NT

Consulting Engineers
ABN 73 102 631 186

PO Box 900
COOLALINGA
NT 0839

Email:ntce@westnet.com.au

Mob: 0427 411 633

12 June 2017

Our ref: MC: \Q010-SWMP:A3

Litchfield Council
P.O. Box 446
HUMPTY DOO
NT 0836

Your Ref. **()**

PROPOSED SHOP & WAREHOUSE

STORMWATER MANAGEMENT PLAN

Lot 30 (35) Henning Rd, Coolalinga

Prepared by:
Michael Cooper
B. Eng (Civil)

INDEX

Contents

ABSTRACT

A *Shop* and *Warehouse* is proposed for 35 Henning Rd., Coolalinga. *Litchfield Council* requires that the developer submit a Stormwater Management Plan*(SWMP)* for *major* & *minor* ARI storm events *(i.e.* Q_{5}, Q_{20} & Q_{100}*)*. The *SWMP* plan is not required to address *extreme* design events, which have a ARI of greater than 100 years. The proposed *SWMP* will incorporate a primary & secondary collection system. The *primary* system will collect the Q_{100} stormwater flow from the commercial component of the development in a detention basin. The *secondary* system will collect the Q_{5} stormwater flow from the remainder of the subject parcel in an in-ground storage tank. The detained stormwater will subsequently be pumped into the Wells Creek Rd open drain in a retarded mode so as to not impact peak flow rates.

Note:

It should be noted that the redirected stormwater will flow down the Wells Creek Rd drain for circa 150m, where it finishes, and the stormwater is redirected back into Wells Creek.

±

(i) INTRODUCTION

This report has been produced in order to identify and address issues affecting the stormwater discharge relating to the proposed Shop & Warehouse development at Lot 30 Henning Rd., Coolalinga. This report details specific requirements and recommendations with regard to stormwater runoff and stormwater quality management. The proposed SWMP will fully control minor and major flooding, improve water quality and significantly reduce site stormwater outflows. All of the Q_{100} stormwater runoff on the subject site from the commercial component of the proposed development will be collected and filtered by the primary *Stormwater Management System* and pumped into the *Wells Creek Rd* roadside drain. The Q_5 stormwater flow from the remainder of the subject parcel will be channeled to an in-ground collection tank and subsequently pumped into the Wells Creek roadside drain. A five-hour time delay switch will be fitted to the pumps ensure there is no contribution to peak flows.

An *Open Detention Basin* in conjunction with active and passive stormwater treatment systems has been identified as the most suitable mechanisms to mitigate peak flows from the proposed development and improve water quality. A detention basin may be defined as a mechanism for the storage of stormwater runoff for short time periods to reduce peak flow rates before being released into the stormwater drainage system in a retarded mode. The volume of stormwater surface runoff involved is relatively unchanged in this process. However, reducing flowrates has the added benefits of minimising downstream channel erosion and also mitigating downstream drainage capacity problems which is an issue for the Wells Creek drainage system.

The proposed detention basin has been designed to have a retardation capacity slightly in excess of a Q_{100} ARI design storm event and will also assist in mitigating *extreme* storm events. A passive bio-filtration area and gross pollutant trap have also been included in the design which will filter contaminants and pollutants in a *1st flush* mode for minor storm flows. (i.e. $<Q_1$) The detention basin will be pumped, in a retarded mode, into the roadside drain which runs parallel to Wells Creek road via an active Hydrocarbon filter. A five-hour time delay switch will ensure that there is no contribution to peak flows from the proposed detention basin. The proposed detention basin will be an earthen bund dam, completely grassed, circa 900mm in height, with a gentle slope so it blends into the existing landscape and does not unduly detract from the visual amenity of the area. The mild slope of the bund will also facilitate mowing and maintenance of the proposed detention basin. The bund dam will be designed in accordance with *AS3798* and will also function as an emergency spillway to allow for *extreme* ARI storm events which exceed the Q_{100} design event.

(ii) SITE CHARACTERISTICS

The subject site is almost completely grassed with a remnant stand of woodland in the south-eastern corner of the parcel. There is an elevated housing commission type house on the site and two small sheds, which equate to circa 1% impervious roof area. These structures will be removed for the proposed development and it is assumed that 35% of the north-eastern portion of the allotment will be sealed pavement/hardstand or roof areas: The proposed development site has a gross area of 23,045m^2 with natural ground levels ranging from 42.2m AHD on the Henning Rd*(northern)* boundary to 37.4m AHD on the southern boundary with Lot 21 where the existing site sheetflow discharges into the headwaters of Wells Creek.

The Geological Map Series of Darwin *(N.T. Geological Survey)* indicates the subject site's surface geology as 5ais located predominantly C_{zl} and C_{zs} over the Bathurst Island formation (K_{id}).

A brief description of the geological formations is as follows;

- **Czl** : nodular, concretionary, piloslitic and vermicular mottled laterite: ferricrete in situ reworked remnants of standard laterite profiles.
- **Czs** : unconsolidated sand, ferruginous and clayey, sandy and gravelly soils; commonly containing limonite, pisolites.
- **Kld** : Bathurst Island formation, radiolarian claystone, sandy claystone, clayey sandstone, quartz sandstone, ferruginous sandstone, glauconitic sandstone, basal conglomerate.

Generally speaking, this translates to a nominal topsoil layer with underlying laterites and a silty, clayey substratum over sandstone. Surface and top layer infiltration rates are assumed to be circa 30mm /hr. A test pit was dug in March 2015 on the subject site adjacent to the boundary with Lot 31 and no ground water was encountered to a depth of 2m. There is no evidence of surface springs or ground water percolation on the subject site.

The management of soil is an important consideration and sedimentation and erosion caused by stormwater runoff is an important factor for the aquatic health of Darwin Harbour. Land Unit Mapping indicates that the subject property is classified 5a. These landforms typically occur on sloping creek margins with sandy loam to sandy clay loam soil types, which generally have uniform coarse sands and are moderately to well drained. The subject site was mostly cleared some time ago and the in-situ soils are compacted and completely grassed. It is not anticipated that there will be any issues with sedimentation or erosion caused by stormwater runoff.

The geological and hydrological aspects of the site indicate that there are no impediments to the proposed use and development of the property.

(iii) STORMWATER RUNOFF

The proposed development site is situated at the headwaters of the *Wells Creek* catchment which forms part of the larger *Elizabeth River* catchment area which in turn is situated within the overall Darwin harbour catchment. Site flows traverse along intermittent streamlines *(Wells Creek)* to the Elizabeth River tidal system circa six kilometers downstream and then eventually discharge into East Arm *(Darwin Harbour)*

The subject site is an independent catchment and there are no defined gully lines on the property with storm water runoff being conveyed predominantly as sheetflow to the boundary of Lot 31 where Wells Creek effectively begins. The proposed *SWMP* will direct stormwater runoff from the hardstand areas into a detention basin and the remainder of the flow from the grassed areas will be directed into an in ground storage tank where it will be pumped, in a retarded mode into the Wells Creek Rd drain. A five-hour time delay will ensure that there is no contribution to peak flows from the proposed detention basin or in ground storage tank

Currently the storm water discharge from the Woolworths Shopping centre site is directed to a culvert under Henning Rd and then into an open concrete lined drain that runs down the western side of Wells Creek Rd before it is redirected into Wells Creek approximately 150_{m} further downstream. The open stormwater drain has a capacity of circa 2,600 $_{l/s}$ and the additional flow from the detention basin and in ground storage tank will not occur during peak stormwater flows. The hydrocarbon filter will incorporate a five-hour time delay before it begins pumping into the open stormwater drain and will not have any significant impact on peak flow rates.

Management of the stormwater discharge on the subject site is mandated by the requirements of *Specific Use Zone Litchfield No. 7 (SL7)* which state;

> *"Drainage works, including pollutant traps, grassed swales, detention basin and a biofiltration area are to be in accordance with a Stormwater Management Plan to mitigate peak discharge and any potential impacts on water quality."*

Schedule 2 of the *Building Regulations* specifies that;

> *". . . any building that will effect a discharge of stormwater on to a road, public place or adjoining property requires consent for the discharge from the local government authority . . .* "

Litchfield Council requires that the developer submit a Stormwater Management Plan *(SWMP)* for approval including detention basin capacity for Q_{5}, Q_{20} & Q_{100} ARI storm events. This report tabulates the pre-development and post development flows which have been calculated from total catchment contributions and are listed in Appendix D (Table 1) & Appendix E (Table 2) respectively. Site discharge calculations were also undertaken in respect to total catchment contributions. Based on the subject site runoff from the commercial component of the development a Q_{100} storm event equates to circa 747_{m}^{3} of required detention capacity *(mitigation)* The proposed *detention basin* has a capacity of circa 950_{m}^{3} which exceeds design requirements for a Q_{100} ARI storm event and will also serve to mitigate *extreme* storm events. The remainder of the SW runoff from the parcel will be collected by an in ground storage tank.

