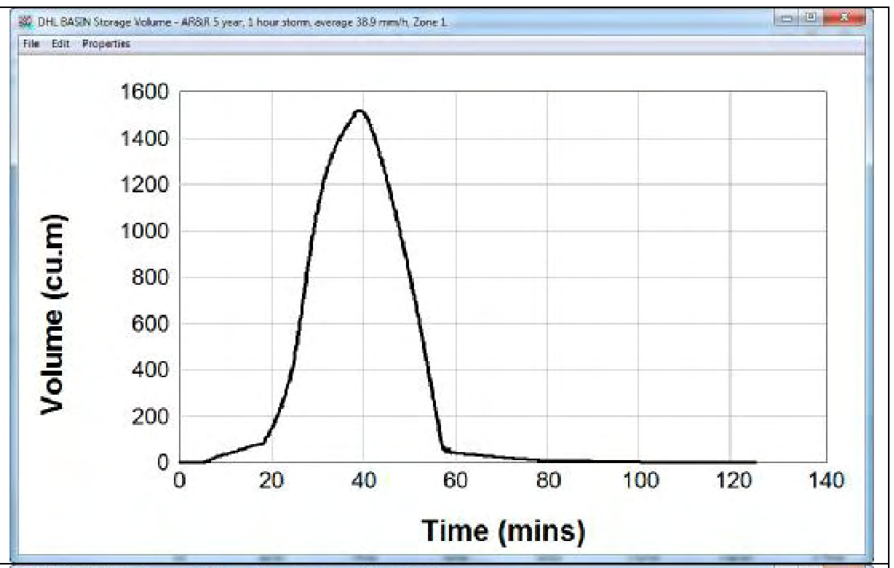
Scale 1: 1,500 (on A3)

