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20 September 2021

Attention: Mr Brent Annis Brown

Dear Brent,

BRUNSLEA PARK, FOREST HILL
APPROX. 500 LOT RESIDENTIAL SUBDIVISION
CONCEPT STORMWATER MANAGEMENT PLAN (*SMP*)

1. INTRODUCTION

Civil Certification Pty Ltd has been engaged by Yarraman Developments Pty Ltd to prepare a concept Stormwater Management Plan (*SMP*) for the proposed 500 lot residential subdivision at the above site.

The aim of this report is to demonstrate how a stormwater treatment & detention strategy that meets the requirements of the City of Wagga Wagga Council and aligns with best practice WSUD can be achieved.

This report is in support of the "*Planning Proposal*" (*PP*) for the proposed subdivision. It should be read in conjunction with all other PP documentation.

2. SITE

The site is illustrated in **Diagram 1** and is located on the west side of Wagga Wagga Airport. It has an area of approximately **156ha** and is broadly split into two catchments (*i.e. the Northern and Southern Catchments*). Both catchments drain to the west and eventually join the Murrumbidgee River.

The site currently contains cleared rural land with some limited patches of large eucalypt trees. An existing residential subdivision is located to the north and north east of the site

The site is proposed to be developed as part of future DAs to incorporate approximately 500 lots, new local streets, parks and all associated servicing / stormwater drainage infrastructure (*refer to **Appendix A** for proposed development layout & land use*).

Diagram 1 – Site Locality

3. CATCHMENTS

The site is located downstream of a number of external catchments. To the west is an 50ha catchment containing parts of the airport. To the south is a 2,500ha catchment serving Gregadoo Creek. An illustration of the catchments in the vicinity of the site is contained in **Figure 2**.

The site itself is divided by a ridge running east west along the "*Active Travel Link*". Areas to the north of the ridge (*i.e. the Northern Catchment*) drain north and join Marshalls Creek which runs to the west. Areas to the south of the ridge (*i.e. the Southern Catchment*) drain south and join Gregadoo Creek which also runs to the west.

For modelling purposes the site catchment has be broken down into a number of sub-catchments (***i.e. A to H***). An illustration of these sub-catchments is contained in **Figure 1.**

4. STORMWATER/WSUD TREATMENT STRATEGY

A stormwater treatment strategy has been formulated for the proposed future development as illustrated in the **Figures** section at the rear of this report and as summarised below:

- Rainwater tanks on all future lots to capture roof runoff and reuse for toilet flushing, cold water laundry and garden irrigation;
- A rehabilitated riparian corridor running through the southern part of the site;
- Gross Pollutant Traps (*GPTs*) to treat both lot and road runoff (*eight in total*); and
- Community based bio-retention/detention basins (*seven in total*).

These measures will control urban generated pollutants at the source and minimise the export of suspended solids, nutrients and litter from the site.

The software package developed by the CRC for Catchment Hydrology termed "MUSIC" (*Model for Urban Stormwater Improvement Conceptualisation*) was used to assess the effectiveness of the proposed site based component of the "*treatment train*".

Details of the MUSIC modelling exercise (*including results*) are included at **Appendix B** and summarised in the following sections.

4.1 TREATMENT TARGETS

The City of Wagga Wagga Council stipulates the following treatment targets for this locality (*i.e., post development average annual load reductions from the CSIRO 1999 BPEMG*):

- Gross Pollutants 70% reduction;
- Total Suspended Solids 80% reduction;
- Total Phosphorous 45% reduction; and
- Total Nitrogen 45% reduction.

4.2 MUSIC

MUSIC is a continual-run conceptual water quality assessment model originally developed by the Cooperative Research Centre for Catchment Hydrology (*CRCCH*). MUSIC can be used to estimate the long-term annual average stormwater volume generated by a catchment as well as the expected pollutant loads. It is able to conceptually simulate the performance of a group of stormwater treatment measures (*treatment train*) to assess whether a proposed strategy is able to meet specified water quality targets.

MUSIC was chosen for this investigation because it has the following attributes:

- It can account for the temporal variation in storm rainfall throughout the year;
- Modelling steps down to 6 minutes to allow accurate modelling of treatment devices;
- It can model a range of treatment devices;
- It can be used to estimate pollutant loads at any location within the catchment; and
- It is based on logical and accepted algorithms.

4.3 MUSIC INPUTS

All MUSIC inputs were selected based on the site's locality, physical characteristics and BPEMG guidelines.

Rainfall and Evaporation (*Climate Template*)

Rainfall and evaporation data adopted in the MUSIC modelling exercise was sourced for this region and contains 6 minute rainfall data over a period of 10 years (*1968 to 1977 inclusive*) resulting in a mean annual rainfall value of 655mm and mean annual evapotranspiration value of 1,116mm. The period contains a mix of dry, average and wet years. .

The long term annual average rainfall for the region is approximately 571mm (*i.e., sourced from BOM Station 07215 – Wagga Wagga AMO*).

Refer to **Diagram 2** for an illustration of the adopted Climate Template data.

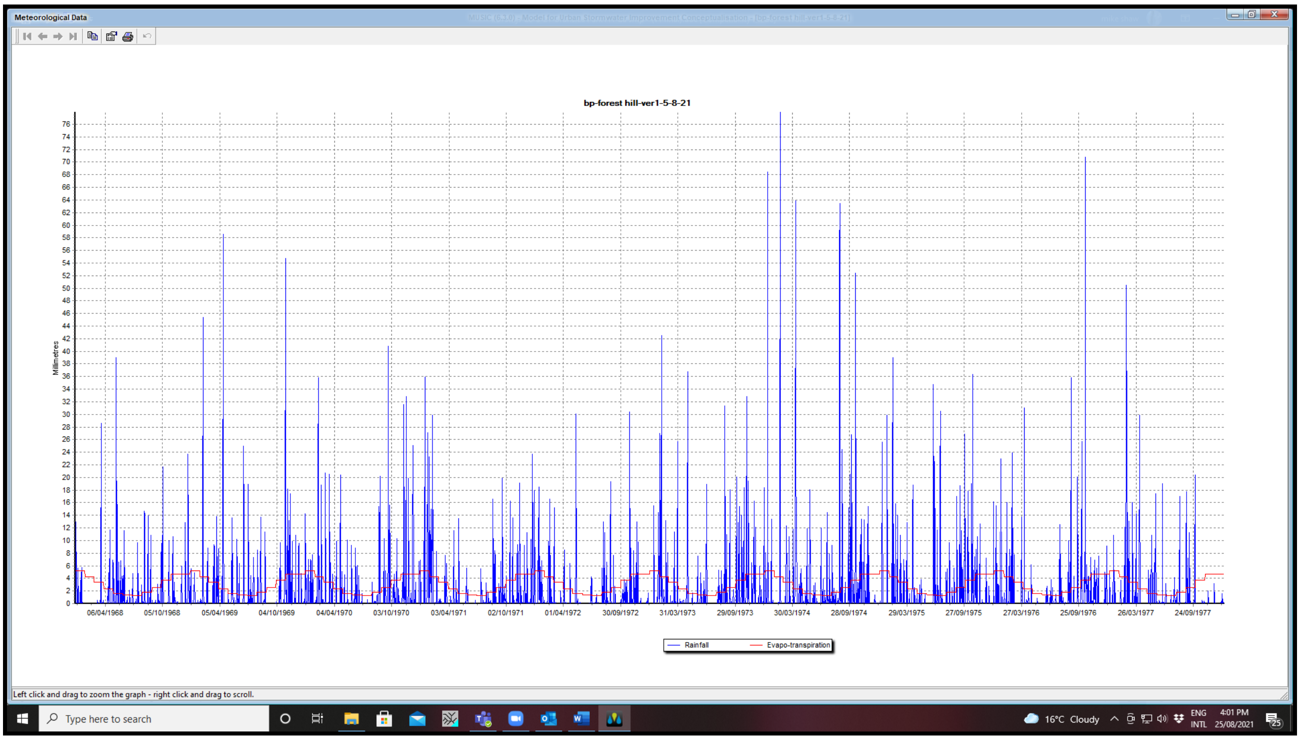

Diagram 2 – Climate Template

Sub Catchment Areas

The site was assessed under proposed conditions and divided into 2 broad catchments (*i.e., north and south draining*). Each catchment was then further subdivided to represent the proposed land uses.

The proposed impervious fraction adopted for each sub-catchment was based on land-use and open space. General Residential land-use was assumed to be 65% impervious, Rural Residential (*2,000m^2*) land-use was assumed to be 50% and Rural Residential (*4,000m^2*) land-use was assumed to be 40%.

The existing catchments were assumed to be 2% impervious. The new rehabilitated riparian corridor was also assumed to be 2% impervious.

All developed sub-catchment areas are proposed to be served by both GPTs and bio-retention/detention basins, except catchment G which is served by a GPT only.

Details of the sub catchment area characteristics are provided in **Table 1**.

Table 1 – Sub catchment Characteristics

Sub Catchment	Area (ha)	Land-use	% Impervious
Proposed Conditions			
A	36.6	Rural Res. (*2,000m² lots*) & Light Industrial	50%
B1	8.0	Rural Res. (*4,000m² lots*)	40%
B2	8.5	Rural Res. (*4,000m² lots*)	40%
C	12.8	Rural Res. (*4,000m² lots*)	40%
D	8.8	Rural Res. (*2,000m² lots*)	50%
RIP	15.7	Rehabilitated Riparian Corridor	2%
South Total	**90.4ha**	**-**	**38.4%**
E	14.5	General Res. & Open Space	65%
F	30.2	General Res. & Open Space	65%
G	2.0	General Res.	65%
H (Stage 1)	18.6	General Res.	65%
North Total	**65.3**	**-**	**65%**
Total Proposed Site	**155.7ha**	**-**	**49.6%**

Soil Data / Characteristics

A summary of the adopted soil parameters is contained in **Table 2**. These values have been derived based on site conditions, the *CSIRO 1999 BPEMG* and the NSW MUSIC Modelling Guidelines, August 2015.

Table 2 – Adopted Soil Data

	Units	Value
Impervious Area Parameters		
Rainfall threshold	mm/day	0
Pervious Area Parameters		
Soil storage capacity	mm	40
Initial storage	% of capacity	20
Field capacity	mm	25
Infiltration capacity coefficient – a		200
Infiltration capacity coefficient – b		1
Groundwater Properties		
Initial depth	mm	1
Daily recharge rate	%	25
Daily base flow rate	%	1
Daily deep seepage rate	%	15

EMC Values

A summary of the adopted EMC values is contained in **Table 3**. These values have been derived based on the site conditions, proposed development, *CSIRO 1999 BPEMG* and the NSW MUSIC Modelling Guidelines August 2015.

Table 3 – EMC Values

Land use	Base Flow						Storm Flow					
	TSS		TP		TN		TSS		TP		TN	
	Mn	SD	Mn	SD	Mn	SD	Mn	SD	Mn	SD	Mn	SD
	(all values expressed as $\log_{10}$ mg/l)											
Urban Gen&RR	1.40	0.17	-0.82	0.19	0.32	0.12	2.19	0.32	-0.65	0.25	0.427	0.19
Riparian Corridor	0.90	0.13	-1.50	0.13	-0.14	0.13	1.90	0.20	-1.10	0.22	-0.08	0.24

4.4 PROPOSED TREATMENT TRAIN

An illustration of the MUSIC network constructed to represent the site under developed conditions is contained at **Diagram 3**. All new developed sub-catchments are treated by a GPT in series with large offline bio-retention/detention basins, apart from catchment G which is served by a GPT only.

The GPT provides primary screening to remove litter and coarse sediment, whilst the Bio-Retention basins provide tertiary treatment to remove fine sediments and nutrients.

Lot based measures (*i.e., rainwater tanks*) and the additional treatment provided in the proposed rehabilitated riparian model were conservatively omitted from the model.

Further details of the individual components of the proposed treatment train are provided below and in **Appendix B**.

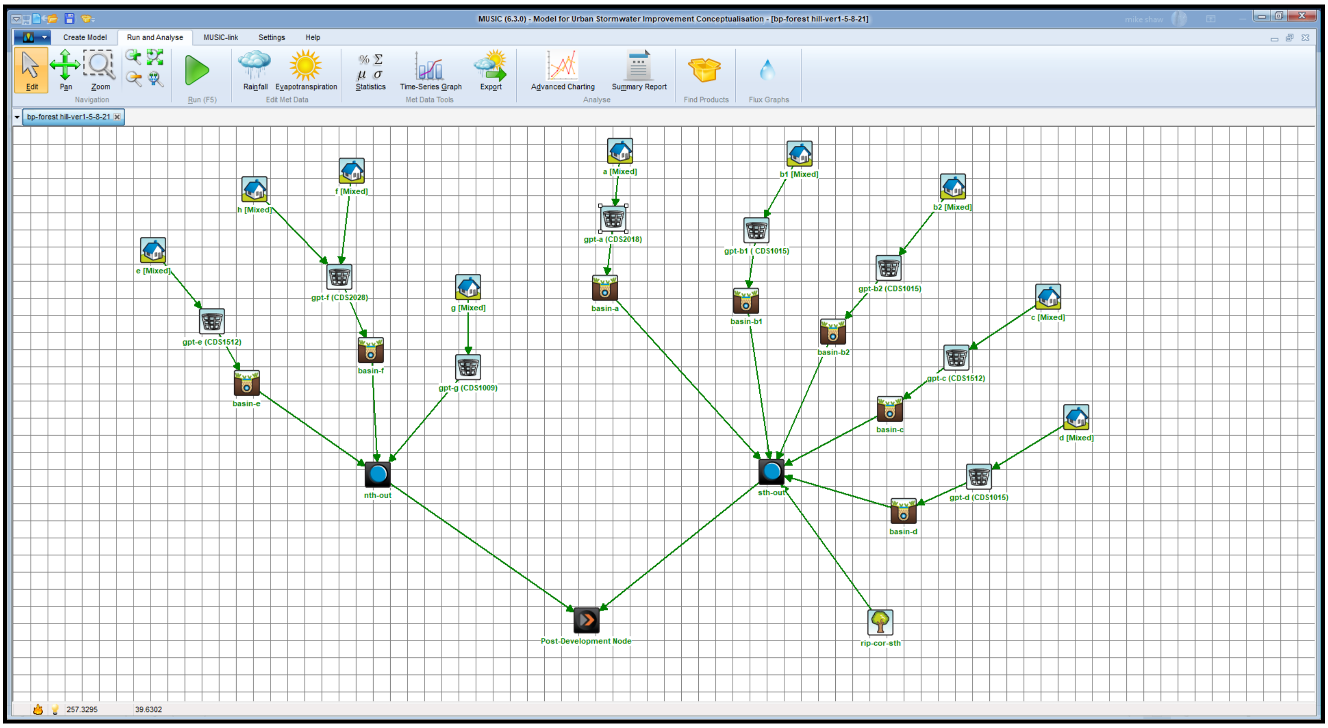

Diagram 3 - Proposed MUSIC Network Diagram

Rainwater Tanks

A minimum rainwater tank volume of 3KL/ future lot in the proposed future "*General Residential*" land-use areas and 10KL for the proposed future "*Rural Residential*" land-use areas will be adopted for subdivision. These tanks will capture runoff from all roof areas and reuse *for garden irrigation, cold water laundry and toilet flushing*. For the proposed future "*General Residential*" land-use areas, the anticipated reuse rate will be approximately 200-250 L/lot/day.

Rainwater tanks provide an indirect treatment mechanism by reducing the volume of water that is needed to be treated further downstream.

Flows in excess of the 1yr ARI are likely to bypass the rainwater tanks.

GPTs

Gross Pollutant Traps (*GPTs*) are proposed at the inlets of all proposed community bio-retention/detention basins. These GPTs will treat all lot and road based runoff, primarily targeting coarse sediment and litter.

For this concept report, CDS GPT's have been modelled for each sub-catchment and sized to treat the 3-6month ARI storm. Equivalent proprietary products are available.

A summary of the GPT sizes adopted in our MUSIC model are included in **Table 4**.

Table 4 – GPT Sizing

Sub Catchment / GPT Name	Area (ha)	CDS Model
A	36.6	CDS2018
B1	8.0	CDS1015
B2	8.5	CDS1015
C	12.8	CDS1512
D	8.8	CDS1015
E	14.5	CDS1512
F & H	48.8	CDS2028
G	2.0	CDS1009
Total Dev A	**140ha**	**-**

BIO-RETENTION BASINS

A total of seven large community or regional style basins are proposed as part of the future development. These basins will act as both water quality treatment and stormwater detention facilities. All basins will be located offline and contain a bio-retention component.

The bio-retention system will consist of an above ground depression containing landscaping of native grasses & shrubs underlain by an infiltration zone and associated under drain. The infiltration zone would consist of a sandy loam topsoil layer, a filter media layer, a gravel transition layer and a subsoil drainage system at the base to collect filtered water. The primary treatment mechanisms for the system are detention/settling at the surface, take up of nutrients by plants, filtering treatment through the media and biological treatment from algal growth on the filter media.

A summary of the proposed bio-retention basin properties is included in **Table 5**.

Table 5– Bio-Retention Basins

Basin Name	Surface Area (m^2)	Filter Area (m^2)	Filter depth (mm)	Extended Detention Depth (mm)
A	9,100	4,550	1,000	200
B1	2,000	1,000	1,000	200
B2	2,500	1,250	1,000	200
C	3,200	1,600	1,000	200
D	2,200	1,100	1,000	200
E	3,600	1,800	1,000	200
F (H)	12,000	6,000	1,000	200
Total	**34,600**	**17,300**	-	-
%Dev A	**2.5%**			

4.5 MUSIC MODELLING RESULTS

The MUSIC modelling results are detailed in **Appendix B** and summarised in **Table 6**.

The results illustrate that implementation of the proposed treatment strategy achieves in excess of the *CSIRO 1999 BPEMG* and best practice treatment targets.

Table 6 – MUSIC Modelling Results

MUSIC model	Location	Annual Flow and Pollutant Load Results				
		Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	GP (kg/yr)
Proposed (Combined Receiving Node)						
	All Source Nodes	564	112,000	150	1,620	21,500
	Residual Load	495	2,110	59	347	20.5
% Effectiveness		**12.2**	**98.1**	**60.6**	**78.6**	**99.9**
Achieve Target			80	45	45	70
			YES	YES	YES	YES
Proposed (South Draining Catchment)						
	All Source Nodes	267	52,300	68.8	766	10,300
	Residual Load	230	883	26.8	153	13.6
% Effectiveness		**13.9**	**98.3**	**61**	**80**	**99.9**
Achieve Target			80	45	45	70
			YES	YES	YES	YES
Proposed (North Draining Catchment)						
	All Source Nodes	297	59,400	81.2	858	11,200
	Residual Load	266	1,230	32.2	194	6.88
% Effectiveness		**10.7**	**97.9**	**60.3**	**77.4**	**99.9**
Achieve Target			80	45	45	70
			YES	YES	YES	YES

4.6 CONSTRUCTION STAGE WATER QUALITY

As part of the future development application for the proposed development, a detailed erosion and sediment control plan would be developed for the site in accordance with Council's guidelines and the NSW Blue Book (*NSW DECC publication titled "Managing Urban Stormwater – Soils and Construction" January 2008*).

The erosion and sediment control plan will outline the strategies proposed to prevent excessive pollutant loads being exported from the site in runoff during and immediately following construction (*i.e., primarily as a result of erosion caused by construction activity*).

A summary of the principal elements of a preferred erosion and sediment control plan for the site is summarised below:

- Minimising the extent of disturbed surfaces at any one time (*i.e., staging of earthworks etc*);
- Stabilising disturbed surfaces immediately upon completion of works (*i.e., hydromulch or vegetation*);
- Diverting clean runoff around disturbed work areas (*i.e., using earth bunds/diversion mounds/channels*);
- Protecting stockpiles (*i.e., using silt fence, diversion bunds, temporary vegetative cover etc*);
- Implementation of dust control/suppression measures during works(*i.e., perimeter fencing, wind velocity monitoring, cessation of earthworks activities during high wind conditions, watering down disturbed areas, setup of recycled water irrigation sprays etc*);
- Use of sediment basins;
- Use of silt fencing downslope of disturbed surfaces;
- Use of silt socks or equivalent around existing drainage structures;
- Use of rock /haybale/mulch check dams along designated overland flow paths;
- Protection of exposed slopes;
- Restriction of vehicle entry/exit points to construction zones;
- Setup of stabilised site access points; and
- Setup of vehicle washdown/wheel wash baths at exit points of disturbed areas.

5. STORMWATER DETENTION STRATEGY

A detention strategy has been formulated for the proposed future subdivision to mitigate the increase in flows generated by the change in land-use.

The strategy is illustrated in the **Figures** section at the rear of this report and consists of a number of large community based detention basins located near the outlet of each sub-catchment.

The proposed detention system has been designed to cater for all sub-catchments. Whilst sub-catchment G does not drain directly to a basin the nearby Basin F has been oversized to ensure the net impact is zero.

5.1 RAFTS

RAFTS has been used to determine the quantity of detention required for the proposed development. Both the pre and post development site conditions were modelled for the 5yr ARI, 20yr ARI and 100yr ARI design storm events.

All sub-catchments were included in the model, including the Stage 1 sub-catchment H as this will ultimately replace be served by Basin F.

5.2 RAFTS PARAMETERS

IFD

The adopted IFD coefficients for the site are included in **Table 7**.

Table 7 – IFD Data

Duration	2 year ARI	50 year ARI
1hr	21.63	43.50
12hr	4.00	7.01
72hr	1.03	1.73

Rainfall Losses

The adopted rainfall losses for the site are included in **Table 8**.

Table 8 – Rainfall Losses

Surface	Initial Loss	Continuing Loss
Pervious	21.3mm	2.5mm/h
Impervious	1.0mm	0mm/h

Other Assumptions

A split sub catchment approach was adopted (*i.e., separate routing of pervious and impervious surfaces of the same sub catchment*). For conservatism zero lags were adopted in all links.

5.3 RAFTS MODEL SCENARIOS

Pre Development Conditions

The adopted pre development condition catchment characteristics for the site are included in **Table 9**.

Table 9 – Pre development Catchment Characteristics

Parameters	North Catchments (E,F,G,H)	South Catchments (A,B1,B2,C,D)
Area (ha)	65.3	90.4
Vectored Average Slope (%)	2	2
Impervious Fraction (%)	2	2
Pervious Mannings “n”	0.045	0.045
Impervious Mannings “n”	0.025	0.025

A RAFTS network was constructed to represent the site under pre development conditions as illustrated in **Diagram 4.**

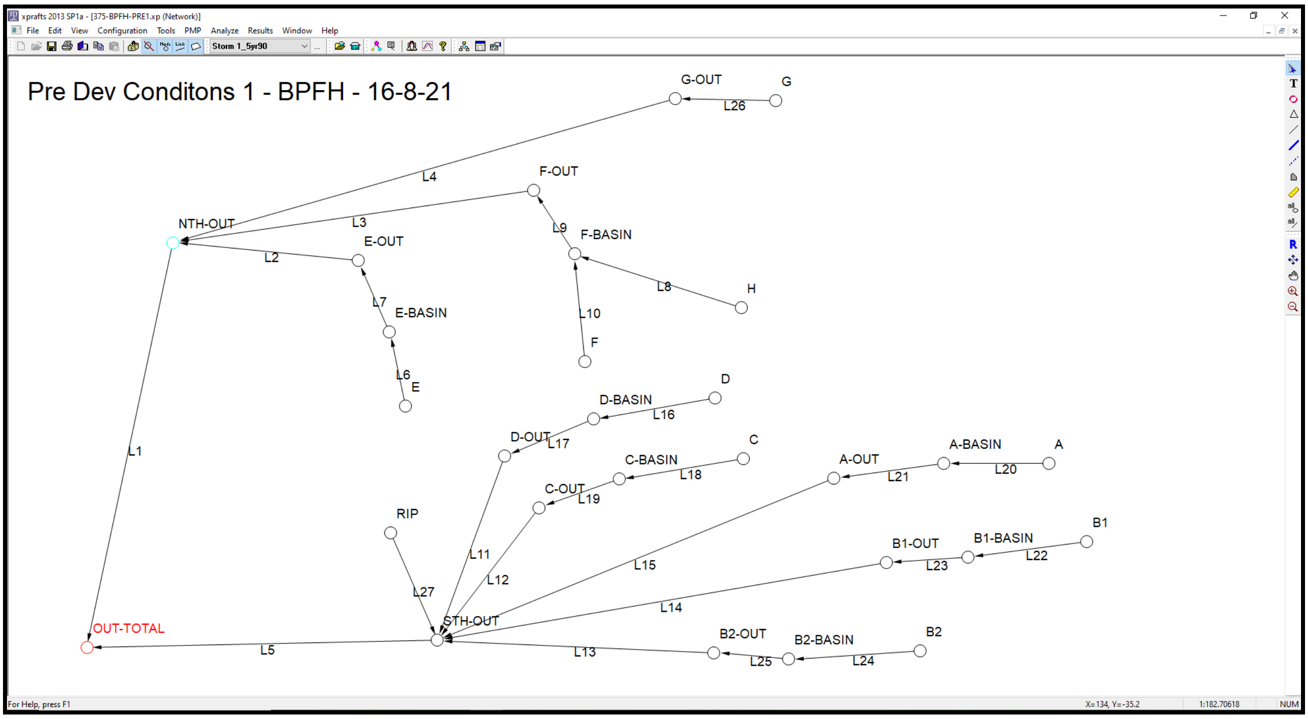

Diagram 4 – Pre Development Condition RAFTS Network

The results of the pre development conditions RAFTS model are summarised in **Table 10**. Details of the model are included at **Appendix C**.