- **OPEN DETENTION BASIN**

Given that adequate area is available, an *Open Detention Basin* is the most efficient and cost effective strategy to manage and mitigate stormwater flows. Design calculations included in this report demonstrate that the proposed *detention basin* is adequate to retain the post-development design flows for a ARI Q_{100} design storm event.

The driveways and roof/hardstand areas of the commercial component of the proposed development will be contoured to direct stormwater to a *'trash rack'* at the south eastern corner of the carpark which will remove gross pollutants and other litter prior to the stormwater entering the detention basin. The remainder the detention basin catchment area are grassed or landscaped areas, which have a gentle slope and these areas will serve to remove sediments and other suspended solids. A *biofiltration* area has been included at the base of the detention basin which will filter contaminants and pollutants in a *1st flush* mode for minor storm flows. (i.e. $<Q_1$) The Q_1 storm event has been adopted as an acceptable design inflow regime, as most contaminants on the site will be conveyed to the *gross pollutant trap* and *biofiltration* area during this event.

In addition, an active *hydrocarbon filter* will further improve stormwater quality before discharging into the Wells Creek stormwater drain at a flow rate of not less than 1.67 $_{l/s}$ which will ensure the basin is emptied of a Q_{100} inflow within five days. To avoid mosquito breeding, and associated issues, the *N.T. Dept. of Health, Entomology,* will not accept detention basins having standing bodies of water for longer than 5 days after a major storm event. The flow capacity of the existing open concrete drain is circa $2.66_{m}{}^{3}{}_{/s}$ and the additional flow from the *detention basin* and *in-ground storage tank* will have no impact on the peak stormwater flow in the Wells Creek road stormwater drain. A five-hour time delay switch will be fitted to the pump ensure there is no contribution to peak flows.

- **IN GROUND STORAGE TANK**

The portion of the SWD that is not collected by the *detention basin* will be collected by an in ground concrete storage tank on the downstream side of the *detention basin*. The in ground storage tank will retain the post-development design flows for a Q_5 ARI design storm event. A concrete invert drain, with a kerb, on the boundary of Lot 31 will direct stormwater flow to the *in-ground storage tank*. Design calculations indicate that the required storage capacity for a Q_5 flow is circa 96,000 litres. It is proposed a 5_m wide x 5_m long x 2_m deep concrete *in-ground storage tank* will be provided to collect this flow. The retained stormwater will be pumped into the Wells Creek Rd stormwater drain at a flow rate of 0.25 $_{l/s}$ which will ensure the basin is emptied of a Q_5 inflow within five days. A five-hour time delay switch will be fitted to the pump to ensure there is no contribution to peak flows.

(iv) STORMWATER QUALITY MANAGEMENT

The stormwater collected on the subject site is ultimately discharged into Darwin harbor via intermittent creeks and gully's circa 6_{km} downstream. The *Darwin Harbour Water Quality Protection Plan (WQPP)* aims to protect Darwin Harbour waterways from excessive land based pollution inputs, particularly nitrogen, phosphorus and suspended sediments. The *WQPP* is supported by the *Water Act* and under *Section 16* it is an offence to cause directly, or indirectly, water to be polluted. Under the *N.T. Waste Management & Pollution Control Act* a person or company must not;

a) Pollute the environment.
b) Cause an environmental nuisance; including unsightly or offensive conditions caused by contaminants or waste.
c) Cause or permit a contaminant or waste to be stored in a manner in which it is likely to leak, spill or escape and cause environmental harm.

The *N.T. Environmental Protection Authority* has the statutory authority under the, *N.T. Waste Management & Pollution Control Act,* to issue remedial directions where contamination or pollution of the environment has occurred. Under section 73 of the *Water Act*, *Beneficial* uses are declared for *Darwin Harbour* and the *Elizabeth River* catchment and may be used as a guide to establish suitable water *Quality Objectives* for the proposed development.

As with any development the containment and treatment of potential pollutants is paramount to attaining and sustaining acceptable water quality parameters whilst protecting environmental values. The implementation of the SWMP will ensure that there is no impact on the subject, or adjoining land and will also ensure that the quality of the storm water discharge does not represent a pollution hazard and is in accordance with the criteria set out in Section 3.4.1 of the *Australian & New Zealand Guidelines for Fresh & Marine Water Quality (ANZECC 2000)* for 95% species protection. Stormwater quality assessment was also undertaken in accordance with the *National Water Quality Management System, Australian Guidelines for Urban Stormwater Management.* In line with national guidelines, the following water quality objectives were adopted as meeting acceptable outcomes:

Parameter	Water Quality Objective
pH	6.0 – 7.5
Dissolved Oxygen	50% - 100% saturation
Total Phosphorus	$<10_u gL^{-1}$
Total Nitrogen	$650_u gL^{-1}$
Chlorophyll-a Chia	$<2_u gL^{-1}$
Turbidity	20 NTU
Suspended solids	50mgL-1 for combined wet & dry periods. 90% ie, 100mgL-1 for wet
Total Aluminum	season
Total Iron	$5_u gL^{-1\ if}$ pH < 6.5 **or** $100_u gL^{-1}$ if pH > $6.55_u gL^{-1}$
Total Arsenic	$300_u gL^{-1}$ to $1000_u gL^{-1}$ (depending on $F_{e\ (II)}$ concentration)
Total Cadmium	$0.7_u gL^{-1}$ i
Total Chromium	$0.2_u gL^{-1}$ to $2_u gL^{-1}$ (depending on hardness)
Total Copper	$1.3_u gL^{-1}$
Total Nickel	$2_u gL^{-1}$ to $5_u gL^{-1}$ (depending on hardness)
Total Lead	$15_u gL^{-1}$ to $150_u gL^{-1}$ (depending on hardness)
Total Zinc	$15_u gL^{-1}$ (depending on hardness)
Total Chlorine	$5_u gL^{-1}$ to $50_u gL^{-1}$ (if iron is not present as $F_{e(II)}$)
Oils * Grease	$0.03_u gL^{-1}$
PAH	no visible films or odour
Litter/Gross pollutants	$< 3_u gL^{-1}$
Faecal coliforms	No anthropogenic *(man made)* material > 5mm in any dimension
	1000 organisms/100_{mL} *(min. 5 samples)* taken at regular intervals
	not exceeding one month with 4 of 5 samples < 4000 organisms/100_{mL}

The proposed development site has a special use zoning*(SL7)* which allows for the development of the subject allotment,

". . . for commercial purposes with a predetermined limit on the size & scale of development . . ."

The intended land use indicates that pollutants will include hydrocarbons from car parking areas, suspended solids, litter, pathogens and the potential release of nutrients. To mitigate these potential pollutants a *gross pollutant trap* and *biofiltration area* have been included in the SWMP. The Q_1 storm event has been adopted as an acceptable design inflow regime, as most contaminants on the site will be conveyed to the *gross pollutant trap* and *biofiltration area* during this event. The *biofiltration area* will be located at the base of the *detention basin* and the nominal specification would be as follows and as shown in Appendix J.

Biofiltration Specification	
Surface & Filter area	150_{m}^{2}
Extended Detention depth	300_{mm}
Transition layer	
Filter material	sandy loam
Filter depth	150_{mm}
D_{50}	0.45_{mm}
K_{sat}	$180_{mm/hr}$
Drainage layer	
Filter material	coarse sand
Filter depth	150_{mm}
D_{50}	0.1_{mm}
K_{sat}	$3{,}600_{mm/hr}$

A hydrocarbon/water separator will pump the retained stormwater runoff from the *detention basin* into the Wells Creek Rd. stormwater drain. Hydrocarbon separators are designed to remove oils, grease & other hydrocarbons from stormwater runoff. They operate on the principle where wastewater enters a cyclone chamber and is spun under extreme centrifugal force, up to 1000 times the force of gravity. The heavier water phase is forced outward and the lighter oil phase migrates toward the center of the core. The hydrocarbons are decanted into a storage container for subsequent collection and the treated water is discharged to the stormwater drain.

Settling or sedimentation is limited to particulate pollutants that drop out of the water column by means of gravitational settling. Pollutants generally attach themselves to heavier sediment particles or suspended solids and settle out of the water. The quality of the stormwater runoff can be estimated using *'MUSIC'*…*"Model for Urban Stormwater Improvement Conceptualisation"* and based on the stated treatment train and Coolalinga 17_{min} IFD rainfall data it is estimated that the following pollutant reductions can be achieved;

Parameter	**Water Quality Objective**	**Modeled Results**
Total suspended solids load	**>** 80% reduction	**>** 94% reduction
Total nitrogen load	**>** 45% reduction	**>** 55% reduction
Total phosphorus load	**>** 60% reduction	**>** 72% reduction
Total gross pollutant load	**>** 90% reduction	**>** 98% reduction

The above parameters are based on the operational stage of the proposed development, during construction an appropriate *Erosion & Sediment Control Plan* must be approved and adhered to.