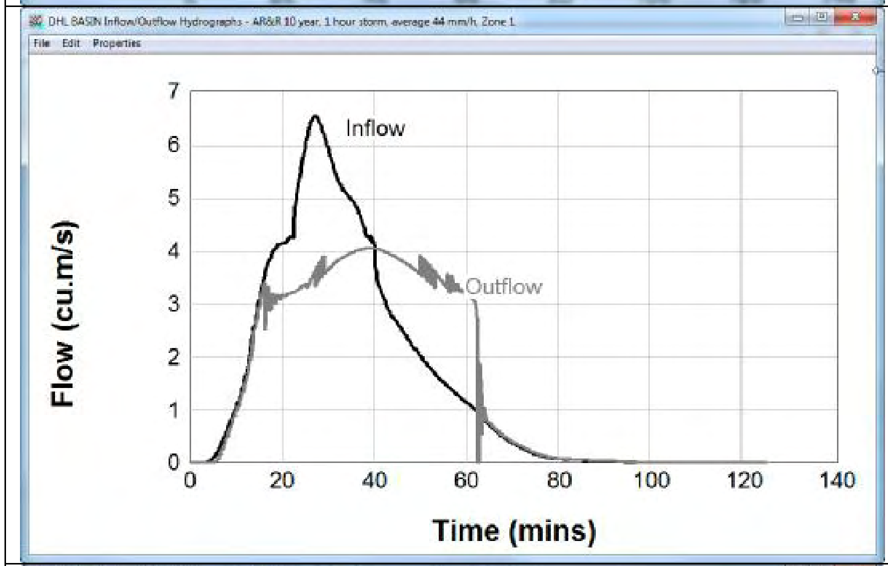
Scale (H:V) = 1:5

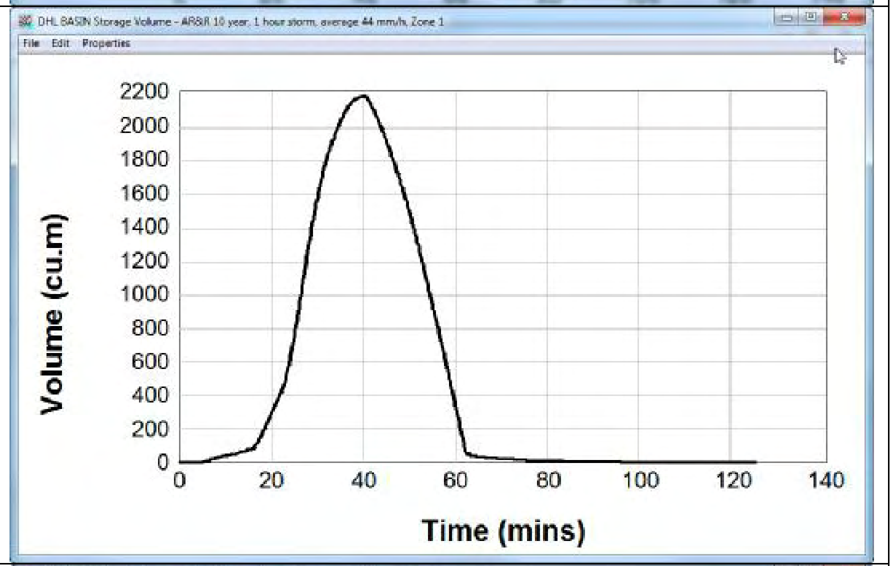
PIPE SIZE & GRADINGS

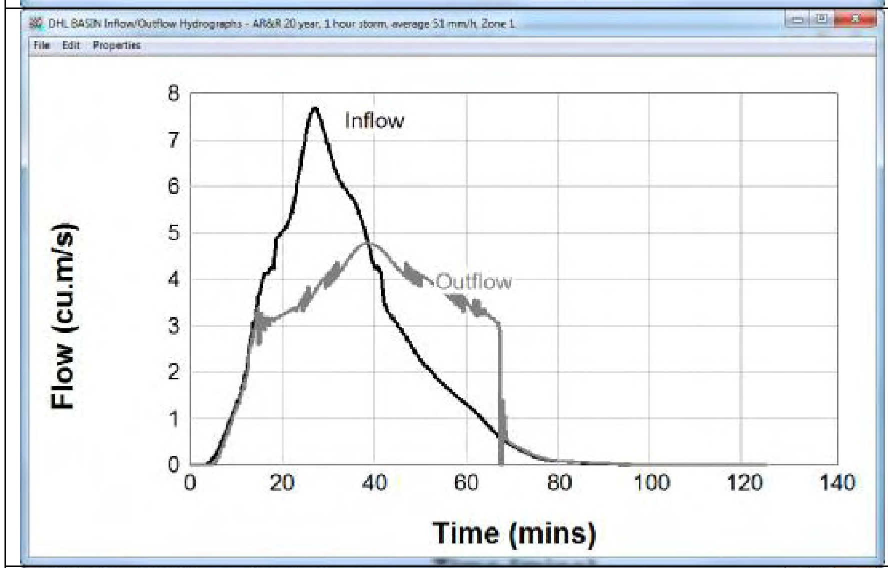
WEST BASIN PERFORMANCE FOR ALL STORMS – Inflow / Outflow Hydrographs & Storage Volumes