The RAFTS results show that under pre development conditions the critical storm duration is generally 120 minutes. The total peak flow discharged from the site under a 100 year ARI storm event is **9.20 m^3/s**. An illustration of the critical 100yr ARI pre development condition site hydrograph is included at **Diagram 5**.

Table 10 – Pre Development Condition RAFTS Results (*Peak Flow m³/s*)

Storm Frequency	Storm Duration (min)	G-OUT	F-OUT	E-OUT	NTH-OUT	D-OUT	C-OUT	A-OUT	B1-OUT	B2-OUT	RIP	STH-OUT	OUT-TOTAL
100yr ARI	45	0.17	2.07	0.74	2.95	0.53	0.68	1.40	0.49	0.52	0.49	4.09	7.04
100yr ARI	60	**0.19**	2.60	0.91	3.67	**0.62**	0.82	1.78	**0.57**	**0.60**	0.62	4.98	8.65
100yr ARI	90	0.18	2.81	0.92	3.85	0.61	0.83	1.98	0.57	0.60	0.71	5.17	9.02
100yr ARI	120	0.17	**2.88**	**0.94**	**3.94**	0.61	**0.85**	**2.03**	0.56	0.59	**0.74**	**5.28**	**9.20**
100yr ARI	180	0.15	2.53	0.81	3.42	0.53	0.74	1.84	0.49	0.52	0.72	4.53	7.94
20yr ARI	90	0.09	1.34	0.45	1.84	0.30	0.40	0.92	0.28	0.29	0.31	2.45	4.28
20yr ARI	120	**0.09**	**1.45**	**0.49**	**2.98**	**0.32**	**0.43**	**1.02**	**0.29**	**0.31**	**0.35**	**2.63**	**4.60**
5yr ARI	90	0.03	0.45	0.16	0.64	0.12	0.15	0.30	0.11	0.11	0.11	0.89	1.53
5yr ARI	120	**0.04**	**0.57**	**0.20**	**0.80**	**0.14**	**0.18**	**0.40**	**0.13**	**0.13**	**0.15**	**1.08**	**1.88**

Note 1. Values shown in bold are critical.
2. Model 375BPFH-Pre1.xp

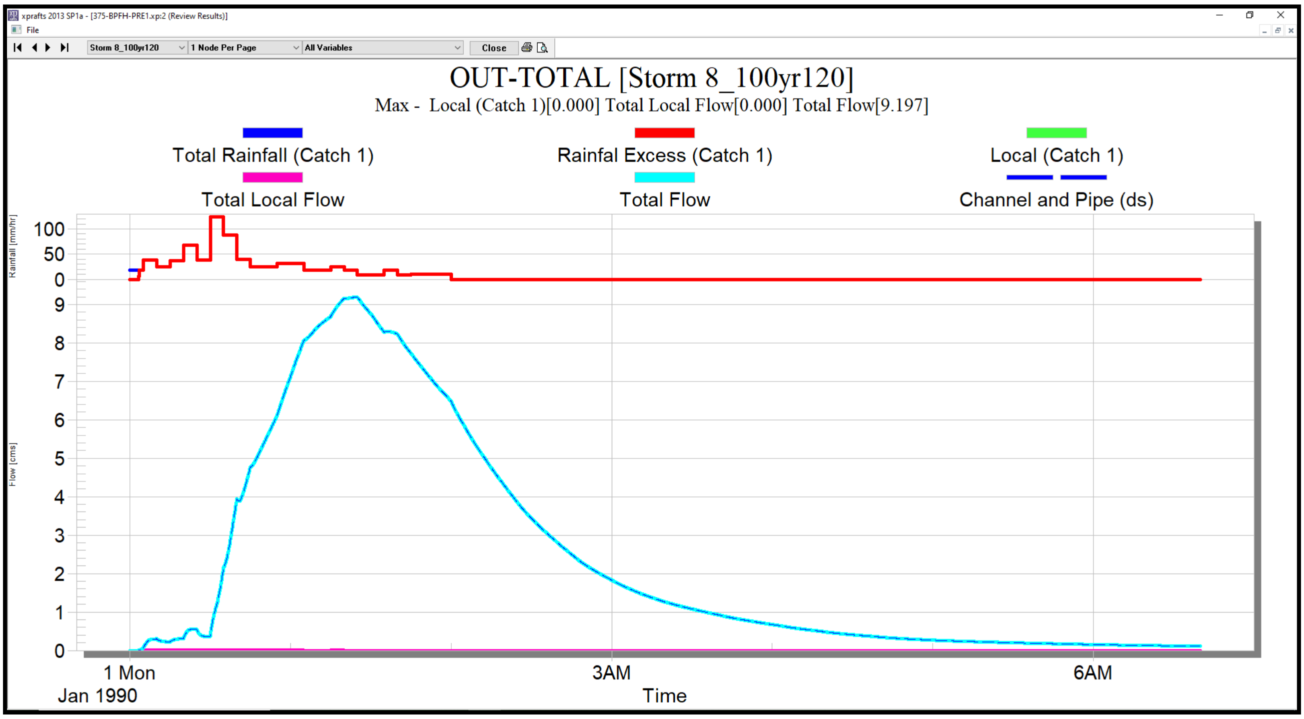

Diagram 5 – Pre Development 100yr ARI Hydrograph

Post Development Conditions

To assess the impact of modifying the pre development land-use of the site (*i.e., increasing the impervious areas*), a proposed condition RAFTS model was established.

The adopted impervious fraction for the developed site catchments averaged 50% impervious (*varies from 40% to 65%*). The vectored average slope was maintained as per pre developed conditions.

A summary of the adopted post development condition catchment characteristics is included in **Table 11**.

Table 11 – Post Development Catchment Characteristics

Parameters	North Catchments (E,F,G,H)	South Catchments (A,B1,B2,C,D)
Area (ha)	65.3	90.4
Vectored Average Slope (%)	2	2
Impervious Fraction (%)	65%	40-50%
Pervious Mannings “n”	0.02	0.02
Impervious Mannings “n”	0.04	0.045

A RAFTS network was constructed to represent the site under post development conditions as illustrated in **Diagram 6.**

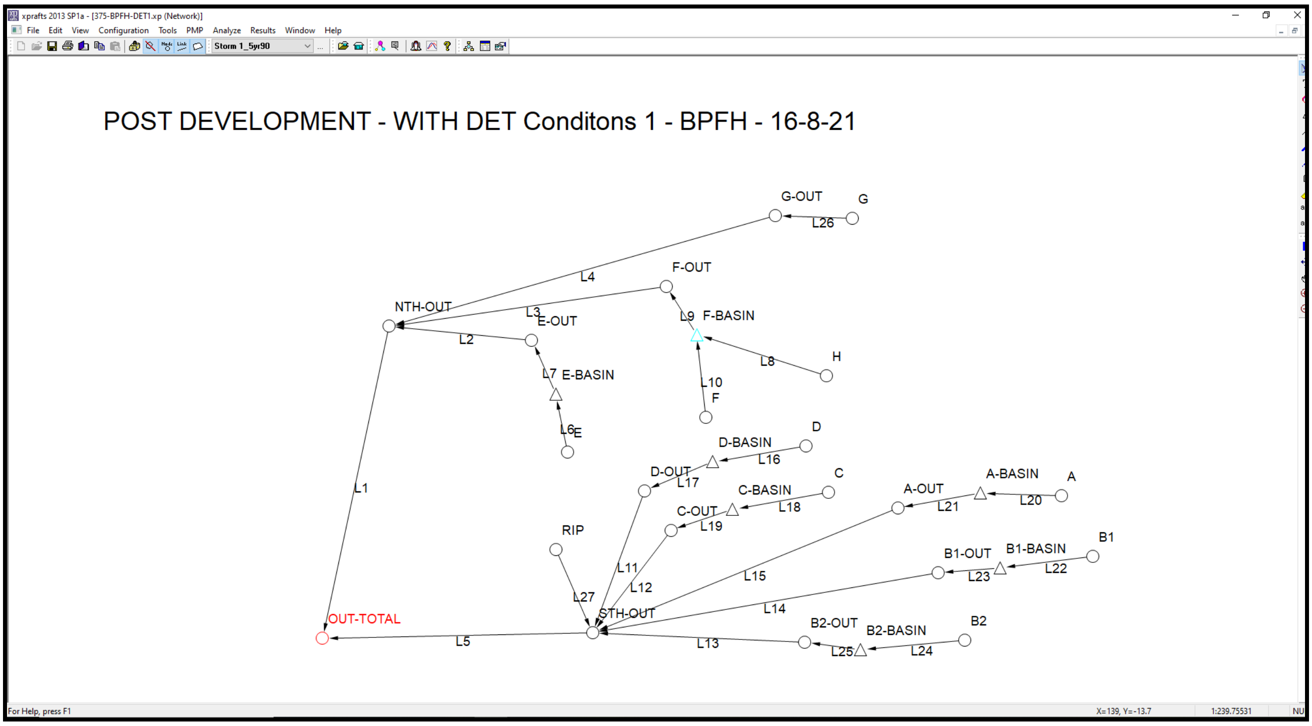

Diagram 6 – Post Development (*With Detention*) RAFTS Network

Detention is proposed to be implemented within the proposed future subdivision/development in the form of large above ground community basins. Seven basins are proposed with a total volume of **36,150m³** (*refer to the **Figures** section at the rear of this report*).

The overall objective of the modelling was to ensure that post development flows did not increase beyond pre development levels. In RAFTS this was modelled by introduction of a detention node incorporating multiple outlet controls and high early discharge. The OSD outlet configuration was determined through iteration to optimise the storage volumes required for the critical storms only.

Table 12 provides a summary of the resultant SSR and PSD values.

Table 12 – Post Development (*With Detention*) PSD and Det. Volume Results

	5yr ARI		20yr ARI		100yr ARI		Max Basin V	OK Y or N
Basin	**PSD**	**V used**	**PSD**	**V used**	**PSD**	**V used**		
F	0.29	9,468	1.22	11,096	2.40	13,177	13,150	Yes
E	0.09	2,891	0.37	3,462	0.82	3,916	4,000	Yes
D	0.07	1,299	0.23	1,653	0.44	2,086	2,200	Yes
C	0.06	1,761	0.21	2,440	0.48	3,119	3,200	Yes
A	0.26	5,873	0.81	7,288	1.60	9,014	9,100	Yes
B1	0.05	1,027	0.15	1,460	0.34	1,865	2,000	Yes
B2	0.05	1,117	0.14	1,709	0.30	2,352	2,500	Yes
TOTAL		**23,436**		**29,108**		**35,529**	**36,150**	

The results of the post development condition RAFTS model are summarised in **Table 13**. Details of the model are included at **Appendix C.**

The RAFTS results show that under post development conditions, the combined total peak flows generated by the site in the 100 year ARI event increases from **9.20 m^3/s** to **29.00 m^3/s** and then back to **7.71m^3/s** after detention. An illustration of the critical 100yr ARI post development condition site hydrograph is included at **Diagram 7**.

The detention volume required to achieve this compliant result was greatest in the 100yr ARI event at **35,529m^3 (*254m^3/ha for the 140ha Dev A*).**

The peak flows in both the 20yrARI, 5yr and 2yr ARI events were also shown to be reduced below pre development conditions.

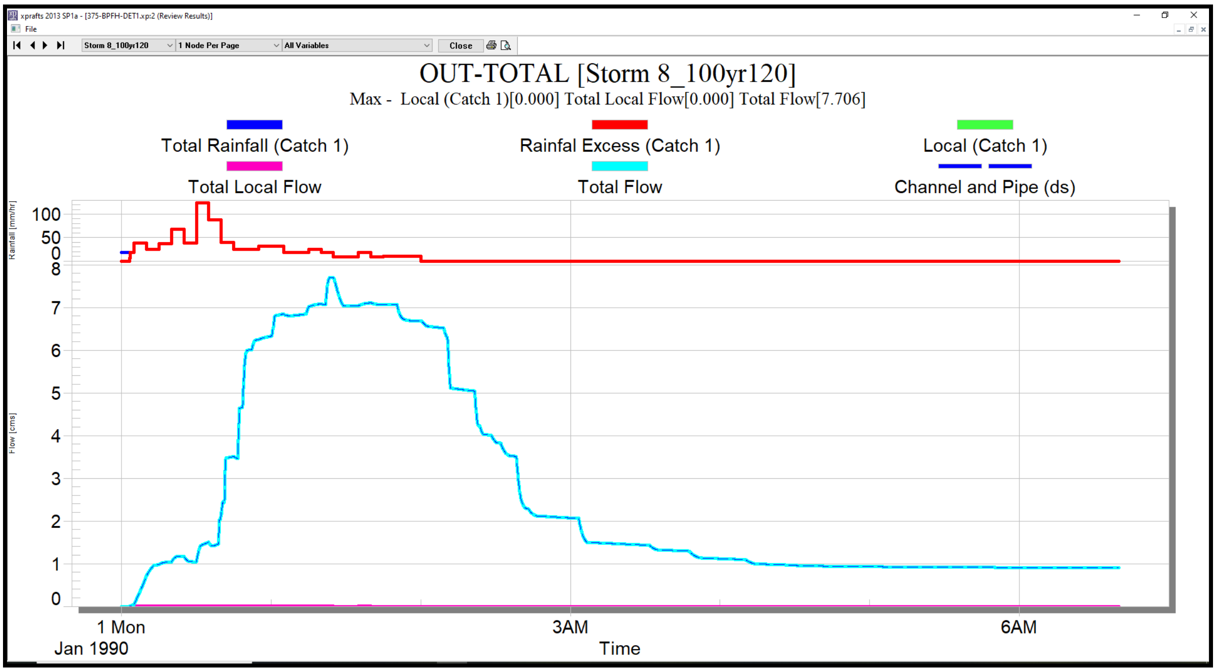

Diagram 7 – Post Development 100yr ARI Hydrograph

Table 13 – Post Development (*With Detention*) Condition RAFTS Results

Storm Frequency	Storm Duration (min)	G-OUT	F-OUT	E-OUT	NTH-OUT	D-OUT	C-OUT	A-OUT	B1-OUT	B2-OUT	RIP	STH-OUT	OUT-TOTAL
100yr ARI	45	0.47	2.40	0.82	3.45	0.44	0.48	1.60	0.34	0.30	0.37	3.36	6.69
100yr ARI	60	0.51	2.81	0.82	3.74	0.44	0.48	1.60	0.34	0.30	0.50	3.65	7.22
100yr ARI	90	**0.52**	2.77	0.82	3.70	0.44	0.48	1.60	0.34	0.30	0.60	3.76	7.41
100yr ARI	120	0.47	**3.04**	**0.82**	**3.96**	**0.44**	**0.48**	**1.60**	**0.34**	**0.30**	0.63	3.79	**7.71**
100yr ARI	180	0.26	2.40	0.82	3.39	0.44	0.48	1.60	0.34	0.30	**0.64**	**3.80**	7.10
20yr ARI	90	**0.40**	1.22	0.37	1.71	0.23	0.21	0.81	0.15	0.14	0.25	1.79	3.44
20yr ARI	120	0.36	**1.67**	**0.37**	**2.10**	**0.23**	**0.28**	**0.81**	**0.15**	**0.14**	**0.30**	**1.91**	**3.89**
5yr ARI	90	**0.29**	0.29	0.09	0.67	0.07	0.06	0.26	0.05	0.05	0.08	0.57	1.23
5yr ARI	120	0.27	**0.58**	**0.09**	**0.68**	**0.07**	**0.08**	**0.31**	**0.05**	**0.05**	**0.12**	**0.66**	**1.32**

Note 1. Values shown in bold are critical.
2. Model 375BPFH-Det1.xp

6. STORMWATER DRAINAGE

A road based stormwater drainage system is proposed in the local streets surrounding the proposed future subdivision. The proposed minor/pipe system capacity would be designed with a minimum 10yr ARI capacity in accordance with the City of Wagga Wagga Council standards. Major flows up to and including the 100yr ARI would be carried safely overland within the road reserve (DV<0.4).

All proposed future subdivision drainage will discharge into the proposed basins for treatment/detention.

Outflow from the basins will be discharged to the receiving waters via a combination of stabilised low flow outlets and high flow weirs.

7. MAINSTREAM FLOODING

Existing Mainstream 100yr ARI flood levels have been provided for the Northern parts of the proposed development adjacent to Marshalls Creek (*approximately RL.183.15*).

All residential development in the northern catchment will be sited a minimum of 500mm above this 100yr ARI flood level.

Existing flooding extents for the southern catchment (*i.e., generated by the Gregadoo Creek and Airport external catchments*) are unknown. A flood study will be completed at DA stage to determine these details and inform the future subdivision design.

8. RIPARIAN CORRIDOR WORKS

The southern area of the proposed development will be split by two open space corridors that will convey/contain floodwaters from upstream catchments and provide a valuable riparian function.

The corridors will contain a meandering low flow channel that is rock lined and incorporate a series of natural pools and riffles. Overbanks will be wide and flat to maximise flood conveyance and be planted with native vegetation. The edges of the corridors will likely contain a vertical component (*i.e., rock walls*) to ensure the future subdivision sits a minimum of 500mm above the 100yr flood level within the floodway.

The proposed bio-retention/detention basins will sit within the corridors with batters/walls to separate local runoff from upstream regional catchment flows. Timing between local and regional catchments will also play a role.

A 100m wide corridor will run from Inglewood Road to the western boundary of the site along the approximate existing alignment of Gregadoo Creek. At Inglewood Road this corridor will convey flows from a large upstream catchment of approximately 2,500ha.

A 60m wide corridor will run from Elizabeth Avenue running west to join the proposed 100m wide corridor. This will convey flows from the approximate 50ha upstream airport catchment.

8. CONCLUSIONS

A conceptual stormwater management plan has been formulated to support the planning proposal for the proposed 500 lot future subdivision of Brunslea Park, Forest Hill. The strategy ensures that both the water quality and quantity treatment targets of the City of wagga Wagga Council are not only achieved but exceeded.

9. QUALIFIERS

This report has been prepared by Mr Michael Shaw. A copy of Michael's CV is included at **Appendix D**.

This report has been prepared for the benefit of Yarraman Developments and the City of Wagga Wagga Council with relation to the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. Copyright in this report is the property of Civil Certification. In preparing this report I have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended.

We trust this report is satisfactory. Should you have any further queries, please do not hesitate to contact me on 0412 264 237.

Yours faithfully

CIVIL CERTIFICATION PTY LTD

Michael Shaw
BE(Civil), MIEAust, CPEng, NER(Civil), APEC Engineer IntPE(Aus)
Accredited Certifier (BDC 0816), RPEQ (24197)
Director
0412 264 237
mshaw@civilvcert.com

FIGURES

CONCEPT STORMWATER MANAGEMENT PLAN

Civil Cert

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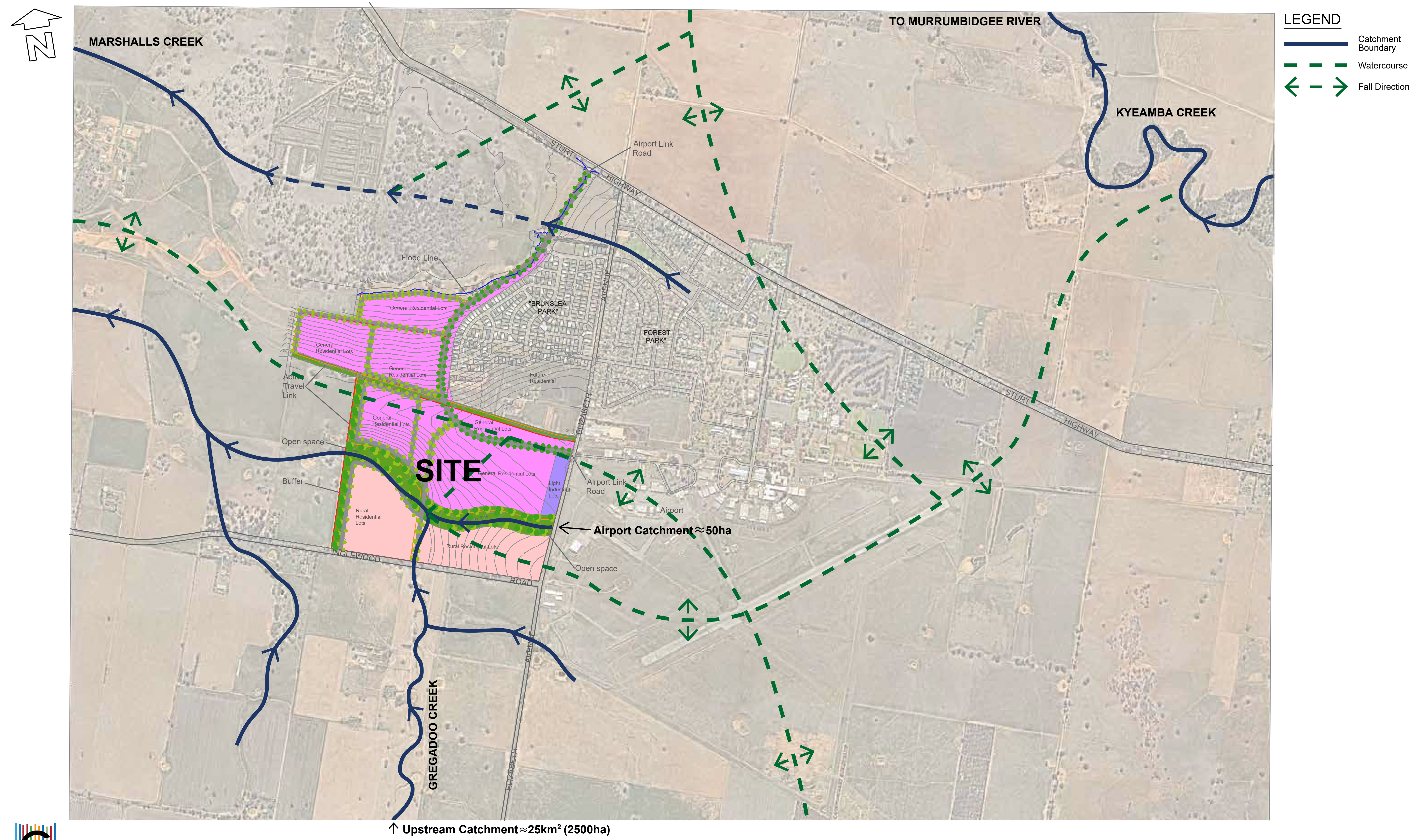
Issue D 25/08/21

NTS.

