STORMWATER MANAGEMENT REPORT

Barkema Lands

NorBelle Creek Watershed

Preliminary Report for Draft Plan Submission

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Executive Summary

This investigation was completed to refine the quantity storage needs for the developing lands within the NorBelle Creek Master Drainage Plan. Two quantity control cells (Cells 1 and 2) are currently in place and provide adequate flooding protection as defined by the targets below.

Target 1: ***Peak 100-yr outflow at Highway 62 = 2.8cms***

Target 2: ***Maximum 100-yr WSEL in Cell 2 = 109.45m***

The existing Cells 1 and 2 are sufficient to support development of Settlers Ridge and Barkema within the current urban boundary limits. Development of Barkema would proceed hand in hand with the expansion of Cell 2, however, it is shown should the expanded facility be unusable or otherwise unavailable, the development of Barkema would still be possible.

Upon completion of the expanded Cell 2, all of Basins 106a, 106b, 108b1 and 110 could be developed without any further quantity controls needed.

As development proceeds into Basin 107, a new facility would be necessary. This would be a combined quantity and quality control facility that would provide treatment for the entire 43ha contributing area.

Final phases of development would encroach into Basin 104. At this basin an existing low area provides ample room for quantity control. GDJE assumed a simple storage:discharge relationship for this reservoir from the MDP with modification to the discharge only (assuming a simple control structure) and showed there is sufficient storage available to maintain the outflow target at Highway 62 and WSEL in Cell 2.

Table 1 shows the storage required for each scenario. It is important to state that the natural storage west of Sidney Street is relied upon in each of the MDP, Ainley Implementation report and the current study. The natural storage must be maintained. This means any road reconstruction of Sidney Street should be carefully reviewed especially as it relates to culvert replacements.

Table 1: Phasing and SWM Quantity Controls

Scenario	Description	Storage Needed	Storage Volume	Target Met
1	Fully Developed Conditions Comparison to Ainley	Existing Cell 1 and Ainley modification to Cell 2	Pond 104 = 3.32ha*m Cell 1 = 2.99ha*m Cell 2 = 7.51ha*m	Yes
2	Check on Spill Volume	NA	Cell 1 = 2.66ha*m Cell 2 = 5.87ha*m	NA
3	Full Development of Basins 106a, 106b, 108b1 and 110	Requires expansion of Cell 2	Cell 1 = 2.91 ha*m Cell 2 = 6.49ha*m	Yes
4	Full Development of all lands	Expanded Cell 2, Ponds 104 and 107	Pond 104 = 3.93ha*m Pond 107 =1.71ha*m Cell 1 = 2.91ha*m Cell 2 = 6.49ha*m	Yes
5	Barkema and Settlers Ridge within the Urban Boundary	Existing Cells 1 and 2	Cell 1 = 2.91ha*m Cell 2 = 6.12ha*m	Yes

Table 2 shows the targets values and that the targets are achieved for each scenario.

Table2: Summary of Targets

Scenario	**Peak Outflow at Highway 62**	**Maximum WSEL in Cell 2**	**Target Met**	**Comment**
Target	**2.8 cms**	**109.45m**		
1	2.821	109.45	**No**	The peak outflow slightly exceeds the 2.8cms target. This is just a comparison Scenario to Ainley model.
2	NA	NA	NA	
3	2.73	109.45	**Yes**	
4	2.73	109.45	**Yes**	This is the fully developed condition.
5	2.73	109.453	**Yes**	3mm exceedance of WSEL is outside of precision limits. Barkema development provides natural expansion to Cell 2 which is ignored in this scenario.

The commercial lands east of Towncentre Drive should not have peak flow control as it would delay the early peak from these lands and contribute to the later and larger peak from the upper watershed.

Revision Notes:

April 17, 2017 revision was prepared to respond to City of Belleville comments regarding the future drainage routes to Cell 2. The flow route from Basins 107 and 104 through Settlers Ridge to Cell 2 is not well defined by the current Settlers Ridge SWM plans and the City is concerned drainage may not be able to be conveyed to the Cell 2. Basin 104 flows westward across Sidney Street and joins with Basins 101, 102, 103 and 105 and must all be routed through Settlers Ridge into Cell 2. GDJE reviewed an option to provide an alternative route through Barkema lands for Basin 107 and confirmed a 750mm storm sewer at 0.75% is sufficient to convey the 100-yr pre-development flows (most stringent condition). This is discussed in Section 3.4.3 Conveyance.

City also requested Settlers Ridge phasing to be clarified. Since the phase numbers have changed and since it may be difficult to keep these clear, GDJE has revised the SWM report to reference Settlers Ridge Lands that may be developed before increased storage is needed as those lands within the urban boundary. All phase numbers are removed.

The capacity at Highway 62 was revised from 2.85cms to 2.8cms per the GGG findings. Thus, all reference to target flows are changed to 2.8cms. The revision was made to improve consistency with recent report by GGG. The controlled outflows for the proposed development scenarios were not affected in this revision as they were sufficiently lower than target.

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1 Purpose and Design Constraints

This report was prepared to support development within the NorBelle Creek Watershed, specifically, for a draft plan of subdivision application on the Barkema lands within the current urban lands designated in the Official Plan.

Mr. and Mrs. Barkema own approximately 41 hectares (101.5 acres) of farm land fronting on Sunningdale Drive and abutting the Settlers Ridge Developments lands on the west and southern sides. Their land holdings also include a road allowance fronting on Highway 62. A 21.1-acre parcel (8.5ha) is currently under consideration for a draft plan of subdivision for residential development.

The Barkemas have retained G.D. Jewell Engineering to prepare a draft plan application and undertake the necessary servicing studies to support the application. This report focusses on the stormwater management needs for the lands in question, but also serves as guidance for further development in the NorBelle Creek Watershed.

Several drainage studies have been authored for the area dating back from 1995 by VanMeer Limited who completed a floodline investigation to the most recent work by Ainley Graham and Associates in 2013 who completed the implementation study that included a design for Cells 1 and 2.

The Ainley study recommended a staged implementation for Cell 2 and to date the second stage of construction of the pond has not been implemented. Cell 1, situated immediately downstream of Cell 2, has been fully constructed.

The current study also provides information to the concerned reader about timing of storage expansions related to development phases of both Settlers Ridge and Barkema.

In all cases, modelling results are compared with two design constraints. These are given in Table 1-1.

Table 1-1: Development Constraints

Location	Constraint	Source
Highway 62 Cross Culvert	Max Peak Flow = 2.8cms	(Ainley Group, 2013) and (Greer Galloway Group, 2012)
Cell 2	100-Yr Water Level = 109.45m	(Ainley Group, 2013)

The first design constraint is provided in previous work and has been the governing design used by MTO for their recent Highway 62 expansion. Original investigations by VanMeer and GGG showed the capacity of the culvert is 2.8cms. Floodline mapping was prepared on this basis in 1995, and this constraint has remained.

The second constraint is the 100-yr water elevation in Cell 2. There are two existing residences along Sidney Street that would be impacted by standing water on their property if the water level in Cell 2 were to exceed 109.45m (the design maximum water level). Scenarios investigated herein are compared to this water level using a reverse comparison with storage and discharge.

The SWM facilities, Cell 1 and Cell 2 are online with NorBelle Creek and therefore provide only quantity controls. Quality treatment is to be provided offline (Quinte Conservation, 2011). Two additional facilities are discussed in this study; these are the facilities for basins 104 and 107. While not specifically the focus of the current investigation, discharge:storage curves were required to be advanced for basins 104 and 107 in order to complete the design for the expansion of Cell 2.

Since the constraints on the system were given by the Master Drainage Plan and Ainley and since target flows are based on the capacity of the Hwy 62 culvert, a post to pre-development peak flow design was not used in this study. It is important to note that the study constraint is more stringent than using pre-development peak flows as target flows.

2 Background

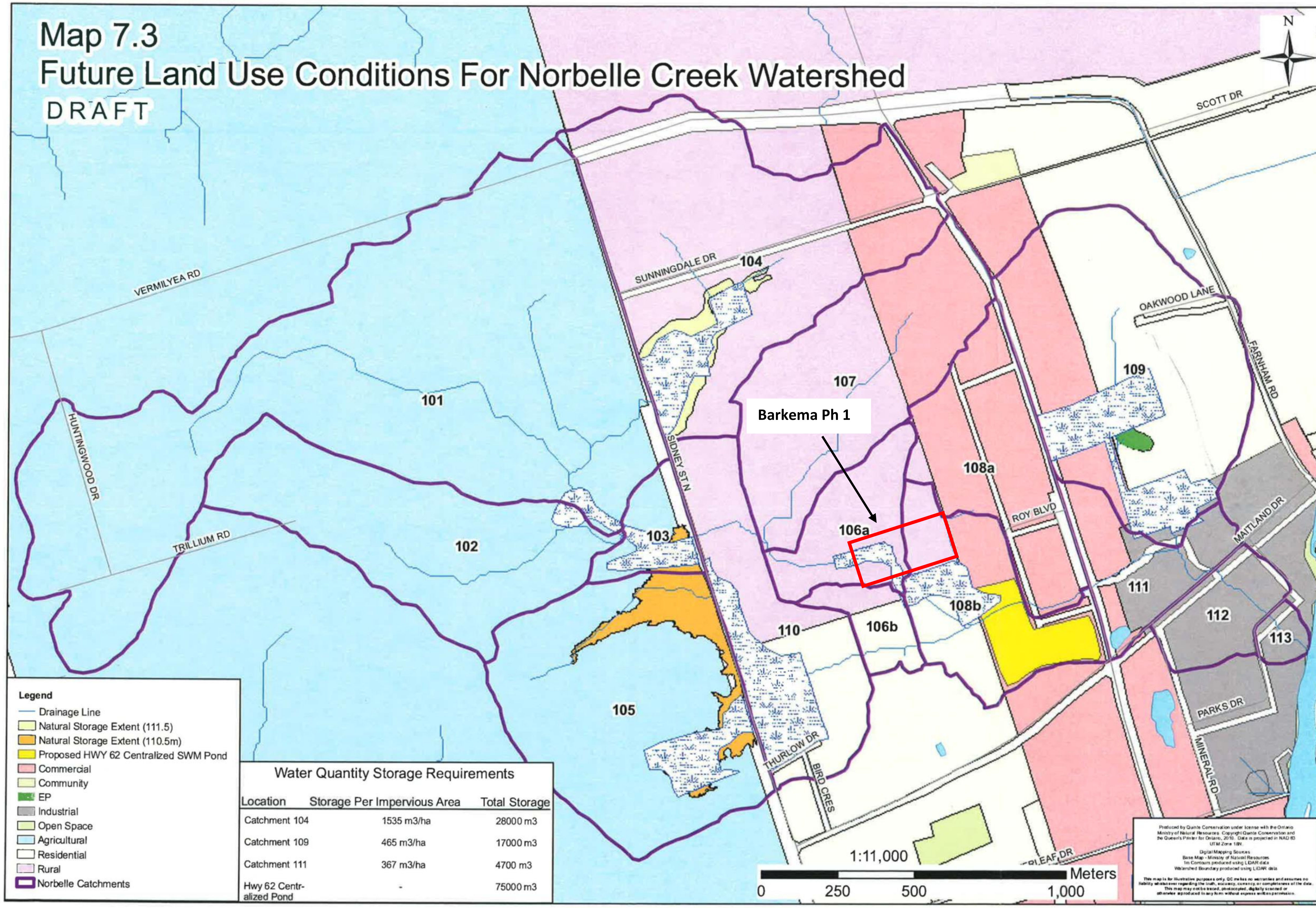
The Barkema lands are situated south of Sunningdale drive, west of Highway 62, and east of Sidney Street (see Figure 2-1). They are bounded by the Settlers Ridge Subdivision on the south and west sides. This is within a rapidly developing area in the catchment of NorBelle Creek.

G.D. Jewell reviewed several background documents to assist with the preparation of the current study. These include:

- NorBelle Creek Master Drainage Plan, Quinte Conservation, 2011 (hydrologic modelling was completed by XCG)
- vanMeer Limited, 1995
- Master Drainage Plan, GGG, 1996
- NorBelle Creek Implementation Plan, Ainley Group, 2013

Additional background documents, related to the former spill from NorBelle Creek into No Name Creek, were also reviewed. These include:

- Settlers Ridge Subdivision, Phase 1 Stormwater Management Report, Ainley Group, 2008
- Upper No Name Creek Water Management Study, Final Report, Gore & Storrie, March 1995
- Stormwater Management Wetland Facility Implementation Plan, Upper No Name Creek, Ecos Garatech (EGA), November 1996
- No Name Creek – North, Stormwater Management Facility Design Brief, VanMeer Limited, December 1998
- Final Drainage Report for Upper No Name Creek / Bell Boulevard Stormwater Management System, Weslake Inc., March 1998
- Stormwater Management Report, Upper No Name Creek, Millennium Parkway Wetland Facility, G.D. Jewell Engineering, 2016



Water Quantity Storage Requirements

Location	Storage Per Impervious Area	Total Storage
Catchment 104	1535 m3/ha	28000 m3
Catchment 109	465 m3/ha	17000 m3
Catchment 111	367 m3/ha	4700 m3
Hwy 62 Centr-alized Pond	-	75000 m3

Figure 2-1: Catchment Area Drawing from MDP – showing Location of Site

3 Hydrologic Modelling

An OTTHYMO model of the catchment was developed to investigate the potential drainage changes to the site. OTTHYMO stands for Ottawa Hydrologic Model and is a Canadian adaptation of HYMO. OTTHYMO is a single event hydrologic model that allows a user to generate a runoff hydrograph from simulated catchments using limited input data. The program will add, route, divert, store and delay hydrographs generating several runoff data parameters such as peak flow, time to peak, volume and runoff coefficient.