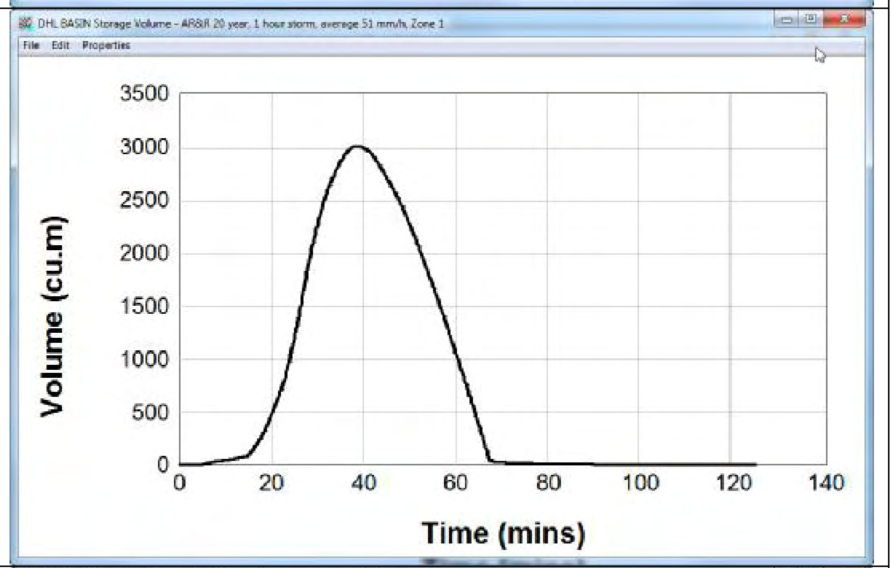


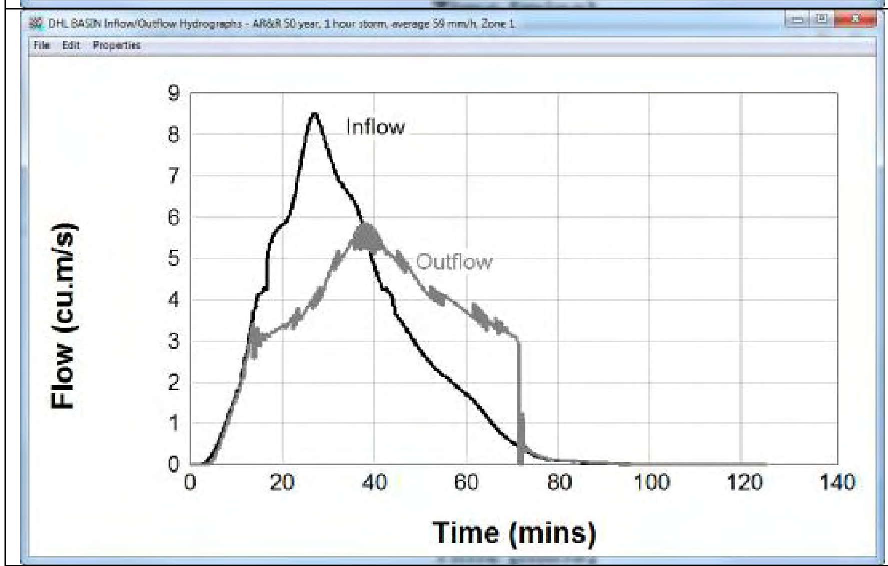


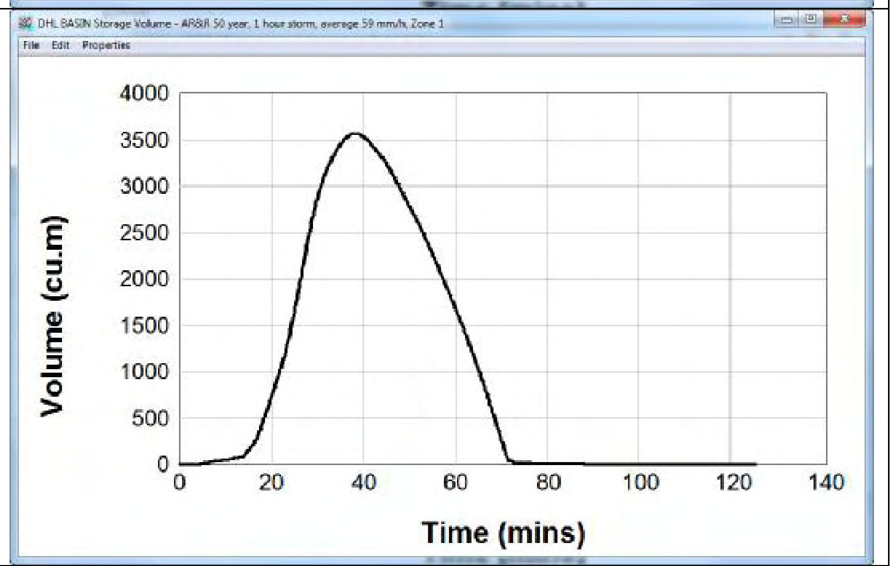


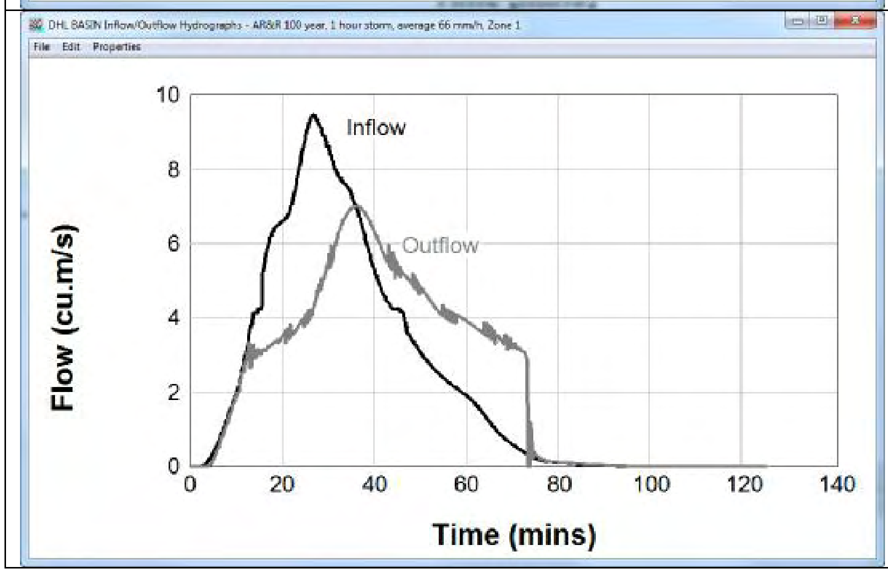