FIGURE 1

REGIONAL CATCHMENT PLAN



Civil Cert

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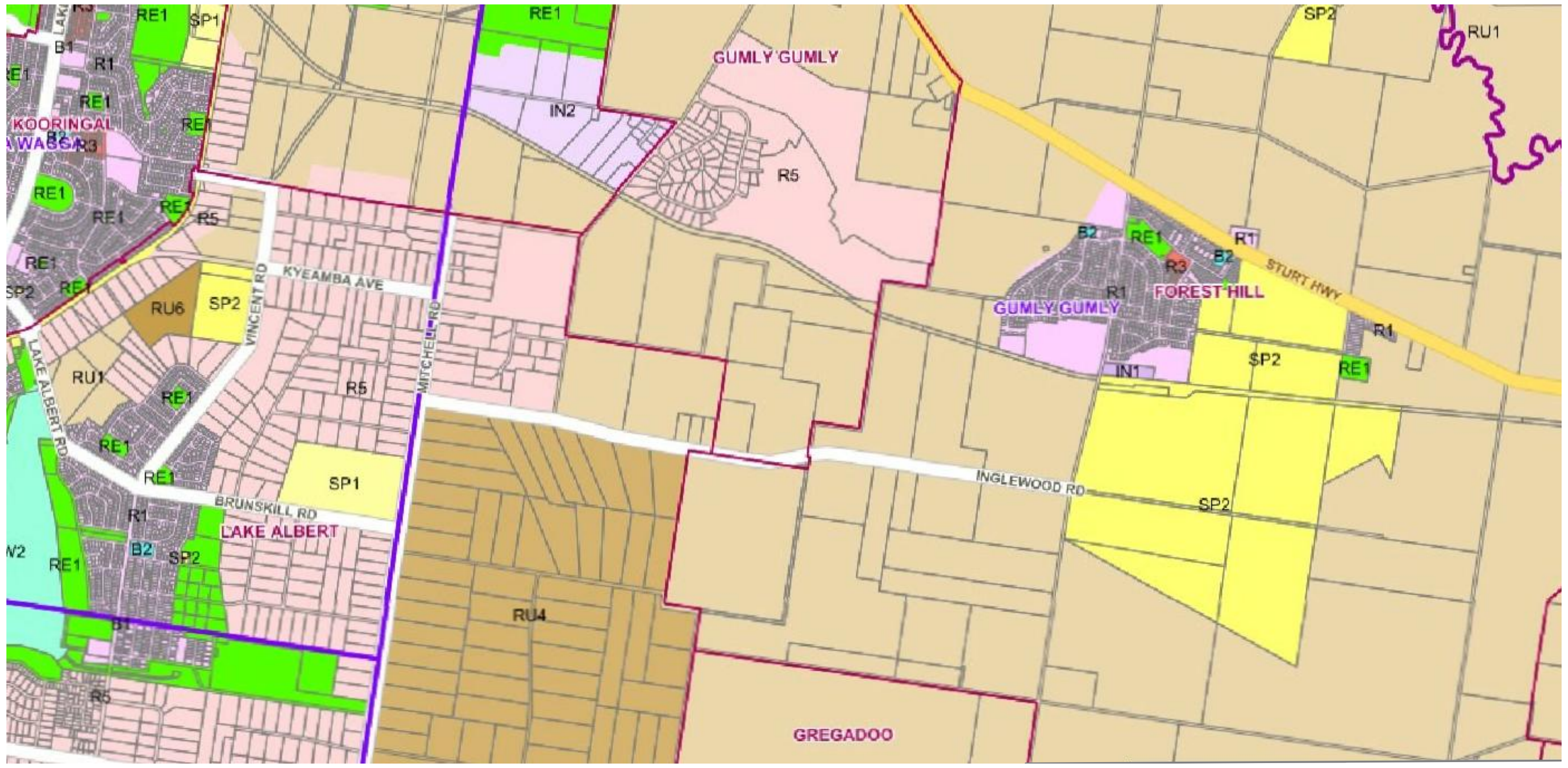
Issue A 25/08/21

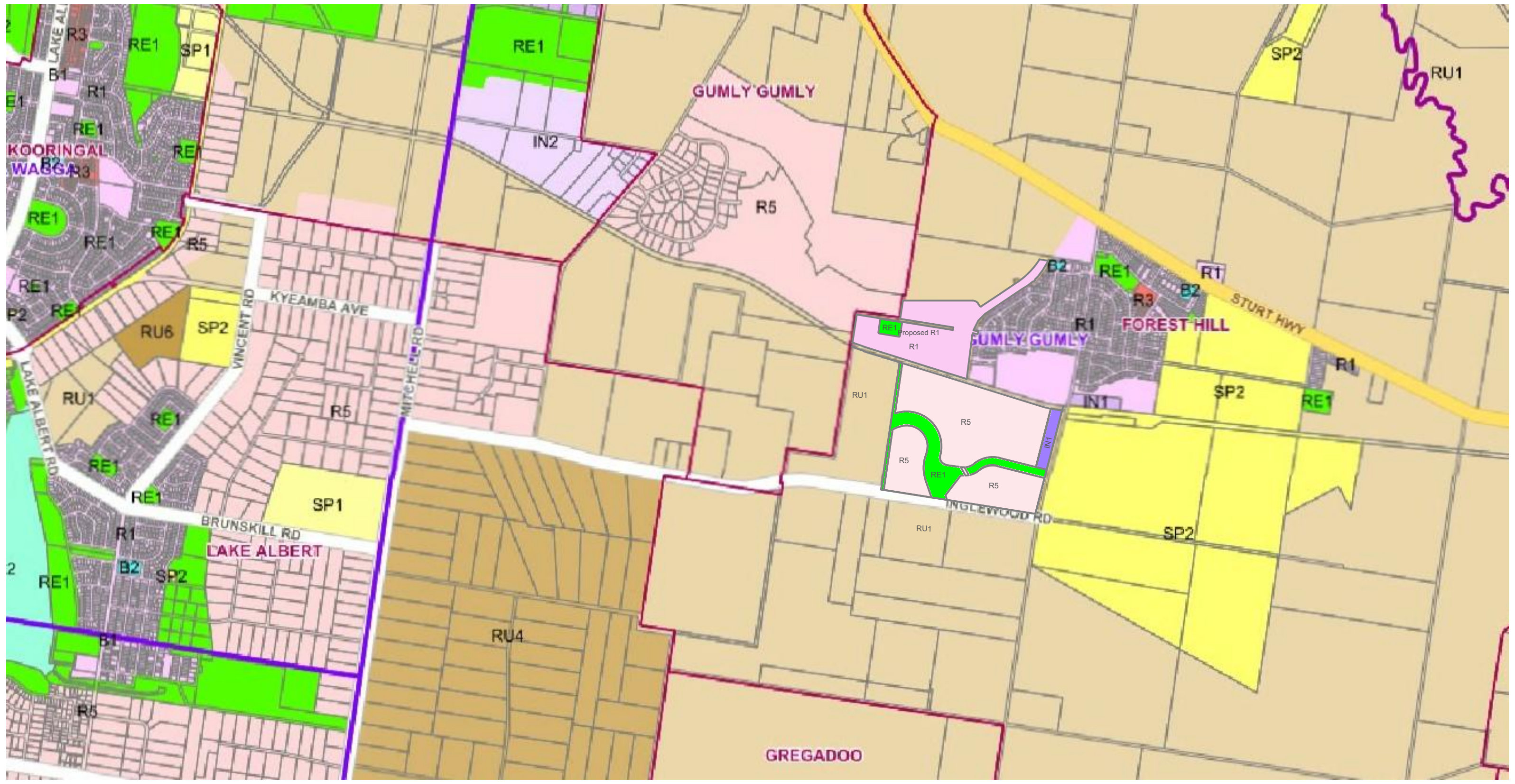
NTS.

FIGURE 2

APPENDIX A (*Proposed Development Layout & Zoning Map*)



Existing Zoning Map



Proposed Zoning Map

Zone

B1	Neighbourhood Centre
B2	Local Centre
B3	Commercial Core
B4	Mixed Use
B5	Business Development
B6	Enterprise Corridor
E1	National Parks and Nature Reserves
E2	Environmental Conservation
E4	Environmental Living
IN1	General Industrial
IN2	Light Industrial
R1	General Residential
R3	Medium Density Residential
R5	Large Lot Residential
RE1	Public Recreation
RE2	Private Recreation
RU1	Primary Production
RU2	Rural Landscape
RU3	Forestry
RU4	Primary Production Small Lots
RU5	Village
RU6	Transition
SP1	Special Activities
SP2	Infrastructure
W1	Natural Waterways
W2	Recreational Waterways

Offices
Thornleigh - 11 Dartford Rd, Thornleigh, NSW, 2120

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Drawn: NB	Datum:
Checked:	Date: 19/10/21
L.G.A: WAGGA WAGGA	A3

Client: WAKEFIELD ASHURST DEVELOPMENTS P/L

Project:
EXISTING AND PROPOSED ZONING PLAN
LOT 1401 DP 1262802 LOT 2 DP 1077748
LOT 2 DP 1262040 LOT 1 DP 1220149

Drg. No. 20974B - Zone
Sheet No. 4
of 6 sheets
Our Ref: 20974B

N

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PO BOX 230
Pennant Hills
N.S.W. 1715

planning consultants

APPENDIX B (*MUSIC*)

Post Dev (*with Treatment*) MUSIC Model

Source nodes

```
Location,total-site-pre-ag,rip-cor-sth,a,b1,b2,c,d,e,h,f,g
ID,1,6,7,8,9,10,11,17,19,20,23
Node
Type,AgriculturalSourceNode,ForestSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourc
eNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode
Zoning Surface Type,,,Mixed,Mixed,Mixed,Mixed,Mixed,Mixed,Mixed,Mixed,Mixed
Total Area (ha),155.7,15.7,36.6,8,8.5,12.8,8.8,14.5,18.6,30.2,2
Area Impervious
(ha),2.74217910447762,0.276507462686566,18.3,3.21611940298507,3.41712686567164,5.14579104477612,4.4,9.3
8117537313433,12.1038805970149,19.538723880597,1.2939552238806
Area Pervious
(ha),152.957820895522,15.4234925373134,18.3,4.78388059701493,5.08287313432836,7.65420895522388,4.4,5.11
882462686567,6.49611940298508,10.661276119403,0.706044776119403
Field Capacity (mm),25,80,25,25,25,25,25,25,25,25,25
Pervious Area Infiltration Capacity coefficient - a,200,200,200,200,200,200,200,200,200,200,200
Pervious Area Infiltration Capacity exponent - b,1,1,1,1,1,1,1,1,1,1,1
Impervious Area Rainfall Threshold (mm/day),0,1,0,0,0,0,0,0,0,0,0
Pervious Area Soil Storage Capacity (mm),40,120,40,40,40,40,40,40,40,40,40
Pervious Area Soil Initial Storage (% of Capacity),20,25,20,20,20,20,20,20,20,20,20
Groundwater Initial Depth (mm),1,10,1,1,1,1,1,1,1,1,1
Groundwater Daily Recharge Rate (%),25,25,25,25,25,25,25,25,25,25,25
Groundwater Daily Baseflow Rate (%),1,5,1,1,1,1,1,1,1,1,1
Groundwater Daily Deep Seepage Rate (%),15,0,15,15,15,15,15,15,15,15,15
Stormflow Total Suspended Solids Mean (log mg/L),2.041,1.9,2.19,2.19,2.19,2.19,2.19,2.19,2.19,2.19,2.19
Stormflow Total Suspended Solids Standard Deviation (log
mg/L),0,0.2,0.32,0.32,0.32,0.32,0.32,0.32,0.32,0.32,0.32
Stormflow Total Suspended Solids Estimation
Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochast
ic,Stochastic,Stochastic
Stormflow Total Suspended Solids Serial Correlation,0,0,0,0,0,0,0,0,0,0,0
Stormflow Total Phosphorus Mean (log mg/L),-0.662,-1.1,-0.65,-0.65,-0.65,-0.65,-0.65,-0.65,-0.65,-
0.65,-0.65
Stormflow Total Phosphorus Standard Deviation (log
mg/L),0,0.22,0.25,0.25,0.25,0.25,0.25,0.25,0.25,0.25,0.25
Stormflow Total Phosphorus Estimation
Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochast
ic,Stochastic,Stochastic
Stormflow Total Phosphorus Serial Correlation,0,0,0,0,0,0,0,0,0,0,0
Stormflow Total Nitrogen Mean (log mg/L),0.314,-
0.075,0.427,0.427,0.427,0.427,0.427,0.427,0.427,0.427,0.427
Stormflow Total Nitrogen Standard Deviation (log
mg/L),0,0.24,0.19,0.19,0.19,0.19,0.19,0.19,0.19,0.19,0.19
Stormflow Total Nitrogen Estimation
Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochast
ic,Stochastic,Stochastic
Stormflow Total Nitrogen Serial Correlation,0,0,0,0,0,0,0,0,0,0,0
Baseflow Total Suspended Solids Mean (log mg/L),1.4,0.9,1.4,1.4,1.4,1.4,1.4,1.4,1.4,1.4,1.4
Baseflow Total Suspended Solids Standard Deviation (log
mg/L),0,0.13,0.17,0.17,0.17,0.17,0.17,0.17,0.17,0.17,0.17
Baseflow Total Suspended Solids Estimation
Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochast
ic,Stochastic,Stochastic
Baseflow Total Suspended Solids Serial Correlation,0,0,0,0,0,0,0,0,0,0,0
Baseflow Total Phosphorus Mean (log mg/L),-0.88,-1.5,-0.82,-0.82,-0.82,-0.82,-0.82,-0.82,-0.82,-0.82,-
0.82
Baseflow Total Phosphorus Standard Deviation (log
mg/L),0,0.13,0.19,0.19,0.19,0.19,0.19,0.19,0.19,0.19,0.19
Baseflow Total Phosphorus Estimation
Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochast
ic,Stochastic,Stochastic
Baseflow Total Phosphorus Serial Correlation,0,0,0,0,0,0,0,0,0,0,0
Baseflow Total Nitrogen Mean (log mg/L),0.074,-0.14,0.32,0.32,0.32,0.32,0.32,0.32,0.32,0.32,0.32
Baseflow Total Nitrogen Standard Deviation (log
mg/L),0,0.13,0.12,0.12,0.12,0.12,0.12,0.12,0.12,0.12,0.12
Baseflow Total Nitrogen Estimation
Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochast
ic,Stochastic,Stochastic
Baseflow Total Nitrogen Serial Correlation,0,0,0,0,0,0,0,0,0,0,0
Flow based constituent generation - enabled,Off,Off,Off,Off,Off,Off,Off,Off,Off,Off,Off
Flow based constituent generation - flow file, , , , , , , , , , ,
Flow based constituent generation - base flow column, , , , , , , , , , ,
```

Flow based constituent generation - pervious flow column, , , , , , , , , , ,
Flow based constituent generation - impervious flow column, , , , , , , , , , ,
Flow based constituent generation - unit, , , , , , , , , , ,
OUT - Mean Annual Flow (ML/yr),149,7.41,135,25.0,26.6,40.0,32.5,66.0,84.7,138,9.11
OUT - TSS Mean Annual Load (kg/yr),16.1E3,308,27.4E3,5.05E3,5.18E3,8.05E3,6.35E3,13.3E3,17.0E3,27.3E3,1.83E3
OUT - TP Mean Annual Load (kg/yr),32.2,0.364,35.7,6.63,6.79,10.9,8.34,18.0,23.1,37.6,2.48
OUT - TN Mean Annual Load (kg/yr),304,7.39,393,72.7,79.5,116,97.4,191,245,395,26.4
OUT - Gross Pollutant Mean Annual Load (kg/yr),160,13.6,5.33E3,997,1.06E3,1.59E3,1.28E3,2.50E3,3.20E3,5.20E3,344
Rain In (ML/yr),1020.26,102.877,239.829,52.4216,55.6979,83.8746,57.6637,95.0142,121.88,197.892,13.1054
ET Loss (ML/yr),815.973,96.0439,97.8625,25.6688,27.2731,41.0698,23.5297,27.1392,34.8132,56.5245,3.74336
Deep Seepage Loss (ML/yr),58.209,0,6.98115,1.83112,1.94556,2.92979,1.67853,1.93603,2.48346,4.03228,0.267039
Baseflow Out (ML/yr),3.29852,4.9134,0.395599,0.103764,0.110249,0.166022,0.0951166,0.109708,0.140729,0.228496,0.0151322
Imp. Stormflow Out (ML/yr),20.4051,1.77459,119.914,20.9686,22.2792,33.5498,28.8319,61.7592,79.2222,128.63,8.51852
Perv. Stormflow Out (ML/yr),125.238,0.72424,15.0201,3.9397,4.18593,6.30352,3.61139,4.16541,5.34322,8.67554,0.574539
Total Stormflow Out (ML/yr),145.643,2.49883,134.935,24.9083,26.4651,39.8534,32.4433,65.9246,84.5654,137.305,9.09306
Total Outflow (ML/yr),148.942,7.41223,135.33,25.0121,26.5754,40.0194,32.5384,66.0343,84.7061,137.534,9.10819
Change in Soil Storage (ML/yr),-2.86991,-0.578498,-0.344195,-0.0902807,-0.0959232,-0.144449,-0.0827573,-0.095453,-0.122443,-0.198806,-0.0131659
TSS Baseflow Out (kg/yr),82.855,41.2839,10.4404,2.73847,2.96733,4.58584,2.56005,3.03036,3.88722,6.12163,0.417981
TSS Total Stormflow Out (kg/yr),16006.3,267.192,27389.8,5050.13,5177.44,8040.48,6349.97,13251,16997.9,27303.2,1827.72
TSS Total Outflow (kg/yr),16089.1,308.476,27400.3,5052.87,5180.41,8045.07,6352.53,13254,17001.7,27309.3,1828.14
TP Baseflow Out (kg/yr),0.434829,0.161692,0.0657557,0.0172474,0.0186503,0.0271546,0.0160905,0.017944,0.0230178,0.0380433,0.002475
TP Total Stormflow Out (kg/yr),31.7169,0.202529,35.6798,6.60856,6.77318,10.8619,8.32036,17.9936,23.0814,37.5249,2.48187
TP Total Outflow (kg/yr),32.1517,0.364221,35.7456,6.62581,6.79183,10.889,8.33645,18.0115,23.1044,37.563,2.48435
TN Baseflow Out (kg/yr),3.91127,3.82374,0.850392,0.223054,0.242238,0.364266,0.208989,0.24071,0.308772,0.489421,0.0332013
TN Total Stormflow Out (kg/yr),300.117,3.56822,391.73,72.4526,79.2807,115.583,97.2178,190.809,244.762,394.92,26.3185
TN Total Outflow (kg/yr),304.028,7.39196,392.581,72.6756,79.5229,115.947,97.4268,191.05,245.071,395.409,26.3517
GP Total Outflow (kg/yr),160.039,14.9775,5337.72,998.459,1060.86,1597.53,1283.39,2497.32,3203.46,5201.32,344.458

No Imported Data Source nodes

USTM treatment nodes

Location,basin-a,basin-b1,basin-b2,basin-c,basin-d,basin-e,basin-f
ID,12,13,14,15,16,18,22
Node Type,BioRetentionNodeV4,BioRetentionNodeV4,BioRetentionNodeV4,BioRetentionNodeV4,BioRetentionNodeV4,BioRetentionNodeV4,BioRetentionNodeV4
Lo-flow bypass rate (cum/sec),0,0,0,0,0,0,0
Hi-flow bypass rate (cum/sec),10,10,10,10,10,10,10
Inlet pond volume, , , , , , ,
Area (sqm),9100,2000,2500,3200,2200,3600,12000
Initial Volume (m^3), , , , , , ,
Extended detention depth (m),0.2,0.2,0.2,0.2,0.2,0.2,0.2
Number of Rainwater tanks, , , , , , ,
Permanent Pool Volume (cubic metres), , , , , , ,
Proportion vegetated, , , , , , ,
Equivalent Pipe Diameter (mm), , , , , , ,
Overflow weir width (m),25,20,20,25,25,25,50
Notional Detention Time (hrs), , , , , , ,
Orifice Discharge Coefficient, , , , , , ,
Weir Coefficient,1.7,1.7,1.7,1.7,1.7,1.7,1.7
Number of CSTR Cells,3,3,3,3,3,3,3
Total Suspended Solids - k (m/yr),8000,8000,8000,8000,8000,8000,8000

```
Total Suspended Solids - C* (mg/L),20,20,20,20,20,20,20
Total Suspended Solids - C** (mg/L), , , , , , ,
Total Phosphorus - k (m/yr),6000,6000,6000,6000,6000,6000,6000
Total Phosphorus - C* (mg/L),0.13,0.13,0.13,0.13,0.13,0.13,0.13
Total Phosphorus - C** (mg/L), , , , , , ,
Total Nitrogen - k (m/yr),500,500,500,500,500,500,500
Total Nitrogen - C* (mg/L),1.4,1.4,1.4,1.4,1.4,1.4,1.4
Total Nitrogen - C** (mg/L), , , , , , ,
Threshold Hydraulic Loading for C** (m/yr), , , , , , ,
Horizontal Flow Coefficient,3,3,3,3,3,3,3
Reuse Enabled,Off,Off,Off,Off,Off,Off,Off
Max drawdown height (m), , , , , , ,
Annual Demand Enabled,Off,Off,Off,Off,Off,Off,Off
Annual Demand Value (ML/year), , , , , , ,
Annual Demand Distribution, , , , , , ,
Annual Demand Monthly Distribution: Jan, , , , , , ,
Annual Demand Monthly Distribution: Feb, , , , , , ,
Annual Demand Monthly Distribution: Mar, , , , , , ,
Annual Demand Monthly Distribution: Apr, , , , , , ,
Annual Demand Monthly Distribution: May, , , , , , ,
Annual Demand Monthly Distribution: Jun, , , , , , ,
Annual Demand Monthly Distribution: Jul, , , , , , ,
Annual Demand Monthly Distribution: Aug, , , , , , ,
Annual Demand Monthly Distribution: Sep, , , , , , ,
Annual Demand Monthly Distribution: Oct, , , , , , ,
Annual Demand Monthly Distribution: Nov, , , , , , ,
Annual Demand Monthly Distribution: Dec, , , , , , ,
Daily Demand Enabled,Off,Off,Off,Off,Off,Off,Off
Daily Demand Value (ML/day), , , , , , ,
Custom Demand Enabled,Off,Off,Off,Off,Off,Off,Off
Custom Demand Time Series File, , , , , , ,
Custom Demand Time Series Units, , , , , , ,
Filter area (sqm),4550,1000,1250,1600,1100,1800,6000
Filter perimeter (m),270,126,141,160,132,170,309
Filter depth (m),1,1,1,1,1,1,1
Filter Median Particle Diameter (mm), , , , , , ,
Saturated Hydraulic Conductivity (mm/hr),100,100,100,100,100,100,100
Infiltration Media Porosity,0.35,0.35,0.35,0.35,0.35,0.35,0.35
Length (m), , , , , , ,
Bed slope, , , , , , ,
Base Width (m), , , , , , ,
Top width (m), , , , , , ,
Vegetation height (m), , , , , , ,
Vegetation Type,Vegetated with Effective Nutrient Removal Plants,Vegetated with Effective Nutrient
Removal Plants,Vegetated with Effective Nutrient Removal Plants,Vegetated with Effective Nutrient
Removal Plants,Vegetated with Effective Nutrient Removal Plants,Vegetated with Effective Nutrient
Removal Plants,Vegetated with Effective Nutrient Removal Plants
Total Nitrogen Content in Filter (mg/kg),800,800,800,800,800,800,800
Orthophosphate Content in Filter (mg/kg),55,55,55,55,55,55,55
Is Base Lined?,No,No,No,No,No,No,No
Is Underdrain Present?,Yes,Yes,Yes,Yes,Yes,Yes,Yes
Is Submerged Zone Present?,No,No,No,No,No,No,No
Submerged Zone Depth (m), , , , , , ,
B for Media Soil Texture,13,13,13,13,13,13,13
Proportion of upstream impervious area treated, , , , , , ,
Exfiltration Rate (mm/hr),0.4,0.4,0.4,0.4,0.4,0.4,0.4
Evaporative Loss as % of PET,100,100,100,100,100,100,100
Depth in metres below the drain pipe, , , , , , ,
TSS A Coefficient, , , , , , ,
TSS B Coefficient, , , , , , ,
TP A Coefficient, , , , , , ,
TP B Coefficient, , , , , , ,
TN A Coefficient, , , , , , ,
TN B Coefficient, , , , , , ,
Sfc,0.61,0.61,0.61,0.61,0.61,0.61,0.61
S*,0.37,0.37,0.37,0.37,0.37,0.37,0.37
Sw,0.11,0.11,0.11,0.11,0.11,0.11,0.11
Sh,0.05,0.05,0.05,0.05,0.05,0.05,0.05
Emax (m/day),0.008,0.008,0.008,0.008,0.008,0.008,0.008
Ew (m/day),0.001,0.001,0.001,0.001,0.001,0.001,0.001
IN - Mean Annual Flow (ML/yr),135,25.0,26.6,40.0,32.5,66.0,222
IN - TSS Mean Annual Load (kg/yr),8.22E3,1.52E3,1.55E3,2.41E3,1.91E3,3.98E3,13.3E3
IN - TP Mean Annual Load (kg/yr),25.0,4.64,4.75,7.62,5.84,12.6,42.5
IN - TN Mean Annual Load (kg/yr),393,72.7,79.5,116,97.4,191,640
IN - Gross Pollutant Mean Annual Load (kg/yr),107,19.9,21.2,31.9,25.6,49.9,168
```