The user may simulate a catchment by selecting from an urban (Standhyd) or a rural (Nashyd, Wilhyd or SCShyd) unit hydrograph depending on the degree of development measured as imperviousness. Catchment parameters such as:

- catchment area
- imperviousness, total and directly connected
- runoff coefficient or curve number
- length and slope of impervious area
- length of and slope of pervious area
- time to peak of the catchment
- Manning's roughness coefficient
- storage coefficient

Precipitation inputs may be provided using precipitation gauge statistics from Intensity Duration Frequency curves or it may be an historic storm read in from an external file. Precipitation has a total depth, duration and distribution that describe how much rain falls and when. The hydrologic model estimates how much of the precipitation input is translated to output (runoff) using data supplied about the catchment. The volume of water, measured as depth of water in mm, is conserved throughout the model per Equation 1.

Equation 1

$$Rainfall\ depth = Runoff\ depth + Losses$$

Losses include those through interception depression storage (Initial Abstraction) and infiltration determined using one of three infiltration methods; SCS curve number (CN), proportional loss coefficient (C), or Horton's Infiltration equation. Diversions are another means of subtracting volume from the model output (a loss). These can be imposed by the user with the DUHYD or Divert HYD command. Evaporative losses are ignored.

Peak flows are generated in the Nash unit hydrograph method assuming the runoff is routed through a series of linear reservoirs (the number of which is selected by the user). In the Standard unit hydrograph method, the impervious areas are separated from the pervious and hydrographs are derived for each and added to develop a catchment-wide hydrograph.

Storage, lags or routing through channels do not subtract from the runoff volume, but result in delays of the times to peak and can lead to changes in the peak flow, typically by reducing the peaks. Most stormwater management objectives are focussed on the magnitude of the peak flows, while some may be interested in volume of runoff.

Existing conditions catchments were modelled using the Nash Unit Hydrograph (Nashyd) and proposed conditions with the Standard Unit Hydrograph (Stanhyd). The following sections describe the development of the modelling inputs and the results of modelling.

3.1 Model Development

A hydrologic model is a mathematical simplification of various parameters that contribute to runoff during rainfall events. Parameters include:

- Precipitation – intensity, duration and frequency as well as distribution
- Catchment area
- Percent imperviousness – runoff volume, time to peak and peak flow increase with percent imperviousness
- Soil conditions – these determine how much and how quickly water will be removed from runoff through infiltration. This may be expressed as a Curve Number, or by a runoff coefficient or using an infiltration model such as Horton's Infiltration
- Slope – peak flows increase with slope
- Initial abstraction – depth of precipitation input that is subtracted from the model and does not contribute to runoff. This value is different for impervious and pervious areas and is expressed as two values.
- Manning's n – frictional coefficient that affects the time to peak. This value is different for impervious and pervious areas and is expressed as two values.

The Settlers Ridge SWM Implementation Report included refinements within the drainage areas and made changes to the development limits allowing for increased impervious cover as compared to the MDP vision (see Sections 3.1.2 and 3.1.3). GDJE built upon the Implementation Report limits of development and employed the discretization used by Ainley.

3.1.1 Precipitation

The master drainage plan provided the design storm used in both the Settlers Ridge development report (Ainley Group, 2013) and the current study.

The precipitation depths in Table 3-1 below are provided from the MDP. The precipitation depths are distributed following the AES storm distribution (Quinte Conservation, 2011). This distribution is given in Table 3-2 as a percentage of depths per hourly increment.

Table 3-1: Precipitation Depths from the Master Drainage Plan

Return Period (yrs)	**5**	**10**	**25**	**50**	**100**
12-hr depth (mm)	53.2	60.1	68.7	75.1	81.5

Table 3-2: AES Distribution

Time Step (hr)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Depth (%)	13	26	20	15	14	8	3	1	0	0	0	0

3.1.2 Catchment Area

Catchment areas from the MDP were used as modified by Ainley (see Figure 3-1). Table 3-3 lists the catchment areas and the online quantity control ponds to which they contribute. Portions of basin 108 are uncontrolled and drain directly to the Norbelle system downstream of Cell 1 or along the Hwy 62 and Towncentre Drive ditch system. Since Cell 2 drains through Cell 1, all areas contributing to Cell 2 naturally contribute to Cell 1.

Catchment areas 108a and 108b within the MDP were subdivided into many smaller areas in the Settlers Ridge SWM Implementation report naming them 108a through 108i. Unfortunately, the nomenclature in the Implementation report is not easily comparable to the MDP. For example, basin 108a is 29ha in the MDP, but 9.32ha in the Implementation report. GDJE has maintained the Settlers nomenclature, but for clarity, when referencing the Implementation plan catchments 108 series, GDJE uses *italics*. When referencing the MDP basins 108a or 108b, GDJE uses vertical text.

Table 3-3: Catchment Areas for OTTHYMO Model – Post-Development

Catchment	**Area (ha)**	**Cell 2**	**Cell 1**	**Uncontrolled**
101	150	Yes	Yes	
102	46	Yes	Yes	
103	8	Yes	Yes	
104	76	Yes	Yes	
105	60	Yes	Yes	
106a	16	Yes	Yes	
106b	6	Yes	Yes	
107	43	Yes	Yes	
108b1	12.4	Yes	Yes	
108d	10.67		Yes	
108f	0.77		Yes	
108e	4.31			Yes
108g	3.78			Yes
108abc	23.91			Yes
108h	1.47			Yes
108i	1.43			Yes
110	33	Yes	Yes	
Total	**496.74**	**450.4**	**461.84**	**34.9**

The Barkema lands lie within basins 104, 107, 106a and a portion of 108a and 108b. The initial phase of development is within the current urban area in basins 108b and 106a.

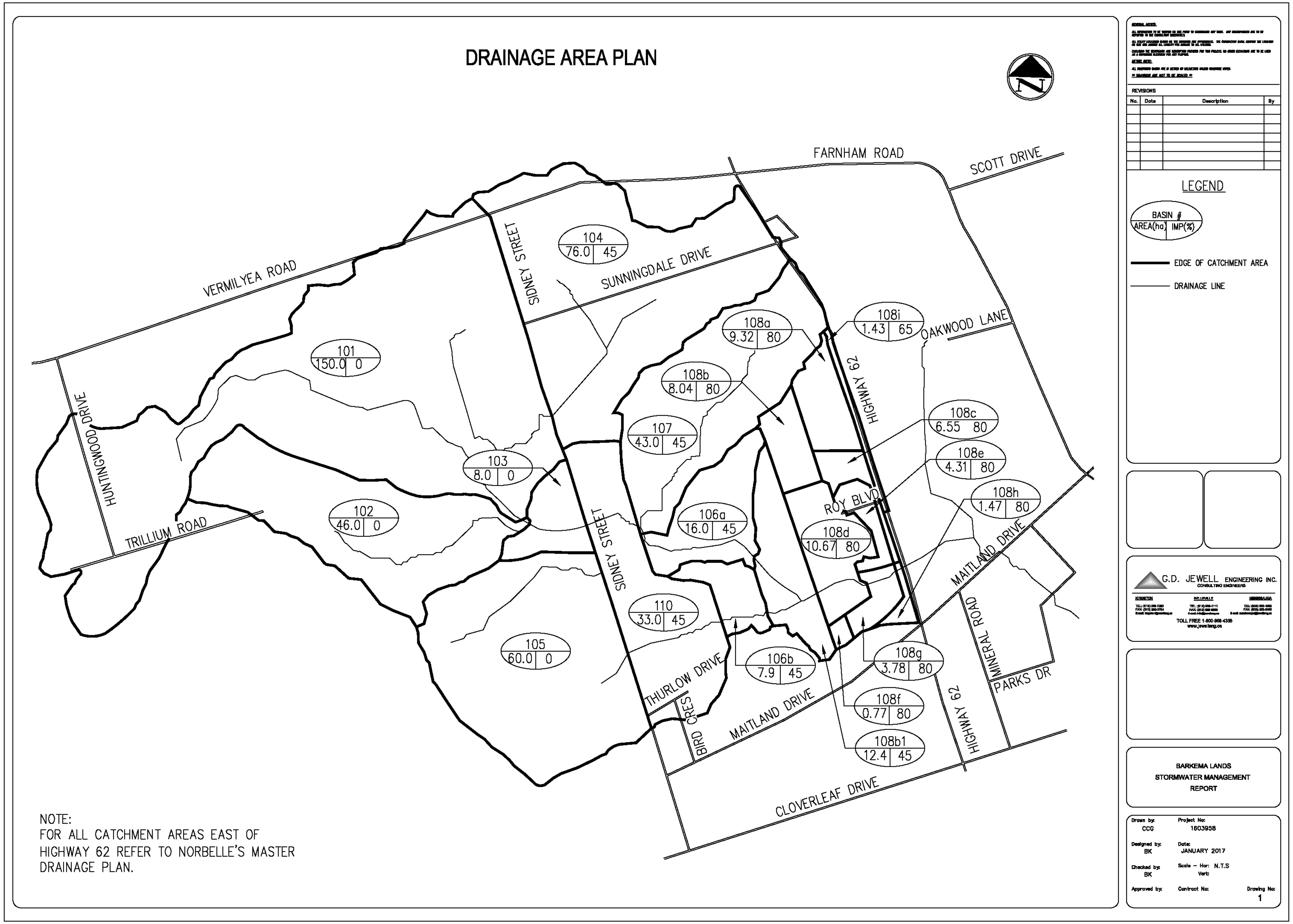


Figure 3-1: Catchment Areas – as Revised by Ainley Stormwater Management Report, 2013

3.1.3 Imperviousness

Site imperviousness is an estimate of the portion of the site that will be 'hardened'. These areas include the roof, asphalt and gravelled areas.

Site imperviousness for developed conditions was estimated in the MDP, but these were modified by Ainley as shown in Table 3-4.

Table 3-4: Impervious Percentages for Post-Development Areas

Catchment	MDP Imp (%)	Ainley Imp (%)
101	0	0
102	0	0
103	0	0
104	24	45
105	0	0
106a	15	45
106b	37	45
107	36	45
108a	80	
108b	58	
108ba	50	
108b1		45
108d		80
108f		80
108e		80
108g		80
108abc	80	80
108h		80
108i		65
110	34	45

3.1.4 Soils

The soils were described in the MDP as Type C soils. These have typically low infiltration values and are not useful for infiltration technologies in stormwater management. Hydrologic modelling emulates the soil conditions through the use of curve numbers discussed in the next section.

3.1.5 Curve Number

Curve numbers are used in the Soil Conservation Services (now known as the *National Resources Conservation Service*) methodology for estimating the proportion of precipitation that will runoff the lands from that portion that will infiltrate. Curve numbers are a function of soil type, land cover, slope, and land use. The higher the curve number – the greater the proportion of precipitation that is expected to runoff the lands.

The MDP curve numbers were adopted by Ainley and have been continued in this investigation. The slight exception was in 106b where GDJE used CN = 79 instead of CN = 78. This is slightly more conservative.

Table 3-5: SCS Curve Numbers

Catchment	CN
101	79
102	78
103	74
104	81
105	83
106a	82
106b	79 (AG = 78)
107	80
108a	
108b	
108ba	
108b1	77
108d	76
108f	76
108e	76
108g	76
108abc	76
108h	76
108i	76
110	79

3.1.6 Time to Peak

The OTTHYMO model requires a time to peak (T_p) for rural areas modelled using the Nash unit hydrograph. The times to peak were provided for each basin in the MDP and these were also adopted by Ainley. The current study employed the same times to peak. See the OTTHYMO model output in Appendix C for more detail on the times to peak.

3.1.7 Topographic Data

Topographic data was originally collected by Quinte Conservation using LiDAR that was specifically flown for the MDP area. Basin discretization was also performed by Quinte Conservation. GDJE employed the same topographic dataset.

3.2 Existing Conditions

The existing conditions modelling was performed by Quinte Conservation in the MDP. It was determined that a post to pre methodology would not be used in NorBelle, but the capacity of the Highway 62 culvert would set the target outflows. These have been discussed in the Background section, but are discussed further in Section 3.2.1.

3.2.1 Target Flows

Target outflow for NorBelle Creek was resolved in the MDP in their Scenario A that provided 75,000m^3 of storage upstream of Highway 62 to achieve a peak outflow at Highway 62 of 2.85cms (p19, Table

7.11). The MDP also reviewed potential land use change in the Rural areas to Residential with an impervious cover of 50%. For this modified scenario, the storage in the central facility (Cells 1 and 2) increases to 93,000m^3. GGG, in communication with MTO after the MDP was completed, determined the capacity at Highway 62 was slightly restricted by changes from the recent Highway 62 upgrades. A capacity of 2.8cms was confirmed.

Ainley determined a peak outflow of 2.79cms based on their varied development scenario and total storage of 73,300m^3 in Cell 2 and 29,500m^3 in Cell 1. In their Implementation report, it is noted the 100-yr water elevation in Cell 2 is set at 109.45m. Development has proceeded on this basis and it would not be practical to make any changes to the quantity control in the system that will lead to an elevation in Cell 2 that would exceed this value.

GDJE maintained the target outflows at Highway 62 of 2.8cms following the MDP requirements.

Thus the targets measured in the current study are:

Target 1: ***Peak 100-yr outflow at Highway 62 = 2.8cms***

Target 2: ***Maximum 100-yr WSEL in Cell 2 = 109.45m***

The storage required to achieve the target outflows is the subject of the discussion below.