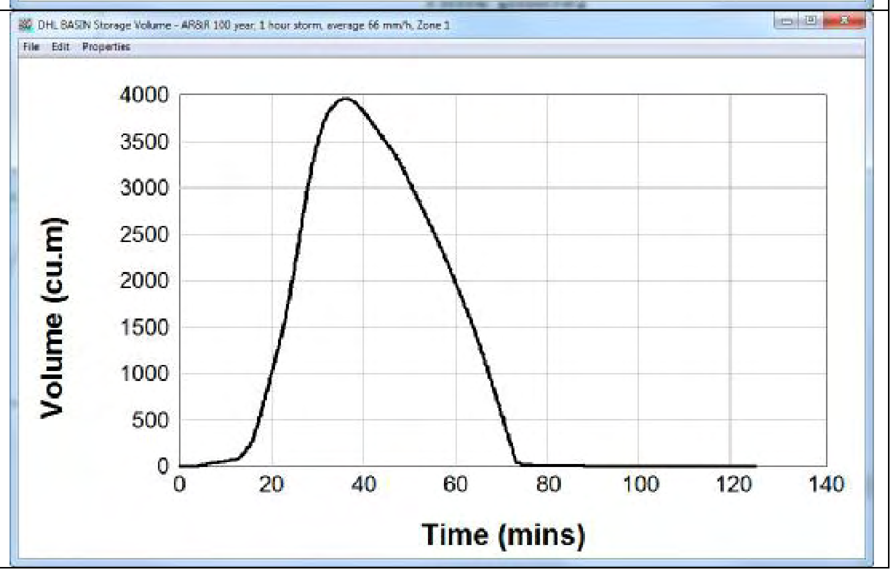






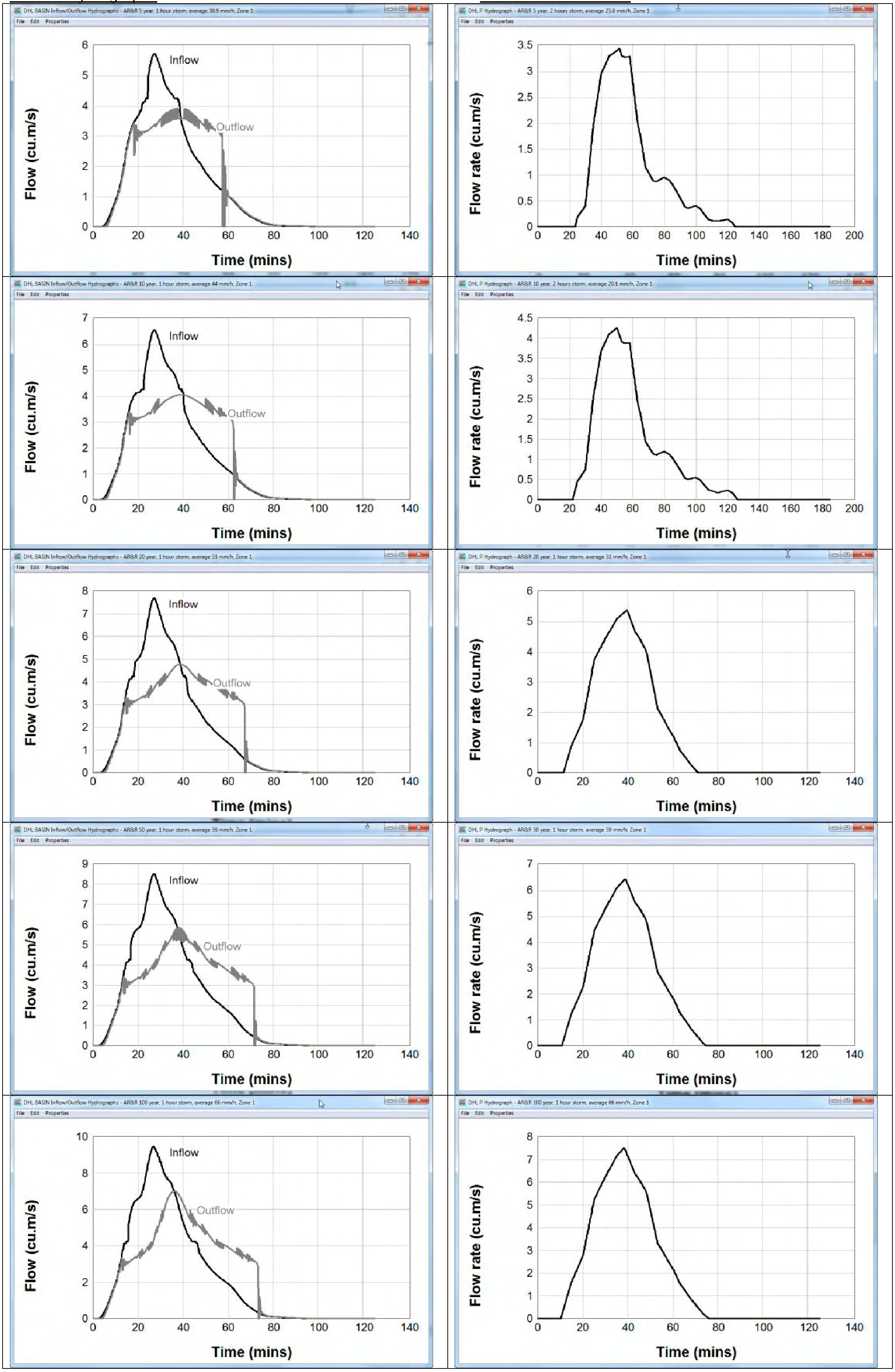




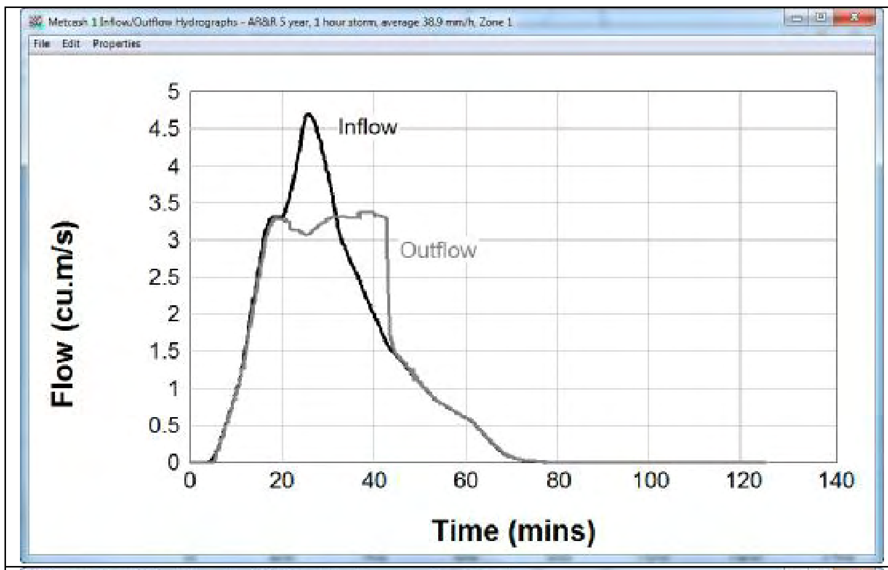


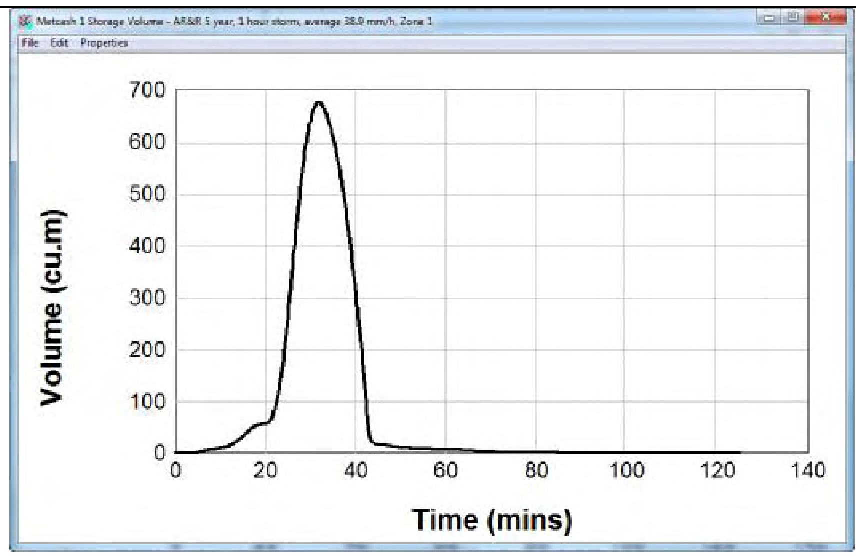