OUT - Mean Annual Flow (ML/yr),117,21.1,21.8,33.8,28.2,58.7,198
OUT - TSS Mean Annual Load (kg/yr),305,55.6,50.7,89.2,73.6,155,524
OUT - TP Mean Annual Load (kg/yr),14.0,2.52,2.60,4.03,3.35,6.97,23.5
OUT - TN Mean Annual Load (kg/yr),77.0,13.9,13.8,22.2,18.6,38.4,129
OUT - Gross Pollutant Mean Annual Load (kg/yr),0.00,0.00,0.00,0.00,0.00,0.00,0.00
Flow In (ML/yr),135.33,25.012,26.5753,40.0193,32.5383,66.0342,222.239
ET Loss (ML/yr),10.2473,2.23805,2.78588,3.58088,2.47702,4.08541,13.622
Infiltration Loss (ML/yr),7.77051,1.6348,1.96615,2.61542,1.87688,3.21737,10.742
Low Flow Bypass Out (ML/yr),0,0,0,0,0,0,0
High Flow Bypass Out (ML/yr),0,0,0,0,0,0,0
Orifice / Filter Out (ML/yr),113.49,20.4397,21.4936,32.708,27.2573,56.6662,190.781
Weir Out (ML/yr),3.81894,0.700306,0.331219,1.11622,0.926429,2.05795,7.06857
Transfer Function Out (ML/yr),0,0,0,0,0,0,0
Reuse Supplied (ML/yr),0,0,0,0,0,0,0
Reuse Requested (ML/yr),0,0,0,0,0,0,0
% Reuse Demand Met,0,0,0,0,0,0,0
% Load Reduction,13.3164,15.4809,17.8756,15.4804,13.3829,11.0701,10.9744
TSS Flow In (kg/yr),8220.06,1515.86,1554.12,2413.51,1905.76,3976.2,13293.3
TSS ET Loss (kg/yr),0,0,0,0,0,0,0
TSS Infiltration Loss (kg/yr),17.7528,3.78165,4.49926,6.03801,4.29444,7.30458,24.5098
TSS Low Flow Bypass Out (kg/yr),0,0,0,0,0,0,0
TSS High Flow Bypass Out (kg/yr),0,0,0,0,0,0,0
TSS Orifice / Filter Out (kg/yr),227.185,41.3233,43.9189,66.1263,54.5833,112.16,377.395
TSS Weir Out (kg/yr),78.2005,14.2867,6.74359,23.0968,19.0261,42.4589,146.647
TSS Transfer Function Out (kg/yr),0,0,0,0,0,0,0
TSS Reuse Supplied (kg/yr),0,0,0,0,0,0,0
TSS Reuse Requested (kg/yr),0,0,0,0,0,0,0
TSS % Reuse Demand Met,0,0,0,0,0,0,0
TSS % Load Reduction,96.2849,96.3314,96.7401,96.3032,96.1375,96.1114,96.0578
TP Flow In (kg/yr),25.0219,4.63806,4.75427,7.62229,5.8355,12.608,42.467
TP ET Loss (kg/yr),0,0,0,0,0,0,0
TP Infiltration Loss (kg/yr),0.931631,0.19648,0.236585,0.314277,0.225007,0.384421,1.2841
TP Low Flow Bypass Out (kg/yr),0,0,0,0,0,0,0
TP High Flow Bypass Out (kg/yr),0,0,0,0,0,0,0
TP Orifice / Filter Out (kg/yr),13.4577,2.42936,2.56103,3.88751,3.23247,6.70197,22.5609
TP Weir Out (kg/yr),0.504054,0.0921842,0.0431235,0.146034,0.1209,0.26879,0.928529
TP Transfer Function Out (kg/yr),0,0,0,0,0,0,0
TP Reuse Supplied (kg/yr),0,0,0,0,0,0,0
TP Reuse Requested (kg/yr),0,0,0,0,0,0,0
TP % Reuse Demand Met,0,0,0,0,0,0,0
TP % Load Reduction,44.2016,45.6336,45.2249,47.0822,42.535,44.7118,44.6878
TN Flow In (kg/yr),392.58,72.6754,79.5227,115.947,97.4265,191.049,640.479
TN ET Loss (kg/yr),0,0,0,0,0,0,0
TN Infiltration Loss (kg/yr),4.81092,1.01313,1.20869,1.61606,1.16071,1.9893,6.64284
TN Low Flow Bypass Out (kg/yr),0,0,0,0,0,0,0
TN High Flow Bypass Out (kg/yr),0,0,0,0,0,0,0
TN Orifice / Filter Out (kg/yr),68.327,12.3346,13.0204,19.7559,16.4497,34.0734,114.509
TN Weir Out (kg/yr),8.69366,1.57217,0.783476,2.44214,2.15743,4.37176,14.4919
TN Transfer Function Out (kg/yr),0,0,0,0,0,0,0
TN Reuse Supplied (kg/yr),0,0,0,0,0,0,0
TN Reuse Requested (kg/yr),0,0,0,0,0,0,0
TN % Reuse Demand Met,0,0,0,0,0,0,0
TN % Load Reduction,80.3809,80.8645,82.6416,80.8549,80.9013,79.8768,79.8587
GP Flow In (kg/yr),106.624,19.937,21.183,31.8992,25.6363,49.9089,167.969
GP ET Loss (kg/yr),0,0,0,0,0,0,0
GP Infiltration Loss (kg/yr),0,0,0,0,0,0,0
GP Low Flow Bypass Out (kg/yr),0,0,0,0,0,0,0
GP High Flow Bypass Out (kg/yr),0,0,0,0,0,0,0
GP Orifice / Filter Out (kg/yr),0,0,0,0,0,0,0
GP Weir Out (kg/yr),0,0,0,0,0,0,0
GP Transfer Function Out (kg/yr),0,0,0,0,0,0,0
GP Reuse Supplied (kg/yr),0,0,0,0,0,0,0
GP Reuse Requested (kg/yr),0,0,0,0,0,0,0
GP % Reuse Demand Met,0,0,0,0,0,0,0
GP % Load Reduction,100,100,100,100,100,100,100
PET Scaling Factor,2.1,2.1,2.1,2.1,2.1,2.1,2.1

Generic treatment nodes

Location,gpt-f (CDS2028),gpt-e (CDS1512),gpt-g (CDS1009),gpt-a (CDS2018),gpt-b1 (CDS1015), gpt-b2 (CDS1015),gpt-c (CDS1512),gpt-d (CDS1015)
ID,21,24,25,26,27,28,29,30
Node Type,GPTNode,GPTNode,GPTNode,GPTNode,GPTNode,GPTNode,GPTNode,GPTNode
Lo-flow bypass rate (cum/sec),0,0,0,0,0,0,0,0
Hi-flow bypass rate (cum/sec),0.8,0.22,0.1,0.53,0.18,0.18,0.22,0.18

```
Flow Transfer Function
Input (cum/sec),0,0,0,0,0,0,0,0
Output (cum/sec),0,0,0,0,0,0,0,0
Input (cum/sec),10,10,10,10,10,10,10,10
Output (cum/sec),10,10,10,10,10,10,10,10
Input (cum/sec), , , , , , , ,
Output (cum/sec), , , , , , , ,
Input (cum/sec), , , , , , , ,
Output (cum/sec), , , , , , , ,
Input (cum/sec), , , , , , , ,
Output (cum/sec), , , , , , , ,
Input (cum/sec), , , , , , , ,
Output (cum/sec), , , , , , , ,
Input (cum/sec), , , , , , , ,
Output (cum/sec), , , , , , , ,
Input (cum/sec), , , , , , , ,
Output (cum/sec), , , , , , , ,
Input (cum/sec), , , , , , , ,
Output (cum/sec), , , , , , , ,
Input (cum/sec), , , , , , , ,
Output (cum/sec), , , , , , , ,
Gross Pollutant Transfer Function
Enabled,True,True,True,True,True,True,True,True
Input (kg/ML),0,0,0,0,0,0,0,0
Output (kg/ML),0,0,0,0,0,0,0,0
Input (kg/ML),100,100,100,100,100,100,100,100
Output (kg/ML),2,2,2,2,2,2,2,2
Input (kg/ML), , , , , , , ,
Output (kg/ML), , , , , , , ,
Input (kg/ML), , , , , , , ,
Output (kg/ML), , , , , , , ,
Input (kg/ML), , , , , , , ,
Output (kg/ML), , , , , , , ,
Input (kg/ML), , , , , , , ,
Output (kg/ML), , , , , , , ,
Input (kg/ML), , , , , , , ,
Output (kg/ML), , , , , , , ,
Input (kg/ML), , , , , , , ,
Output (kg/ML), , , , , , , ,
Input (kg/ML), , , , , , , ,
Output (kg/ML), , , , , , , ,
Input (kg/ML), , , , , , , ,
Output (kg/ML), , , , , , , ,
Total Nitrogen Transfer Function
Enabled,True,True,True,True,True,True,True,True
Input (mg/L),0,0,0,0,0,0,0,0
Output (mg/L),0,0,0,0,0,0,0,0
Input (mg/L),50,50,50,50,50,50,50,50
Output (mg/L),50,50,50,50,50,50,50,50
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Total Phosphorus Transfer Function
Enabled,True,True,True,True,True,True,True,True
Input (mg/L),0,0,0,0,0,0,0,0
Output (mg/L),0,0,0,0,0,0,0,0
Input (mg/L),100,100,100,100,100,100,100,100
Output (mg/L),70,70,70,70,70,70,70,70
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
```

```
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Total Suspended Solids Transfer Function
Enabled,True,True,True,True,True,True,True,True
Input (mg/L),0,0,0,0,0,0,0,0
Output (mg/L),0,0,0,0,0,0,0,0
Input (mg/L),100,100,100,100,100,100,100,100
Output (mg/L),30,30,30,30,30,30,30,30
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
Input (mg/L), , , , , , , ,
Output (mg/L), , , , , , , ,
TSS Flow based Efficiency Enabled,Off,Off,Off,Off,Off,Off,Off,Off
TSS Flow based Efficiency, , , , , , , ,
TP Flow based Efficiency Enabled,Off,Off,Off,Off,Off,Off,Off,Off
TP Flow based Efficiency, , , , , , , ,
TN Flow based Efficiency Enabled,Off,Off,Off,Off,Off,Off,Off,Off
TN Flow based Efficiency, , , , , , , ,
GP Flow based Efficiency Enabled,Off,Off,Off,Off,Off,Off,Off,Off
GP Flow based Efficiency, , , , , , , ,
IN - Mean Annual Flow (ML/yr),222,66.0,9.11,135,25.0,26.6,40.0,32.5
IN - TSS Mean Annual Load (kg/yr),44.3E3,13.3E3,1.83E3,27.4E3,5.05E3,5.18E3,8.05E3,6.35E3
IN - TP Mean Annual Load (kg/yr),60.7,18.0,2.48,35.7,6.63,6.79,10.9,8.34
IN - TN Mean Annual Load (kg/yr),640,191,26.4,393,72.7,79.5,116,97.4
IN - Gross Pollutant Mean Annual Load (kg/yr),8.40E3,2.50E3,344,5.33E3,997,1.06E3,1.59E3,1.28E3
OUT - Mean Annual Flow (ML/yr),222,66.0,9.11,135,25.0,26.6,40.0,32.5
OUT - TSS Mean Annual Load (kg/yr),13.3E3,3.98E3,548,8.22E3,1.52E3,1.55E3,2.41E3,1.91E3
OUT - TP Mean Annual Load (kg/yr),42.5,12.6,1.74,25.0,4.64,4.75,7.62,5.84
OUT - TN Mean Annual Load (kg/yr),640,191,26.4,393,72.7,79.5,116,97.4
OUT - Gross Pollutant Mean Annual Load (kg/yr),168,49.9,6.88,107,19.9,21.2,31.9,25.6
Flow In (ML/yr),222.24,66.0342,9.10815,135.33,25.0121,26.5754,40.0193,32.5383
ET Loss (ML/yr),0,0,0,0,0,0,0,0
Infiltration Loss (ML/yr),0,0,0,0,0,0,0,0
Low Flow Bypass Out (ML/yr),0,0,0,0,0,0,0,0
High Flow Bypass Out (ML/yr),0,0,0,0,0,0,0,0
Orifice / Filter Out (ML/yr),0,0,0,0,0,0,0,0
Weir Out (ML/yr),0,0,0,0,0,0,0,0
Transfer Function Out (ML/yr),222.24,66.0342,9.10815,135.33,25.0121,26.5754,40.0193,32.5383
Reuse Supplied (ML/yr),0,0,0,0,0,0,0,0
Reuse Requested (ML/yr),0,0,0,0,0,0,0,0
% Reuse Demand Met,0,0,0,0,0,0,0,0
% Load Reduction,0,0,0,0,0,0,0,0
TSS Flow In (kg/yr),44310.9,13254,1828.14,27400.2,5052.86,5180.39,8045.05,6352.52
TSS ET Loss (kg/yr),0,0,0,0,0,0,0,0
TSS Infiltration Loss (kg/yr),0,0,0,0,0,0,0,0
TSS Low Flow Bypass Out (kg/yr),0,0,0,0,0,0,0,0
TSS High Flow Bypass Out (kg/yr),0,0,0,0,0,0,0,0
TSS Orifice / Filter Out (kg/yr),0,0,0,0,0,0,0,0
TSS Weir Out (kg/yr),0,0,0,0,0,0,0,0
TSS Transfer Function Out (kg/yr),13293.3,3976.2,548.442,8220.06,1515.86,1554.12,2413.52,1905.76
TSS Reuse Supplied (kg/yr),0,0,0,0,0,0,0,0
TSS Reuse Requested (kg/yr),0,0,0,0,0,0,0,0
TSS % Reuse Demand Met,0,0,0,0,0,0,0,0
```

TSS % Load Reduction,70,70,70,70,70,70,70,70
TP Flow In (kg/yr),60.6672,18.0115,2.48434,35.7454,6.62579,6.79181,10.889,8.33642
TP ET Loss (kg/yr),0,0,0,0,0,0,0,0
TP Infiltration Loss (kg/yr),0,0,0,0,0,0,0,0
TP Low Flow Bypass Out (kg/yr),0,0,0,0,0,0,0,0
TP High Flow Bypass Out (kg/yr),0,0,0,0,0,0,0,0
TP Orifice / Filter Out (kg/yr),0,0,0,0,0,0,0,0
TP Weir Out (kg/yr),0,0,0,0,0,0,0,0
TP Transfer Function Out (kg/yr),42.467,12.608,1.73904,25.0219,4.63806,4.75427,7.62229,5.8355
TP Reuse Supplied (kg/yr),0,0,0,0,0,0,0,0
TP Reuse Requested (kg/yr),0,0,0,0,0,0,0,0
TP % Reuse Demand Met,0,0,0,0,0,0,0,0
TP % Load Reduction,30.0001,30,30.0001,29.9998,29.9999,29.9999,29.9999,30
TN Flow In (kg/yr),640.479,191.049,26.3516,392.58,72.6754,79.5227,115.946,97.4266
TN ET Loss (kg/yr),0,0,0,0,0,0,0,0
TN Infiltration Loss (kg/yr),0,0,0,0,0,0,0,0
TN Low Flow Bypass Out (kg/yr),0,0,0,0,0,0,0,0
TN High Flow Bypass Out (kg/yr),0,0,0,0,0,0,0,0
TN Orifice / Filter Out (kg/yr),0,0,0,0,0,0,0,0
TN Weir Out (kg/yr),0,0,0,0,0,0,0,0
TN Transfer Function Out (kg/yr),640.479,191.049,26.3516,392.58,72.6754,79.5227,115.946,97.4266
TN Reuse Supplied (kg/yr),0,0,0,0,0,0,0,0
TN Reuse Requested (kg/yr),0,0,0,0,0,0,0,0
TN % Reuse Demand Met,0,0,0,0,0,0,0,0
TN % Load Reduction,0,0,0,0,0,0,0,0
GP Flow In (kg/yr),8398.47,2495.45,344.2,5331.18,996.848,1059.15,1594.96,1281.81
GP ET Loss (kg/yr),0,0,0,0,0,0,0,0
GP Infiltration Loss (kg/yr),0,0,0,0,0,0,0,0
GP Low Flow Bypass Out (kg/yr),0,0,0,0,0,0,0,0
GP High Flow Bypass Out (kg/yr),0,0,0,0,0,0,0,0
GP Orifice / Filter Out (kg/yr),0,0,0,0,0,0,0,0
GP Weir Out (kg/yr),0,0,0,0,0,0,0,0
GP Transfer Function Out (kg/yr),167.969,49.9089,6.884,106.624,19.937,21.183,31.8992,25.6363
GP Reuse Supplied (kg/yr),0,0,0,0,0,0,0,0
GP Reuse Requested (kg/yr),0,0,0,0,0,0,0,0
GP % Reuse Demand Met,0,0,0,0,0,0,0,0
GP % Load Reduction,100,100,100,100,100,100,100,100

Other nodes
Location,Pre-Development Node,Post-Development Node,nth-out,sth-out
ID,2,3,4,5
Node Type,PreDevelopmentNode,PostDevelopmentNode,JunctionNode,JunctionNode
IN - Mean Annual Flow (ML/yr),149,495,266,230
IN - TSS Mean Annual Load (kg/yr),16.1E3,2.11E3,1.23E3,883
IN - TP Mean Annual Load (kg/yr),32.2,59.0,32.2,26.8
IN - TN Mean Annual Load (kg/yr),304,347,194,153
IN - Gross Pollutant Mean Annual Load (kg/yr),160,20.5,6.88,13.6
OUT - Mean Annual Flow (ML/yr),149,495,266,230
OUT - TSS Mean Annual Load (kg/yr),16.1E3,2.11E3,1.23E3,883
OUT - TP Mean Annual Load (kg/yr),32.2,59.0,32.2,26.8
OUT - TN Mean Annual Load (kg/yr),304,347,194,153
OUT - Gross Pollutant Mean Annual Load (kg/yr),160,20.5,6.88,13.6
% Load Reduction,0.00,12.2,10.7,13.9
TSS % Load Reduction,0.00,98.1,97.9,98.3
TN % Load Reduction,0.00,78.6,77.4,80.0
TP % Load Reduction,0.00,60.6,60.3,61.0
GP % Load Reduction,0.00,99.9,99.9,99.9

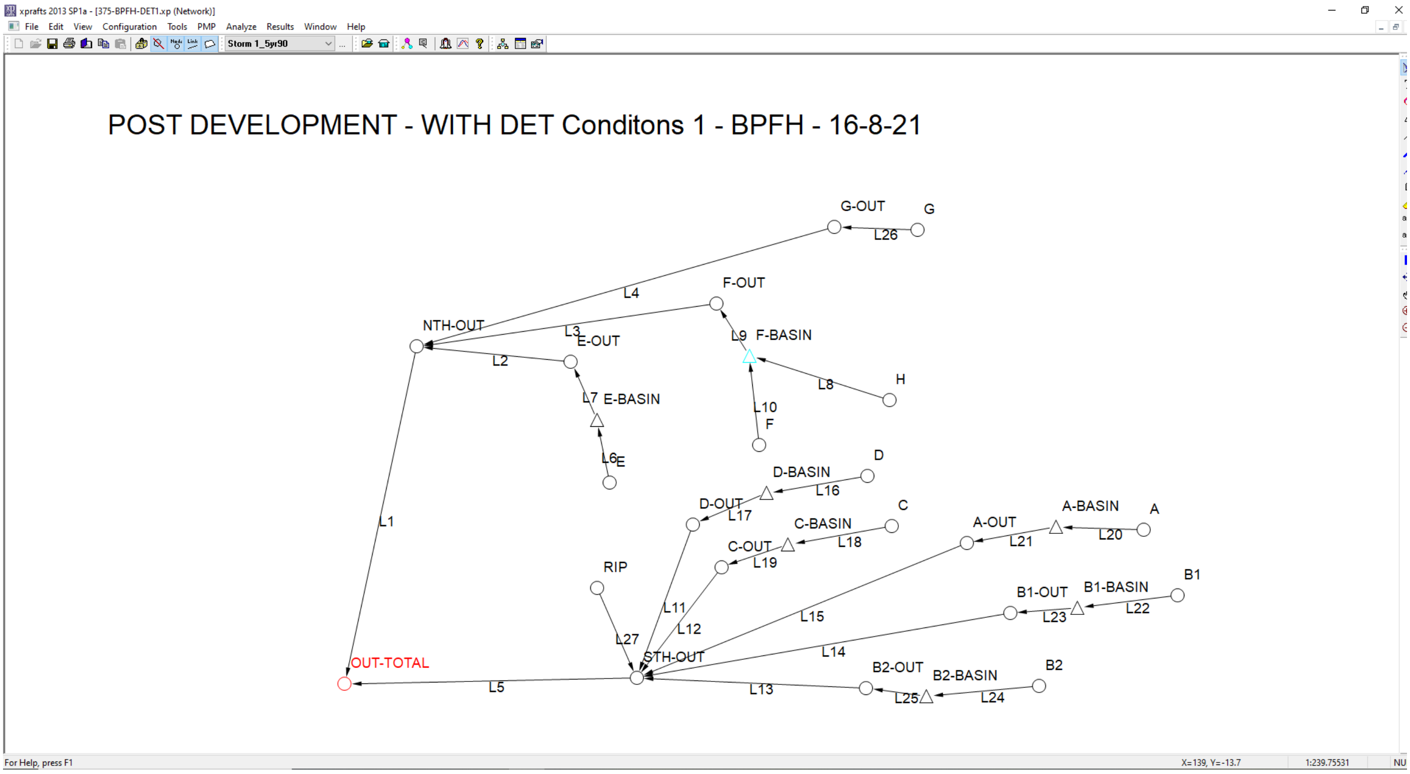
Links
Location,Drainage Link
Source node ID,1,4,5,6,12,13,14,15,16,18,19,20,21,22,17,24,23,25,7,26,8,27,9,28,10,29,11,30
Target node ID,2,3,3,5,5,5,5,5,5,4,21,21,22,4,24,18,25,4,26,12,27,13,28,14,29,15,30,16
Muskingum-Cunge Routing,Not Routed
Muskingum K, ,
Muskingum theta, ,
IN - Mean Annual Flow (ML/yr),149,266,230,7.41,117,21.1,21.8,33.8,28.2,58.7,84.7,138,222,198,66.0,66.0,9.11,9.11,135,135,25.0,25.0,26.6,26.6,40.0,40.0,32.5,32.5

IN - TSS Mean Annual Load
(kg/yr),16.1E3,1.23E3,883,308,305,55.6,50.7,89.2,73.6,155,17.0E3,27.3E3,13.3E3,524,13.3E3,3.98E3,1.83E3,548,27.4E3,8.22E3,5.05E3,1.52E3,5.18E3,1.55E3,8.05E3,2.41E3,6.35E3,1.91E3
IN - TP Mean Annual Load
(kg/yr),32.2,32.2,26.8,0.364,14.0,2.52,2.60,4.03,3.35,6.97,23.1,37.6,42.5,23.5,18.0,12.6,2.48,1.74,35.7,25.0,6.63,4.64,6.79,4.75,10.9,7.62,8.34,5.84
IN - TN Mean Annual Load
(kg/yr),304,194,153,7.39,77.0,13.9,13.8,22.2,18.6,38.4,245,395,640,129,191,191,26.4,26.4,393,393,72.7,72.7,79.5,79.5,116,116,97.4,97.4
IN - Gross Pollutant Mean Annual Load
(kg/yr),160,6.88,13.6,13.6,0.00,0.00,0.00,0.00,0.00,0.00,3.20E3,5.20E3,168,0.00,2.50E3,49.9,344,6.88,5.33E3,107,997,19.9,1.06E3,21.2,1.59E3,31.9,1.28E3,25.6
OUT - Mean Annual Flow
(ML/yr),149,266,230,7.41,117,21.1,21.8,33.8,28.2,58.7,84.7,138,222,198,66.0,66.0,9.11,9.11,135,135,25.0,25.0,26.6,26.6,40.0,40.0,32.5,32.5
OUT - TSS Mean Annual Load
(kg/yr),16.1E3,1.23E3,883,308,305,55.6,50.7,89.2,73.6,155,17.0E3,27.3E3,13.3E3,524,13.3E3,3.98E3,1.83E3,548,27.4E3,8.22E3,5.05E3,1.52E3,5.18E3,1.55E3,8.05E3,2.41E3,6.35E3,1.91E3
OUT - TP Mean Annual Load
(kg/yr),32.2,32.2,26.8,0.364,14.0,2.52,2.60,4.03,3.35,6.97,23.1,37.6,42.5,23.5,18.0,12.6,2.48,1.74,35.7,25.0,6.63,4.64,6.79,4.75,10.9,7.62,8.34,5.84
OUT - TN Mean Annual Load
(kg/yr),304,194,153,7.39,77.0,13.9,13.8,22.2,18.6,38.4,245,395,640,129,191,191,26.4,26.4,393,393,72.7,72.7,79.5,79.5,116,116,97.4,97.4
OUT - Gross Pollutant Mean Annual Load
(kg/yr),160,6.88,13.6,13.6,0.00,0.00,0.00,0.00,0.00,0.00,3.20E3,5.20E3,168,0.00,2.50E3,49.9,344,6.88,5.33E3,107,997,19.9,1.06E3,21.2,1.59E3,31.9,1.28E3,25.6

Catchment Details

Catchment Name,bp-forest hill-ver1-5-8-21
Timestep,Day
Start Date,1/01/1968
End Date,31/12/1977
Rainfall Station, 70014 CANBERRA
ET Station,User-defined monthly PET
Mean Annual Rainfall (mm), 655
Mean Annual ET (mm), 1116
MUSIC-link Area, ACT Government
MUSIC-link Scenario, ACT Development