3.3 Proposed Conditions

Proposed conditions looks at full buildout of all development lands conceived by the Official Plan for the City of Belleville as shown in Map 7.3 of the MDP.

Several scenarios were investigated by GDJE to advance the implementation of quantity control facilities as development proceeds. These are discussed below.

3.3.1 Development Scenario

Scenario 1

This scenario was constructed to match the SWMHYMO model included in Ainley's Implementation plan. The scenario includes full development of all lands, natural storage in Basin 104 and west of Sidney Street (in Basins 103 and 105) as well as constructed storage in Cell 1 and Cell 2. Residential development is assumed at 45% imperviousness and commercial development is 80%.

The OTTHYMO model for this scenario is NBELLE.

Scenario 2

A second scenario was developed to investigate the storage requirement solely from the redirection of the spill into No Name Creek. The residential lands were modelled using a rural hydrograph and commercial lands along Highway 62 were considered developed.

The OTTHYMO model for this scenario is NBELLEv1

Scenario 3

Scenario 3 considers full development of Basins 106a, 106b, 108b1 and 110. In this scenario the Cell 2 is enlarged with an additional 4,000m^3 of storage in the Barkema subdivision. Basins 104 and 107 are considered in their natural states. The natural storage in Basin 104 is maintained.

The OTTHYMO model for this scenario is NBELLEv2

Scenario 4

This scenario considers the additional quantity controls required as Basins 104 and 107 are developed. The natural storage in Basin 104 is engaged by reducing outflows. The storage:discharge relationship from Ainley is altered to reduce outflows. This would be accomplished by constructing and outflow structure. Additional storage is provided for Basin 107. Current plans by Ainley show a proposed quality control facility for Basin 107. This scenario assumes a combined pond measuring 180m x 60m. This would be considered the full development scenario.

The OTTHYMO model for scenario 4 is NBELLEv3

Scenario 5

This scenario considers how much development can occur with the existing conditions storage. Basins 104 and 107 are left undeveloped.

The OTTHYMO model for scenario 5 is NBELLEv4

3.3.2 Inputs – Proposed Conditions – Full Development (Scenario 3)

The following inputs listed in Table 3-6 were used in the hydrologic model to represent the fully developed scenario (Scenario 3). The inputs were maintained from the Ainley Implementation report. In the developed conditions, pervious areas are assumed to have 35m length and 5% slope. This is somewhat conservative since most developments used slopes of less than 2% on grassed areas. The pervious length of 35m produces a rapid response from the pervious areas and would also be conservative.

Table 3-6: Proposed Conditions Model Inputs

Basin	Area (ha)	Imp (%)	Tp Nash UH (h)	Impervious Area					Pervious Area				
				XIMP (%)	IA (mm)	n	L (m)	S (%)	CN	IA (mm)	n	L (m)	S (%)
101	150	0	1.7						79	11.1			
102	46	0	0.7						78	11.1			
103	8	0	0.6						74	11.1			
104	76	45		35	0.6	0.013	1300	0.6	81	2.5	0.25	35	5
105	60	0	0.6						83	11.1			
106a	16	45		35	0.6	0.013	455	0.6	78	2.5	0.25	35	5
106b	6	45		35	0.6	0.013	390	0.6	79	2.5	0.25	35	5
107	43	45		35	0.6	0.013	975	0.6	80	2.5	0.25	35	5
108b1	12.4	45		35	0.6	0.013	520	0.6	77	2.5	0.25	35	5
108d	10.67	80		60	0.6	0.013	100	0.6	76	2.5	0.25	35	5

Basin	**Area (ha)**	**Imp (%)**	**Tp Nash UH (h)**	**Impervious Area**					**Pervious Area**				
				XIMP (%)	IA (mm)	n	L (m)	S (%)	CN	IA (mm)	n	L (m)	S (%)
108f	0.77	80		60	0.6	0.013	350	0.6	76	2.5	0.25	35	5
108e	4.31	80		60	0.6	0.013	200	0.6	76	2.5	0.25	35	5
108g	3.78	80		60	0.6	0.013	250	0.6	76	2.5	0.25	35	5
108abc	23.91	80		60	0.6	0.013	700	0.6	76	2.5	0.25	35	5
108h	1.47	80		60	0.6	0.013	125	0.6	76	2.5	0.25	35	5
108i	1.43	65		45	0.6	0.013	100	0.6	76	2.5	0.25	35	5
110	33	45		35	0.6	0.013	390	0.6	79	2.5	0.25	35	5
Total	**496.74**												

3.4 Quantity Control

In the fully developed condition there will be four constructed storage facilities. These are:

- Cell 1
- Cell 2
- Basin 107
- Basin 104

Quantity control for Cells 1 and 2 is provided online. That is, the whole of NorBelle Creek flows through the ponds. Ainley designed Cell 2 for a future expansion that was recommended to be “constructed prior to the approval of phase 3 *(editorial note: this is now called phase 6)* of Settlers Ridge” (Ainley, 2013).

The existing storage in Cell 2 is not explicitly stated in the Settlers 2013 report. GDJE backed out the existing conditions by subtraction of the volume of the proposed expansion that was identified by surface area, side slopes and depth. The Cell 2 pond has a flat bottom at 108.2m. Storage below this depth is found in the channel storage through the Settlers Ridge lands. The existing conditions storage is shown in the third column of Table 3-7.

GDJE developed a depth:storage relationship for the proposed expansion on the Barkema lands. The pond expansion would have a bottom elevation at 108.4m adjacent to the Cell 2 pond and would gently increase in elevation northward. This will help to ensure the dry pond storage in the Barkema lands will drain. The expanded storage is summed with the existing to develop the proposed storage for Cell 2 in column 4 of Table 3-7.

Table 3-7: Stage:Storage:Discharge Relationship for Cell 2 – Expanded

Stage	**Discharge**	**Cell 2 – Existing**	**Cell 2 - Expanded**
(m)	**m^3/s**		**m^3**
108.0	0	0.068	0.068
108.1	0.0308	0.568	0.568
108.2	0.1166	1.068	1.068
108.3	0.241	1.448	1.448
108.4	0.3874	1.832	1.852
108.5	0.5405	2.220	**2.263**
108.6	0.7662	2.612	**2.680**
108.7	1.0267	3.008	**3.103**
108.8	1.2753	3.407	**3.533**
108.9	1.5309	3.811	**3.969**
109.0	1.7455	4.219	**4.413**
109.1	2.0646	4.631	**4.862**
109.2	2.3338	5.047	**5.319**
109.3	2.5985	5.467	**5.782**
109.4	2.8567	5.891	**6.251**
109.5	3.1018	6.319	**6.727**

The discharge from Cell 2 is controlled partly by the backwater of Cell 1 and partly by the size of the culvert between the two cells. GDJE did not adjust the discharge (column 2 of Table 3-7). The top of ponding was planned to be 109.45m in the Implementation report. At this elevation the discharge is 2.98cms. Storage available in the existing cell is 6.105ha*m and in the expanded cell there is 6.489ha*m at that elevation.

Cell 1 is in place and will not be expanded. The interested reader may review the OTTHYMO model output in Appendix C to see the storage:discharge relationship for Cell 1 that was transcribed from the Implementation report. Storage:discharge relationships for Ponds 104 and 107 are provided in Appendix A.

Basin 107 will require a storage facility. At this location a combined facility can be entertained. GDJE prepared a sample pond sizing for Basin 107 that will provide both quality and quantity treatment. A wetpond measuring 180m X 60m (measured at the high water line) with 2m of active storage depth and 5:1 side slopes will provide 17,067m^3 of active storage. See Table 3-8 for pond dimensions and elevations.

Table 3-8: Pond Sizing for Basin 107

Pond Sizing

Bryon Keene, P.Eng.
2017-01-18

BMP Type:	Wetpond	Pond Type:	Combined

Dimensions *(Select from Quality, Quantity or Combined)*

	Elevation (m)	Depth (m)	Length (m)	Width (m)	Area (m^2)
Full Storage (Active)	110	2.00	180.0	60.0	10,800
Top of Extended Detention	108.8	0.80	168.0	48.0	10,800
Top of Permanent Pool	108	1.0	160.0	40.0	6,400
Top of Pond Berm	110.3	0.3	*(Pond Freeboard)*		11,529
Bottom of Pond	107.0	3.0			4,500

Constraints

Length:Width Ratio Full _:1	3	Side Slope _:1	5

Quantity Control

First Guess for Active Storage		**Active Storage Check**	
Assume Full Depth of Runoff Volume (m^3)	**26,037**	Active storage available (cu.m)	**17,066.7**

3.4.1 Scenario Evaluation

OTTHYMO models were prepared for the various scenarios as discussed in Section 3.3.1.

Scenario 1 – Comparison with Ainley SWMHYMO model

The inputs from Ainley's SWMHYMO model were checked in the GDJE OTTHYMO model to provide a standard of comparison. In this scenario, the Cell 2 pond shown in Ainley's Implementation report was used. Fully developed conditions are assumed. The check was performed at the Highway 62 crossing where Ainley's model produced a peak flow of 2.791cms and the current study produced a result of 2.821cms. This is close agreement. It also shows the GDJE model is slightly more conservative and adds more confidence on the results if proposed conditions scenarios meet target outflows.

Scenario 2 – Spill Investigation

The effect of eliminating the spill to No Name Creek was checked to see the effect on storage in Cells 1 and 2. This assumes no development upstream of the ponds. The Cell 2 facility tested here is the proposed modified pond for the Barkema lands. The storage used is 5.87ha*m in Cell 2 and 2.66ha*m in Cell 1. The peak flow is 2.46 at Highway 62.

Scenario 3 – Full development of Basins 106a, 106b, 108b1 and 110

This scenario tests the enlarged Cell 2 onto the Barkema lands for the full buildout of the contributing lands with the exception of Basins 104 and 107. These would have separate quantity controls. The peak storage in Cell 2 is 6.49ha*m (top of pond = 109.45m) and 2.91ha*m in Cell 1. The peak flow at Highway 62 is 2.73cms.

With reference to the targets (Section 3.2.1), one finds the maximum permissible Cell 2 WSEL will be reached. However, the peak outflow at Highway 62 is slightly under the maximum permissible.

As phases of development proceed in Settlers Ridge and the Barkema lands, the pond expansion proposed with Barkema Subdivision would be adequate to maintain the required flooding protection during the 100-yr event for all development within the four basins listed above.

Scenario 4 – Full development of all lands

New storage facilities are conceived for Basins 104 and 107 to permit full development of contributing lands within. In order to achieve the target elevation in Cell 2 and outflow at Highway 62, the site developers must construct two facilities.

Pond 104

This facility treats 76ha of contributing residential lands with 45% imperviousness. Peak outflow from the facility is 0.31cms and storage required is 3.93ha*m.

Pond 107

The facility treats 43ha of contributing residential lands also with 45% imperviousness. Peak outflow is 0.61cms and storage required is 1.71ha*m.

Scenario 5 – Tests all of Settlers Ridge and Barkema within Urban Boundary

This scenario assumes existing conditions for Basins 104 and 107, full development of 106b and 108b1, but partial development within Basins 106a and 110 for the lands planned for Settlers Ridge and Barkema within the urban boundary. A conservative assumption is made that the expansion of Cell 2, that would be concurrent with development of Barkema lands within the urban boundary, is not completed or available. This is a conservative test, since it is reasonable to assume the expanded facility would be completed as Barkema lands develop.

Nevertheless, it was found that Settlers Ridge and Barkema lands within the urban boundary could be developed without the Cell 2 expansion. The Cell 2 WSEL would be 109.453m. The implied precision in this value is not supported by the data, but it suggests the Cell 2 water level would be at maximum permissible.

Again, this is an unlikely scenario, but it was completed to add confidence in the sequencing of construction.

3.4.2 Discussion about Storage Opportunities

There is natural storage on the west side of Sidney Street that is not manipulated in any of the scenarios and there would be opportunity for storage enhancement there. However, this would be discouraged as the lands are located in Quinte West and are under private ownership. Further, the lands are established wetlands and their manipulation would not be supported by the conservation authority.

The commercial lands east of Towncentre Drive were reviewed for opportunity to provide onsite storage. GDJE found storage on the commercial lands was not beneficial to achieve the peak flow control required for Highway 62. The reason flow controls are recommended on the commercial lands is due to the lag times of the hydrographs. The commercial lands peak quickly and are experienced at the Highway 62 crossing within minutes of the excess precipitation peak. However, there is a long delay in the arrival of the peak flows from the upper watershed at Highway 62. Thus, there are two peaks in the hydrograph. The hydrograph at Highway 62 can be seen as the red line in Figure 3-2. Flows are on the Y-axis and time (given in hours) is on the X-axis. An observer standing at Highway 62 would see flows rising to an early peak about 3 hours after excess rainfall from a 12-hour event. The peak would fall slightly for the next 7 hours and the contribution from the upper watershed would be observed by a second and larger rise in water level. The second peak is more gradual and would remain higher than the first peak for a period of about 10 hours. The water would slowly recede over the next 24 hours.

Detaining any water from the commercial lands moves the early peak closer to the main peak with the associated risk of superimposing the peak flows and resulting in a higher second peak. The early peak is approximately 2cms and is well below the 2.8cms capacity of the crossing and therefore does not present a problem.

There is no benefit in providing peak flow control to the commercial lands and it would be counterproductive to do so. Storage can be provided in Basins 104 and 107 or by expansion of Cells 1 and 2. The natural storage west of Sidney Street must be maintained.