To maintain the ongoing viability of the stormwater treatment train the following maintenance procedures will be followed;

- Grassed Areas[1]: Mow & weed as required, maintain clear waterway flow area.
- Gross Pollutant Trap: inspect at the beginning of the wet season & weekly intervals thereafter. Clean out as required.
- Biofiltration Area: Weed as required, inspect at 12 monthly intervals before each wet season. Replace biofiltration filter material after 5 years or when contamination becomes apparent.
- Hydrocarbon Filter: Maintain/inspect as per manufacturers operations & maintenance enter into supply contract with oil recycler licensed with the EPA to empty reservoir at monthly intervals or as required.

Note:

1. Maintenance & mowing of grassed areas is a requirement of the *Dept. of Entomology* to reduce mosquito breeding areas.

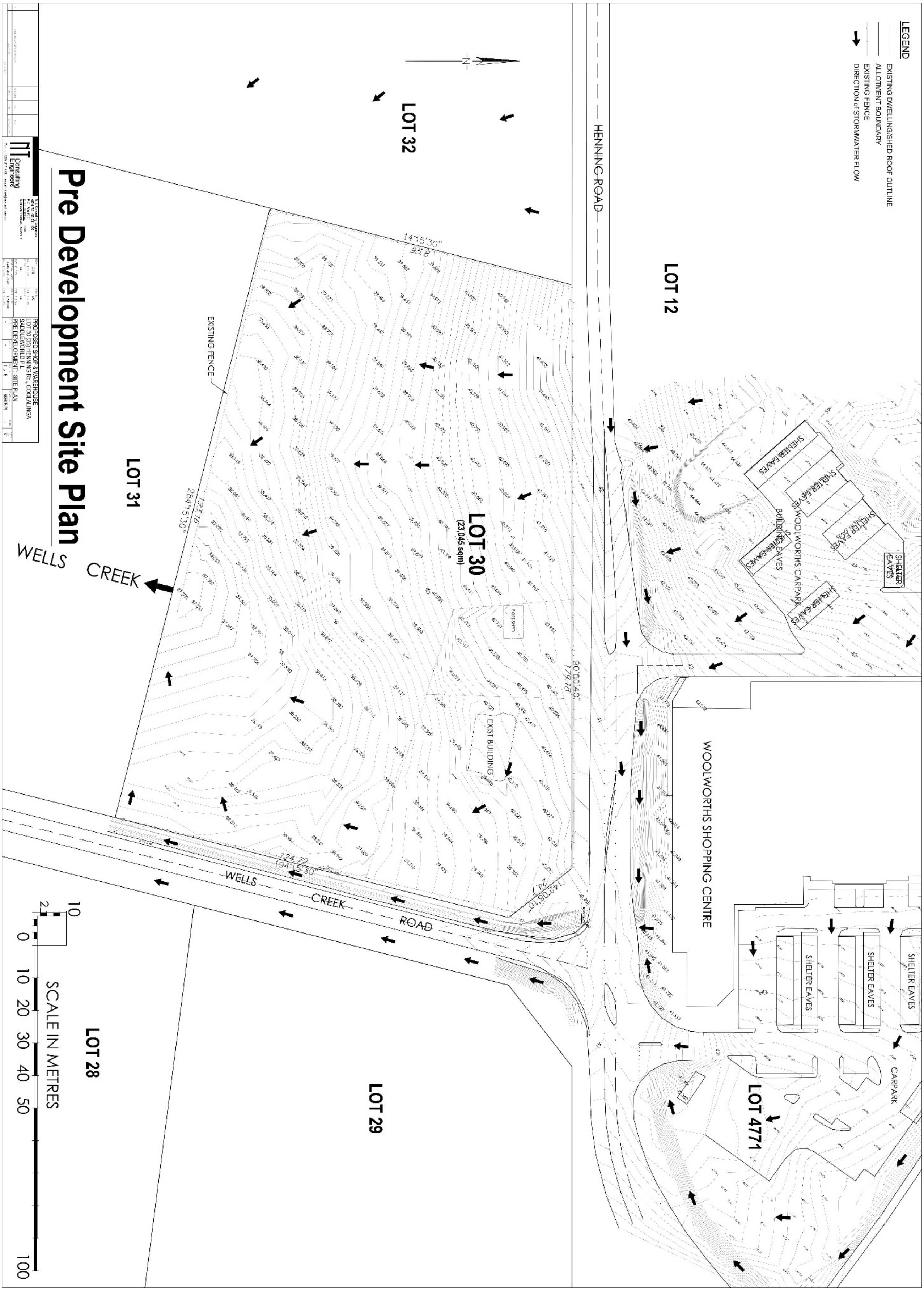
(vi) CONCLUSION

The proposed *Stormwater Management Plan* will mitigate and retard peak stormwater flows in excess of the required design Q_{100} storm event. The proposed stormwater treatment train indicates that the *Storm Water Management Plan* is a viable strategy that can attain acceptable stormwater polishing and site discharge water quality outcomes. This will be beneficial for the Wells Creek drainage system as the reduced flowrate will mitigate downstream erosion and flooding. The subject sites topography, geomorphology and hydrology are suitable for the proposed regime to address stormwater mitigation/retardation and stormwater quality management.

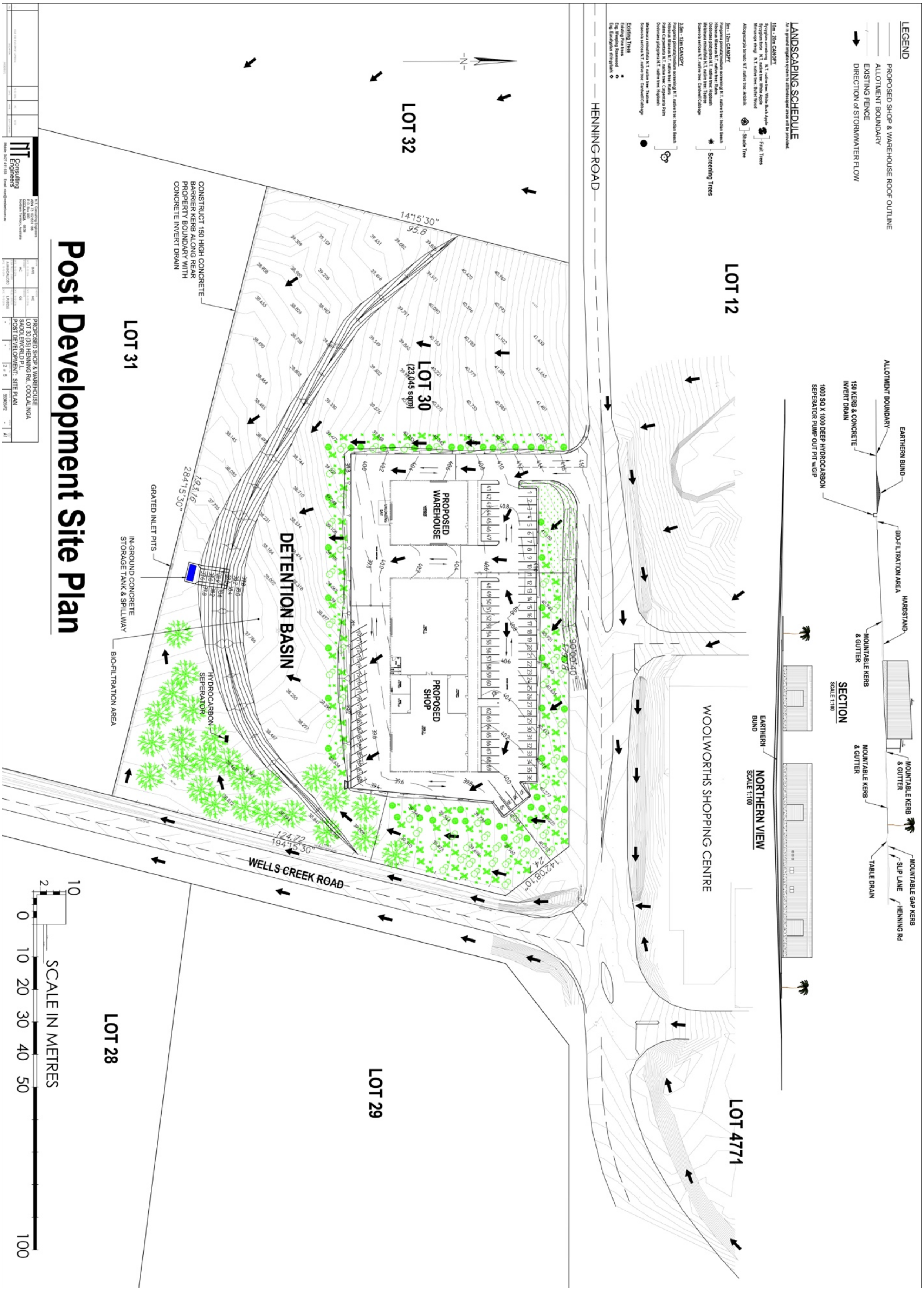
References:

Australian Rainfall & Runoff (Vol's I & II)
Storm Design in Small Urban Catchments: Australian Road Research
Northern Territory Planning Scheme
Northern Territory Building Regulations
Northern Territory Water Act
Darwin Harbour Water Quality Management Plan
Australian & New Zealand Guidelines for Fresh & Marine Water Quality (ANZECC 2000)
National Water Quality Management Strategy, Australian Guidelines for Urban Stormwater Management
Hydraulics of Precast Concrete Conduits: Concrete Pipe Association of Australasia
Iowa Stormwater Management Manual: Detention Basin Outlet Structures
Bureau of Meteorology: Hydro meteorological Advisory Service
Litchfield Council – General Planning Requirements: STORMWATER DRAINAGE
Territory Parks & Wildlife Commission: Land Conservation Unit – Land Units of Howard Springs/Humpty Doo

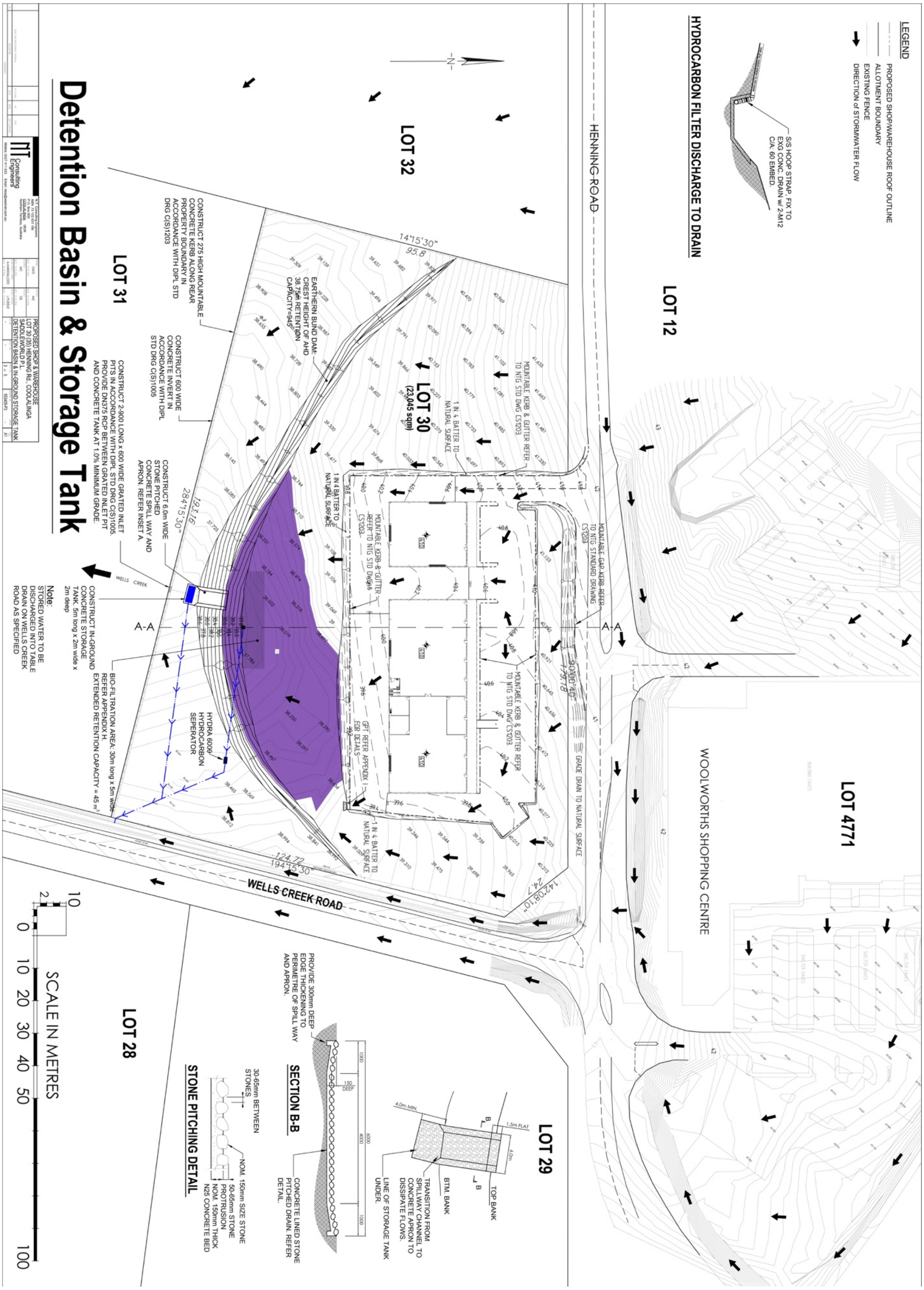
APPENDIX A: Pre Development Site Plan



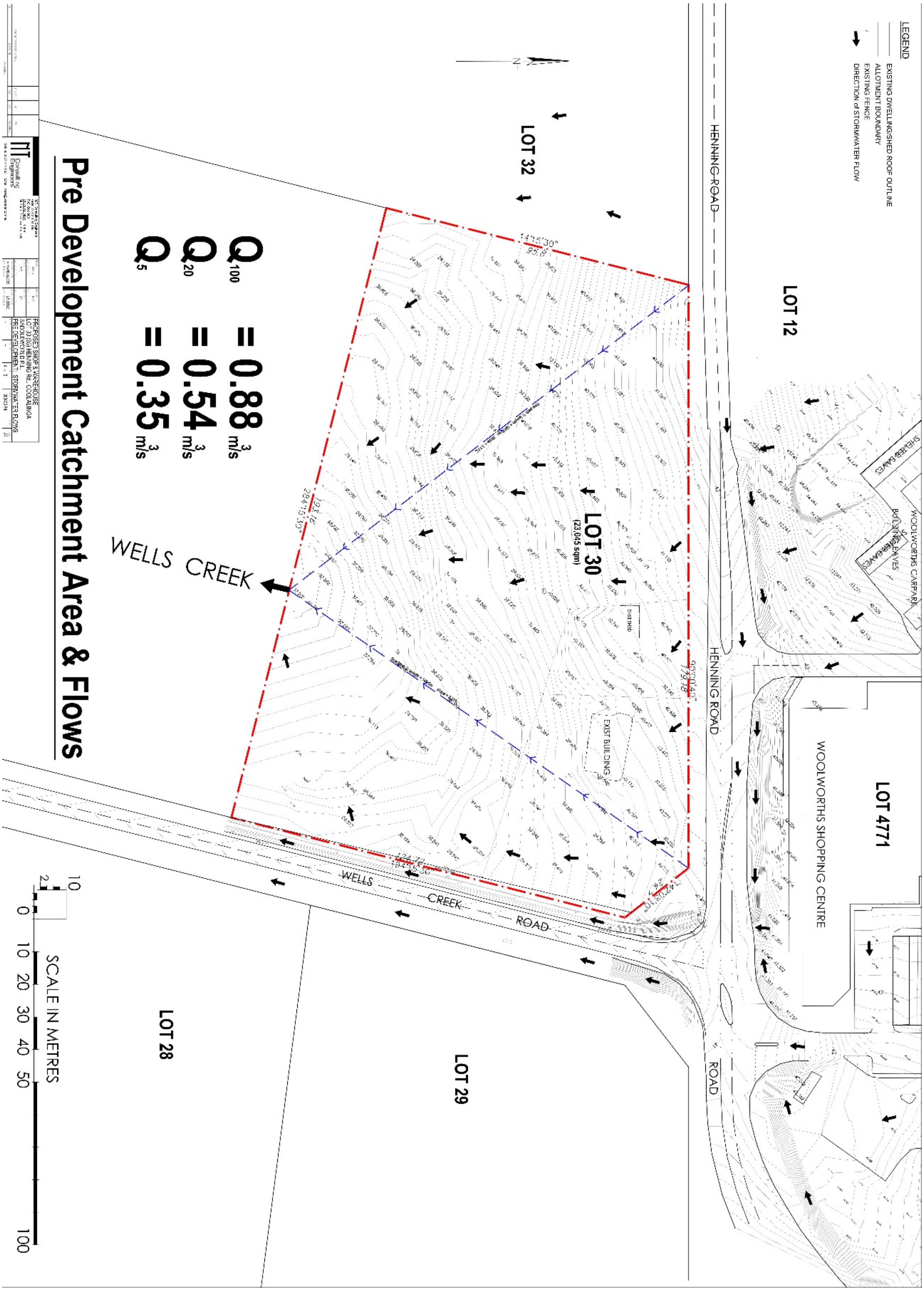
APPENDIX B: <u>Post Development</u> Site Plan