APPENDIX C (*RAFTS*)


xprafts 2013 SP1a - [375-BPFH-DET1.xp (Network)]
File Edit View Configuration Tools PMP Analyze Results Window Help
Storm 1_5yr90
POST DEVELOPMENT - WITH DET Conditons 1 - BPFH - 16-8-21
G-OUT
G
L26
L4
F-OUT
NTH-OUT
L3
E-OUT
L9
F-BASIN
L2
L8
H
L7
E-BASIN
L10
F
L6
E
D-BASIN
D
L16
D-OUT
L17
C
C-BASIN
A-BASIN
A
A-OUT
L1
L18
L20
C-OUT
L21
L19
RIP
B1
B1-OUT
B1-BASIN
L22
L11
L15
L23
L12
L27
L14
STH-OUT
OUT-TOTAL
B2-OUT
B2-BASIN
B2
L5
L13
L25
L24
For Help, press F1
X=139, Y=-13.7
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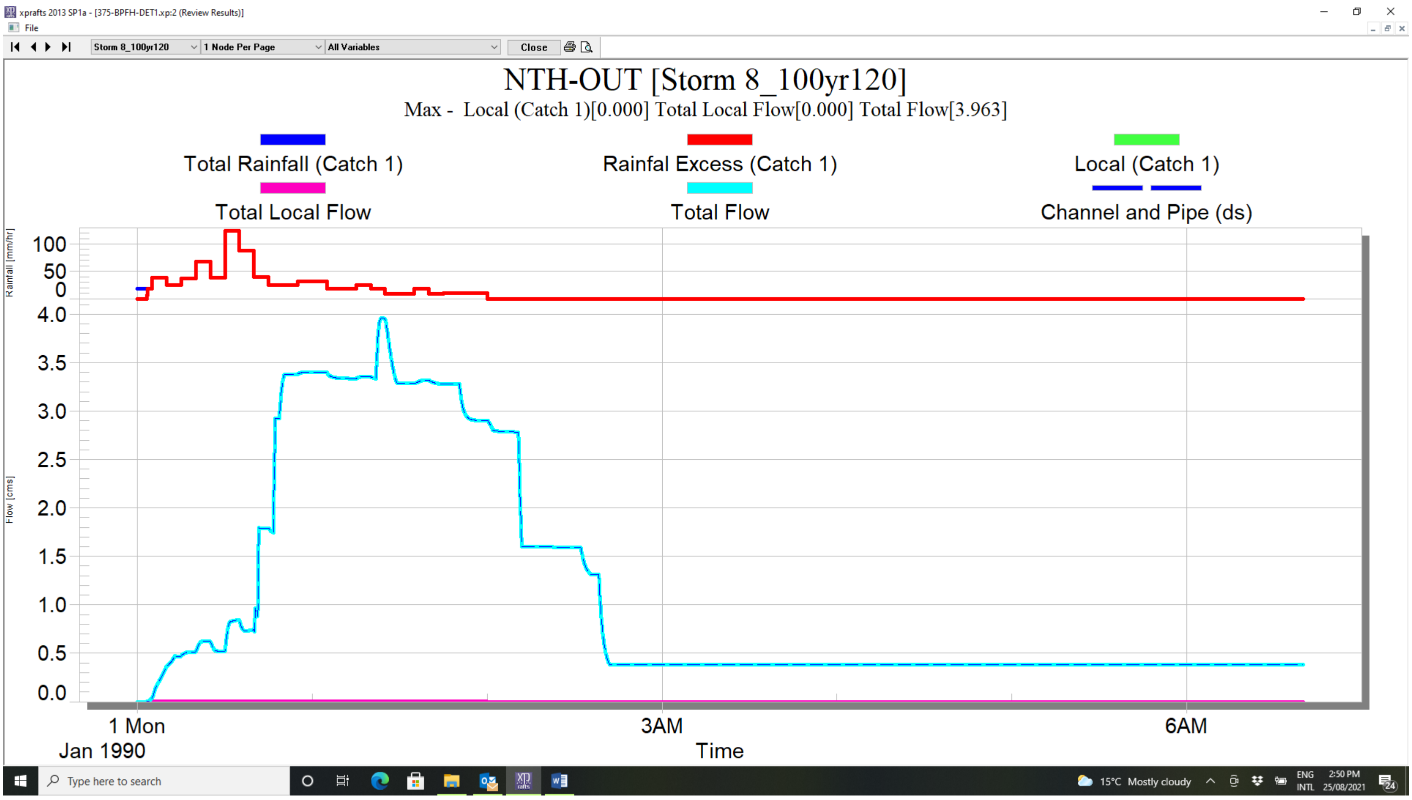
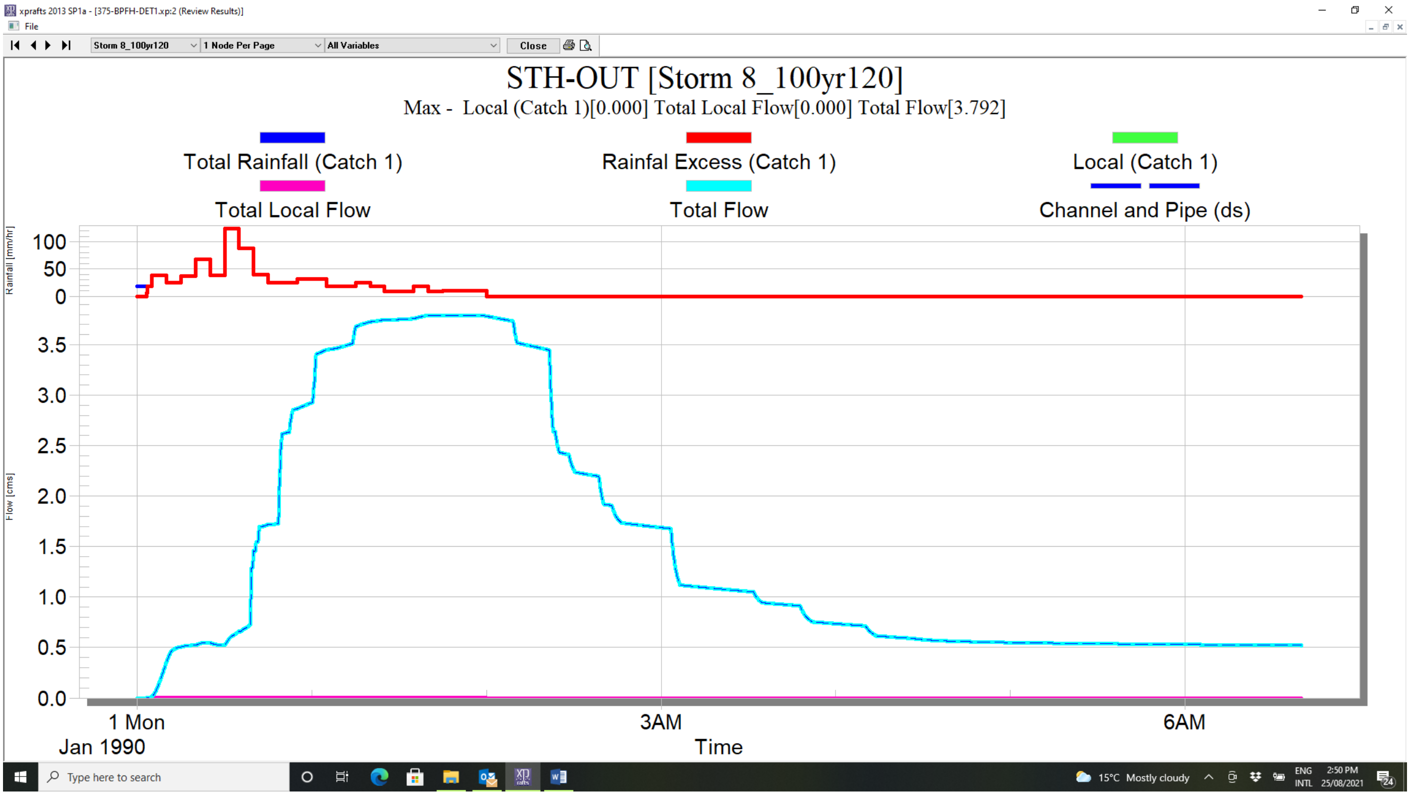
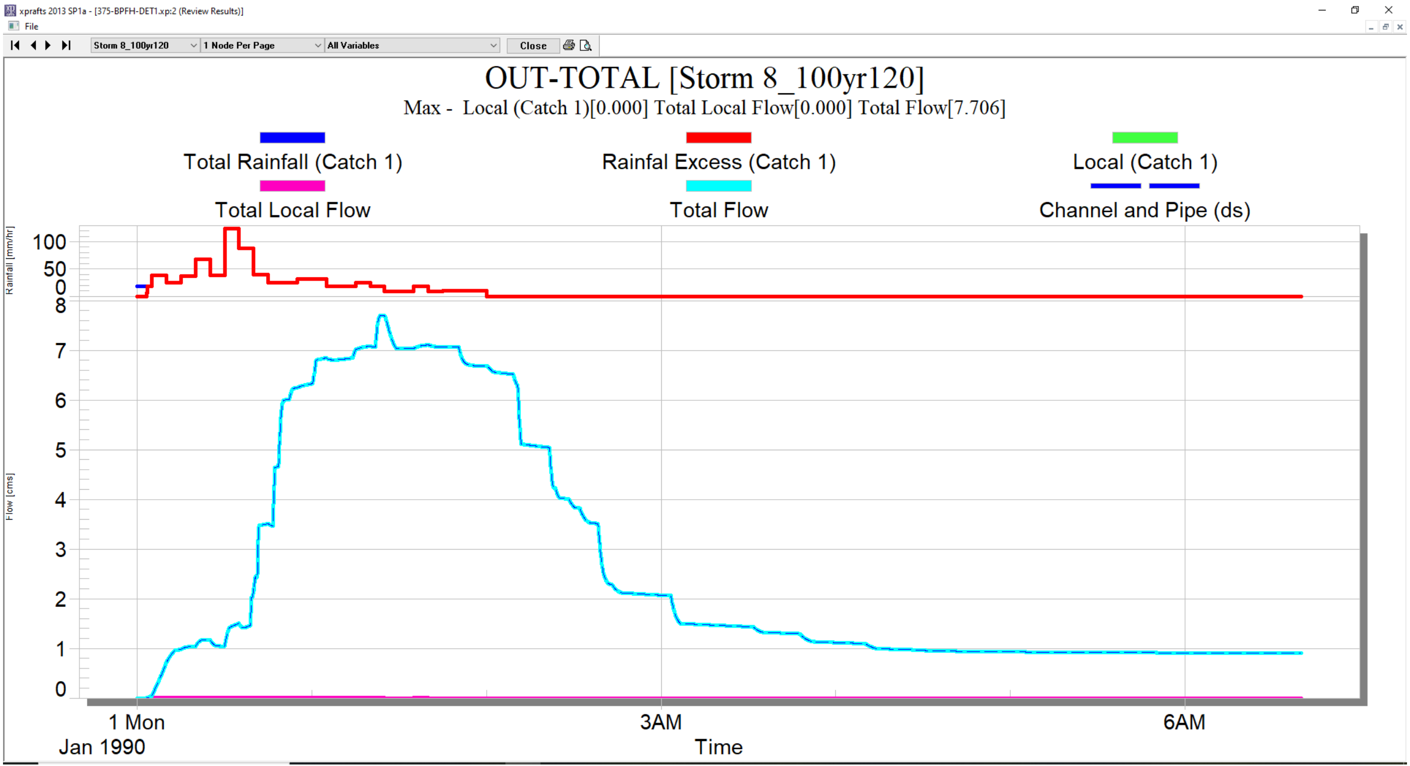
NU

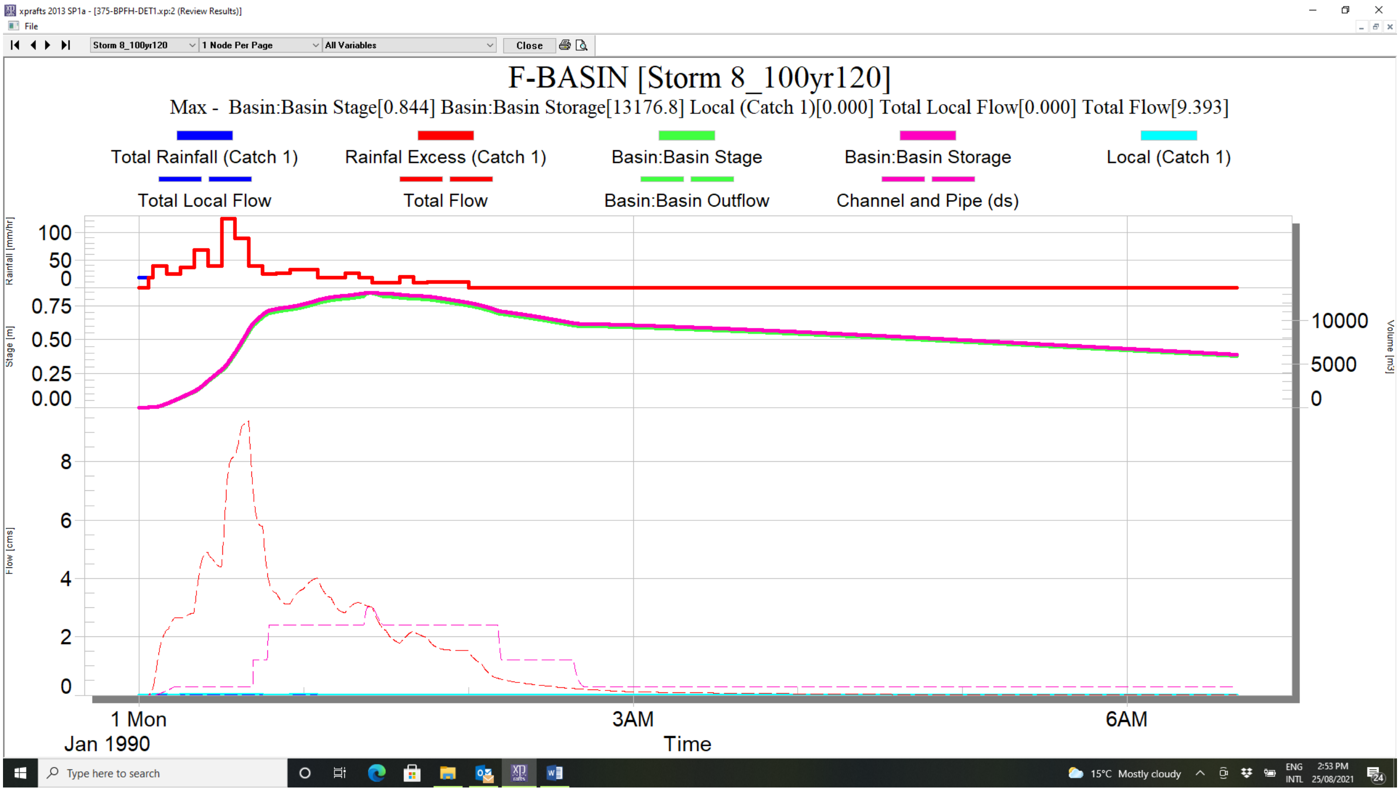

xprafts 2013 SP1a - [375-BPFH-DET1.xp:2 (Review Results)]
File
Storm 8_100yr120
1 Node Per Page
All Variables
Close
NTH-OUT [Storm 8_100yr120]
Max - Local (Catch 1)[0.000] Total Local Flow[0.000] Total Flow[3.963]
Total Rainfall (Catch 1)
Rainfal Excess (Catch 1)
Local (Catch 1)
Total Local Flow
Total Flow
Channel and Pipe (ds)
Rainfall [mm/hr]
100
50
0
Flow [cms]
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1 Mon
Jan 1990
3AM
6AM
Time
Type here to search
15°C Mostly cloudy
ENG
INTL
2:50 PM
25/08/2021

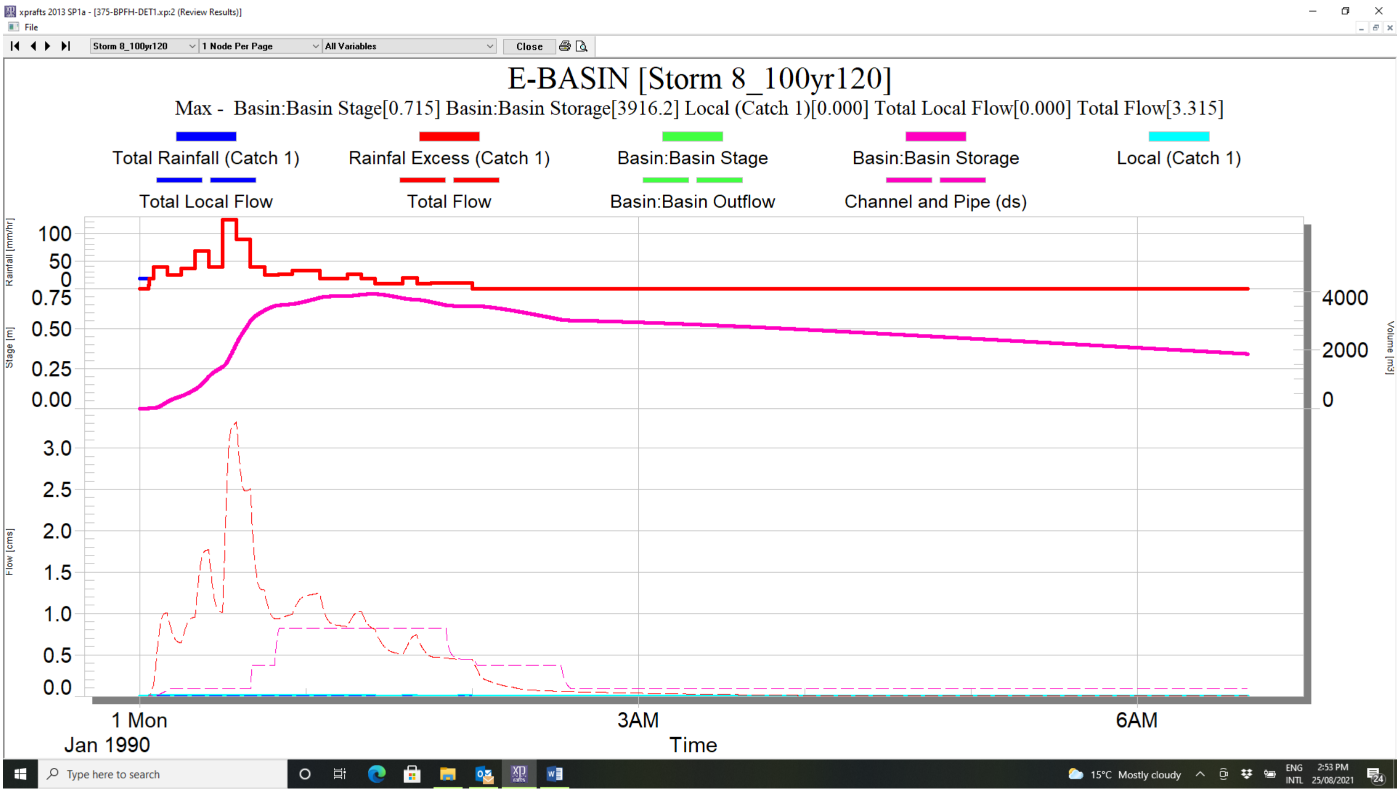


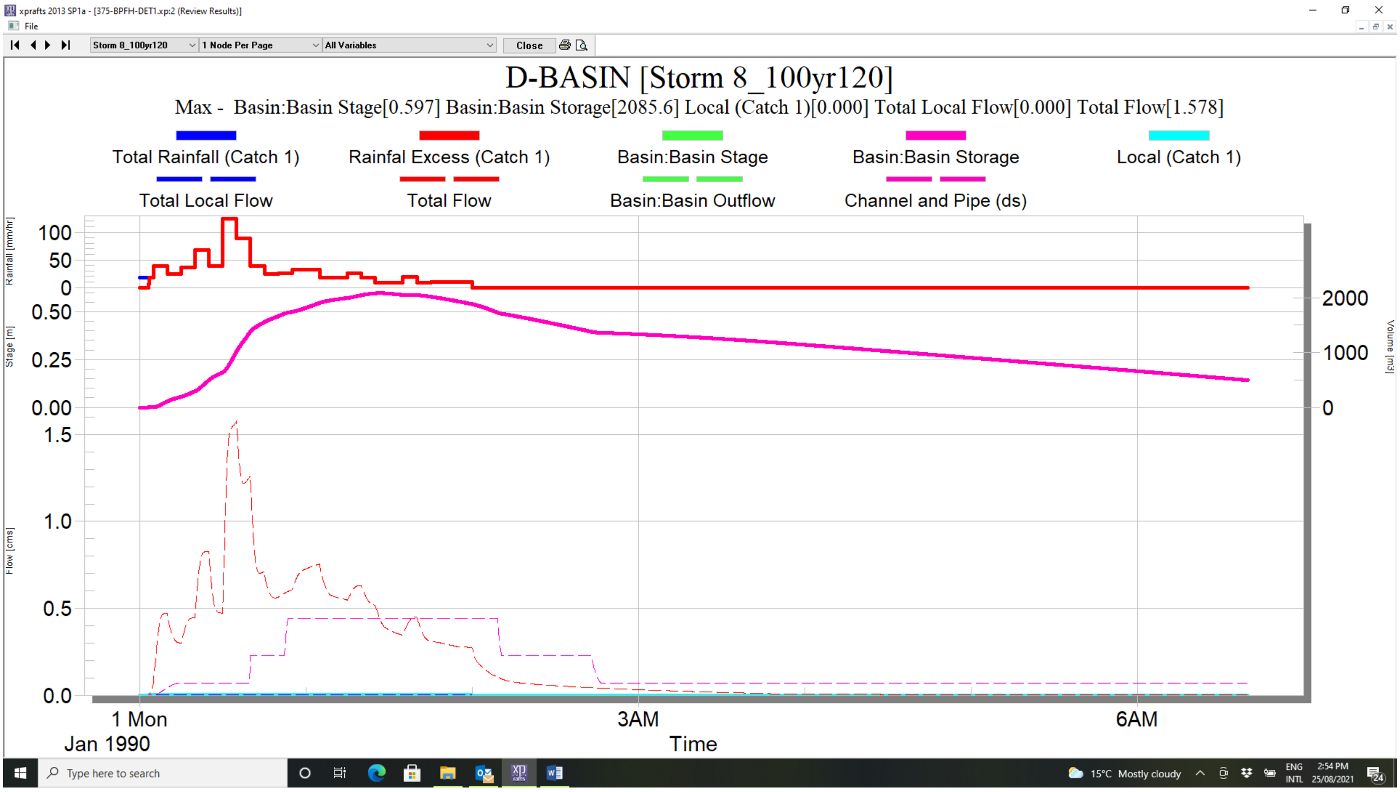
xprafts 2013 SP1a - [375-BPFH-DET1.xp:2 (Review Results)]
File
Storm 8_100yr120
1 Node Per Page
All Variables
Close
STH-OUT [Storm 8_100yr120]
Max - Local (Catch 1)[0.000] Total Local Flow[0.000] Total Flow[3.792]
Total Rainfall (Catch 1)
Rainfal Excess (Catch 1)
Local (Catch 1)
Total Local Flow
Total Flow
Channel and Pipe (ds)
Rainfall [mm/hr]
Flow [cms]
1 Mon
Jan 1990
3AM
6AM
Time
Type here to search
15°C Mostly cloudy
ENG INTL
2:50 PM
25/08/2021



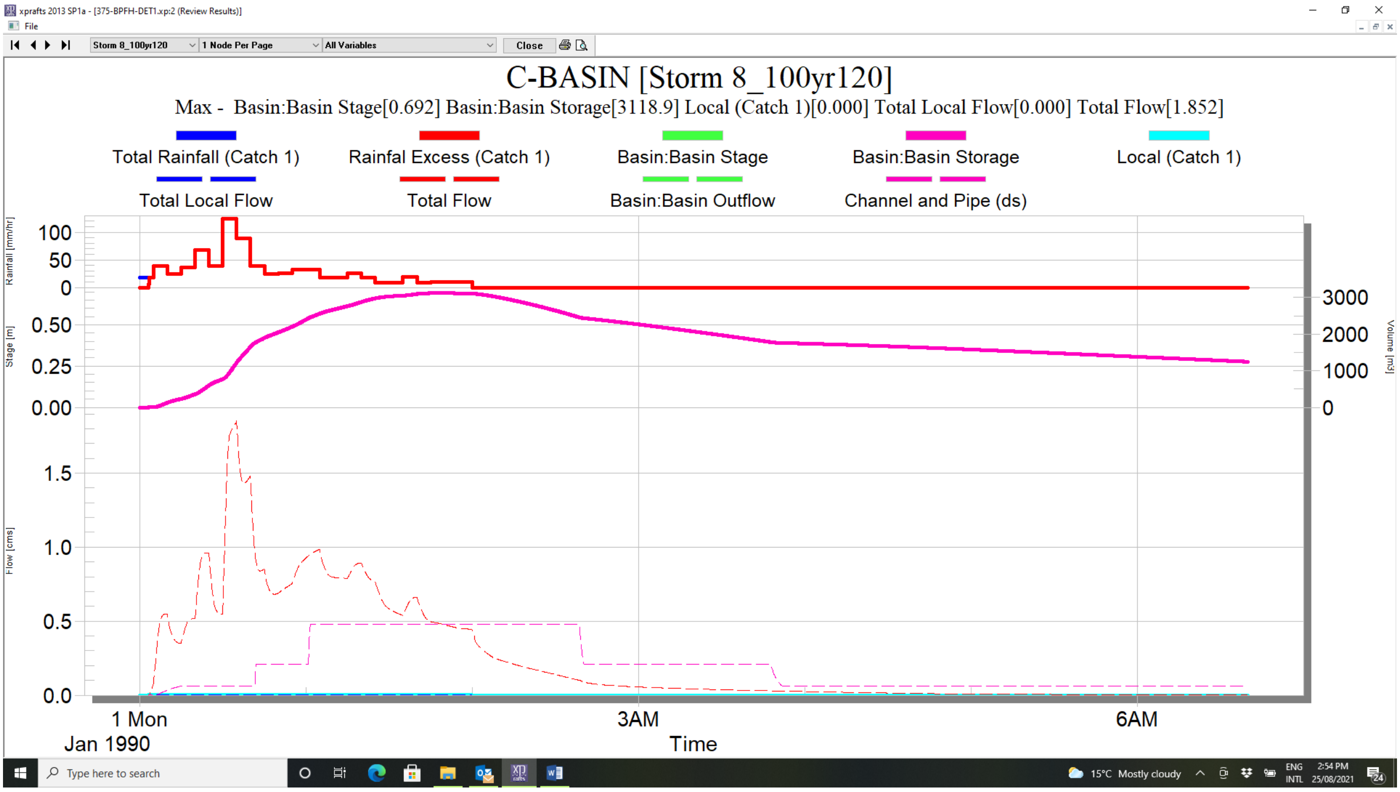
xprafts 2013 SP1a - [375-BPFH-DET1.xp:2 (Review Results)]
File
Storm 8_100yr120
1 Node Per Page
All Variables
Close
OUT-TOTAL [Storm 8_100yr120]
Max - Local (Catch 1)[0.000] Total Local Flow[0.000] Total Flow[7.706]
Total Rainfall (Catch 1)
Rainfal Excess (Catch 1)
Local (Catch 1)
Total Local Flow
Total Flow
Channel and Pipe (ds)
Rainfall [mm/hr]
Flow [cms]
1 Mon
Jan 1990
3AM
6AM
Time