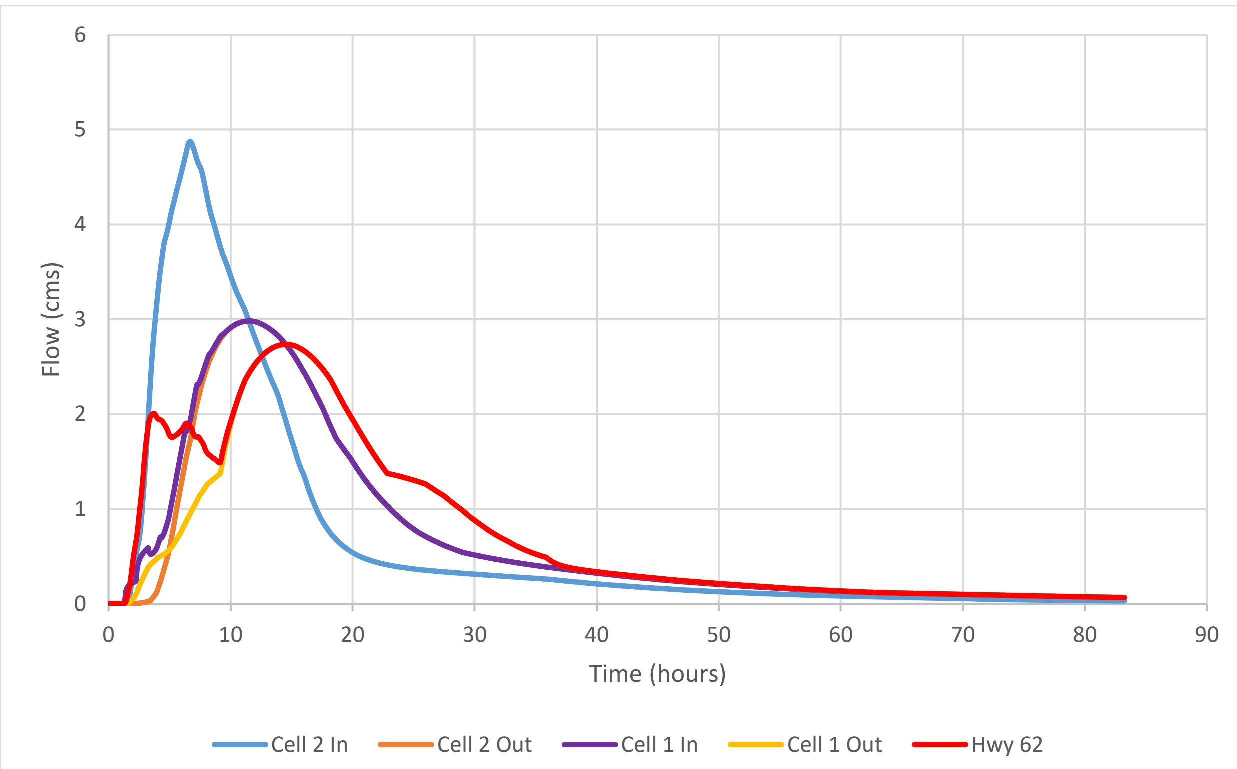


Figure 3-2: Full Development (Scenario 4) Hydrographs of NorBelle Creek flowing through Cells 2 and 1 and at Highway 62

3.4.3 Alternate Conveyance Route

Conveyance of drainage from Basins 104 and 107 through Settlers Ridge lands has not been fully provided by Ainley's design. As conveyance issues are resolved through their SWM concepts, the City has requested Barkema provide an alternate route in the event the preferred route through Settlers Ridge channel is not confirmed. Basin 104 drains across Sidney Street to combine with Basins 101, 102, 103 and 105. Rerouting of this basin through Barkema would not be possible. This drainage is received by the existing channel. Future development of Basin 104 would be controlled below existing and would not put any further pressure on the receiving system.

The path for Basin 107 has been affected by the Settlers Ridge development. Ideally, outflows from Basin 107 would be received by the channel and conveyed to Cell 2. If this route is not secured, GDJE investigated the potential to reroute Basin 107 directly to Cell 2 through Barkema lands. Two flow conditions were analyzed and discussed below;

- post-development controlled outflows from proposed SWMF 107 and
- pre-development conditions 100-yr uncontrolled from Basin 107.

3.4.3.1 Post-Development 100-Yr Controlled – Basin 107

The minor event would typically be routed through pipes and the major event by overland flows in the road network. In the developed condition, Basin 107 would have a stormwater management facility with peak outflow of 0.61cms (OTTHYMO NBELLEV3). Outflows from this facility, if required to be conveyed through Barkema lands to Cell 2, could be accommodated in a 675mm storm sewer at 0.75% slope. It would not be advisable to allow outflows from Basin 107 to use the major system (road network) and therefore, **all outflows from the SWMF would be routed through the sewer network**.

3.4.3.2 Pre-Development 100-Yr Uncontrolled – Basin 107

The most stringent flow condition is the existing conditions 100-yr runoff event. In the existing conditions Basin 107 has a peak flow of 0.96cms during the 100-yr event (OTTHYMO NBELLEV4). The peak flow from this event would need to be accommodated in a storm sewer system since it would not be advisable to direct drainage from such a large catchment to the streets.

This flow can be accommodated through the provision of a 750mm storm sewer at 0.75% slope. This size of pipe can be easily accommodated through the proposed road allowances and drainage easements to Cell 2. **All uncontrolled existing conditions runoff from Basin 107 can be accommodated through the sewer network.** Since this is the most stringent flow condition, the 750mm pipe would be required.

3.4.3.3 Impact of Alternate Routing on Peak Flows

Peak flows may be affected by channel routing or other time shifting methods applied in model analyses. The hydrograph of incoming flows to Cell 2 included outflows from Basin 107 without any time shifting or routing. This is a conservative modelling assumption. Therefore, rerouting of Basin 107 through Barkema directly to Cell 2 will result in the same peak flows and has no impact on the analysis.

3.5 Quality Control

With the exception of Basin 107 and potentially Basin 104, quality controls will be provided offline for areas draining to Cells 1 and 2. Quality controls must meet the Enhanced (Level 1) objectives (Bay of Quinte Restoration Council, 2006).

Basin 107 has the potential for a combined facility that would provide both quality and quantity control. The required facility to treat 43ha at 45% imperviousness must contain 5,375m^3 of permanent pool storage and have an extended detention capacity of 1,720m^3. An erosion control storage amount is calculated separately using OTTHYMO by routing a 25mm, 4-hour rainfall event with a Chicago distribution. The storage volume for that event is 5,581m^3. The volume is conservatively determined as the volume of the entire runoff.

The quality control summary is provided below in Table 3-9.

Table 3-9: Sizing for Level 1 Facility for Basin 107

Quality Control

Quality Control Criteria			Permanent Pool Storage (m3/ha) at 45% Imp		
			Enhanced	*Normal*	*Basic*
Imperviousness (percent)	45.0%				
Protection Level	Enhanced	*(per MOE, 2003)*	125.0	60.0	27.5
(Select from Enhanced, Normal, Basic, or User Defined)					
Land Area (ha)	43		Extended Detention (m^3/ha)	40	

Quality Summary and Check

Storage Voume (m^3)		Required	Provided	Surplus	Check
Permanent Pool (Dead)		5,375	5,433	58	OK
Extended Detention	*Greater*	1,720	5,777	4,057	OK
Erosion - 25mm Event	*of*	5,581	5,777	196	OK
Total Quality		10,956			

The forebay sizing conforms to the Ministry of Environment and Climate Change sizing requirement for settling calculations (Ontario Ministry of the Environment, 2003). The calculations are included in Appendix B. The quality pond will draw down within approximately 30 hours exceeding the minimum 24-hour recommendation (see Appendix B).

Sediment will accumulate in Pond 107 as development proceeds. GDJE completed a maintenance calculation assuming all the development is completed in year 1. The quality pond would fill to a point where removal efficiency drops below 75% and would have a projected major maintenance interval of 36 years (see Appendix B).

The conceptual quality control facility for Pond 107 would be suitable for implementation as the subdivision develops.

Pond 104 does not have a conceptual quality treatment plan at this stage of development. The lands are currently within the Rural Land Use designation of the City of Belleville Official Plan and have not be designated environmentally protected. There is a potential for a combined facility to be located there. This would need to be reviewed by the conservation authority.

3.6 Siltation and Erosion Controls

Construction of subdivisions involves the movement of and exposure of soils and is typically protracted in time. There is a high risk of erosion leading to sediment deposition into the City storm sewer system and the NorBelle Creek. Typical sediment and erosion control measures include:

- Siltation fencing
- Strawbale check dams
- Rip-rap check dams
- Filter sock inserts in catchbasins

Controls are to be placed downstream of all active work areas and upstream of protected receivers. Controls should also be placed around stockpiles of topsoils and fill materials.

Typical OPSDs provide good instruction on the correct placement and construction of the controls. The controls provide some protection if they are properly maintained, but they should be considered last resort measures. The most effective means of control are those which prevent or reduce erosion at the source. This would include diligent stabilization of exposed areas immediately after grading is completed. Stabilization measures include sod, erosion blankets or rip-rap and filter cloth on steep slopes as well as topsoil and hydroseed on gently sloped areas (<10%).

Existing stormwater management facilities should not be used for control of sediment. The site developer and contractor should actively maintain the new drainage works to remove accumulations of sediment within catchbasin sumps.

The expansion of Cell 2 will require some earth excavation and placement along the perimeter as well as the removal of a portion of the adjacent berm to make the connection. A silt fence should be located 15m south of the berm during the modifications and be maintained until the pond expansion is stabilized or as directed by the City. There would be benefit in maintaining this silt fence for up to 2 growing seasons.

4 Maintenance

The dry pond facilities would be maintained according to the approved SWM report prepared by Ainley. The design of the expanded Cell 2 is slightly varied from the Ainley design in that the bottom is slightly sloped to improve the interevent drainage out of the pond. Municipal access is provided at several locations to assist with inspections and also to allow for drainage to enter the facility through storm sewers and overland.

In the Cell 2 expansion, municipal staff would monitor accumulation of sediment at storm sewer outlets. Although all outlets would have an OGS unit capturing sediment prior to discharging into the facility, it is understood that some fine sediment will not be captured and may accumulate in the dry pond. If accumulation is excessive, it may indicate the OGS unit has not been recently maintained or it could also indicate improper or poorly maintained sediment and erosion controls have been used in the developing lands.

The maintenance plan is not prepared for Pond 107 that is designed in concept herein. A Stormwater Management Report and maintenance plan, would be prepared for review and approval in advance of development on lands outside of the current urban boundary. Based on the conceptual design herein, the Pond 107 facility would require cleanout after 36 years of operation. This is in excess of a typical 20-year cleanout frequency and suggests the preliminary sizing of Pond 107 is acceptable.

5 Conclusions

This investigation was completed to refine the quantity storage needs for the developing lands within the NorBelle Creek Master Drainage Plan. Two quantity control cells (Cells 1 and 2) are currently in place and provide adequate flooding protection as defined by the target outflow at Highway 62 of 2.8cms. A further limitation is imposed by existing development on Sidney Street with respect to the backwater elevation driven by the 100-yr water level of 109.45m in Cell 2.

Thus, evaluations were compared to the two target values repeated below.

Target 1: ***Peak 100-yr outflow at Highway 62 = 2.8cms***

Target 2: ***Maximum 100-yr WSEL in Cell 2 = 109.45m***

Table 5-1 shows the storage required for each scenario. It is important to state that the natural storage west of Sidney Street is relied upon in all of the MDP, Ainley Implementation report and the current study. The natural must be maintained. This means any road reconstruction of Sidney Street should be carefully reviewed especially as it relates to culvert replacements.

Table 5-1: Phasing and SWM Quantity Controls

Scenario	Description	Storage Needed	Storage Volume	Target Met
1	Fully Developed Conditions Comparison to Ainley	Existing Cell 1 and Ainley modification to Cell 2	Pond 104 = 3.32ha*m Cell 1 = 2.99ha*m Cell 2 = 7.51ha*m	Yes
2	Check on Spill Volume	NA	Cell 1 = 2.66ha*m Cell 2 = 5.87ha*m	NA
3	Full Development of Basins 106a, 106b, 108b1 and 110	Requires expansion of Cell 2	Cell 1 = 2.91 ha*m Cell 2 = 6.49ha*m	Yes
4	Full Development of all lands	Expanded Cell 2, Ponds 104 and 107	Pond 104 = 3.93ha*m Pond 107 =1.71ha*m Cell 1 = 2.91ha*m Cell 2 = 6.49ha*m	Yes
5	Barkema and Settlers Ridge within the Urban Boundary	Existing Cells 1 and 2	Cell 1 = 2.91ha*m Cell 2 = 6.12ha*m	Yes

Table 5-2 shows the targets values and that the targets are achieved for each scenario. Peak flows are controlled to 2.73cms at Highway 62 and WSEL in Cell 2 is maintained at 109.45m. The slight exception is in Scenario 5 where a 3mm exceedance is possible. This implied precision is not within the limitations of the study.

Table 5-2: Summary of Targets

Scenario	**Peak Outflow at Highway 62**	**Maximum WSEL in Cell 2**	**Targets Met**	**Comment**
Target	**2.8 cms**	**109.45m**		
1	2.821	109.45	**No**	The peak outflow slightly exceeds the 2.8cms target. This is just a comparison Scenario to Ainley model.
2	NA	NA	NA	
3	2.73	109.45	**Yes**	
4	2.73	109.45	**Yes**	This is the fully developed condition.
5	2.73	109.453	**Yes**	3mm exceedance of WSEL is outside of precision limits. Barkema development provides natural expansion to Cell 2 which is ignored in this scenario.