WEST BASIN PERFORMANCE RELATIVE TO STATE OF NATURE FOR ALL STORMS –

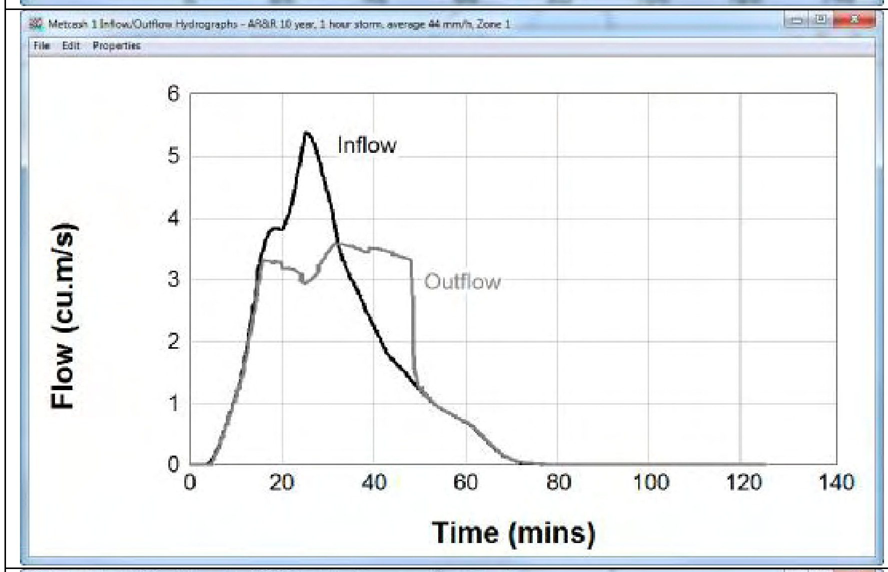
Outflow Hydrographs | State of Nature Flows