APPENDIX C: Detention Basin Layout



APPENDIX D: Pre Development Site Stormwater Flows



APPENDIX D: Pre-Development: Site Stormwater Flows

- **OVERLAND SURFACE SHEETFLOWS**

Time of Concentration

Friend's equation: $t_c = (107.n.L^{0.333}) / S^{0.2}$

Hortons n factor	**Concrete**	**Bare ground**	**Low grass**	**High grass**	**Vegetated**
	0.013	0.027	0.035	0.050	0.060

Flow Path 1: $t_c = 13.7_{mins}$

n Horton's roughness coefficient **0.030**
L Overland sheetflow path length **154.3m**
S Slope of surface **3.11%**

-

Flow Path 2: $t_c = 17_{mins}$

n Horton's roughness coefficient **0.035**
L Overland sheetflow path length **149.5m**
S Slope of surface **2.27%**

-

Adopt Time of concentration **t_c = 17 mins**

- Overland Surface Sheetflow calculations **(0.1 % IMPERVIOUS)**

Rational Method

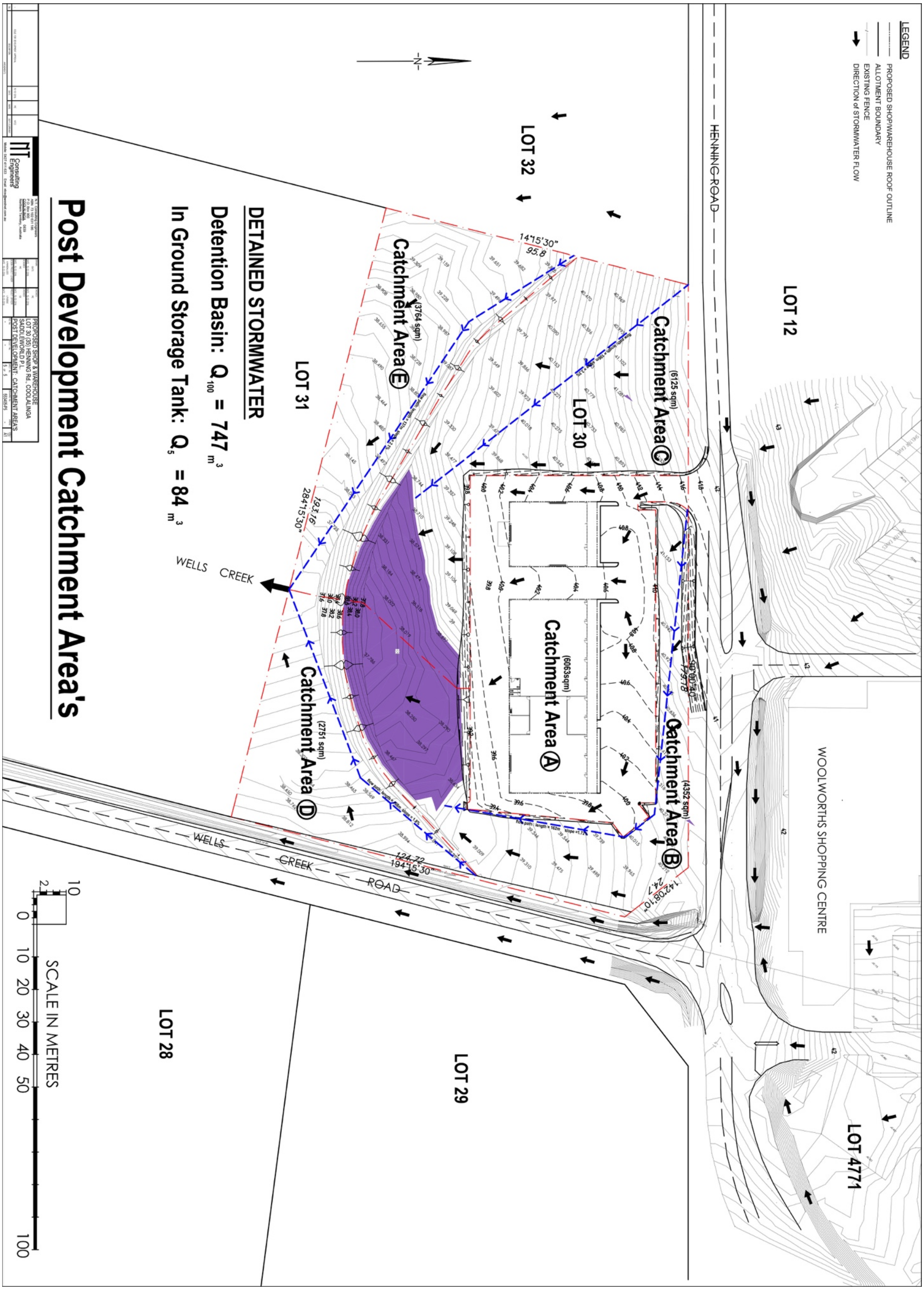
Rational Formula: **Q = 0.00278 x C.I.A**

C **Rational Method Runoff Coefficient** (LITCHFIELD COUNCIL-PLANNING: STORMWATER DRAINAGE)
F_y **Frequency Factor (**ARR Book VIII: Table 1.6 **)**
I **Rainfall Intensity** *(mm/hr)* AND **t_c = 17.0 mins**
A **2.3045ha**

Table 1.0 Pre-Development Overland Surface Sheetflows

			Q_5				Q_{20}				Q_{100}
I_{17} (mm/h)	F_y	C	Q_5 (m^3/s)	I_{17} (mm/h)	F_y	C	Q_{20} (m^3/s)	I_{17} (mm/h)	F_y	C	Q_{100} (m^3/s)
139	0.95	0.41	**0.35**	173	1.05	0.46	**0.54**	222	1.20	0.52	**0.88**

APPENDIX E: Post-Development: Site Stormwater Flows



APPENDIX E: Post Development: Site Stormwater Flows

- **OVERLAND SURFACE SHEETFLOWS**

Time of Concentration

Friend's equation: $t_c = (107.n.L^{0.333}) / S^{0.2}$

Hortons n factor	Concrete	Bare ground	Low grass	High grass	Vegetated
	0.013	0.027	0.035	0.050	0.060

Rational Method

Rational Formula: **Q = 0.00278 x C.I.A**

C Rational Method Runoff Coefficient (LITCHFIELD COUNCIL-PLANNING: STORMWATER DRAINAGE)

F_y **Frequency Factor (**ARR Book VIII: Table 1.6 **)**

Catchment A: - Hydrograph Routing method

Adopt Time of concentration t_c **= 5 mins**

Catchment B: - Rational method

Flow Path

n Horton's roughness coefficient 0.027
L Overland sheetflow path length 162m
S Slope of surface 1.72%

$t_{c(i)} = 15$ mins

Time of concentration t_c **= 15 mins**

Catchment C: - Rational method

n Horton's roughness coefficient 0.030
L Overland sheetflow path length 106m
S Slope of surface 3.3%

Time of concentration t_c **= 12 mins**

Catchment D: - Rational method

n Horton's roughness coefficient 0.035
L Overland sheetflow path length 108m
S Slope of surface 1.8%

Time of concentration t_c **= 13.6 mins**

Catchment E: - Rational method

n Horton's roughness coefficient 0.030
L Overland sheetflow path length 137m
S Slope of surface 2.1%

Time of concentration t_c **= 14 mins**

- **OVERLAND SURFACE SHEETFLOWS**

Table 2.0 Post-Development Overland Surface Sheetflows

			Q_5				Q_{20}				Q_{100}
(1.0 % IMPERVIOUS) **Catchment A:** adopt t_c = 5$_{mins}$ A=0.6063$_{ha}$											
I_5 (mm/h)	F_y	C	Q_5 (m^3/s)	I_5 (mm/h)	F_y	C	Q_{20} (m^3/s)	I_5 (mm/h)	F_y	C	Q_{100} (m^3/s)
187	0.95	0.86	**0.26**	229	1.05	0.95	**0.39**	268	1.20	1	**0.54**
(0.1 % IMPERVIOUS) **Catchment B:** t_c = 15$_{mins}$ A=0.4352$_{ha}$											
I_{15} (mm/h)	F_y	C	Q_5 (m^3/s)	I_{15} (mm/h)	F_y	C	Q_{20} (m^3/s)	I_{15} (mm/h)	F_y	C	Q_{100} (m^3/s)
136	0.95	0.41	**0.06**	167	1.05	0.46	**0.10**	200	1.20	0.52	**0.15**
(0.1 % IMPERVIOUS) **Catchment C:** t_c = 12$_{mins}$ A=0.6125$_{ha}$											
I_{12} (mm/h)	***F_y***	***C***	Q_5 (m^3/s)	I_{12} (mm/h)	F_y	C	Q_{20} (m^3/s)	I_{12} (mm/h)	F_y	C	Q_{100} (m^3/s)
149	0.95	0.41	**0.10**	182	1.05	0.46	**0.15**	217	1.20	0.52	**0.23**
(0.1 % IMPERVIOUS) **Catchment D:** t_c = 13.6$_{mins}$ A=0.2751$_{ha}$											
I_{14} (mm/h)	F_y	C	Q_5 (m^3/s)	I_{14} (mm/h)	F_y	C	Q_{20} (m^3/s)	I_{14} (mm/h)	F_y	C	Q_{100} (m^3/s)
141	0.95	0.41	**0.04**	174	1.05	0.46	**0.064**	206	1.20	0.52	**0.098**
(0.1 % IMPERVIOUS) **Catchment E:** t_c = 14$_{mins}$ A=0.3764$_{ha}$											
I_{14} (mm/h)	F_y	C	Q_5 (m^3/s)	I_{14} (mm/h)	F_y	C	Q_{20} (m^3/s)	I_{14} (mm/h)	F_y	C	Q_{100} (m^3/s)
140	0.95	0.41	**0.06**	172	1.05	0.46	**0.087**	205	1.20	0.52	**0.134**