Final phases of development would encroach into Basin 104. In this basin an existing low area provides ample room for quantity control. GDJE assumed a simple storage:discharge relationship for this reservoir that modifies the discharge only and showed there is sufficient storage available in Basin 104 to compensate for development within the basin. The outflow target at Highway 62 and WSEL in Cell 2 are satisfied.

The commercial lands east of Towncentre Drive do not contribute to the peak flows and onsite storage is not beneficial for peak flow control at Highway 62.

An alternate route for drainage from Basin 107 can be accommodated through Barkema lands with provision of a 750mm storm sewer that can be placed within the proposed road and easement network.

6 Recommendations

The study findings should be used to guide future development in the NorBelle Creek area upstream of Highway 62. The following recommendations are offered:

Recommendation 1

The existing Cells 1 and 2 are sufficient to support development of Settlers Ridge and the Barkema lands within the current urban boundary. Development of Barkema could precede the facility expansion, but this is not a likely scenario since the facility expansion can readily be completed as part of development of Barkema.

Recommendation 2

Upon completion of the expanded Cell 2, all of Basins 106a, 106b, 108b1 and 110 could be developed without any further quantity controls needed.

Recommendation 3

As development proceeds into Basin 107, a new facility would be necessary. This would be a combined quantity and quality control facility that would provide treatment for the entire 43ha contributing area.

Recommendation 4

Development within Basin 104 would require peak flow compensation by installation of an outlet structure along Sidney Street. This facility could make us of the natural land contours.

Recommendation 5

Commercial lands east of Towncentre Drive should not have peak flow control.

Prepared and Submitted by:

Bryon Keene, P.Eng.

G.D. Jewell Engineering Ltd.

7 References

Ainley Group. (2013). *Stormwater Management Design Brief, NorBelle Creek Implementation Plan.*

Bay of Quinte Restoration Council. (2006). *Bay of Quinte Remedial Action Plan Implementation Area, Stormwater Management Design Guidelines.*

Ontario Ministry of the Environment. (2003). *Stormwater Management Planning and Design Manual.* Queen's Printer for Ontario.

Ontario Ministry of Transportation. (1997). *Drainage Management Manual.*

Quinte Conservation. (2011). *NorBelle Creek Master Drainage Plan.*

APPENDIX A

Storage:Discharge Curves for Basins 104 and 107

Stage:Storage:Discharge Calculations – Pond 107

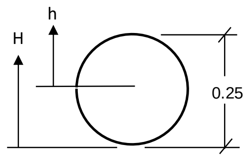
Select Pond Control: Orifice and Weir

Select Storage Value Method: Auto

Active Storage Calculations

Full Storage Elevation (m)	**110**	
Depth of Active Storage (m)	**2**	
Bottom of Active Storage (m)	**108**	
Active Volume (cu.m)	**17,067**	approx

Select Stage Increment (m) 0.1
(not less than 0.01 m)



Outlet 1			Outlet 2			Outlet 3		
Orifice			**Sharp Crested Weir**			**Broad Crested Weir**		
Formula			Formula			Formula		
$Q = CA_o(2gh)^{0.5}$			$Q = 1.84LH_1^{3/2}$			$Q = 1.67LH_1^{3/2}$		
Invert	108.00	m	**Weir Inv.**	109.10	m	**Inv.**	110.00	m
Coeff	0.60		**Coeff**	0.60		**Length**	2.0	m
Orifice Dia =	0.25	m	**Weir Length**	0.45	m			
			End Contractions: Reduces L by 0.2H			*(No End Contractions)*		
Area =	0.049	m^2						
Obvert =	108.25	m						

					Low Flow Outlet (Orifice)			Sharp Crested Weir		Emergency Spillway		Total
Elevation	**Length**	**Width**	**Incr Vol**	**Cum vol**	**Weir (H)**	**Head (h)**	**Flow (Q)**	**Head (H_1)**	**Flow (Q)**	**Head (H_1)**	**Flow (Q)**	**Discharge**
m	**m**	**m**	**m3**	**m3**	**m**	**m**	**cms**	**m**	**cms**	**m**	**cms**	**cms**
108	160	40	0	0	0.000	-0.125	0.000	0.000	0.000	0.000	0.000	0.0000
108.1	161	41	650	650	0.100	-0.025	0.004	0.000	0.000	0.000	0.000	0.0044
108.2	162	42	670	1,320	0.200	0.075	0.031	0.000	0.000	0.000	0.000	0.0313
108.3	163	43	691	2,011	0.300	0.175	0.055	0.000	0.000	0.000	0.000	0.0546
108.4	164	44	711	2,722	0.400	0.275	0.068	0.000	0.000	0.000	0.000	0.0684
108.5	165	45	732	3,454	0.500	0.375	0.080	0.000	0.000	0.000	0.000	0.0799
108.6	166	46	753	4,207	0.600	0.475	0.090	0.000	0.000	0.000	0.000	0.0899
108.7	167	47	774	4,981	0.700	0.575	0.099	0.000	0.000	0.000	0.000	0.0989
108.8	168	48	796	5,777	0.800	0.675	0.107	0.000	0.000	0.000	0.000	0.1072
108.9	169	49	817	6,594	0.900	0.775	0.115	0.000	0.000	0.000	0.000	0.1148
109	170	50	839	7,433	1.000	0.875	0.122	0.000	0.000	0.000	0.000	0.1220
109.1	171	51	861	8,294	1.100	0.975	0.129	0.000	0.000	0.000	0.000	0.1288
109.2	172	52	883	9,178	1.200	1.075	0.135	0.100	0.025	0.000	0.000	0.1603
109.3	173	53	906	10,083	1.300	1.175	0.141	0.200	0.067	0.000	0.000	0.2089
109.4	174	54	928	11,011	1.400	1.275	0.147	0.300	0.118	0.000	0.000	0.265
109.5	175	55	951	11,963	1.500	1.375	0.153	0.400	0.172	0.000	0.000	0.325
109.6	176	56	974	12,937	1.600	1.475	0.158	0.500	0.228	0.000	0.000	0.386
109.7	177	57	997	13,934	1.700	1.575	0.164	0.600	0.282	0.000	0.000	0.446
109.8	178	58	1,021	14,954	1.800	1.675	0.169	0.700	0.334	0.000	0.000	0.503
109.9	179	59	1,044	15,999	1.900	1.775	0.174	0.800	0.382	0.000	0.000	0.556
110	180	60	1,068	17,067	2.000	1.875	0.179	0.900	0.424	0.000	0.000	0.603
110.1	181	61	1,092	18,159	2.100	1.975	0.183	1.000	0.460	0.100	0.106	0.749
110.2	182	62	1,116	19,275	2.200	2.075	0.188	1.100	0.488	0.200	0.299	0.975
110.3	183	63	1,141	20,416	2.300	2.175	0.192	1.200	0.508	0.300	0.549	1.249

Storage:Discharge Relationship for Pond 104

DISCHARGE (cms)	STORAGE ha*m
0	0
0.2	1.725
0.3	3.554
0.4	6.245
0.6	9.787
1.0	10.93

APPENDIX B

Quality Pond Sizing for Basin 107

Forebay Sizing – Pond 107

Forebay Sizing
Barkema Subdivision - NorBelle Creek

Bryon Keene, P.Eng.
2017-01-18

Permanent Pool Dimensions

Length (m)=	160	Side Slope (X:1) =	5	
Width (m)=	99	Depth (m) =	0.55	*Average*
Bot Width (m) =	93.5			

Select Forebay Length (m) = 53.33
Assume 1/3 of Permanent Pool Length

Calculate Settling Length (m) = **13.8** OK
Equation 4.5 (MOE, 2003)

$$Distance = \sqrt{\frac{rQ_p}{V_s}}$$

Where:

r =	0.54	= L:W ratio of forebay
Q_p =	0.105	= Peak Outflow Rate during Quality Event (cms)
V_s =	0.0003	= Settling Velocity for 0.15mm dia particle

Calculate Dispersion Length (m) = **41.6** OK
Equation 4.6 (MOE, 2003)

$$Distance = \frac{8Q}{dV_f}$$

Where:

Q =	2.600	= Inlet Flow Rate (cms)
d =	1	= Depth of Permanent Pool in Forebay (m)
V_f =	0.5	= Maximum Velocity in the Forebay (m/s)

Min. Forebay Deep Zone Bottom Width (m) = **5.2** OK
Equation 4.7 (MOE, 2003)

$$Width = \frac{Dist}{8}$$

Where:

Dist =	41.6	= Dispersion Length (m) *from Equation 4.6*

Check Average Inflow Velocity < 0.15 (m/s) **0.05** OK

$$V = \frac{Q}{A}$$

Where:

V =	Average Velocity in Forebay (m/s)	
Q =	2.6	= Inlet Flow Rate (cms)
A =	52.94	= Cross-sectional Area (m^2)

Sediment Storage Calculations
Barkema Subdivision - NorBelle Creek

Bryon Keene, P.Eng.
2017-01-18

Development Constraints

Tributary Area =	**43.00**	**ha**
Imperviousness =	**45.0%**	
Sediment Loading at 45% =	**1.25**	**m^3/ha**
Required Protection =	**Enhanced**	**80%**
Target Maint. Removal Efficiency =		**75%**

5% below design efficiency of 80%

Permanent Pool Sizing Criteria ***per MOE, 2003***

Treatment Options	m3 / ha @ 45% Imp	Volume Req'd	Removal Efficiency
Basic	27.5	1,182.5	60%
Normal	60.0	2,580.0	70%
Enhanced	125.0	5,375.0	80%

Berm Slopes

Main	**5**	:1
Forebay	**3**	:1

Permanent Pool Sizing - Calculations

	Volume (m^3)	Depth (m)
Permanent Pool	**5,433**	**1**
Added Sediment Storage (Forebay)	**0.0**	**0**
Total	**5,433**	**1**
Required	**5,375**	
Surplus	**58**	

Pond Data

Pond Feature	Elevation	Forebay				Entire Pond			
		Length	Width	Depth	Volume	Length	Width	Depth	Volume
Top of Permanent Pool	108.0	53.33	40	1.0	1,733.2	160	40	1	5,433
Bottom of Main Pond	107.0	45.33	30	0	0.0	45.33	30	0	0.0
Bottom of Forebay	107.0	45.33	30	0	0.0				
				Total	**1,733**			**Total**	**5,433**

Maintenance Interval Calculation

Year	Forebay Volume	P.P. Storage Available	P.P. % of Req'd	Removal Efficiency	Sediment Removal	Sediment Deposition in year	Total Sediment Accum.	Volume of Forebay Remaining	Volume of P.P. Remaining	Sediment Depth in Forebay
	m^3	m^3	%	%	m^3/ha	m^3	m^3	m^3	m^3	m
1	1,733	5,433	101%	80.0%	1.00	43.0	43.0	1,690	5,390	0.03
2	1,690	5,390	100%	80.0%	1.00	43.0	86.0	1,647	5,347	0.06
3	1,647	5,347	99%	79.9%	1.00	42.9	128.9	1,604	5,304	0.09
4	1,604	5,304	99%	79.7%	1.00	42.9	171.8	1,561	5,262	0.12
5	1,561	5,262	98%	79.6%	0.99	42.8	214.6	1,519	5,219	0.15
6	1,519	5,219	97%	79.4%	0.99	42.7	257.3	1,476	5,176	0.18
7	1,476	5,176	96%	79.3%	0.99	42.6	299.9	1,433	5,133	0.21
8	1,433	5,133	96%	79.1%	0.99	42.5	342.4	1,391	5,091	0.24
9	1,391	5,091	95%	79.0%	0.99	42.5	384.9	1,348	5,048	0.26
10	1,348	5,048	94%	78.8%	0.99	42.4	427.3	1,306	5,006	0.29
11	1,306	5,006	93%	78.7%	0.98	42.3	469.6	1,264	4,964	0.32
12	1,264	4,964	92%	78.5%	0.98	42.2	511.8	1,221	4,922	0.34
13	1,221	4,922	92%	78.4%	0.98	42.1	553.9	1,179	4,879	0.37
14	1,179	4,879	91%	78.2%	0.98	42.0	595.9	1,137	4,837	0.40
15	1,137	4,837	90%	78.1%	0.98	42.0	637.9	1,095	4,795	0.42
16	1,095	4,795	89%	77.9%	0.97	41.9	679.8	1,053	4,754	0.45
17	1,053	4,754	88%	77.8%	0.97	41.8	721.6	1,012	4,712	0.47
18	1,012	4,712	88%	77.6%	0.97	41.7	763.3	970	4,670	0.50
19	970	4,670	87%	77.5%	0.97	41.6	805.0	928	4,628	0.52
20	928	4,628	86%	77.3%	0.97	41.6	846.5	887	4,587	0.54
21	887	4,587	85%	77.2%	0.96	41.5	888.0	845	4,545	0.57
22	845	4,545	85%	77.0%	0.96	41.4	929.4	804	4,504	0.59
23	804	4,504	84%	76.9%	0.96	41.3	970.7	762	4,463	0.61
24	762	4,463	83%	76.7%	0.96	41.2	1012.0	721	4,421	0.64
25	721	4,421	82%	76.6%	0.96	41.2	1053.2	680	4,380	0.66
26	680	4,380	81%	76.4%	0.96	41.1	1094.2	639	4,339	0.68
27	639	4,339	81%	76.3%	0.95	41.0	1135.3	598	4,298	0.70
28	598	4,298	80%	76.1%	0.95	40.9	1176.2	557	4,257	0.72
29	557	4,257	79%	76.0%	0.95	40.9	1217.0	516	4,216	0.74
30	516	4,216	78%	75.9%	0.95	40.8	1257.8	475	4,176	0.77
31	475	4,176	78%	75.7%	0.95	40.7	1298.5	435	4,135	0.79
32	435	4,135	77%	75.6%	0.94	40.6	1339.1	394	4,094	0.81
33	394	4,094	76%	75.4%	0.94	40.5	1379.7	354	4,054	0.83
34	354	4,054	75%	75.3%	0.94	40.5	1420.1	313	4,013	0.85
35	313	4,013	75%	75.1%	0.94	40.4	1460.5	273	3,973	0.87
36	273	3,973	74%	75.0%	0.94	40.3	1500.8	232	3,933	0.89
37	232	3,933	73%	74.8%	0.94	40.2	1541.0	192	3,892	0.91
38	192	3,892	72%	74.7%	0.93	40.1	1581.2	152	3,852	0.93
39	152	3,852	72%	74.6%	0.93	40.1	1621.2	112	3,812	0.95
40	112	3,812	71%	74.4%	0.93	40.0	1661.2	72	3,772	0.97
41	72	3,772	70%	74.3%	0.93	39.9	1701.2	32	3,732	0.98
42	32	3,732	69%	74.1%	0.93	39.8	1741.0	-8	3,692	1.00
43	-8	3,692	69%	74.0%	0.92	39.8	1780.8	-48	3,653	1.02
44	-48	3,653	68%	73.8%	0.92	39.7	1820.4	-87	3,613	1.04
45	-87	3,613	67%	73.7%	0.92	39.6	1860.1	-127	3,573	1.06
46	-127	3,573	66%	73.6%	0.92	39.5	1899.6	-166	3,534	1.08
47	-166	3,534	66%	73.4%	0.92	39.5	1939.1	-206	3,494	1.09