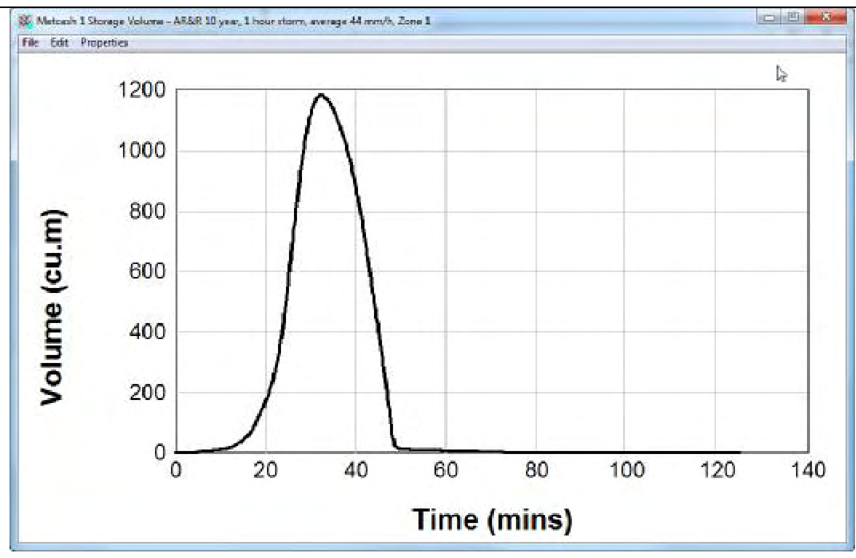


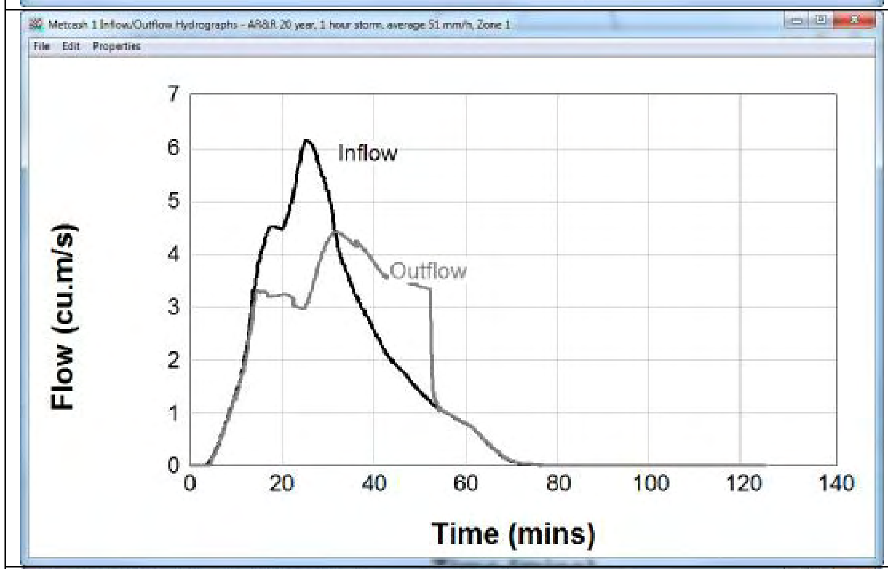
BASIN PERFORMANCE FOR ALL STORMS – Inflow / Outflow Hydrographs & Storage Volumes

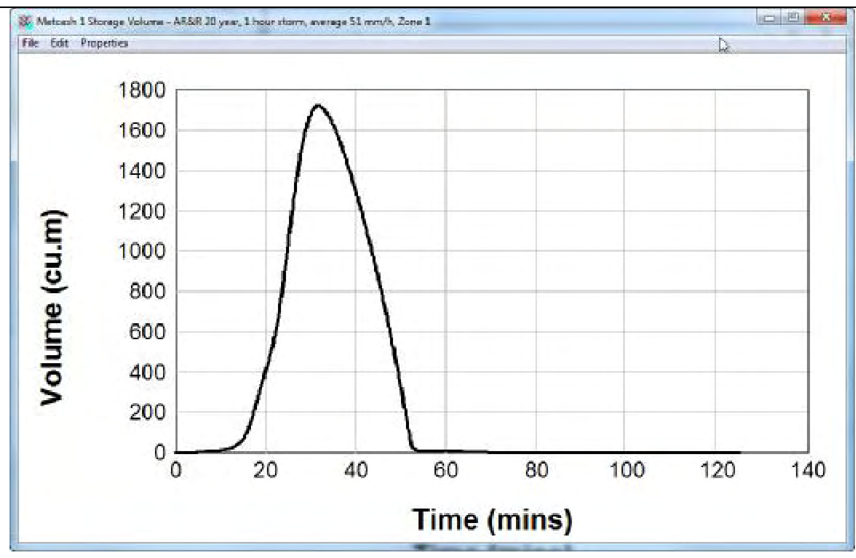

Metcash 1 Inflow/Outflow Hydrographs - AR&R 5 year, 1 hour storm, average 38.9 mm/h, Zone 1
File Edit Properties
Flow (cu.m/s)
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
Inflow
Outflow
0 20 40 60 80 100 120 140
Time (mins)