DETAINED VOLUME: DETENTION BASIN: Q_{100}

Combined Catchment A, B & C (IFD_{12mins} = 217 mm/hr)						
Q100	T_c (mins)	Area (ha)	F	C	IFD (mm/h)	Q(m3/s)
Catchment A	5	0.6063	1.2	1	217	0.44
Catchment B	15	0.4352	1.2	0.52	217	0.16
Catchment C	12	0.6125	1.2	0.52	217	0.23

Total: 747m^3

DETAINED VOLUME: DETENTION BASIN: Q_{100}

Combined Catchment A, B & C (IFD_{15mins} = 200 mm/hr)						
Q100	T_c (mins)	Area (ha)	F	C	IFD (mm/hr)	Q(m^3/s)
Catchment A	5	0.6063	1.2	1	200	0.40
Catchment B	15	0.4352	1.2	0.52	200	0.15
Catchment C	12	0.6125	1.2	0.52	200	0.21

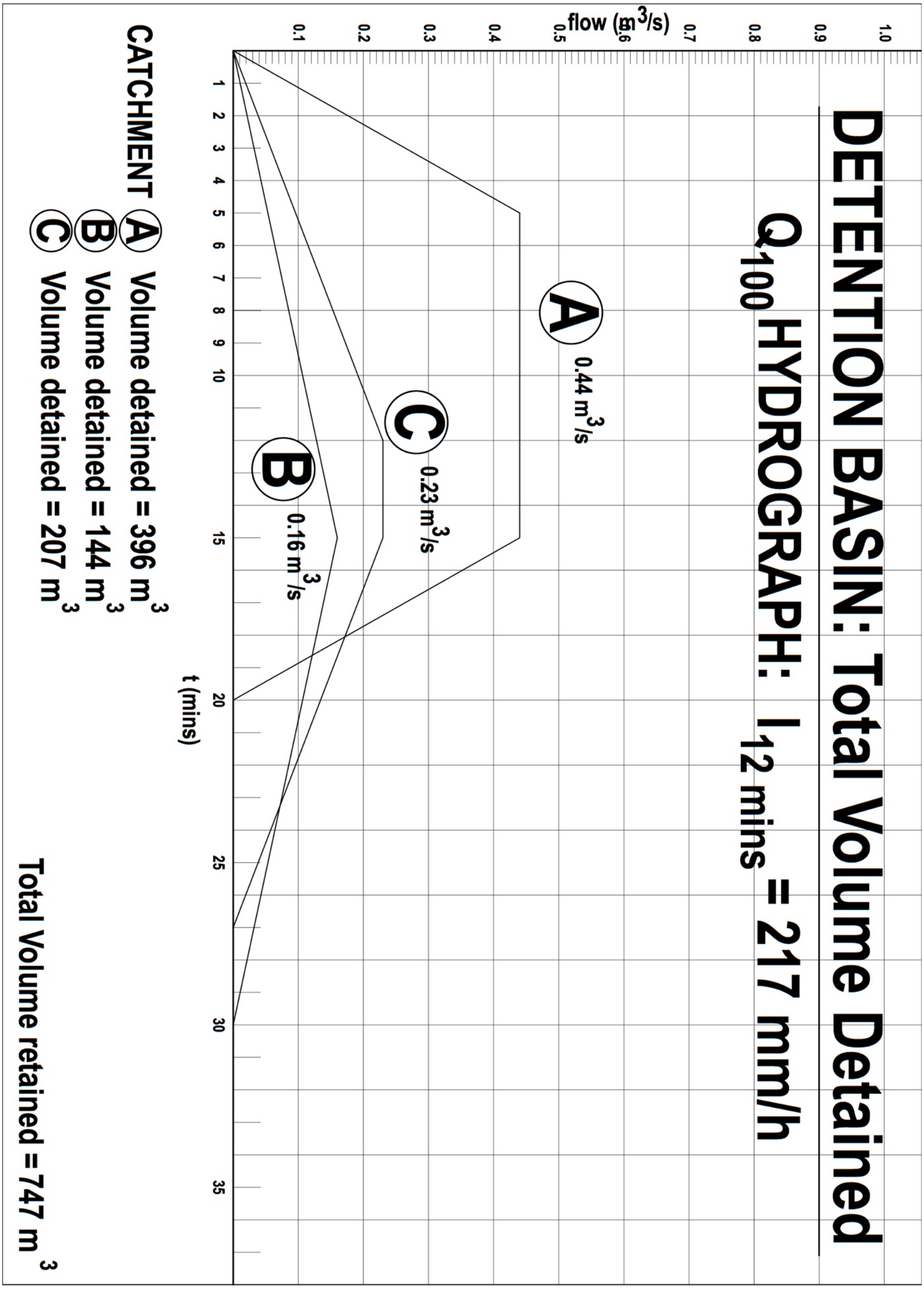
Total: 684m^3

DETAINED VOLUME: STORAGE TANK: Q_5

Combined Catchment D & E (IFD_{14mins} = 140 mm/hr)						
Q5	T_c (min)s	Area (ha)	F	C	IFD (mm/hr)	Q(m^3/s)
Catchment D	14	0.2751	0.95	0.41	140	0.04
Catchment E	14	0.3764	0.95	0.41	140	0.06

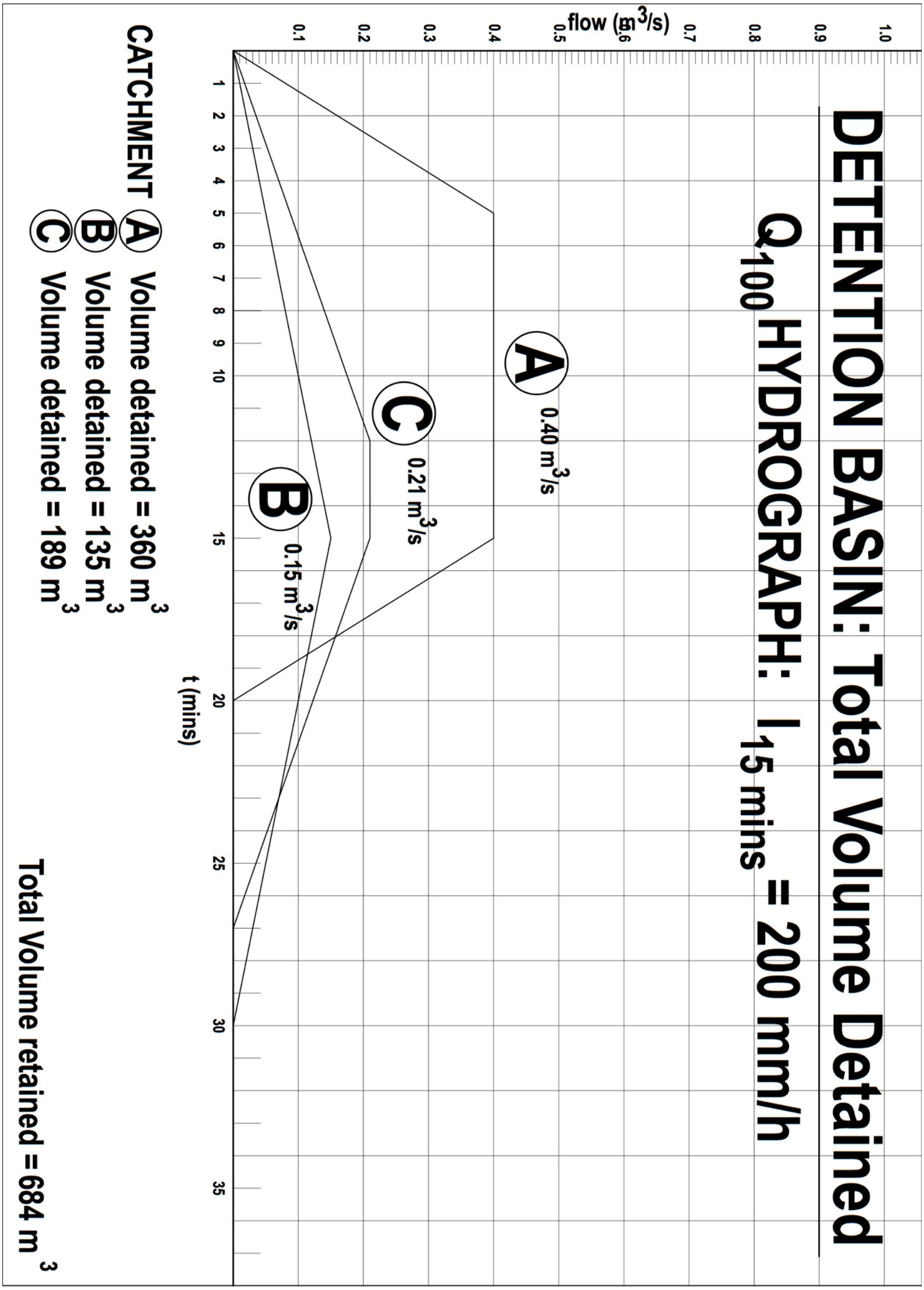
APPENDIX F . . . . DETENTION BASIN INFLOWS