APPENDIX C

OTTHYMO Modelling Output

Scenario 4 – Full Development

```
===============================================================================

        OOO    TTTTT  TTTTT  H   H  Y   Y  M   M   OOO     I N T E R H Y M O
       O   O     T      T    H   H   Y Y   MM MM  O   O   * * * 1989a * * *
       O   O     T      T    HHHHH    Y    M M M  O   O
       O   O     T      T    H   H    Y    M   M  O   O
        OOO      T      T    H   H    Y    M   M   OOO     __________01637

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  Input   filename: nbellev3.dat
  Output  filename: nbellev3.out
  Summary filename: nbellev3.sum




DATE: 11-21-2016                      TIME: 15:44:21


COMMENTS: ____________________________________________________________


-------------------------------------------------------------------------------
*
  ****************************
  ** SIMULATION NUMBER:   1 **
  ****************************

*
*                   Settlers Ridge and Barkema - Nor-Belle Creek
*                   Lots 1, 2 and 3, Conc. 3 and 4, Thurlow Township
*                   Belleville Rainfall using Nor-Belle Creek MDP, 2011
*                   and Ainley SWM Implementation Report, April 2013
*
*                   100Yr Event based on Ainley SWMHYMO
*                   2017 January 3
*                   Bryon Keene, P.Eng., Jewell Engineering
*
*                   To support Barkema Lands Draft Plan Application
*
*                   NBELLE model is conversion of Settlers SWMHYMO model and
*                   represents fully developed conditions with the expanded
*                   pond on Barkema Lands - Note: the full Settlers pond did
*                   not get constructed.
*
*                   NBELLEV1 model is altered to determine how much storage
*                   in Cell 2 is required solely due to spill containment.
*
*                   NBELLEV2 model is altered to allow full development of
```

```
*                  catchments 110, 106a, 106b,and 108b1.
*                  The Settlers pond is enlarged with the addition of
*                  0.4ha*m storage on Barkema lands.
*
*                  NBELLEV3 model considers how basins 104 and 107 will be
*                  developed. 104 will have reduced outflow at Sidney St.
*                  107 will have a combined quantity/quality pond.

--------------------
|    READ STORM    |    Filename: QUALITY.STM
| Ptotal= 25.00 mm |    Comments: 4 Hr Chicago 25mm
--------------------
                    TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                     hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                     .08    1.73 |  1.08    7.10 |  2.08    4.61 |  3.08    2.28
                     .17    1.83 |  1.17   10.69 |  2.17    4.21 |  3.17    2.19
                     .25    1.94 |  1.25   23.51 |  2.25    3.88 |  3.25    2.11
                     .33    2.07 |  1.33   68.86 |  2.33    3.61 |  3.33    2.04
                     .42    2.23 |  1.42   29.90 |  2.42    3.38 |  3.42    1.97
                     .50    2.41 |  1.50   17.13 |  2.50    3.18 |  3.50    1.91
                     .58    2.64 |  1.58   12.05 |  2.58    3.00 |  3.58    1.86
                     .67    2.92 |  1.67    9.35 |  2.67    2.84 |  3.67    1.80
                     .75    3.28 |  1.75    7.68 |  2.75    2.70 |  3.75    1.75
                     .83    3.74 |  1.83    6.55 |  2.83    2.58 |  3.83    1.70
                     .92    4.41 |  1.92    5.73 |  2.92    2.47 |  3.92    1.66
                    1.00    5.41 |  2.00    5.10 |  3.00    2.37 |  4.00    1.62

------------------------------------------------------------------------------


--------------------
| CALIB            |
| STANDHYD  (0107) |   Area     (ha)=  43.00
|ID= 1 DT= 5.0 min |   Total Imp(%)=  45.00   Dir. Conn.(%)=  35.00
--------------------
                            IMPERVIOUS    PERVIOUS (i)
    Surface Area      (ha)=     19.35        23.65
    Dep. Storage      (mm)=       .60         2.50
    Average Slope      (%)=       .60         5.00
    Length             (m)=    975.00        35.00
    Mannings n            =      .013         .250

    Max.eff.Inten.(mm/hr)=      34.85        14.42
               over  (min)      20.00        10.00
    Storage Coeff.   (min)=     17.80 (ii)   25.66 (ii)
    Unit Hyd. Tpeak  (min)=     20.00        30.00
    Unit Hyd. peak   (cms)=       .06          .04
                                                        *TOTALS*
    PEAK FLOW        (cms)=      1.01          .34         1.21 (iii)
    TIME TO PEAK     (hrs)=      2.17         2.42         2.25
    RUNOFF VOLUME     (mm)=     24.40         6.83        12.98
    TOTAL RAINFALL    (mm)=     25.00        25.00        25.00
```

```
     RUNOFF COEFFICIENT   =        .98          .27            .52


       (i) CN PROCEDURE SELECTED FOR RAINFALL LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) COMPUTATIONAL TIME STEP SHOULD BE SMALL OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
*
****************************************************************************
*                   100 Year Storm
****************************************************************************
*                         Post-Development Flow

--------------------
|    READ STORM    |    Filename: 12AES100.STM
| Ptotal= 81.52 mm |    Comments: 12 Hr AES from XCG NorBelle
--------------------
                 TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                 1.00     .00 |  4.00   16.30 |  7.00    6.52 | 10.00     .00
                 2.00   10.60 |  5.00   12.23 |  8.00    2.45 | 11.00     .00
                 3.00   21.19 |  6.00   11.41 |  9.00     .82 | 12.00     .00

-------------------------------------------------------------------------------

*CHICAGO STORM       IUNITS=2 TD=6.0 HRS R=0.333 STD=5 MIN ICASE =2
*                    (TIME, INTENSITY)= 5,91.6 10,66.5 15,54.4 30,35.9
*                    60,22.1 120,13.5 360,6.3 720,3.7 1440,2.1 END=-1
*                   Basin 104 Sunningdale Area
--------------------
| CALIB            |
| STANDHYD  (0104) |   Area    (ha)=  76.00
|ID= 1 DT= 5.0 min |   Total Imp(%)=  45.00   Dir. Conn.(%)=  35.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=      34.20         41.80
     Dep. Storage     (mm)=        .60          2.50
     Average Slope     (%)=        .60          5.00
     Length            (m)=    1300.00         35.00
     Mannings n           =       .013          .250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.

                              IMPERVIOUS    PERVIOUS (i)
     Max.eff.Inten.(mm/hr)=      21.19         14.42
                over (min)       25.00         15.00
     Storage Coeff.  (min)=      25.81 (ii)    36.55 (ii)
     Unit Hyd. Tpeak (min)=      25.00         40.00
```

```
     Unit Hyd. peak  (cms)=        .04          .03
                                                        *TOTALS*
     PEAK FLOW       (cms)=       1.44         1.43        2.64 (iii)
     TIME TO PEAK    (hrs)=       4.17         5.33        5.08
     RUNOFF VOLUME    (mm)=      80.92        48.57       59.89
     TOTAL RAINFALL   (mm)=      81.52        81.52       81.52
     RUNOFF COEFFICIENT   =        .99          .60         .73


       (i) CN PROCEDURE SELECTED FOR RAINFALL LOSSES:
            CN*  =  81.0    Ia = Dep. Storage  (Above)
      (ii) COMPUTATIONAL TIME STEP SHOULD BE SMALL OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
*CALIB NASHYD        ID=1 NHYD 104 DT=5 MIN AREA=76HA DWF=0.0 CN=82 IA=11.1
*                    N=3 TP= 0.6HR RAIN=-1
*                   Route Basin 104 through natural storage east of Sidney
*
*ROUTE RESERVOIR     ID=9 NHYD=2000 IDIN=1 DT=5 MIN
*                    DISCHARGE   STORAGE
*                    0           0
*                    .4          1.725
*                    .8          3.554
*                    1.2         6.245
*                    1.6         9.787
*                    1.75        10.93
*                     -1
*                   Basin 104 Routing altered to cut outflow in half
--------------------
| RESERVOIR (2000) |
| IN= 1---> OUT= 9 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                           .000        .000   |     .400      6.245
                           .200       1.725   |     .600      9.787
                           .300       3.554   |    1.000     10.930

                              AREA      QPEAK     TPEAK        R.V.
                              (ha)      (cms)     (hrs)        (mm)
     INFLOW : ID= 1 (0104)   76.00       2.64      5.08       59.89
     OUTFLOW: ID= 9 (2000)   76.00        .31      9.92       56.92

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)= 11.90
                  TIME SHIFT OF PEAK FLOW         (min)=290.00
                  MAXIMUM  STORAGE   USED       (ha.m.)=  3.93

--------------------------------------------------------------------------------
*                   Save Hydrograph from Wetland Outflow
--------------------
```

```
| SAVE HYD  (2000) |   AREA       (ha)=  76.00
| ID= 9   PCYC=*** |   QPEAK     (cms)=    .31 (i)
| DT= 5.0 min      |   TPEAK     (hrs)=   9.92
--------------------   VOLUME     (mm)=  56.92
  Filename: 104CONT.hyd
  Comments: 100-Yr Peak Flow Basin 104

     (i)  PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
*                   Basin 101 Huntingwood to Sidney - No Development
--------------------
| CALIB            |
| NASHYD    (0101) |   Area    (ha)= 150.00   Curve Number   (CN)= 79.0
|ID= 2 DT= 5.0 min |   Ia      (mm)=  11.10   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.70

     Unit Hyd Qpeak  (cms)=   3.37

     PEAK FLOW       (cms)=   2.85 (i)
     TIME TO PEAK    (hrs)=   6.83
     RUNOFF VOLUME    (mm)=  35.95
     TOTAL RAINFALL   (mm)=  81.52
     RUNOFF COEFFICIENT   =    .44

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD   (1001) |
|   9 +  2 =  7    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 9 (2000):    76.00      .31     9.92    56.92
        + ID2= 2 (0101):   150.00     2.85     6.83    35.95
          ==================================================
          ID = 7 (1001):   226.00     3.11     6.92    43.00

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
*                   Basin 102 Trillium to Sidney - No Development
--------------------
| CALIB            |
| NASHYD    (0102) |   Area    (ha)=  46.00   Curve Number   (CN)= 78.0
|ID= 3 DT= 5.0 min |   Ia      (mm)=  11.10   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .70

     Unit Hyd Qpeak  (cms)=   2.51

     PEAK FLOW       (cms)=    .98 (i)
```

```
     TIME TO PEAK     (hrs)=   6.08
     RUNOFF VOLUME     (mm)=  34.90
     TOTAL RAINFALL    (mm)=  81.52
     RUNOFF COEFFICIENT   =    .43

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (1002) |
|   7 +  3 =  6    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 7 (1001):   226.00     3.11     6.92    43.00
        + ID2= 3 (0102):    46.00      .98     6.08    34.90
          ==================================================
          ID = 6 (1002):   272.00     3.98     6.42    41.63

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
*                  Basin 103 Small area west of Sidney - No Development
--------------------
| CALIB            |
| NASHYD    (0103) |   Area     (ha)=   8.00   Curve Number   (CN)= 74.0
|ID= 4 DT= 5.0 min |   Ia       (mm)=  11.10   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .60

     Unit Hyd Qpeak  (cms)=    .51

     PEAK FLOW       (cms)=    .15 (i)
     TIME TO PEAK    (hrs)=   6.08
     RUNOFF VOLUME    (mm)=  31.04
     TOTAL RAINFALL   (mm)=  81.52
     RUNOFF COEFFICIENT   =    .38

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (1003) |
|   6 +  4 =  9    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 6 (1002):   272.00     3.98     6.42    41.63
        + ID2= 4 (0103):     8.00      .15     6.08    31.04
          ==================================================
          ID = 9 (1003):   280.00     4.13     6.42    41.33

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
```

```
-------------------------------------------------------------------------------
*                   Basin 105 Southwest of Sidney - No Development
--------------------
| CALIB            |
| NASHYD    (0105) |   Area     (ha)=  60.00   Curve Number   (CN)= 83.0
|ID= 5 DT= 5.0 min |   Ia       (mm)=  11.10   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .60

     Unit Hyd Qpeak  (cms)=   3.82

     PEAK FLOW       (cms)=   1.51 (i)
     TIME TO PEAK    (hrs)=   4.42
     RUNOFF VOLUME    (mm)=  40.50
     TOTAL RAINFALL   (mm)=  81.52
     RUNOFF COEFFICIENT   =    .50

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------


--------------------
| ADD HYD   (1004) |
|   9 +  5 =  1    |          AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 9 (1003):   280.00     4.13     6.42    41.33
        + ID2= 5 (0105):    60.00     1.51     4.42    40.50
          ==================================================
          ID = 1 (1004):   340.00     5.53     6.17    41.18

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
*                   Route Basins 101, 102, 103, 104, 105
*                   through natural storage east of Sidney
--------------------
| RESERVOIR (2001) |