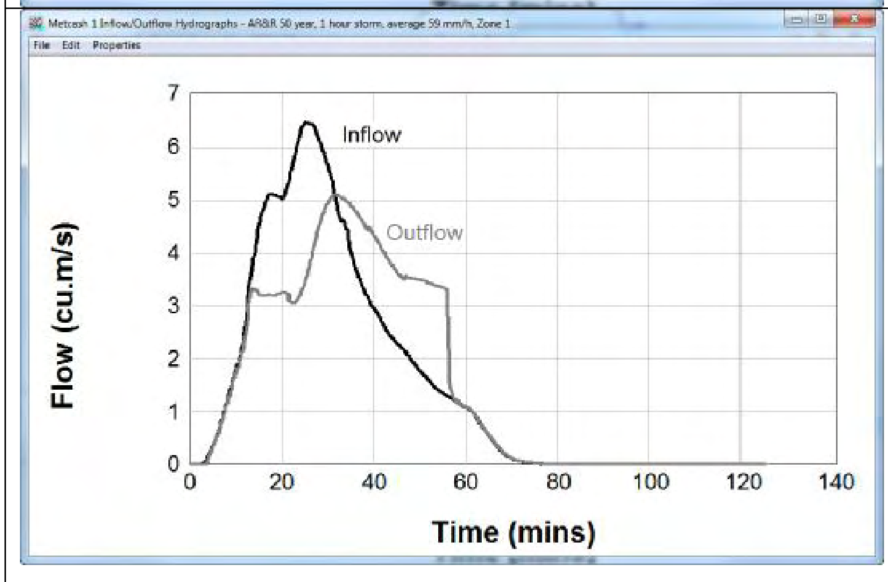

Metcash 1 Storage Volume - AR&R 5 year, 1 hour storm, average 38.9 mm/h, Zone 1
File Edit Properties
Volume (cu.m)
0 100 200 300 400 500 600 700
0 20 40 60 80 100 120 140
Time (mins)

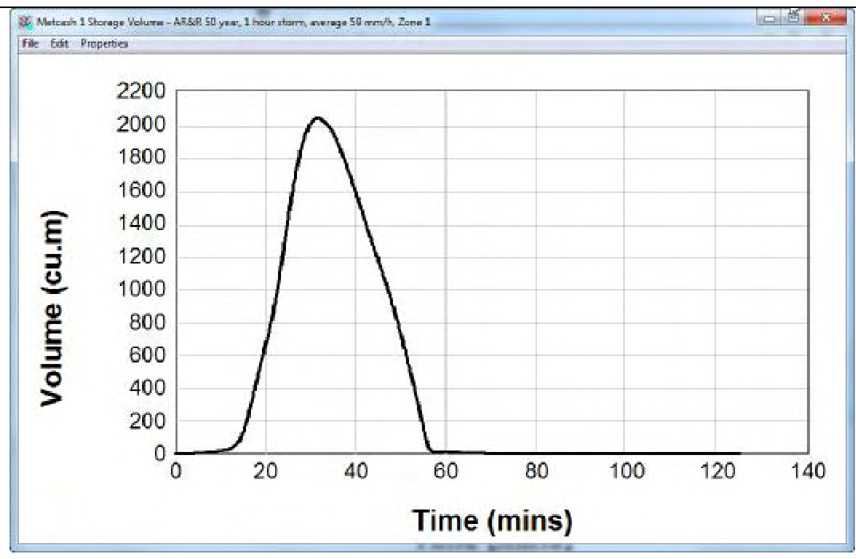

Metcash 1 Inflow/Outflow Hydrographs - AR&R 10 year, 1 hour storm, average 44 mm/h, Zone 1
File Edit Properties
Flow (cu.m/s)
0 1 2 3 4 5 6
Inflow
Outflow
0 20 40 60 80 100 120 140
Time (mins)


Metcash 1 Storage Volume - AR&R 10 year, 1 hour storm, average 44 mm/h, Zone 1
File Edit Properties
Volume (cu.m)
0 200 400 600 800 1000 1200
0 20 40 60 80 100 120 140
Time (mins)


Metcash 1 Inflow/Outflow Hydrographs - AR&R 20 year, 1 hour storm, average 51 mm/h, Zone 1
File Edit Properties
Flow (cu.m/s)
0 1 2 3 4 5 6 7
Inflow
Outflow
0 20 40 60 80 100 120 140
Time (mins)