(Q_{100} I_{12} = 217 mm/hr)

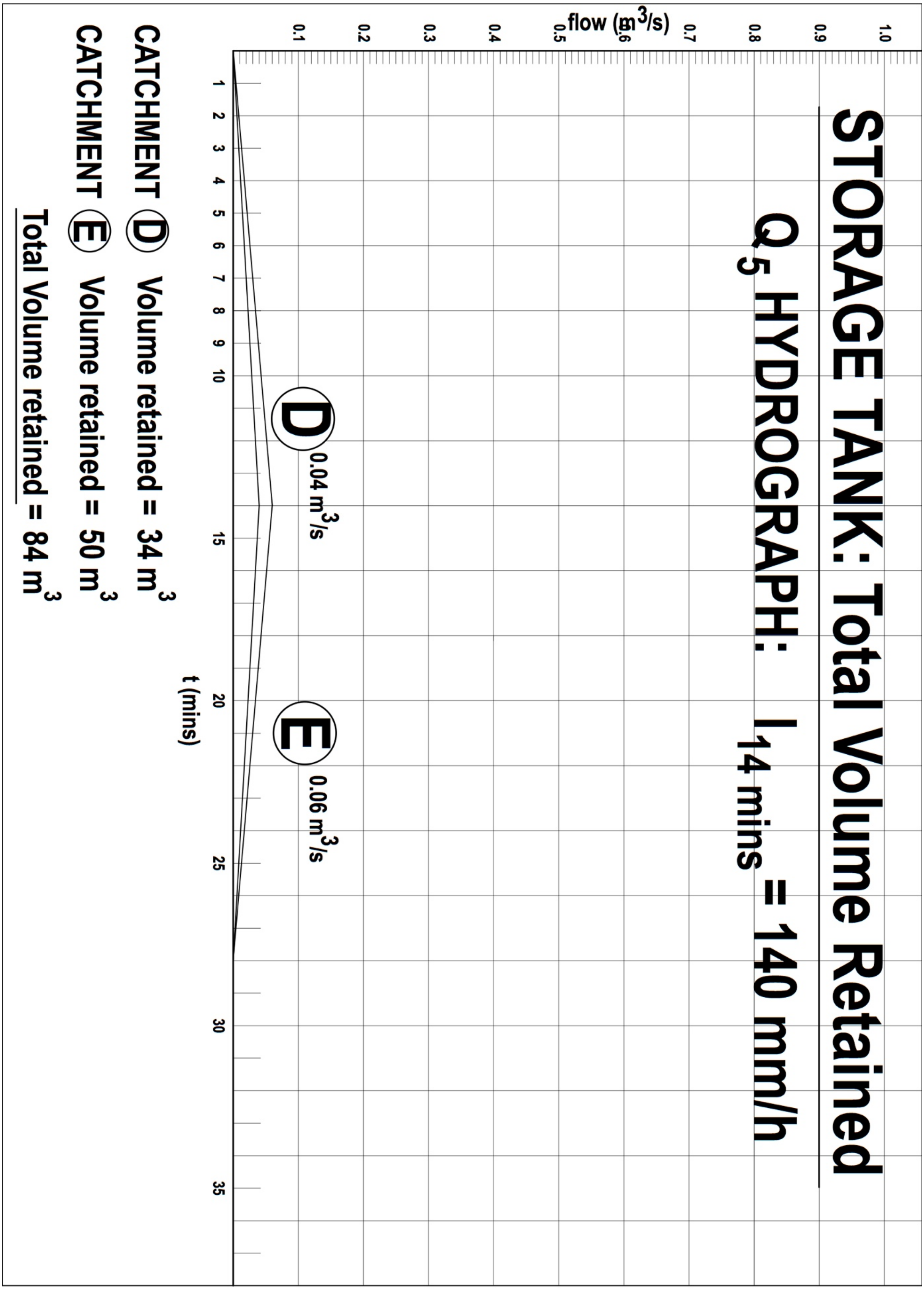


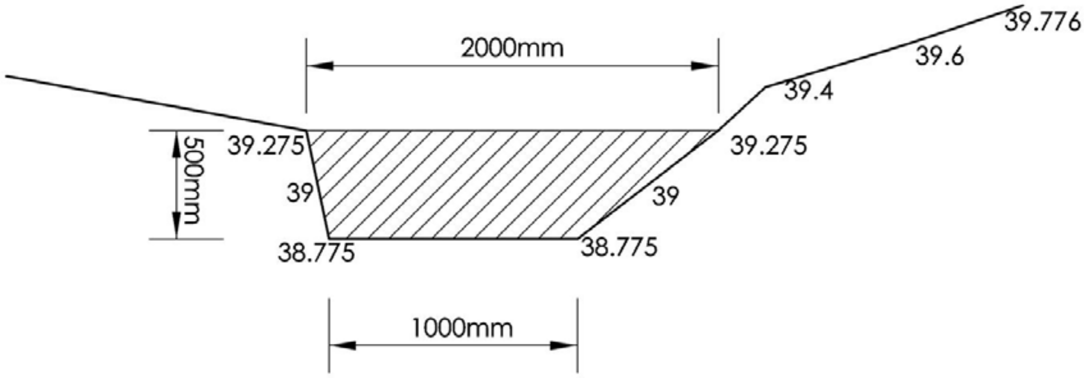
APPENDIX F . . . . DETENTION BASIN INFLOWS

(Q_{100} I_{15} = 200 mm/hr)



(Q_5 I_{14} = 140 mm/hr)





CROSS SECTIONAL AREA - 0.761m²

Slope: S = 1.398/130 = 0.0108

P = 2.332m

WELLS CREEK Rd DRAIN

FLOW CAPACITY of WELLS CREEK ROAD TRAPAZOIDAL DRAIN

CROSS-SECTIONAL AREA (A)	=	0.761 m^2
WETTED PERIMETER (P)	=	2.332 m
LENGTH (L)	=	130 m
CHANGE IN ELEVATION (ΔH)	=	1.398 m
SLOPE (S)	=	0.0108 m