| IN= 1---> OUT= 9 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                           .000        .000   |    1.950      1.824
                           .050        .007   |    2.660      3.571
                           .180        .123   |    3.230      6.043
                          1.180        .882   |     .000       .000

                              AREA     QPEAK     TPEAK       R.V.
                              (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 1 (1004)   340.00     5.53      6.17      41.18
     OUTFLOW: ID= 9 (2001)   340.00     2.88      8.67      41.17

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)= 52.16
                  TIME SHIFT OF PEAK FLOW         (min)=150.00
```

```
                    MAXIMUM   STORAGE   USED       (ha.m.)=  4.53

--------------------------------------------------------------------------------
*                    Save Hydrograph at Sidney St
--------------------
| SAVE HYD  (2001) |   AREA       (ha)= 340.00
| ID= 9   PCYC=*** |   QPEAK     (cms)=   2.88 (i)
| DT= 5.0 min      |   TPEAK     (hrs)=   8.67
--------------------   VOLUME     (mm)=  41.17
  Filename: 104SID.hyd
  Comments: 100-Yr Peak Flow at Sidney st

     (i)  PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
*                    Sidney Street Crossing - Route flows to Cell 2
*                    Since Ainley considered storage in the channel for Cell 2
*                    the channel routing is about 400m, dist to pond is 1190m
--------------------
| ROUTE CHN (3004) |
| IN= 9---> OUT= 8 |     Routing time step (min)'=  5.00
--------------------

               SECTION No    =*****    No. of Segments  =   3
               Channel Slp % =  .20    Floodplain Slp % = .20

               <--------- CROSS SECTION DATA ---------->
               Distance      Elevation       Manning
                    .00        109.80          .0500
                   2.00        109.07          .0500
                   5.50        109.07      .0500 / .0300  Main Channel
                   6.00        108.57          .0300      Main Channel
                   9.00        108.57          .0300      Main Channel
                   9.50        109.07      .0300 / .0500  Main Channel
                  13.00        109.07          .0500
                  15.00        109.80          .0500


               Valley Sections =   1
               Channel Length  =  400.0
               Channel Slope % =   .200

      <---------------------- TRAVEL TIME TABLE ---------------------->
       DEPTH    ELEV       VOLUME     FLOW RATE    VELOCITY    TRAV.TIME
        (m)      (m)      (cu.m.)      (cms)        (m/s)       (min)
        .06   108.64    .766E+02        .0            .23       29.10
        .12   108.70    .156E+03        .1            .36       18.75
        .19   108.76    .239E+03        .3            .46       14.61
        .25   108.82    .325E+03        .4            .54       12.30
        .31   108.89    .414E+03        .6            .62       10.80
        .37   108.95    .506E+03        .9            .69        9.73
```

```
          .44   109.01    .602E+03      1.1            .75        8.92
          .50   109.07    .700E+03      1.4            .80        8.29
          .57   109.14    .995E+03      1.8            .74        8.98
          .63   109.21    .130E+04      2.4            .74        9.02
          .70   109.27    .161E+04      3.1            .76        8.81
          .76   109.34    .194E+04      3.8            .78        8.52
          .83   109.40    .227E+04      4.6            .81        8.20
          .90   109.47    .261E+04      5.5            .85        7.89
          .96   109.54    .296E+04      6.5            .88        7.59
         1.03   109.60    .333E+04      7.6            .91        7.32
         1.09   109.67    .370E+04      8.7            .94        7.07
         1.16   109.73    .408E+04      9.9            .97        6.84
         1.23   109.80    .447E+04     11.2           1.01        6.63

                                     <---- hydrograph ---->   <---  channel --->
                               AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                               (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
     INFLOW : ID= 9 (2001)   340.00     2.88    8.67  41.17       .68        .75
     OUTFLOW: ID= 8 (3004)   340.00     2.88    8.83  41.16       .68        .75


-------------------------------------------------------------------------------
*                   Basin 110 Area east of Sidney, Thurlow Dr
--------------------
| CALIB             |
| STANDHYD  (0110) |    Area     (ha)=  33.00
|ID= 1 DT= 5.0 min |    Total Imp(%)=  45.00   Dir. Conn.(%)=  35.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area      (ha)=     14.85        18.15
     Dep. Storage      (mm)=       .60         2.50
     Average Slope      (%)=       .60         5.00
     Length             (m)=   1040.00        35.00
     Mannings n            =      .013         .250

     Max.eff.Inten.(mm/hr)=     21.19        13.49
                over (min)      25.00        15.00
     Storage Coeff.  (min)=     22.58 (ii)   33.60 (ii)
     Unit Hyd. Tpeak (min)=     25.00        35.00
     Unit Hyd. peak  (cms)=       .05          .03
                                                          *TOTALS*
     PEAK FLOW       (cms)=       .64          .59           1.12 (iii)
     TIME TO PEAK    (hrs)=      3.83         5.00           4.75
     RUNOFF VOLUME    (mm)=     80.92        46.18          58.33
     TOTAL RAINFALL   (mm)=     81.52        81.52          81.52
     RUNOFF COEFFICIENT   =       .99          .57            .72


       (i) CN PROCEDURE SELECTED FOR RAINFALL LOSSES:
            CN*   =  79.0     Ia = Dep. Storage  (Above)
      (ii) COMPUTATIONAL TIME STEP SHOULD BE SMALL OR EQUAL
```

```
          THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
*CALIB NASHYD         ID=1 NHYD 110 DT=5 MIN AREA=33HA DWF=0.0 CN=79 IA=11.1
*                     N=3 TP= 0.2HR RAIN=-1

--------------------
| ADD HYD   (1005) |
|   8 +  1 =  2    |          AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 8 (3004):   340.00     2.88     8.83    41.16
        + ID2= 1 (0110):    33.00     1.12     4.75    58.33
          ==================================================
          ID = 2 (1005):   373.00     3.55     6.92    42.68

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
*                    Basin 106b at Farmer's Crossing
--------------------
| CALIB            |
| STANDHYD  (1062) |   Area     (ha)=   6.00
|ID= 3 DT= 5.0 min |   Total Imp(%)=  45.00   Dir. Conn.(%)=  35.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area      (ha)=       2.70         3.30
     Dep. Storage      (mm)=        .60         2.50
     Average Slope      (%)=        .60         5.00
     Length             (m)=     390.00        35.00
     Mannings n           =        .013         .250

     Max.eff.Inten.(mm/hr)=      21.19        13.49
                over (min)       15.00        15.00
     Storage Coeff.  (min)=      12.53 (ii)   23.56 (ii)
     Unit Hyd. Tpeak (min)=      15.00        25.00
     Unit Hyd. peak  (cms)=        .08          .05
                                                            *TOTALS*
     PEAK FLOW       (cms)=        .12          .11             .22 (iii)
     TIME TO PEAK    (hrs)=       3.42         4.50            3.50
     RUNOFF VOLUME    (mm)=      80.92        46.18           58.31
     TOTAL RAINFALL   (mm)=      81.52        81.52           81.52
     RUNOFF COEFFICIENT   =        .99          .57             .72


       (i) CN PROCEDURE SELECTED FOR RAINFALL LOSSES:
            CN*  =  79.0    Ia = Dep. Storage  (Above)
      (ii) COMPUTATIONAL TIME STEP SHOULD BE SMALL OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
```

```
--------------------------------------------------------------------------------
*CALIB NASHYD         ID=3 NHYD 1062 DT=5 MIN AREA=6HA DWF=0.0 CN=79 IA=11.1
*                     N=3 TP= 0.1HR RAIN=-1

--------------------
| ADD HYD   (1006) |
|   2 +  3 =  1    |         AREA     QPEAK     TPEAK      R.V.
--------------------         (ha)     (cms)     (hrs)      (mm)
          ID1= 2 (1005):   373.00      3.55      6.92     42.68
        + ID2= 3 (1062):     6.00       .22      3.50     58.31
          ==================================================
          ID = 1 (1006):   379.00      3.67      6.92     42.93

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
*                    Basin 107 from Hwy 62, Barkema and Central Settlers
--------------------
| CALIB            |
| STANDHYD  (0107) |   Area     (ha)=  43.00
|ID= 2 DT= 5.0 min |   Total Imp(%)=  45.00   Dir. Conn.(%)=  35.00
--------------------
                             IMPERVIOUS    PERVIOUS (i)
     Surface Area      (ha)=      19.35         23.65
     Dep. Storage      (mm)=        .60          2.50
     Average Slope      (%)=        .60          5.00
     Length             (m)=     975.00         35.00
     Mannings n            =       .013          .250

     Max.eff.Inten.(mm/hr)=      21.19         13.94
                over (min)       20.00         15.00
     Storage Coeff.  (min)=      21.72 (ii)    32.60 (ii)
     Unit Hyd. Tpeak (min)=      20.00         35.00
     Unit Hyd. peak  (cms)=        .05           .03
                                                              *TOTALS*
     PEAK FLOW       (cms)=        .84           .80             1.48 (iii)
     TIME TO PEAK    (hrs)=       3.92          5.08             4.83
     RUNOFF VOLUME    (mm)=      80.92         47.36            59.10
     TOTAL RAINFALL   (mm)=      81.52         81.52            81.52
     RUNOFF COEFFICIENT   =        .99           .58              .72


       (i) CN PROCEDURE SELECTED FOR RAINFALL LOSSES:
            CN*   =  80.0     Ia = Dep. Storage  (Above)
      (ii) COMPUTATIONAL TIME STEP SHOULD BE SMALL OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
*CALIB NASHYD         ID=2 NHYD 107 DT=5 MIN AREA=43HA DWF=0.0 CN=80 IA=11.1
*                     N=3 TP= 0.7HR RAIN=-1
```

```
*                    Proposed combined facility in Settlers for Basin 107
--------------------
| RESERVOIR (2002) |
| IN= 2---> OUT= 9 |
| DT=  5.0 min     |      OUTFLOW     STORAGE    |  OUTFLOW     STORAGE
--------------------       (cms)      (ha.m.)    |   (cms)      (ha.m.)
                            .000        .000     |    .129        .829
                            .004        .065     |    .160        .918
                            .055        .201     |    .265       1.101
                            .068        .272     |    .325       1.196
                            .080        .345     |    .446       1.393
                            .090        .421     |    .503       1.495
                            .099        .498     |    .556       1.600
                            .107        .578     |    .603       1.707
                            .115        .659     |    .749       1.816
                            .122        .743     |    .000        .000

                                 AREA     QPEAK      TPEAK        R.V.
                                 (ha)     (cms)      (hrs)        (mm)
     INFLOW : ID= 2 (0107)      43.00      1.48       4.83       59.10
     OUTFLOW: ID= 9 (2002)      43.00       .61       8.25       58.30

                   PEAK  FLOW  REDUCTION [Qout/Qin](%)= 41.20
                   TIME SHIFT OF PEAK FLOW         (min)=205.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  1.71

-------------------------------------------------------------------------------
--------------------
| SAVE HYD  (2002) |   AREA       (ha)=  43.00
| ID= 9   PCYC=*** |   QPEAK     (cms)=    .61  (i)
| DT= 5.0 min      |   TPEAK     (hrs)=   8.25
--------------------   VOLUME     (mm)=  58.30
  Filename: 107out.hyd
  Comments: 100-Yr Peak Outflow from Pond 107

     (i)  PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
*                    Basin 106a Central Barkema and Settlers
--------------------
| CALIB            |
| STANDHYD  (1061) |   Area    (ha)=  16.00
|ID= 3 DT= 5.0 min |   Total Imp(%)=  45.00   Dir. Conn.(%)=  35.00
--------------------
                                 IMPERVIOUS    PERVIOUS (i)
     Surface Area      (ha)=        7.20          8.80
     Dep. Storage      (mm)=         .60          2.50
     Average Slope      (%)=         .60          5.00
     Length             (m)=      455.00         35.00
     Mannings n           =         .013          .250
```

```
    Max.eff.Inten.(mm/hr)=      21.19         13.05
               over (min)       15.00         15.00
    Storage Coeff.  (min)=      13.75 (ii)    24.92 (ii)
    Unit Hyd. Tpeak (min)=      15.00         25.00
    Unit Hyd. peak  (cms)=        .08           .05
                                                         *TOTALS*
    PEAK FLOW       (cms)=        .33           .29          .56 (iii)
    TIME TO PEAK    (hrs)=       3.50          4.58         3.58
    RUNOFF VOLUME    (mm)=      80.92         45.03        57.58
    TOTAL RAINFALL   (mm)=      81.52         81.52        81.52
    RUNOFF COEFFICIENT   =        .99           .55          .71


      (i) CN PROCEDURE SELECTED FOR RAINFALL LOSSES:
           CN*  =  78.0    Ia = Dep. Storage  (Above)
     (ii) COMPUTATIONAL TIME STEP SHOULD BE SMALL OR EQUAL