Metcash 1 Storage Volume - AR&R 20 year, 1 hour storm, average 51 mm/h, Zone 1
File Edit Properties
Volume (cu.m)
0 200 400 600 800 1000 1200 1400 1600 1800
0 20 40 60 80 100 120 140
Time (mins)


Metcash 1 Inflow/Outflow Hydrographs - AR&R 50 year, 1 hour storm, average 59 mm/h, Zone 1
File Edit Properties
Flow (cu.m/s)
0 1 2 3 4 5 6 7
Inflow
Outflow
0 20 40 60 80 100 120 140
Time (mins)


Metcash 1 Storage Volume - AR&R 50 year, 1 hour storm, average 59 mm/h, Zone 1
File Edit Properties
Volume (cu.m)
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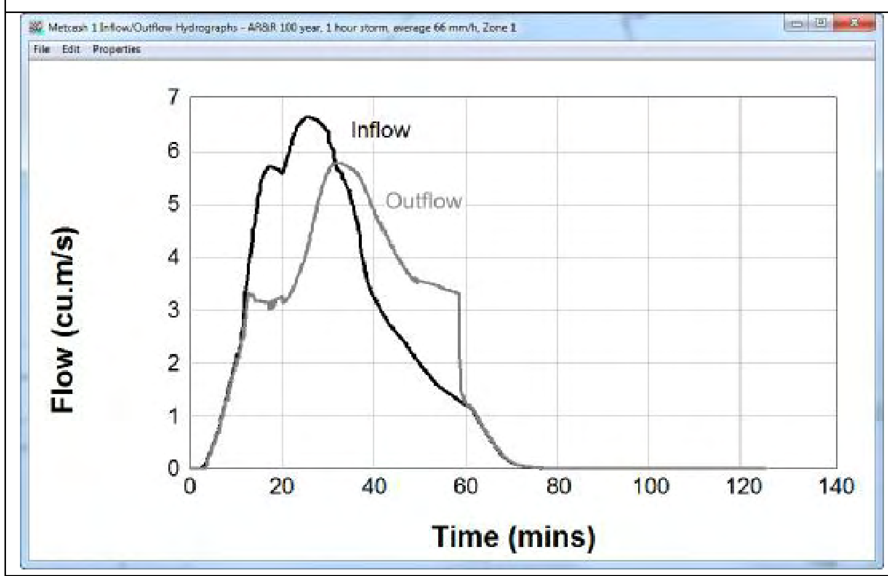
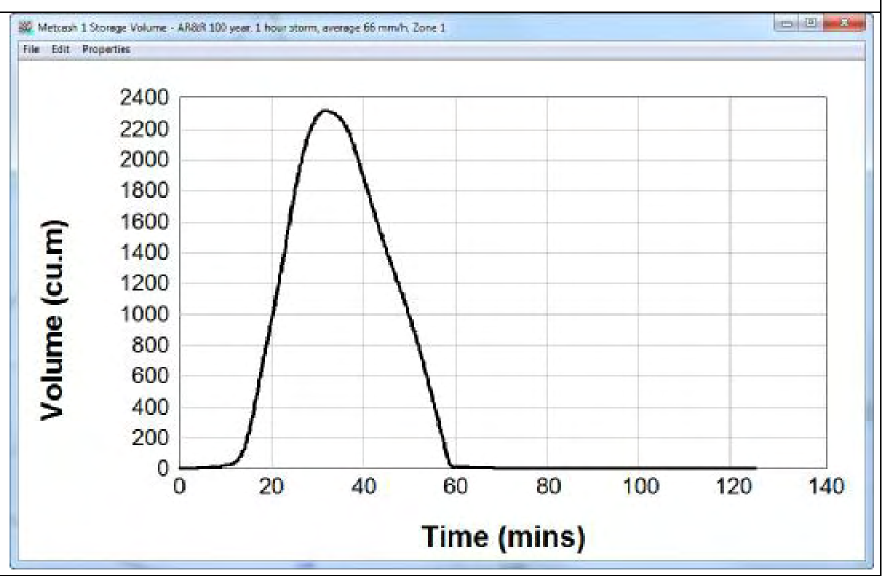
0 20 40 60 80 100 120 140
Time (mins)


Metcash 1 Inflow/Outflow Hydrographs - AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
File Edit Properties
Flow (cu.m/s)
0 1 2 3 4 5 6 7
Inflow
Outflow
0 20 40 60 80 100 120 140
Time (mins)


Metcash 1 Storage Volume - AR&R 100 year, 1 hour storm, average 66 mm/h, Zone 1
File Edit Properties
Volume (cu.m)
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400
0 20 40 60 80 100 120 140
Time (mins)

WESTBASIN PERFORMANCE RELATIVE TO STATE OF NATURE, FOR ALL STORMS –

Outflow Hydrographs | State of Nature Flows