F-BASIN [Storm 8_100yr120]
Max - Basin:Basin Stage[0.844] Basin:Basin Storage[13176.8] Local (Catch 1)[0.000] Total Local Flow[0.000] Total Flow[9.393]
Total Rainfall (Catch 1)
Rainfal Excess (Catch 1)
Basin:Basin Stage
Basin:Basin Storage
Local (Catch 1)
Total Local Flow
Total Flow
Basin:Basin Outflow
Channel and Pipe (ds)
Rainfall [mm/hr]
Stage [m]
Flow [cms]
Volume [m3]
1 Mon
Jan 1990
3AM
6AM
Time

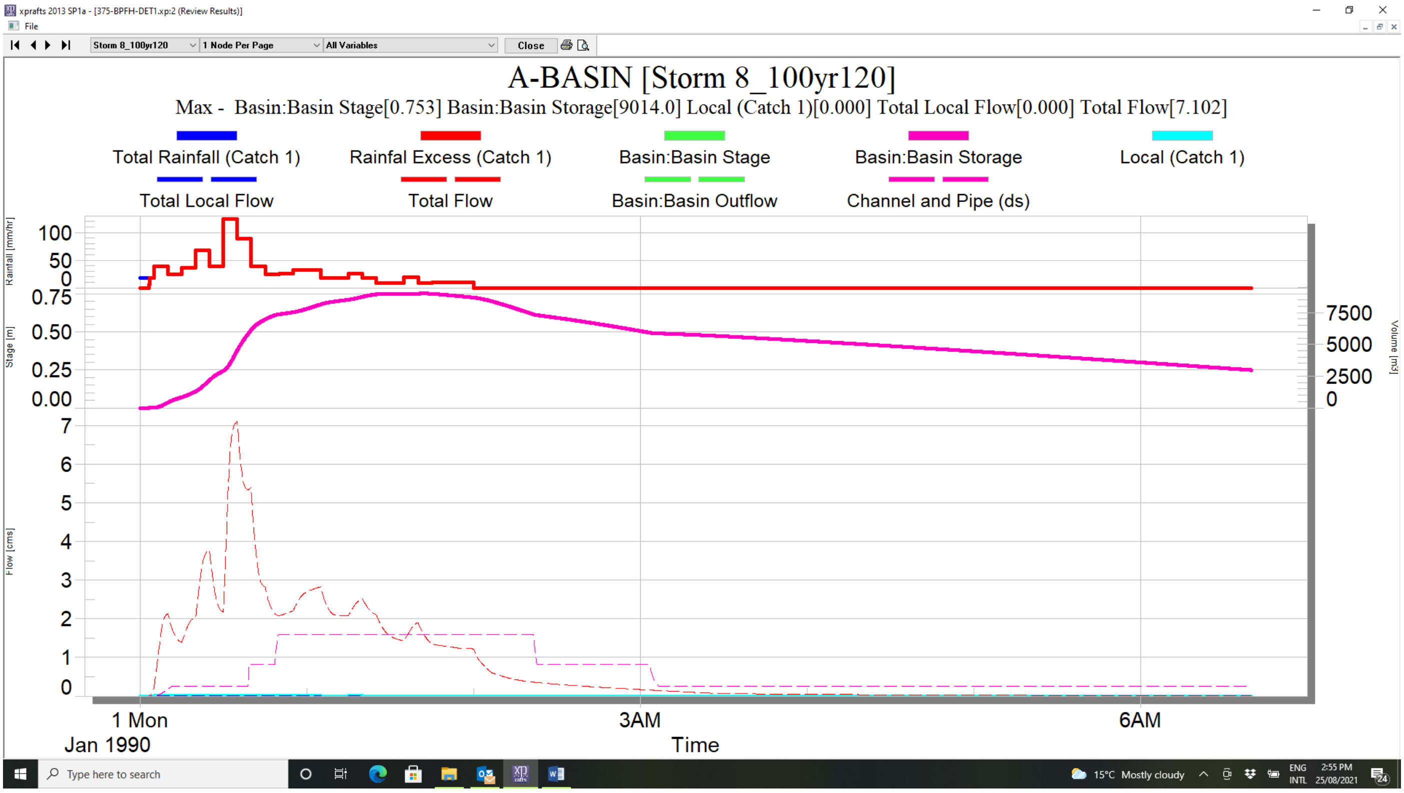

E-BASIN [Storm 8_100yr120]
Max - Basin:Basin Stage[0.715] Basin:Basin Storage[3916.2] Local (Catch 1)[0.000] Total Local Flow[0.000] Total Flow[3.315]
Total Rainfall (Catch 1)
Rainfal Excess (Catch 1)
Basin:Basin Stage
Basin:Basin Storage
Local (Catch 1)
Total Local Flow
Total Flow
Basin:Basin Outflow
Channel and Pipe (ds)
Rainfall [mm/hr]
Stage [m]
Flow [cms]
Volume [m3]
1 Mon
Jan 1990
3AM
6AM
Time

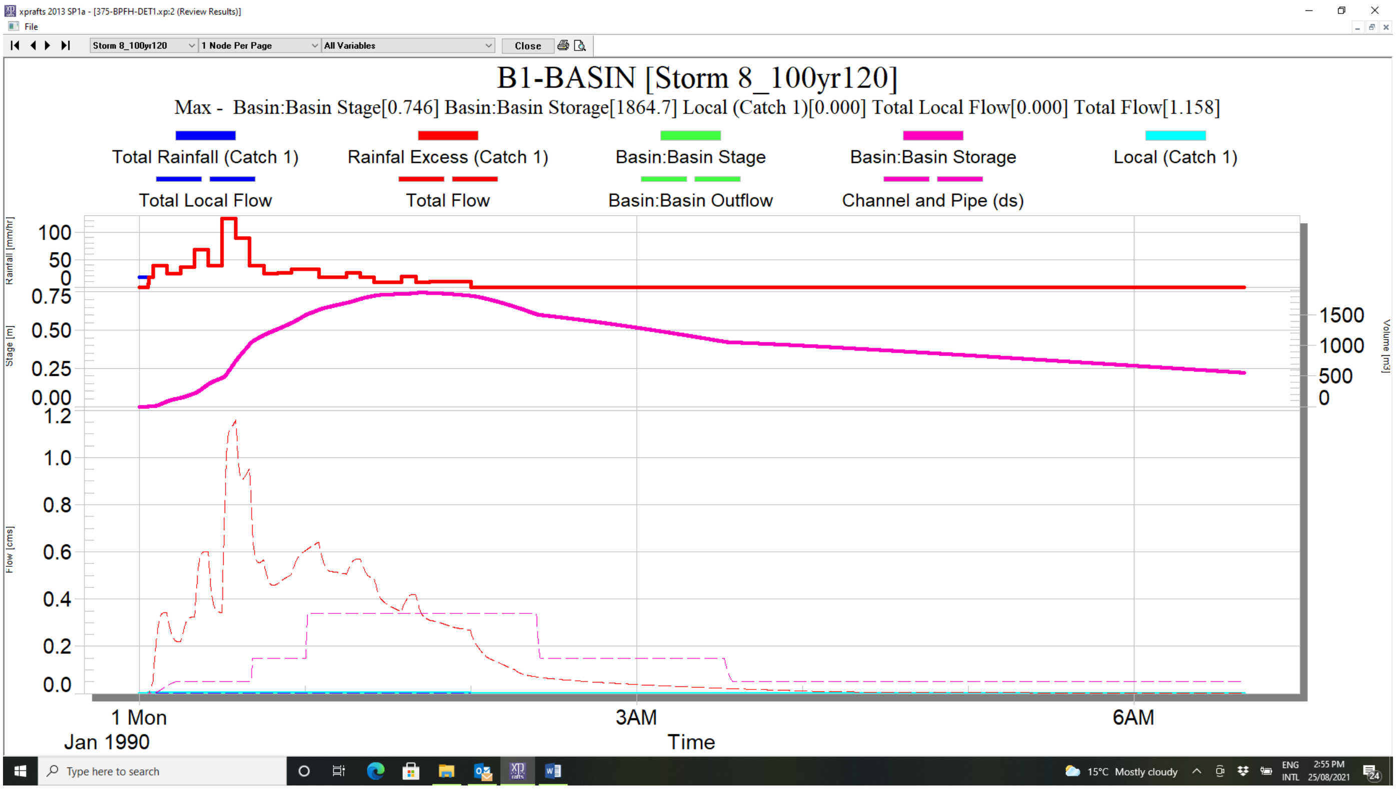


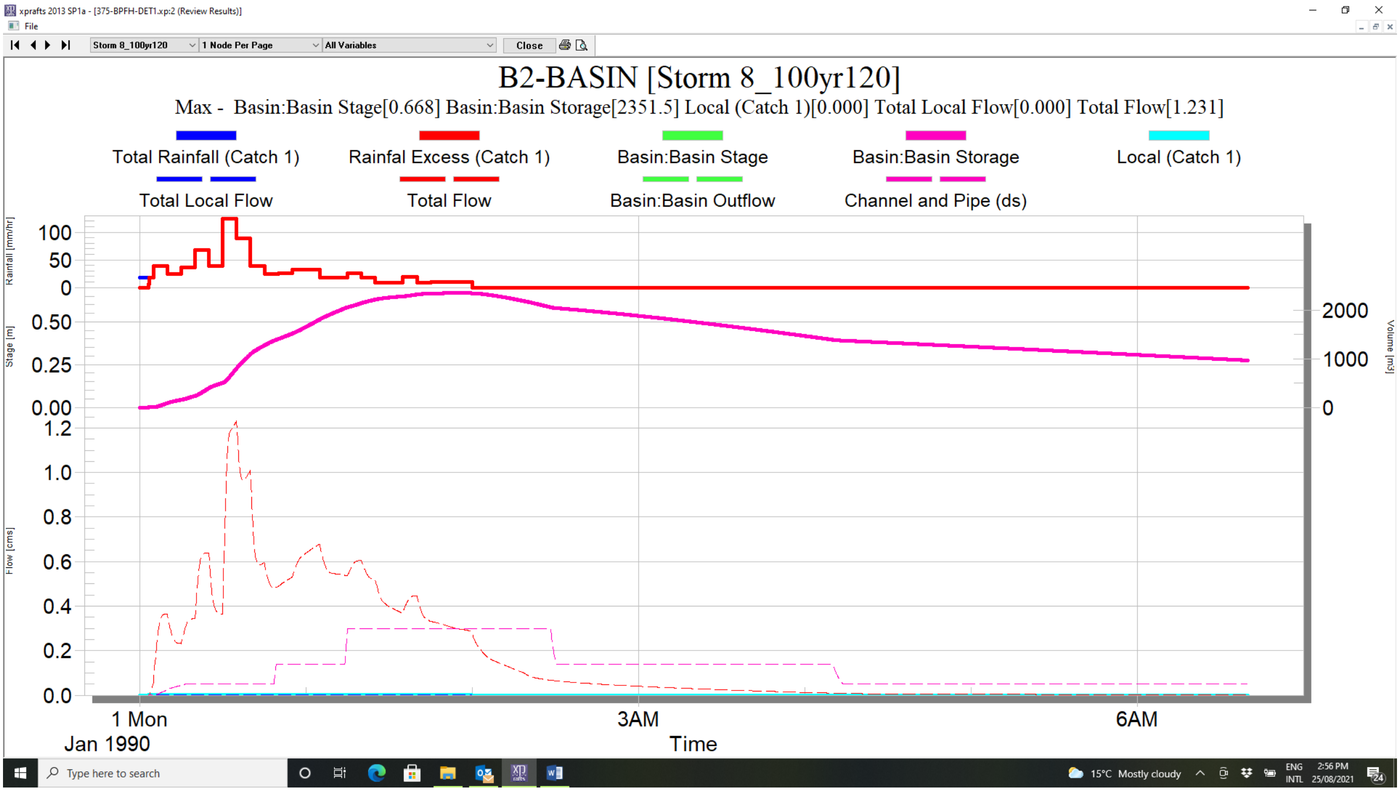
xprafts 2013 SP1a - [375-BPFH-DET1.xp2 (Review Results)]
D-BASIN [Storm 8_100yr120]
Max - Basin:Basin Stage[0.597] Basin:Basin Storage[2085.6] Local (Catch 1)[0.000] Total Local Flow[0.000] Total Flow[1.578]
Total Rainfall (Catch 1)
Rainfal Excess (Catch 1)
Basin:Basin Stage
Basin:Basin Storage
Local (Catch 1)
Total Local Flow
Total Flow
Basin:Basin Outflow
Channel and Pipe (ds)
Rainfall [mm/hr]
Stage [m]
Flow [cms]
Volume [m3]
1 Mon
Jan 1990
3AM
6AM
Time



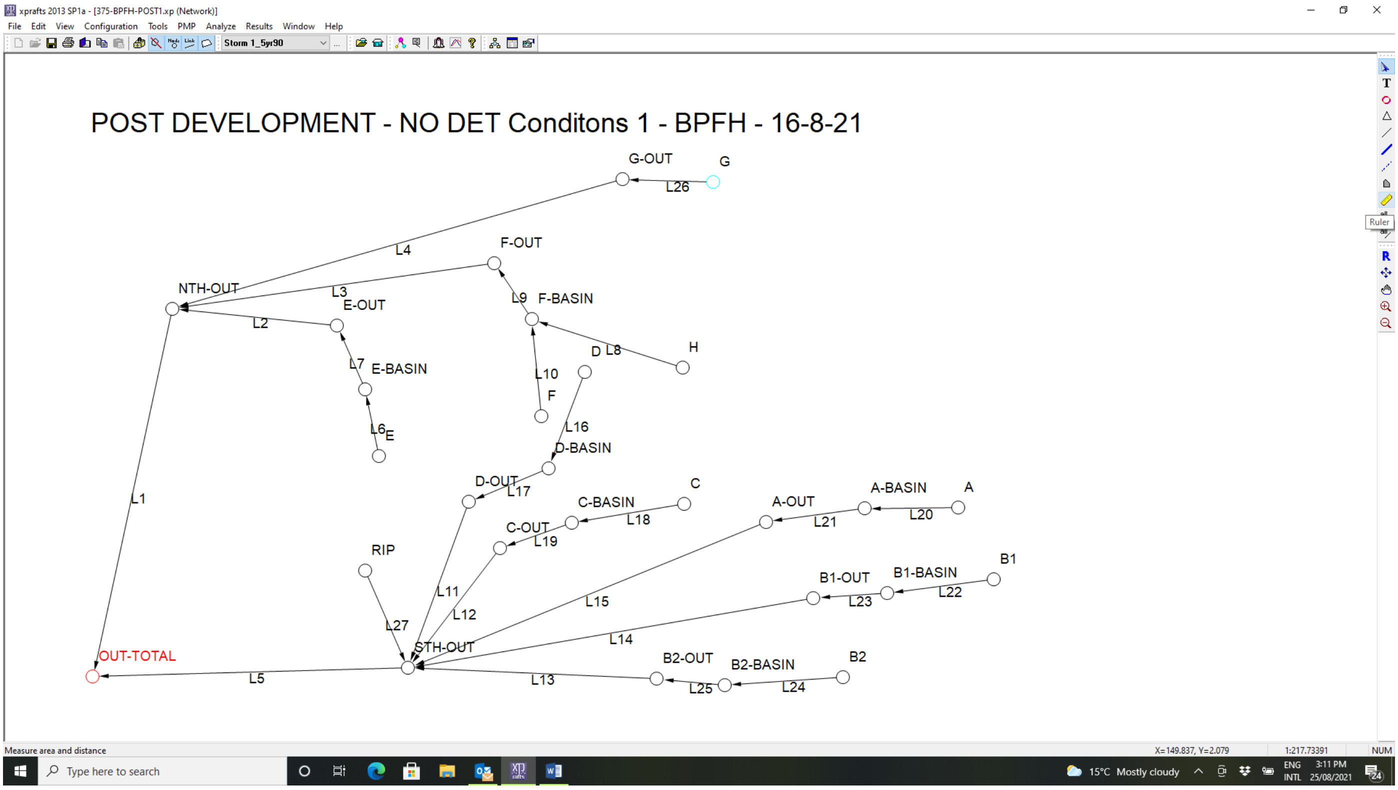
xprafts 2013 SP1a - [375-BPFH-DET1.xp2 (Review Results)]
C-BASIN [Storm 8_100yr120]
Max - Basin:Basin Stage[0.692] Basin:Basin Storage[3118.9] Local (Catch 1)[0.000] Total Local Flow[0.000] Total Flow[1.852]
Total Rainfall (Catch 1)
Rainfal Excess (Catch 1)
Basin:Basin Stage
Basin:Basin Storage
Local (Catch 1)
Total Local Flow
Total Flow
Basin:Basin Outflow
Channel and Pipe (ds)
Rainfall [mm/hr]
Stage [m]
Flow [cms]
Volume [m3]
1 Mon
Jan 1990
3AM
6AM
Time

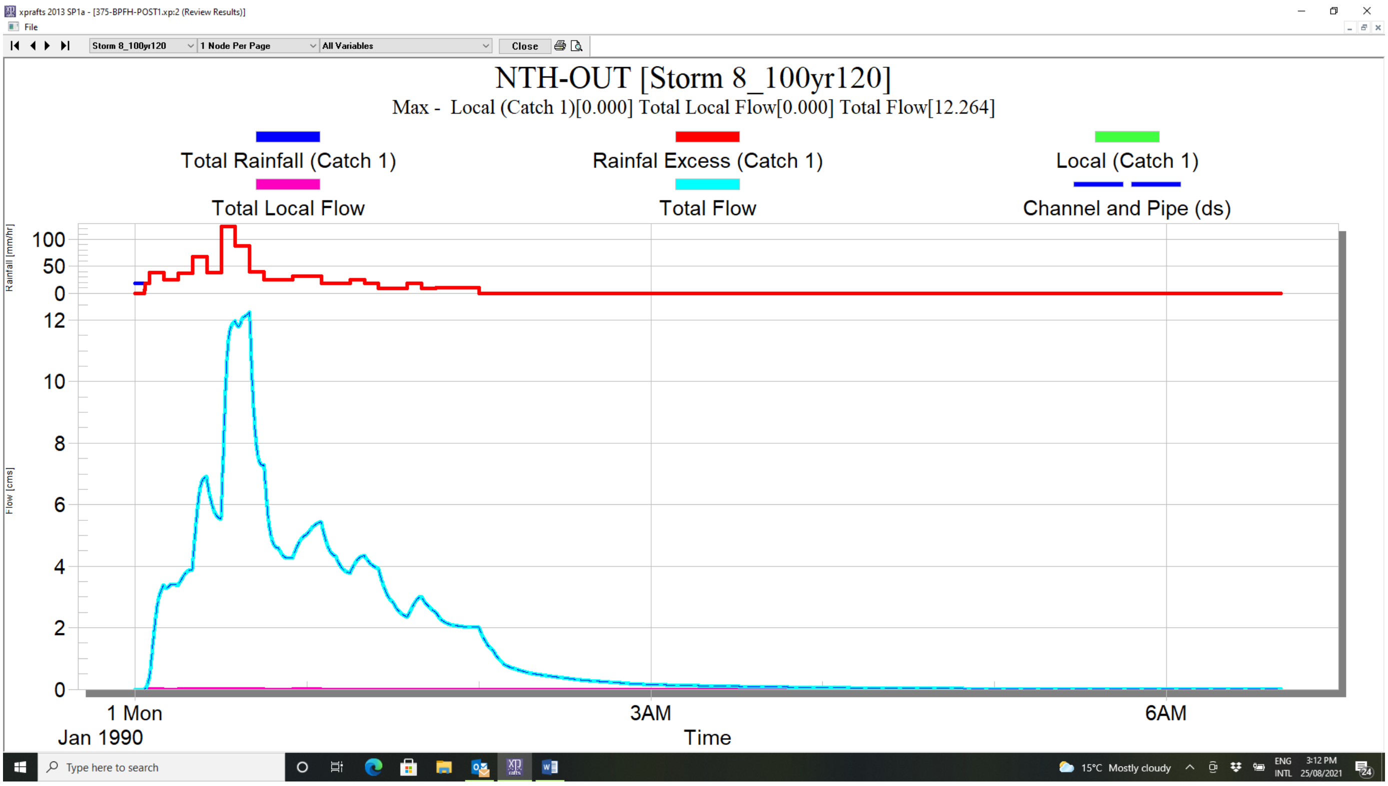

A-BASIN [Storm 8_100yr120]
Max - Basin:Basin Stage[0.753] Basin:Basin Storage[9014.0] Local (Catch 1)[0.000] Total Local Flow[0.000] Total Flow[7.102]
Total Rainfall (Catch 1)
Rainfal Excess (Catch 1)
Basin:Basin Stage
Basin:Basin Storage
Local (Catch 1)
Total Local Flow
Total Flow
Basin:Basin Outflow
Channel and Pipe (ds)
Rainfall [mm/hr]
Stage [m]
Flow [cms]
Volume [m3]
1 Mon
Jan 1990
3AM
6AM
Time

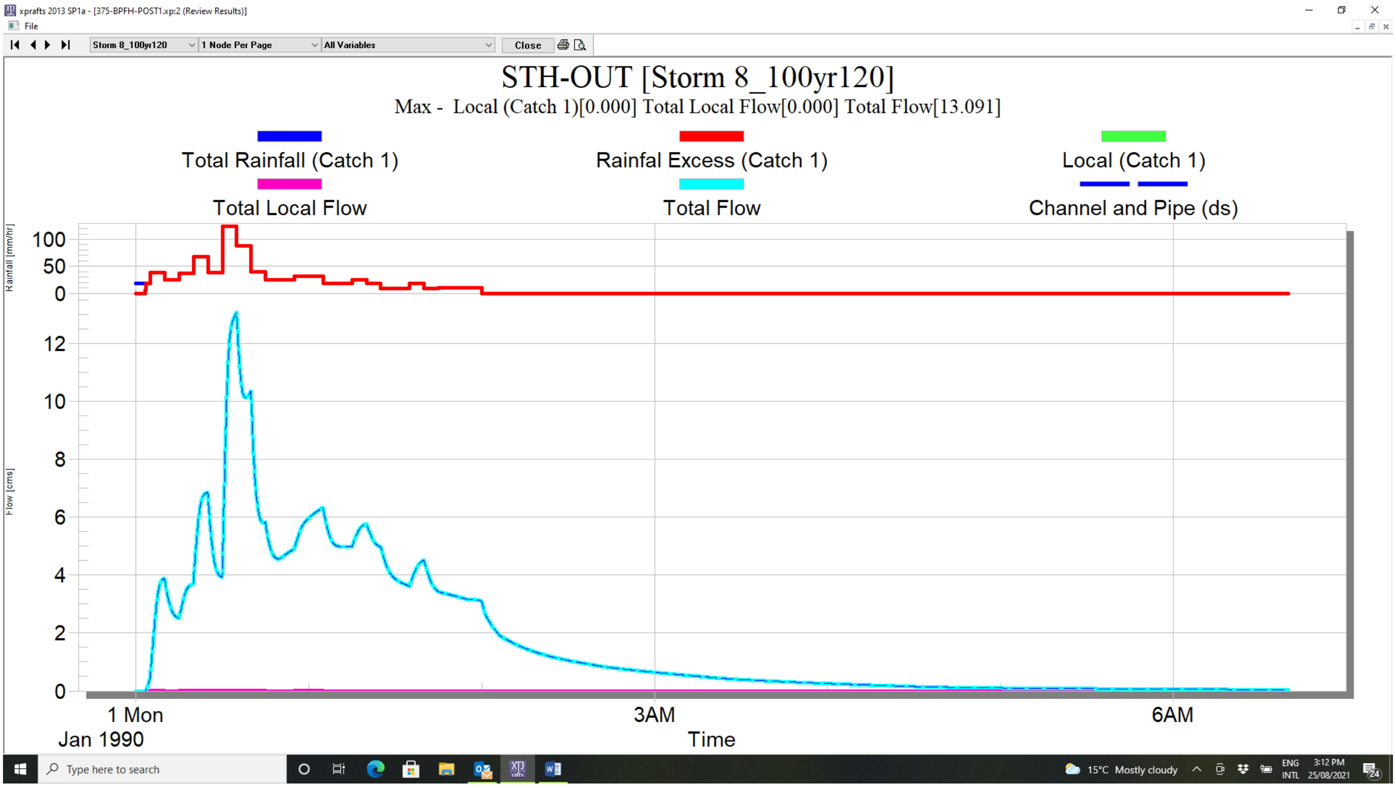

B1-BASIN [Storm 8_100yr120]
Max - Basin:Basin Stage[0.746] Basin:Basin Storage[1864.7] Local (Catch 1)[0.000] Total Local Flow[0.000] Total Flow[1.158]
Total Rainfall (Catch 1)
Rainfal Excess (Catch 1)
Basin:Basin Stage
Basin:Basin Storage
Local (Catch 1)
Total Local Flow
Total Flow
Basin:Basin Outflow
Channel and Pipe (ds)
Rainfall [mm/hr]
Stage [m]
Flow [cms]
Volume [m3]
1 Mon
Jan 1990
3AM
6AM
Time