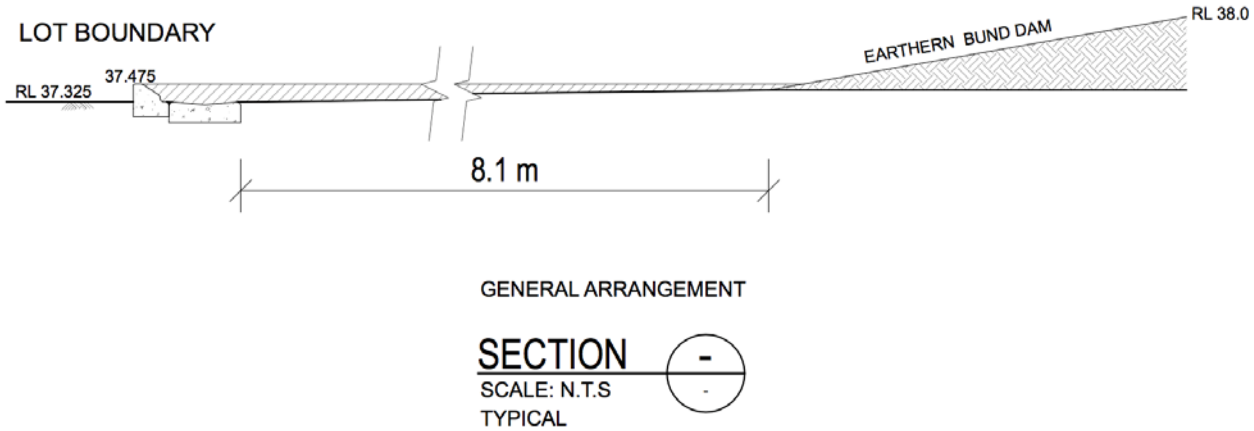
WHERE:

$$R = A/P$$
$$= 0.761/2.332$$
$$= 0.326 \text{ m}$$

$$v = 1/n(R^{2/3} \cdot S^{1/2})$$
$$v = 1/0.014(0.326^{2/3} \cdot 0.0108^{1/2})$$
$$v = 3.49 \text{ m/s`}$$

$$Q = v \cdot A$$
$$= 3.49 \cdot 0.761$$
$$= 2.66 \text{ m}^3/\text{s}$$

APPENDIX I . . . . FLOW CAPACITY of Concrete Invert & Kerb



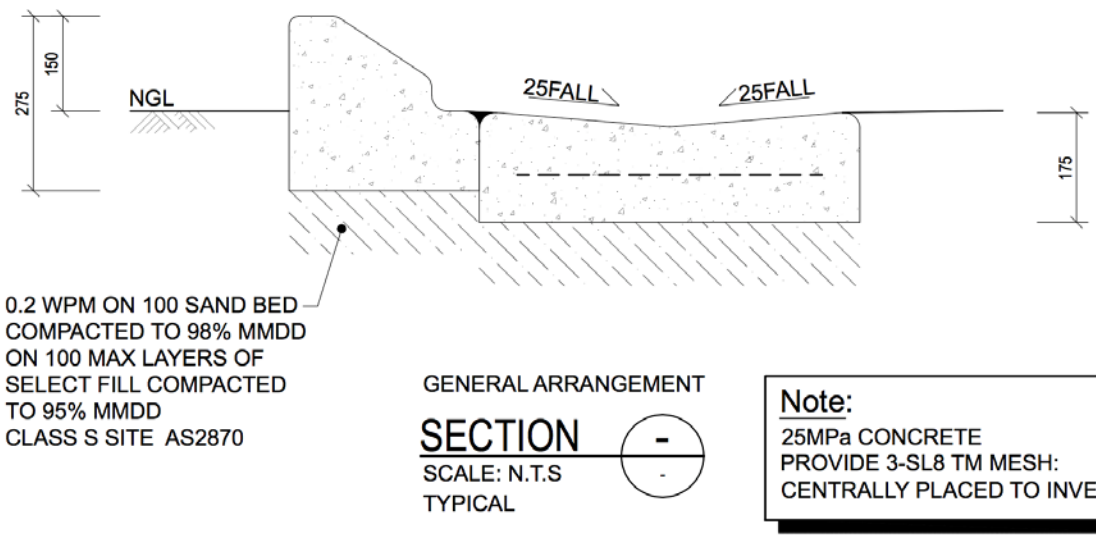
CROSS-SECTIONAL AREA (A)	=	0.958	m^2
WETTED PERIMETER (P)	=	9.734	m
LENGTH (L)	=	119.9	m
CHANGE IN ELEVATION (ΔH)	=	2.200	m
SLOPE (S)	=	0.0183	m

WHERE:

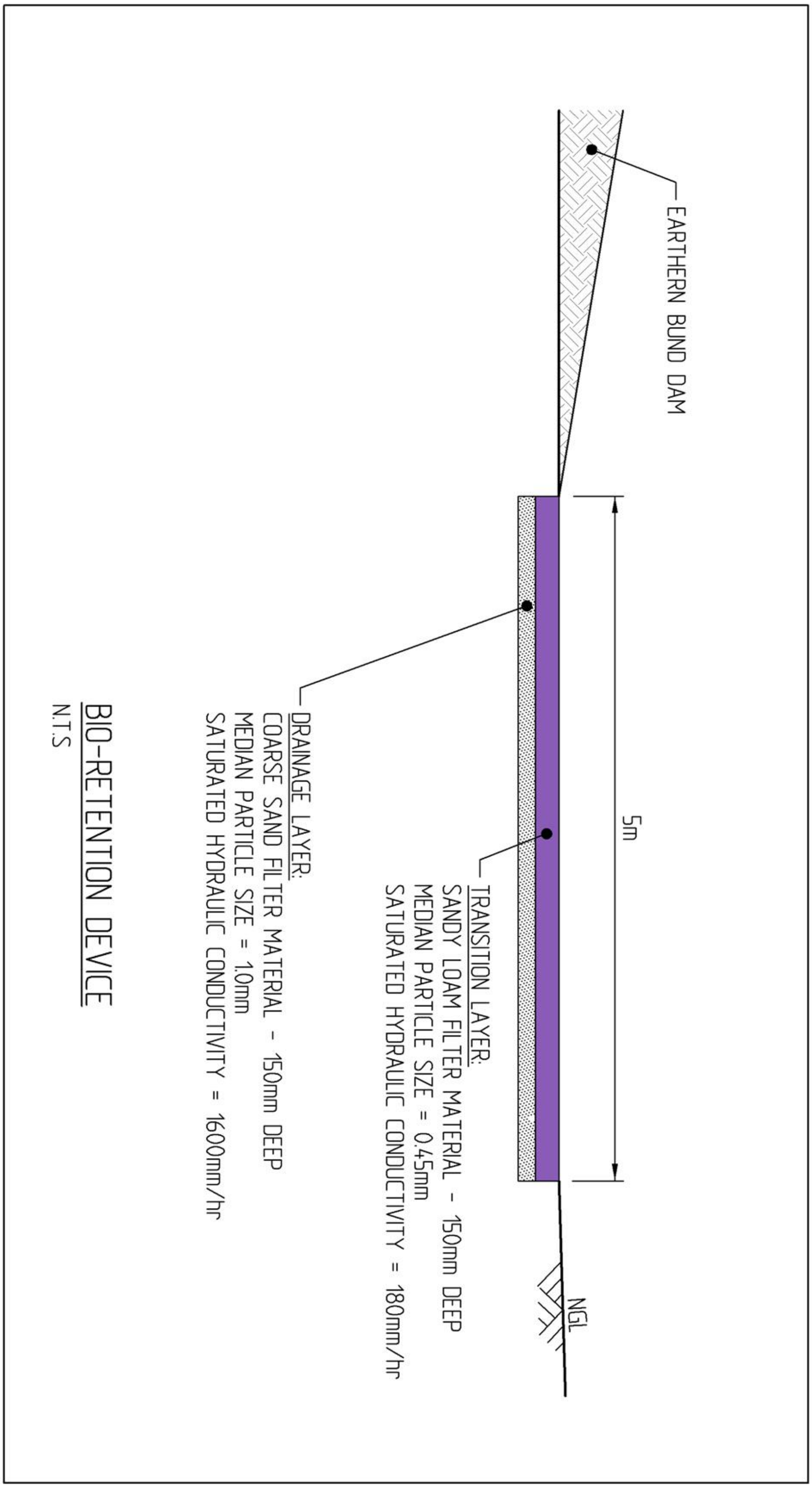
$$R = A/P$$
$$= 0.958/9.734$$
$$= 0.1012 \text{ m}$$

$$v = 1/n(R^{2/3} \cdot S^{1/2})$$
$$v = 1/0.014(0.1012^{2/3} \cdot 0.0183^{1/2})$$
$$v = 2.098 \text{ m/s`}$$

$$Q = v \cdot A$$
$$= 2.098 \cdot 0.985$$
$$= 2.067 \text{ m}^3/\text{s}$$



Note:
25MPa CONCRETE
PROVIDE 3-SL8 TM MESH:
CENTRALLY PLACED TO INVERT


EARTHERN BUND DAM
5m
TRANSITION LAYER:
SANDY LOAM FILTER MATERIAL - 150mm DEEP
MEDIAN PARTICLE SIZE = 0.45mm
SATURATED HYDRAULIC CONDUCTIVITY = 180mm/hr
DRAINAGE LAYER:
COARSE SAND FILTER MATERIAL - 150mm DEEP
MEDIAN PARTICLE SIZE = 1.0mm
SATURATED HYDRAULIC CONDUCTIVITY = 1600mm/hr
NGL
BIO-RETENTION DEVICE
N.T.S

APPENDIX K . . . . Gross Pollutant Trap

The car parking/hardstand areas are contoured to direct gross pollutants and litter to a *gross pollutant trap* on the southern eastern corner of the car parking area. The trap will collect litter and other solids prior to the stormwater discharging to the detention basin.

The *'trash rack'* will be 300mm high constructed from galvanized 12ϕ steel bars at 100 centres as shown below