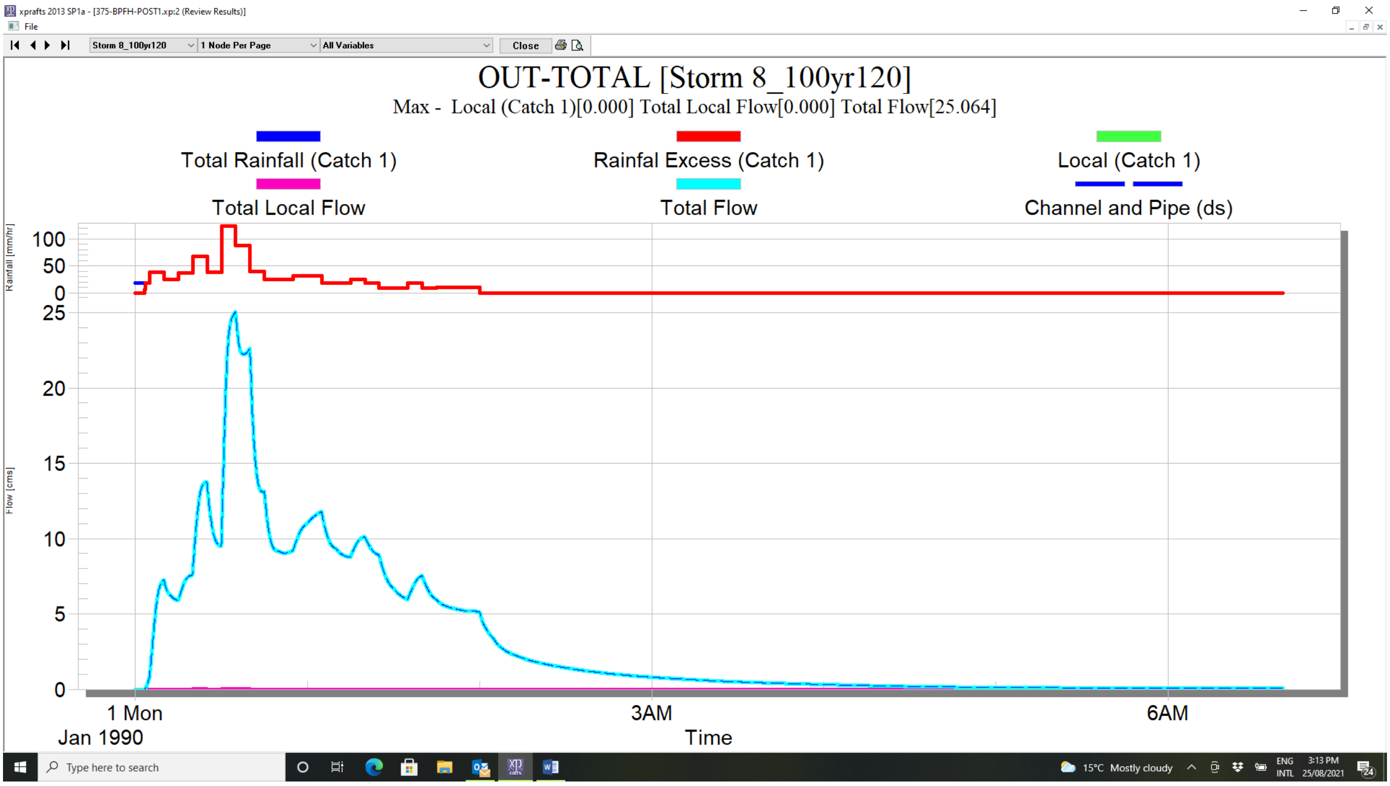
xprafts 2013 SP1a - [375-BPFH-DET1.xp:2 (Review Results)]
File
Storm 8_100yr120
1 Node Per Page
All Variables
Close
B2-BASIN [Storm 8_100yr120]
Max - Basin:Basin Stage[0.668] Basin:Basin Storage[2351.5] Local (Catch 1)[0.000] Total Local Flow[0.000] Total Flow[1.231]
Total Rainfall (Catch 1)
Rainfal Excess (Catch 1)
Basin:Basin Stage
Basin:Basin Storage
Local (Catch 1)
Total Local Flow
Total Flow
Basin:Basin Outflow
Channel and Pipe (ds)
Rainfall [mm/hr]
100
50
0
Stage [m]
0.50
0.25
0.00
Flow [cms]
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2000
1000
0
Volume [m3]
1 Mon
Jan 1990
3AM
6AM
Time
Type here to search
15°C Mostly cloudy
ENG INTL
2:56 PM
25/08/2021


xprafts 2013 SP1a - [375-BPFH-POST1.xp (Network)]
POST DEVELOPMENT - NO DET Conditons 1 - BPFH - 16-8-21
G-OUT
G
L26
L4
F-OUT
NTH-OUT
L3
E-OUT
L9
F-BASIN
L2
H
D L8
L7
E-BASIN
L10
F
L6
E
L16
D-BASIN
L1
D-OUT
L17
C
C-BASIN
A-OUT
A-BASIN
A
C-OUT
L18
L21
L20
L19
RIP
B1
B1-OUT
B1-BASIN
L11
L15
L23
L22
L12
L27
L14
STH-OUT
OUT-TOTAL
B2-OUT
B2-BASIN
B2
L5
L13
L25
L24

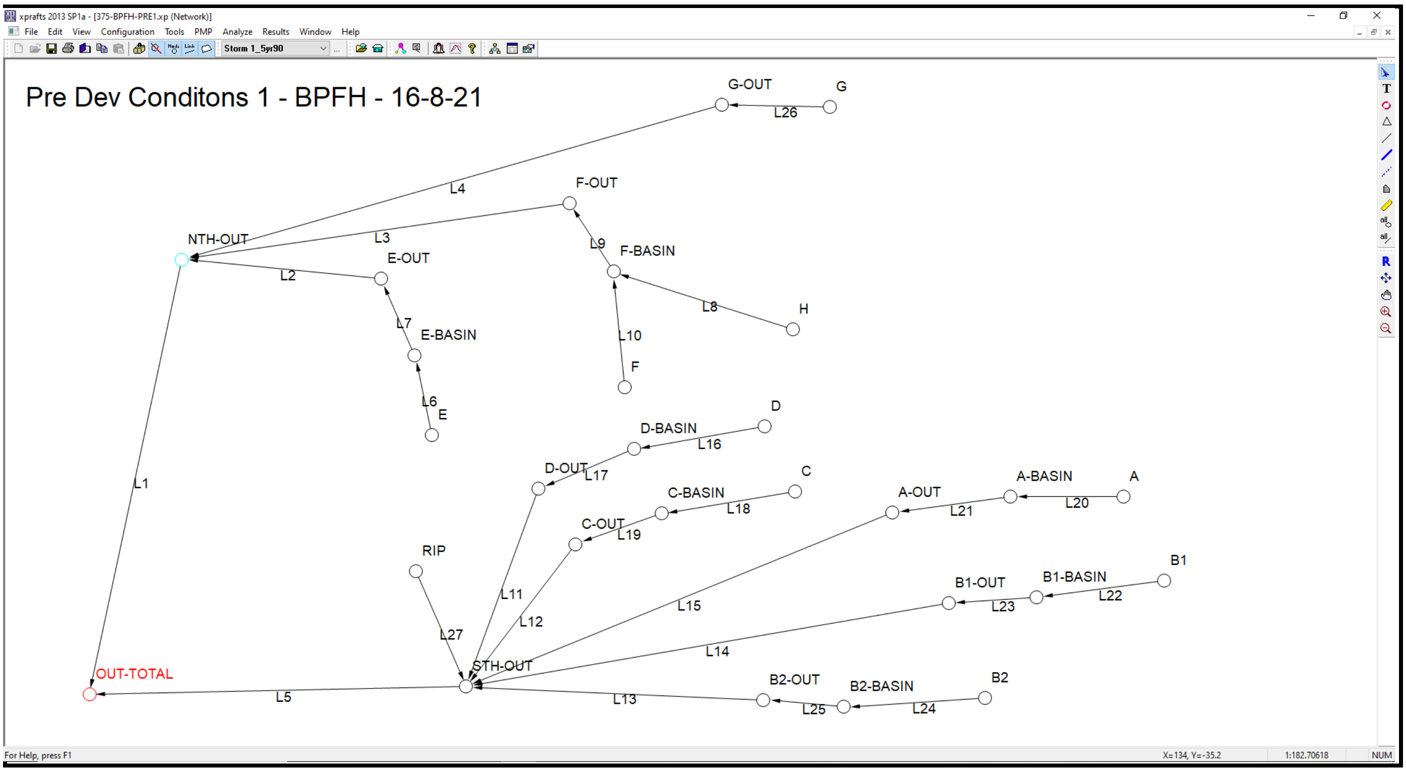

xprafts 2013 SP1a - [375-BPFH-POST1.xp:2 (Review Results)]
Storm 8_100yr120
1 Node Per Page
All Variables
Close
NTH-OUT [Storm 8_100yr120]
Max - Local (Catch 1)[0.000] Total Local Flow[0.000] Total Flow[12.264]
Total Rainfall (Catch 1)
Rainfal Excess (Catch 1)
Local (Catch 1)
Total Local Flow
Total Flow
Channel and Pipe (ds)
Rainfall (mm/hr)
Flow (cms)
100
50
0
12
10
8
6
4
2
0
1 Mon
Jan 1990
3AM
6AM
Time



xprafts 2013 SP1a - [375-BPFH-POST1.xp2 (Review Results)]
File
Storm 8_100yr120
1 Node Per Page
All Variables
Close
STH-OUT [Storm 8_100yr120]
Max - Local (Catch 1)[0.000] Total Local Flow[0.000] Total Flow[13.091]
Total Rainfall (Catch 1)
Rainfal Excess (Catch 1)
Local (Catch 1)
Total Local Flow
Total Flow
Channel and Pipe (ds)
Rainfall [mm/hr]
100
50
0
Flow [cms]
12
10
8
6
4
2
0
1 Mon
Jan 1990
3AM
6AM
Time
Type here to search
15°C Mostly cloudy
ENG INTL
3:12 PM
25/08/2021



xprafts 2013 SP1a - [375-BPFH-POST1.xp2 (Review Results)]
File
Storm 8_100yr120
1 Node Per Page
All Variables
Close
OUT-TOTAL [Storm 8_100yr120]
Max - Local (Catch 1)[0.000] Total Local Flow[0.000] Total Flow[25.064]
Total Rainfall (Catch 1)
Rainfal Excess (Catch 1)
Local (Catch 1)
Total Local Flow
Total Flow
Channel and Pipe (ds)
Rainfall [mm/hr]
100
50
0
Flow [cms]
25
20
15
10
5
0
1 Mon
Jan 1990
3AM
6AM
Time
Type here to search
15°C Mostly cloudy
ENG INTL
3:13 PM
25/08/2021


xprafts 2013 SP1a - [375-BPFH-PRE1.xp (Network)]
File Edit View Configuration Tools PMP Analyze Results Window Help
Storm 1_5yr90
Pre Dev Conditons 1 - BPFH - 16-8-21
G-OUT
G
L26
L4
F-OUT
NTH-OUT
L3
L9
F-BASIN
E-OUT
L2
L8
H
L7
E-BASIN
L10
F
L6
E
D
D-BASIN
L16
D-OUT
L17
C
C-BASIN
L18
A-OUT
A-BASIN
A
L1
L21
L20
C-OUT
L19
RIP
B1
B1-OUT
B1-BASIN
L11
L15
L22
L23
L12
L27
L14
STH-OUT
OUT-TOTAL
B2-OUT
B2-BASIN
B2
L5
L13
L25
L24
For Help, press F1
X=134, Y=-35.2
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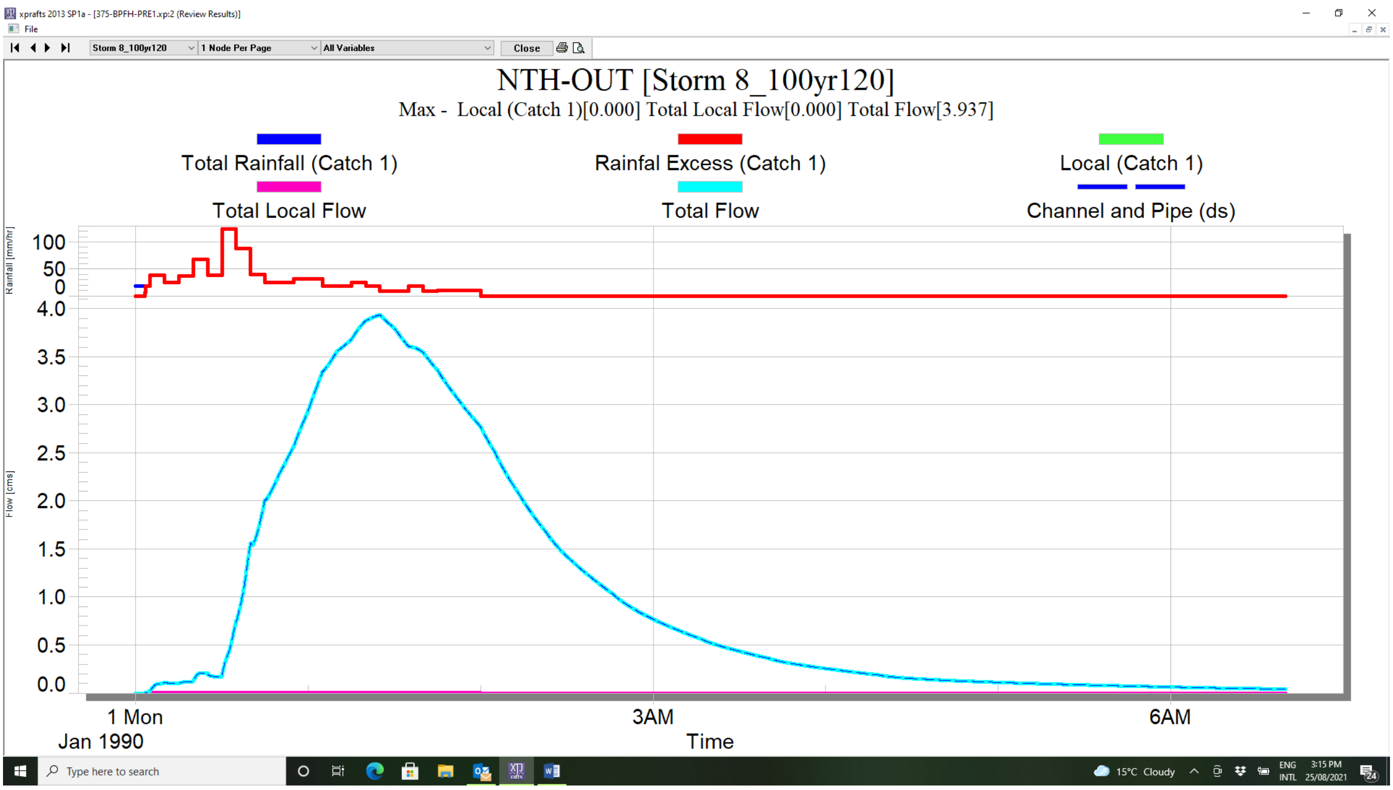
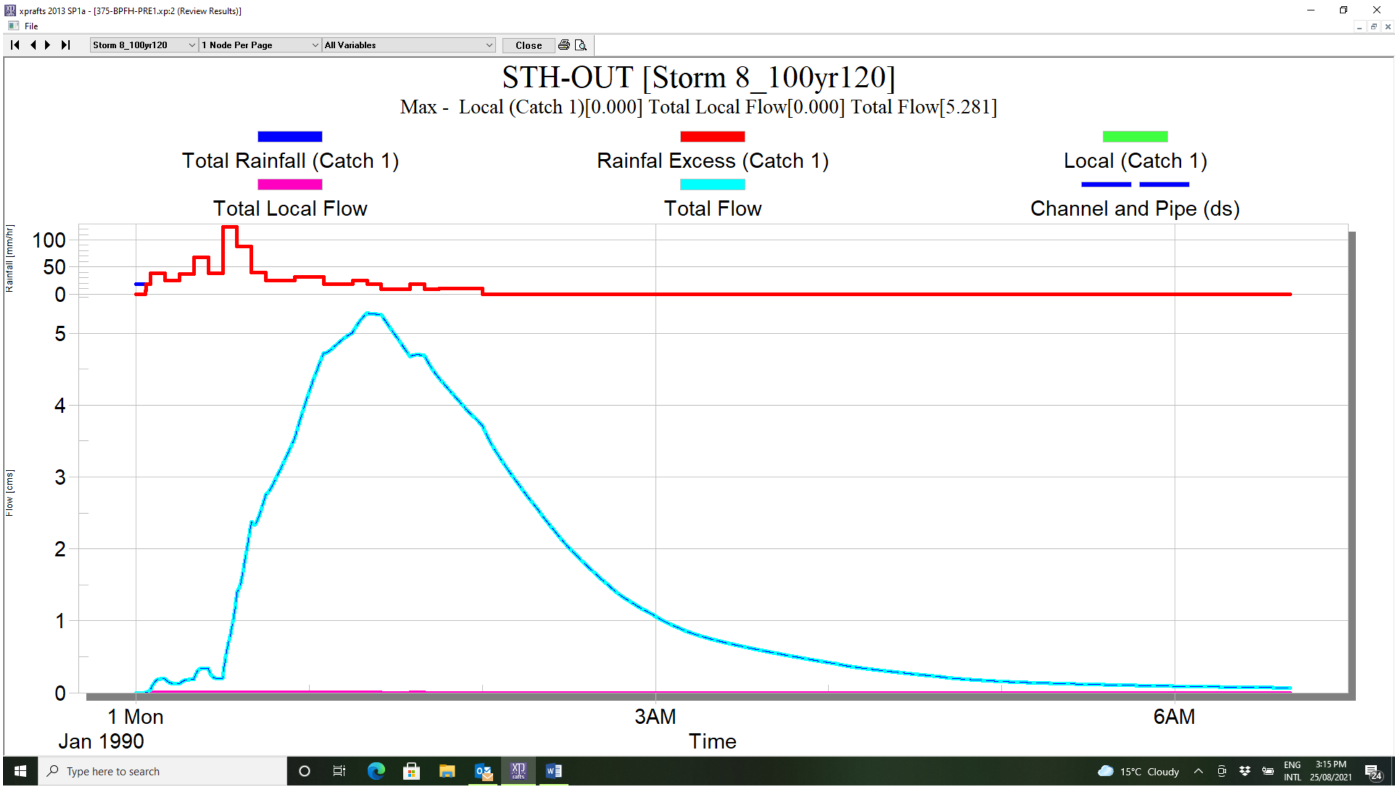
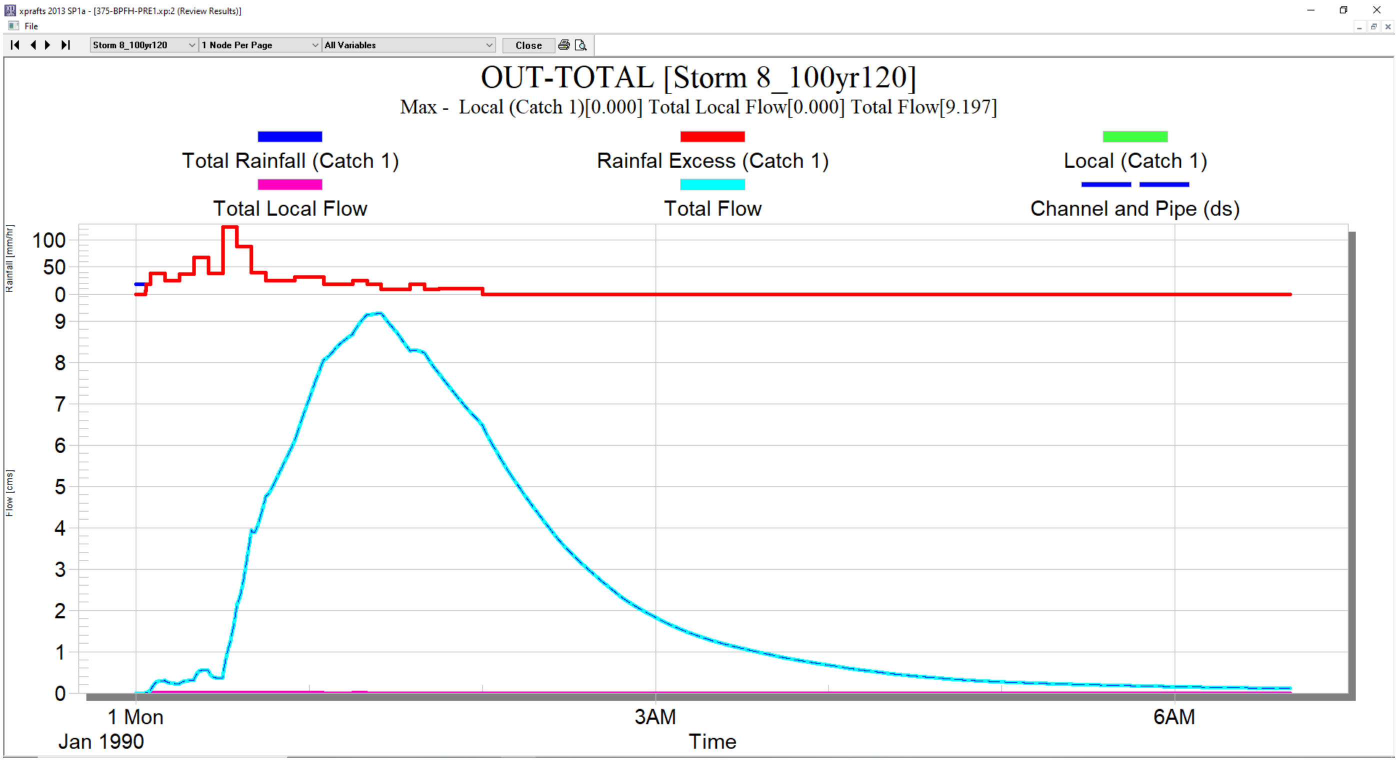
NUM


xprafts 2013 SP1a - [375-BPFH-PRE1.xp:2 (Review Results)]
File
Storm 8_100yr120
1 Node Per Page
All Variables
Close
NTH-OUT [Storm 8_100yr120]
Max - Local (Catch 1)[0.000] Total Local Flow[0.000] Total Flow[3.937]
Total Rainfall (Catch 1)
Rainfal Excess (Catch 1)
Local (Catch 1)
Total Local Flow
Total Flow
Channel and Pipe (ds)
Rainfall [mm/hr]
100
50
0
Flow [cms]
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1 Mon
Jan 1990
3AM
6AM
Time
Type here to search
15°C Cloudy
ENG
INTL
3:15 PM
25/08/2021



xprafts 2013 SP1a - [375-BPFH-PRE1.xp2 (Review Results)]
File
Storm 8_100yr120
1 Node Per Page
All Variables
Close
STH-OUT [Storm 8_100yr120]
Max - Local (Catch 1)[0.000] Total Local Flow[0.000] Total Flow[5.281]
Total Rainfall (Catch 1)
Rainfal Excess (Catch 1)
Local (Catch 1)
Total Local Flow
Total Flow
Channel and Pipe (ds)
Rainfall [mm/hr]
Flow [cms]
1 Mon
Jan 1990
3AM
6AM
Time
Type here to search
15°C Cloudy
ENG
INTL
3:15 PM
25/08/2021



xprafts 2013 SP1a - [375-BPFH-PRE1.xp2 (Review Results)]
File
Storm 8_100yr120
1 Node Per Page
All Variables
Close
OUT-TOTAL [Storm 8_100yr120]
Max - Local (Catch 1)[0.000] Total Local Flow[0.000] Total Flow[9.197]
Total Rainfall (Catch 1)
Rainfal Excess (Catch 1)
Local (Catch 1)
Total Local Flow
Total Flow
Channel and Pipe (ds)
Rainfall [mm/hr]
Flow [cms]
1 Mon
Jan 1990
3AM
6AM
Time

LOCATION 35.150 S 147.450 E * NEAR.. Forest Hill NSW

LIST OF COEFFICIENTS TO EQUATIONS OF THE FORM

$ln(I) = A + B \times (ln(T)) + C \times (ln(T))^2 + D \times (ln(T))^3 + E \times (ln(T))^4 + F \times (ln(T))^5 + G \times (ln(T))^6$

T = TIME IN HOURS AND I = INTENSITY IN MILLIMETRES PER HOUR

RETURN PERIOD	A	B	C	D	E	F	G
1	2.787071	-0.62043E+0	-0.40485E-1	0.10178E-1	0.52410E-3	-0.56242E-3	0.37213E-4
2	3.051620	-0.62757E+0	-0.41469E-1	0.10143E-1	0.60652E-3	-0.54424E-3	0.31510E-4
5	3.323019	-0.64592E+0	-0.45984E-1	0.10017E-1	0.11470E-2	-0.50339E-3	0.78125E-5
10	3.461665	-0.65607E+0	-0.47302E-1	0.10043E-1	0.11981E-2	-0.49209E-3	0.66898E-5
20	3.620587	-0.66481E+0	-0.49389E-1	0.10125E-1	0.14416E-2	-0.49020E-3	-0.14632E-5
50	3.804105	-0.67465E+0	-0.51202E-1	0.10143E-1	0.15915E-2	-0.48180E-3	-0.62248E-5
100	3.929076	-0.68110E+0	-0.52937E-1	0.99153E-2	0.18481E-2	-0.44005E-3	-0.22125E-4

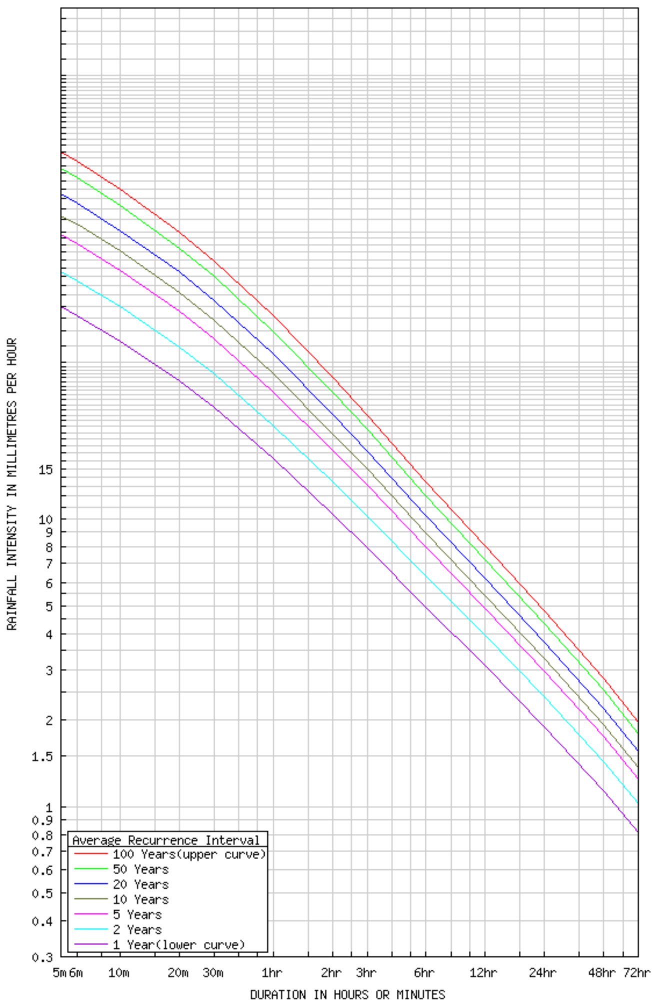
RAINFALL INTENSITY IN mm/h FOR VARIOUS DURATIONS AND RETURN PERIODS

	RETURN PERIOD (YEARS)						
DURATION	1	2	5	10	20	50	100
5 mins	54.9	72.3	97.9	114.	136.	166.	190.
6 mins	51.1	67.4	90.9	106.	126.	154.	176.
10 mins	41.6	54.7	73.4	85.6	101.	123.	141.
20 mins	30.2	39.6	52.8	61.2	72.3	87.6	99.8
30 mins	24.4	31.9	42.3	48.9	57.7	69.7	79.3
1 hour	16.2	21.1	27.7	31.9	37.4	44.9	50.9
2 hours	10.4	13.5	17.4	19.8	23.1	27.5	31.0
3 hours	7.93	10.2	13.1	14.9	17.2	20.4	22.9
6 hours	4.95	6.36	7.99	8.98	10.3	12.1	13.5
12 hours	3.09	3.94	4.88	5.44	6.22	7.25	8.05
24 hours	1.90	2.42	2.97	3.29	3.75	4.34	4.81
48 hours	1.13	1.43	1.75	1.93	2.20	2.54	2.81
72 hours	.809	1.02	1.24	1.37	1.55	1.79	1.97

(Raw data: 21.63, 4.00, 1.03, 43.50, 7.01, 1.73,skew= 0.200)

HYDROMETEOROLOGICAL ADVISORY SERVICE

* ENSURE THE COORDINATES ARE THOSE REQUIRED SINCE DATA IS BASED ON THESE AND NOT LOCATION NAME.



APPENDIX D (*CV*)

Civil Certification Pty Ltd
Accredited Certifiers
Civil Engineering
ABN 56 607 721 595
0412 264 237

Michael J Shaw
BE MIEAust CPEng NER

Director
Civil Certification Pty Ltd

Resume

1. SUMMARY

Michael is a senior civil engineer with over 26 years' experience in the fields of civil engineering, road design, drainage, hydrology, stormwater management and urban infrastructure design. He operates his own business specialising in subdivision certification and stormwater management. Michael has worked on many civil design projects ranging from development of large scale strategic masterplans to detailed design of stormwater management facilities and urban infrastructure for residential subdivisions. His expertise lies in solving complicated drainage problems, water sensitive urban design (*WSUD*), erosion & sediment control, flooding, detailed civil design, understanding the local government approvals process and managing multidisciplinary teams. Michael's experience covers all facets of civil engineering for urban development from due diligence through to approvals, detailed design, superintendency and certification. He has also provided expert advice to the Land and Environment Court with relation to flooding, drainage, riparian, detention and stormwater quality issues.

2. EXPERIENCE

Positions Held -& Location

- Oct 2010 – Present: Director, Civil Certification Pty Ltd, Sydney, NSW, Australia
- April 2008-Sept 2010: Manager, Urban Infrastructure, Environment Group - Worley Parsons, Sydney, NSW, Australia.
- Aug. 2007-March 2008: Principal Engineer – Urban Infrastructure - Worley Parsons incorporating Patterson Britton & Partners, Sydney, NSW, Australia;
- Nov. 1997-Jul. 2007: Senior Associate – Urban Infrastructure - Patterson Britton & Partners, Sydney, NSW, Australia;
- Aug. 1996-Oct 1997: Water Resources Engineer – Willing & Partners, Sydney, NSW, Australia;
- Feb. 1991-Aug. 1994: Design Engineer, Development Engineer, Investigation Engineer & Survey Assistant – Ryde City Council, Sydney, NSW, Australia.

Standout Projects

- ***Stormwater Management Strategies(SMS)***

- Port Jackson South Stormwater Management Plan *(2,870ha catchment*);
- Drummoyne Council Stormwater Quality Strategy *(830ha catchment*);
- Lake Illawarra South Stormwater Quality Strategy *(1,548ha catchment*);
- Elliot Lake Stormwater Quality Strategy *(1,220ha catchment*);
- Scotland Island SMS *(53ha catchment*);
- Corks Lane Milton, DA Stage SMS (*150 lot residential subdivision*);

- Pasadena, Church Point, DA Stage Stormwater Management and Reuse Strategy (*mixed use dev.*);
- Yallambee Ave West Gosford, DA Stage SMS *(100 lot residential subdivision*);
- CSIRO Greystanes, Employment Lands SMS *(60ha industrial site*);
- Warriewood Valley, Sector 3, Rezoning Stage SMS *(130 lot residential subdivision*);
- Warriewood Valley, Sector 8, Rezoning to Subdivision Certificate Stage SMS *(140 lot residential subdivision*);
- Warriewood Valley, Buffer Areas 1 and 2, Rezoning and DA Stage SMS (*300 lot residential subdivision;*
- Warriewood Valley, Buffer Area 3, Rezoning and DA Stage SMS (*250 townhouse subdivision*);
- Macarthur Square Regional Centre Masterplan DA Stage WSUD Strategy (*61ha residential subdivision*);
- Department of Defence Site, Ermington ("*Ermington Riverfront*") DA Stage SMS (*20ha residential subdivision;*
- West Kembla Grange, Wollongong, Aquatic Issues Assessment (*858ha catchment*);
- Eastwood Quarry, Masterplan/Rezoning Stage SMS (*20ha residential subdivision*);
- Perentie and Dawes Road Masterplan, Belrose, Stormwater Quality Strategy (*30ha residential subdivision*);
- Walter Road, Ingleside DA Stage SMS (*15ha rural residential subdivision*);
- Domayne, Austlink Park Belrose SMS (large *commercial use development*);
- Grassmere LES, Camden SMS (*50ha rural residential subdivision*);
- Warriewood Valley (*Sectors C, D, & 12*) Rezoning Stage SMS *(100 lot residential subdivision*);
-Summer Hill Flour Mill Concept Plan Application Stormwater Management Plan and Flood Study (*250 dwelling high density residential subdivision*);
- Mt Penang Stormwater Management Strategy;
- Ashlar Golf Course Redevelopment – Flood and WSUD Strategy for 100 dwelling Residential Subdivision;

▸ ***Water Sensitive Urban Design (WSUD)***

- Sand Filtration Unit, Drummoyne Park (*ie Stormwater Treatment*);
- Barnwell Park Golf Course Stormwater Treatment and Reuse;
- Powell Creek Reserve Eco Carpark;
- Warriewood Valley, Sector 10, Detailed Design of WSUD elements (*bio-retention systems and wetland for 170 lot residential subdivision*);
- Warriewood Valley, Sector 12, Detailed Design of WSUD elements (*bio-retention systems and wetland for 180 lot residential subdivision*);
- Rouse Hill Regional Centre – Detailed design and performance analysis of bio retention systems, raingardens and constructed wetland;

- Hezlett Road, North Kellyville – Generic lot based raingarden design, road bio-retention swale design and detention offset analysis;
- Voyager Point (*DHA*) – Detailed Design of Detention/Bio-Retention Basins for 200 lot residential subdivision;

▸ ***Riparian/Creek Design/Investigation***

- Wollondilly Shire Riparian Corridor Definition Study;
- Parsley Bay, Woollahra, Creekline Rehabilitation;
- Embankment Stabilisation Design, Koloona Ave, Byarong Creek ,Wollongong;
- Embankment Stabilisation Design, 5 sites along Cabbage Tree Creek, Towradgi Creek and Byarong Creek, Wollongong;
- Prospect Creek, Fairfield – Design of confluence stabilisation and creek rehabilitation measures;
- Narrabeen Creek, Pittwater – Detailed design of creek rehabilitation and embankment stabilisation measures from Graf Ave to Ponderosa Parade;
- Little Bay Central Drainage Corridor – Controlled Activity Approval and detailed design of Central Corridor Drainage Features (*ie wetlands, bio-retention basins, weirs, elevated walkways, bridges, pool/riffle creekline*);
- Sector 8 Warriewood – Controlled Activity Approval for residential development adjoining Fern Creek;
- Nolan’s Reserve Footbridge - Abutment Armour and bridge repair design;
- Middle Creek Footbridge Armour design (*Narrabeen Lakes for Warringah Council*);

▸ ***Civil Subdivision Design***

- Potts Hill, Eastern Precinct – Lead design team for 13ha Industrial development of Sydney Water Surplus Lands. Engaged by Landcom to provide approval documentation for Part 3 Major Project and to deliver detailed design of all subdivision infrastructure (*ie civil, roads, E&S control, RE walls, stormwater, power, sewer, water, recycled water and utility services*);
- Tweed Road, Lithgow, Detailed Design of Civil Infrastructure (*roads, drainage, E&S control, water, sewer and all other utility services*) for a 38 lot residential subdivision;
- Sector 20, Warriewood, Detailed Design of Civil Infrastructure (*roads, drainage, E&S control, water, sewer and all other utility services*) for a 63 lot residential subdivision;
- 7 Orchard Road, Warriewood, Detailed Design of Lot Based Stormwater Management Facilities and Access Road for a 10 lot residential subdivision;
- Heritage Estates, Shoalhaven, Conceptual Design of Civil Infrastructure. (*water, sewage, utility services, roads and drainage*) for 20ha residential subdivision;
- Randwick Defence Site (*Stage 1A*), Detailed Design of Civil Infrastructure (*roads, drainage, water, sewer and all other utility services*) for a 80 lot residential subdivision;

- Cooks Cove Development, Upgrade to Scarborough and Bicentennial Parks – Lead design team for approvals and detailed design of upgrade to park facilities, including carparks, creekline, stormwater drainage, bulk earthworks, access roads, services, *E&S control* etc to accommodate future relocation of facilities from Cooks Cove development site (*Part 3A Major Project*);

▸ ***Drainage Analysis/Design***

- Canada Bay Council city wide DRAINS modelling project *(970ha catchment*);
- Canada Bay Council Detention modelling and OSD policy development;
- City of Canada Bay Council MAPINFO drainage database update;
- Old Bathurst Road, Emu Plains, Detailed Design of Stormwater Management Facilities *(24ha industrial subdivision*);
- Andrew Road, Penrith, Detailed Design of Stormwater Management Facilities *(8ha industrial subdivision*);
- St Mervyns Ave, Woollahra, Stormwater Outlet Extension;
- Grosvenor Street Stormwater Drainage Study;
- Perentie and Dawes Road Masterplan, Belrose, Stormwater Drainage Concept Plan;
- Yulong Concept Drainage Study, Dept Defence Moorebank *(25ha industrial subdivision);*
- Headland Road, Curl Curl OSD Design;
- Cooper Park Amphitheatre , Woollahra, Detailed Stormwater Drainage Design;
- Paradise Avenue, Paradise Beach, Detailed Stormwater Drainage Design;
- Georges River Sailing Club, Seawall and Beach Nourishment Design;
- St Andrew Church, Wahroonga OSD and Stormwater Drainage Design;
- North Sydney Catchment Management Studies (*in total 86ha catchment*);
- Greystanes Estate, Northern Residential Lands, Detailed Design of Water Management Facilities (*70ha residential development*);
- Barina Downs Road, Detention Basin Design (*large regional detention facility*);
- Robertson Road, Scotland Island – Detailed Stormwater Drainage Design;
- Jenkins Road, Dundas - Detention System Design;
- Lot 2 Muir Road, Chullora – Drainage and Detention System Design for Large Industrial Development;

▸ ***Flood Studies (FS)***

- Prospect Creek Channel Enhancement FS;
- Oats Ave, Gladesville FS;
- Casa Paloma Caravan Park FS;
- Kiaora Place Development, Double Bay FS;
- Darling Park/Cross City Tunnel - Flood impact assessment;
- Mowbray Road, Nursing Home, Assessment of overland flow impacts;
- Macquarie Links Golf Course FS (*Bunburry Curran Creek, Campbelltown*);

- Wigan Road, Dee Why FS;
- Green Road FS;
- Anzac Creek, Moorebank FS;
- Eastwood Hotel Drainage/Flooding Study;
- Mona Street, Mona Vale FS;
- Frenchs Creek FS;
- Darling Walk 2D TUFLOW Flood Assessment, Darling Harbour;
- Lynwood Ave, Dee Why Flood Assessment;
- Ashlar Golf Course Development - 2D TUFLOW Flood Study;
- Ashlar Golf Course Development – HEC RAS Flood Modelling Breakfast Creek and Western Channel;

▸ ***Dam Hazard Assessment***

- Kellyville Ridge Dam, Second Ponds Creek, Dam Hazard Assessment;
- UWS Campbelltown Dam Hazard Assessment;
- Hume Golf Course, Albury Dam Hazard Assessment;
- CSIRO, Greystanes Dam Hazard Assessment;
- Honeysuckle Creek Dam DSC Surveillance Report (*Killara Golf Course*);

▸ ***Water Quality Monitoring***

- Sectors 2, 8 and 11 Warriewood, Post construction (*ie residential subdivision*) stormwater quality monitoring;
- Warriewood Valley (*Various Sectors*) Approval Stage Water Quality Monitoring over an 8 year period
- Shellharbour Council Stormwater Monitoring Strategy (*entire Shellharbour LGA - 14,000ha*);
- St Marys Eastern Precinct Water Quality Monitoring Strategy *(160ha residential subdivision*);
- Rouse Hill Regional Centre – Post development Water Quality Monitoring of treatment measures and receiving waters (*Auto sampling and Grab sampling*);
- Water Quality Sampling for Metal Recycling development, Ingleburn.
- 2 Year Surface Water and Bed Sediment Monitoring Program, Ashlar Residential Development, Blacktown
- Sector 3, WWV Residential Development – Pre and Post Development Development Water Quality Monitoring;
- Aussie Skips, Strathfield – EPA Water Quality Monitoring Program.

▸ ***Major Culvert Amplification Design***

- Careel Creek/Barrenjoey Road Culvert Amplification Works (*Pittwater Council and RTA*);
- Nareen Creek /Narrabeen RSL Culvert Entry Upgrade (*Pittwater Council)*;
- Howell Reserve Culvert Entry Upgrade and Drainage Diversion Line (*Pittwater Council);*
- Fern Creek/Garden Street Culvert Amplification (*Pittwater Council*);

- Narrabeen Creek/Ponderosa Pde Culvert Amplification (*Pittwater Council*);
- Garie Beach Culvert Amplification (*RTA and NPWS*);
- Bridge Amplification Design, Narroy Road, Narrabeen.

▶ ***Road/Carpark Design***

- Transport Infrastructure Development Corporation (*TIDC*) Commuter Car Park Program, Detailed Design of At Grade Carparks at Emu Plains Station, Woonona Station and Waterfall Station;
- Rookwood Road Potts Hill, Detailed Design of RTA signalised intersection upgrade (*Landcom)*
- Brunker Road Potts Hill, Detailed Design of RTA signalised intersection upgrade (*Landcom)*
- Scotland Island Road Reserve Masterplan (*53ha area*);
- P&O Port Botany, Detailed Design of Staff Carparking Facilities *(50 spaces*);
- McKeown Street, Maroubra Beach, Detailed Road Design for streetscape improvement works;
- Department of Defence Site, Randwick (*Stages 1A, 1B and Community Centre*), Detailed Road Design for large residential subdivision(*5.6ha residential subdivision*);
- Greystanes Estate Northern Residential Land, Detailed Road Design for large residential subdivision *(50ha residential subdivision*);
- Sector 20 Warriewood, Detailed Road Design for large residential subdivision *(50ha residential subdivision*);
- Lidcombe Botanica, Detailed Road Design for heritage precinct of large residential subdivision;
- Heffron Park Randwick, Detailed Design of 100 space carpark and associated road improvement works.

▶ ***Infrastructure/Servicing Strategies***

- Ermington Naval Stores *(700 lot residential development*);
- Greystanes Estate, Prospect (*250ha residential & employment development*);
- UWS Werrington *(48ha residential development*) ;
- Airds Town Centre Masterplan;
- Sector 7 (*2 Daydream Avenue*), Warriewood *(3ha mixed use commercial/light industrial development*);
- St Mary's (*ADI Site-Eastern Precinct-160ha residential development*);
- Green Square Master Plan, South Sydney (*Zetland*);
- Mt Penang, Gosford Business Park development.

▶ ***Gross Pollutant Traps (GPT's)***

- Dee Why Beach GPT design (*special non proprietary*);
- Birkenhead Point and Brent Street GPTs (*special non proprietary*);
- St Georges Crescent Catchment Oil/Grit Separators (*multiple proprietary*);
- Stormwater Trust Application Assistance, Waterways Authority - Blackwattle Bay GPT;
- Brookvale Creek Rehabilitation – detailed design of large offline GPT/trash rack;

- Drummoyne Council - Three Ways to Improve The Bays GPT Design Project (*special non-proprietary*).

▸ ***General Civil Engineering***

- BER Sydney South, provision of general civil engineering design for Abigroup for a number of Schools in Sydney South;
- McCarr's Creek Road/Pittwater Road Inventory and Condition Assessment;
- Design of steel pedestrian bridge, elevated walkway, stairs and reinforced concrete weirs for residential subdivision at Little Bay;
- Design of playground equipment footings, BBQ shelter footings/slab and small reinforced concrete retaining walls for playground at Sector 8, Warriewood Valley;
- Seawall design 26 Prince Alfred Parade, Newport;
- Reinforced Earth retaining wall design for Sydney Water/Landcom, Potts Hill.

▸ ***Expert Advice / L&E Court***

- DA Stormwater management, West Ryde Urban Village Redevelopment for Ryde City Council (*ie acting on behalf of Council*);
- DA Stormwater management, Top Ryde Shopping Centre Redevelopment for Ryde City Council(*ie acting on behalf of Council*);
- Yulong Moorebank , review of road design for Department of Defence;
- Rushcutters Bay Flood Study Peer Review for Lindsay Bennelong Developments;
- Review of Managing Urban Stormwater Manual April 2004 on behalf of Landcom;
- Clontarf Street, Seaforth – Civil inspections for Landcom res. dev. on behalf of Manly Council;
- Sector 20, Warriewood – Superintendency for $6 million Civil Works Contract;
- Expert witness (*water quality on industrial site*) for L&E Court Case - Phiney Place, Ingleburn (*representing private developer*);
- Expert witness (*drainage, S88K easement)*) for L&E Court Case – Park Street, Mona Vale (*representing adjoining land owner*);
- Expert witness (*drainage/absorption system/easement*) for L&E Court Case – 120 Hopetoun Avenue, Vaucluse (*representing owner/developer*);
- Expert Witness (drainage, riparian, water quality, OSD) – Sector 3, Warriewood Valley (Sunland Developments)
- Expert witness (*drainage/riparian corridor*) for L&E Court Case – 23B Macpherson Street, Warriewood (*representing private developer*);
- Expert witness (*riparian matters/controlled activity application/culvert creek cro*ssing) for Supreme Court Case – Wambo Coal Mine, Warkworth (*representing mine operator*);
- Expert Witness – Anglican Church, Commercial Rd, Rouse Hill – Drainage Matters;

- Expert Witness – Warringah Council, Development at Bantry Bay Rd, Forestville – Stormwater Management/Water Quality and Detention;
- Expert Witness – Abax Contracting, Development at 2 Fern Creek Road Warriewood – Stormwater Drainage, Water Quality, Detention and Flooding.

▸ ***Certification***

- Subdivision PCA for Central Open Space Works, Cobaki (*Tweed Council LGA*) - Part 3A Major Project ;
- Subdivision PCA Lachlan's Line, Macquarie Park (*NSW Urban Growth/Ryde Council LGA*) - Part 3A Major Project;
- St Marys ADI Site – Construction Certificate and Compliance Inspections for Bulk Earthworks, S&E Control and roads;
- Construction Certificate Issue and compliance inspections for Bulk Earthworks and Civil Infrastructure (*Roads & Drainage*), Precincts 1&2 (450 lots) and 6 Cobaki (450 lots) (*Tweed Council LGA*);
- Civil compliance inspections and Part4A certificates for Putney Hill Development, Ryde (100 lots)– Part 3A Major Project (*Ryde Council LGA*);
- Civil Compliance Inspections and certificates for Kiah Development (*Stage 4*), Willoughby (50 lots);
- Civil Compliance inspections and Part4A certificates for DHA Riverfront Development, Ermington (500 lots)– Part 3A Major Project (DHA/*Parramatta Council LGA*);
- Civil Compliance inspections and Part4A certificates for Clemton Park Development (*Australand*) – Part 3A Major Project (*Canterbury Council LGA*);
- Bunya Collector Road CC – Private certification assessment for Landcom;
- Construction Certificate issue (*Private Certification*) for small subdivision at Mount Street, Constitution Hill;
- Construction Certificate issue (*Private Certification*) for small subdivision works at 28 Crescent Rd, Mona Vale;
- Construction Certificate issue (*Private Certification*) for small subdivision works at Brush Rd, Eastwood;
- Part4A Compliance Certificate (Road and Drainage Works) for Retirement Village at Evans Road, Rooty Hill;
- Penrith Lakes Weir 3 CC assessment and compliance inspections for NSW Planning;
- Construction Certificate Drainage Works – Little Street, Lane Cove;
- CC and Inspections – Elara MD103 and Elara RL, Marsden Park (*Stocklands*);
- CC Altrove Stage 7, Schofields (*Stocklands*);
- CC and Inspections, Willowdale (*Stocklands*).

3. EDUCATION & PROFESSIONAL AFFILIATIONS

- Bachelor of Engineering (*Civil*), University of Technology, Sydney, 1996;
- Member, Institution of Engineers, Australia (*MIEAust*);
- Charted Professional Engineer (*CPEng*);
- National Professional Engineers Register (*NER - Civil*);
- NSW Accredited Certifier (*BPAct 2005*) – Categories B1, C1, C2, C3, C4, C6, C7, C12, C15, C16 (*BPB 0816)*
- Member of BPB Disciplinary Committee (*2015-2016*)