          THAN THE STORAGE COEFFICIENT.
    (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
*CALIB NASHYD        ID=3 NHYD 1061 DT=5 MIN AREA=16HA DWF=0.0 CN=78 IA=11.1
*                    N=3 TP= 0.3HR RAIN=-1

--------------------
| ADD HYD   (1007) |
|   9 +  3 =  4    |          AREA     QPEAK     TPEAK      R.V.
--------------------          (ha)     (cms)     (hrs)      (mm)
         ID1= 9 (2002):     43.00       .61      8.25     58.30
       + ID2= 3 (1061):     16.00       .56      3.58     57.58
         ==================================================
         ID = 4 (1007):     59.00       .92      6.58     58.11

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (1008) |
|   1 +  4 =  5    |          AREA     QPEAK     TPEAK      R.V.
--------------------          (ha)     (cms)     (hrs)      (mm)
         ID1= 1 (1006):    379.00      3.67      6.92     42.93
       + ID2= 4 (1007):     59.00       .92      6.58     58.11
         ==================================================
         ID = 5 (1008):    438.00      4.56      6.75     44.97

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
*                   Basin 108b1 Portion of 108b to Settlers pond (Cell 2)
--------------------
| CALIB            |
```

```
| STANDHYD  (1081) |   Area     (ha)=  12.40
|ID= 2 DT= 5.0 min |   Total Imp(%)=  45.00   Dir. Conn.(%)=  35.00
--------------------
                            IMPERVIOUS    PERVIOUS (i)
     Surface Area      (ha)=       5.58         6.82
     Dep. Storage      (mm)=        .60         2.50
     Average Slope      (%)=        .60         5.00
     Length             (m)=     520.00        35.00
     Mannings n            =       .013         .250

     Max.eff.Inten.(mm/hr)=      21.19        12.63
                over (min)       15.00        15.00
     Storage Coeff.  (min)=      14.90 (ii)   26.22 (ii)
     Unit Hyd. Tpeak (min)=      15.00        30.00
     Unit Hyd. peak  (cms)=        .08          .04
                                                          *TOTALS*
     PEAK FLOW       (cms)=        .25          .22            .42 (iii)
     TIME TO PEAK    (hrs)=       3.58         4.75           3.75
     RUNOFF VOLUME    (mm)=      80.92        43.91          56.85
     TOTAL RAINFALL   (mm)=      81.52        81.52          81.52
     RUNOFF COEFFICIENT   =        .99          .54            .70


       (i) CN PROCEDURE SELECTED FOR RAINFALL LOSSES:
            CN*   =  77.0    Ia = Dep. Storage  (Above)
      (ii) COMPUTATIONAL TIME STEP SHOULD BE SMALL OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
*CALIB NASHYD        ID=2 NHYD 1081 DT=5 MIN AREA=12.4HA DWF=0.0 CN=77 IA=11.1
*                    N=3 TP= 0.3HR RAIN=-1

--------------------
| ADD HYD   (1009) |
|   5 +  2 =  1    |          AREA     QPEAK    TPEAK     R.V.
--------------------          (ha)     (cms)    (hrs)     (mm)
          ID1= 5 (1008):   438.00      4.56     6.75     44.97
        + ID2= 2 (1081):    12.40       .42     3.75     56.85
          ==================================================
          ID = 1 (1009):   450.40      4.87     6.67     45.30

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
*                   Inflow to Settlers Pond (Cell 2)
--------------------
| SAVE HYD  (1009) |   AREA       (ha)= 450.40
| ID= 1   PCYC=*** |   QPEAK     (cms)=   4.87 (i)
| DT= 5.0 min      |   TPEAK     (hrs)=   6.67
--------------------   VOLUME     (mm)=  45.30
```

```
  Filename: Cell2in.hyd
  Comments: 100-Yr Peak inflow to Cell 2

     (i)  PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
*                    Route through Settlers (Cell 2)
*                    Pond revised for Dec 23 2016 Concept Barkema Pond
--------------------
| RESERVOIR (2002) |
| IN= 1---> OUT= 9 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                           .000        .000   |   1.275      3.533
                           .031        .568   |   1.531      3.969
                           .117       1.068   |   1.745      4.413
                           .241       1.448   |   2.065      4.862
                           .387       1.852   |   2.334      5.319
                           .540       2.263   |   2.599      5.782
                           .766       2.679   |   2.857      6.251
                          1.027       3.103   |   3.102      6.727

                              AREA     QPEAK     TPEAK       R.V.
                              (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 1 (1009)   450.40     4.87      6.67      45.30
     OUTFLOW: ID= 9 (2002)   450.40     2.98     11.50      43.62

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 61.18
                   TIME SHIFT OF PEAK FLOW        (min)=290.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=   6.49

--------------------------------------------------------------------------------
*                    Outflow from Settlers Pond
--------------------
| SAVE HYD  (2002) |   AREA       (ha)= 450.40
| ID= 9   PCYC=*** |   QPEAK     (cms)=   2.98 (i)
| DT= 5.0 min      |   TPEAK     (hrs)=  11.50
--------------------   VOLUME     (mm)=  43.62
  Filename: Cell2out.hyd
  Comments: 100-Yr Peak outflow from Cell 2

     (i)  PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
*                    Basin 108d Portion of 108 to Nor-Belle pond (Cell 1)
--------------------
| CALIB            |
| STANDHYD  (1082) |   Area     (ha)=  10.67
|ID= 1 DT= 5.0 min |   Total Imp(%)=  80.00   Dir. Conn.(%)=  60.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
```

```
     Surface Area      (ha)=       8.54         2.13
     Dep. Storage      (mm)=        .60         2.50
     Average Slope      (%)=        .60         5.00
     Length             (m)=     100.00        35.00
     Mannings n           =        .013         .250

     Max.eff.Inten.(mm/hr)=       21.19        28.00
                over (min)        10.00        10.00
     Storage Coeff.   (min)=       5.54 (ii)   11.47 (ii)
     Unit Hyd. Tpeak  (min)=       5.00        15.00
     Unit Hyd. peak   (cms)=        .20          .09
                                                           *TOTALS*
     PEAK FLOW        (cms)=        .38          .15          .53 (iii)
     TIME TO PEAK     (hrs)=       3.25         3.33         3.25
     RUNOFF VOLUME     (mm)=      80.92        53.53        69.96
     TOTAL RAINFALL    (mm)=      81.52        81.52        81.52
     RUNOFF COEFFICIENT   =         .99          .66          .86


       (i) CN PROCEDURE SELECTED FOR RAINFALL LOSSES:
            CN*  =  76.0    Ia = Dep. Storage  (Above)
      (ii) COMPUTATIONAL TIME STEP SHOULD BE SMALL OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
*                   Basin 108f Portion of 108 to Nor-Belle pond (Cell 1)
--------------------
| CALIB              |
| STANDHYD  (1083) |   Area     (ha)=    .77
|ID= 2 DT= 5.0 min |   Total Imp(%)=  80.00   Dir. Conn.(%)=  60.00
--------------------
                               IMPERVIOUS    PERVIOUS (i)
     Surface Area      (ha)=        .62          .15
     Dep. Storage      (mm)=        .60         2.50
     Average Slope      (%)=        .60         5.00
     Length             (m)=     350.00        35.00
     Mannings n           =        .013         .250

     Max.eff.Inten.(mm/hr)=       21.19        28.00
                over (min)        10.00        10.00
     Storage Coeff.   (min)=      11.75 (ii)   17.68 (ii)
     Unit Hyd. Tpeak  (min)=      10.00        20.00
     Unit Hyd. peak   (cms)=        .10          .06
                                                           *TOTALS*
     PEAK FLOW        (cms)=        .03          .01          .04 (iii)
     TIME TO PEAK     (hrs)=       3.50         3.67         3.50
     RUNOFF VOLUME     (mm)=      80.92        53.53        69.84
     TOTAL RAINFALL    (mm)=      81.52        81.52        81.52
     RUNOFF COEFFICIENT   =         .99          .66          .86
```

```
        (i) CN PROCEDURE SELECTED FOR RAINFALL LOSSES:
             CN*  =  76.0    Ia = Dep. Storage  (Above)
       (ii) COMPUTATIONAL TIME STEP SHOULD BE SMALL OR EQUAL
            THAN THE STORAGE COEFFICIENT.
      (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD   (1010) |
|   9 +  1 =  3    |          AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 9 (2002):    450.40     2.98    11.50    43.62
        + ID2= 1 (1082):     10.67      .53     3.25    69.96
          ==================================================
          ID = 3 (1010):    461.07     2.98    11.50    44.23

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD   (1011) |
|   3 +  2 =  1    |          AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 3 (1010):    461.07     2.98    11.50    44.23
        + ID2= 2 (1083):       .77      .04     3.50    69.84
          ==================================================
          ID = 1 (1011):    461.84     2.98    11.50    44.27

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| SAVE HYD  (1011) |   AREA       (ha)= 461.84
| ID= 1   PCYC=*** |   QPEAK     (cms)=   2.98 (i)
| DT= 5.0 min      |   TPEAK     (hrs)=  11.50
--------------------   VOLUME     (mm)=  44.27
  Filename: norin.hyd
  Comments: 100-Yr Peak inflow to Cell 1

     (i)  PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
*                   Route through Nor-Belle Pond (Cell 1)
--------------------
| RESERVOIR (2003) |
| IN= 1---> OUT= 9 |
| DT=  5.0 min     |     OUTFLOW     STORAGE   |  OUTFLOW     STORAGE
--------------------      (cms)      (ha.m.)   |   (cms)      (ha.m.)
```

```
                               .000        .000   |      .985       .763
                               .005        .018   |     1.132      1.014
                               .063        .045   |     1.264      1.323
                               .174        .072   |     1.374      1.849
                               .322        .123   |     1.880      2.210
                               .488        .175   |     2.363      2.568
                               .659        .342   |     3.141      3.292
                               .826        .546   |     3.348      3.656

                                  AREA      QPEAK      TPEAK        R.V.
                                  (ha)      (cms)      (hrs)        (mm)
     INFLOW : ID= 1 (1011)      461.84       2.98      11.50       44.27
     OUTFLOW: ID= 9 (2003)      461.84       2.73      14.50       44.17

                    PEAK   FLOW   REDUCTION [Qout/Qin](%)= 91.70
                    TIME SHIFT OF PEAK FLOW         (min)=180.00
                    MAXIMUM  STORAGE   USED        (ha.m.)=  2.91

 -------------------------------------------------------------------------------
 *                    Outflow from Nor-Belle Pond
 --------------------
 | SAVE HYD  (2003) |   AREA       (ha)= 461.84
 | ID= 9   PCYC=*** |   QPEAK     (cms)=   2.73 (i)
 | DT= 5.0 min      |   TPEAK     (hrs)=  14.50
 --------------------   VOLUME     (mm)=  44.17
   Filename: norout.hyd
   Comments: 100-Yr Peak outflow from Cell 1

      (i)  PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 -------------------------------------------------------------------------------
 *                    Basin 108e Portion of 108 uncontrolled
 --------------------
 | CALIB            |
 | STANDHYD  (1084) |   Area     (ha)=   4.31
 |ID= 2 DT= 5.0 min |   Total Imp(%)=  80.00   Dir. Conn.(%)=  60.00
 --------------------
                             IMPERVIOUS    PERVIOUS (i)
     Surface Area      (ha)=      3.45          .86
     Dep. Storage      (mm)=       .60         2.50
     Average Slope      (%)=       .60         5.00
     Length             (m)=    200.00        35.00
     Mannings n            =      .013         .250

     Max.eff.Inten.(mm/hr)=      21.19        28.00
                over (min)      10.00        10.00
     Storage Coeff.   (min)=      8.40 (ii)   14.33 (ii)
     Unit Hyd. Tpeak  (min)=     10.00        15.00
     Unit Hyd. peak   (cms)=       .12          .08
                                                          *TOTALS*
     PEAK FLOW        (cms)=       .15          .06          .21 (iii)
```

```
     TIME TO PEAK    (hrs)=       3.33         3.42           3.33
     RUNOFF VOLUME    (mm)=      80.92        53.53          69.94
     TOTAL RAINFALL   (mm)=      81.52        81.52          81.52
     RUNOFF COEFFICIENT   =        .99          .66            .86


       (i) CN PROCEDURE SELECTED FOR RAINFALL LOSSES:
            CN*   =  76.0    Ia = Dep. Storage  (Above)
      (ii) COMPUTATIONAL TIME STEP SHOULD BE SMALL OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
*                   Basin 108g Portion of 108 uncontrolled
--------------------
| CALIB            |
| STANDHYD  (1085) |   Area    (ha)=   3.78
|ID= 3 DT= 5.0 min |   Total Imp(%)=  80.00   Dir. Conn.(%)=  60.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       3.02          .76
     Dep. Storage     (mm)=        .60         2.50
     Average Slope     (%)=        .60         5.00
     Length            (m)=     250.00        35.00
     Mannings n          =       .013         .250

     Max.eff.Inten.(mm/hr)=      21.19        28.00
                over (min)      10.00        10.00
     Storage Coeff.  (min)=       9.60 (ii)   15.53 (ii)
     Unit Hyd. Tpeak (min)=      10.00        20.00
     Unit Hyd. peak  (cms)=        .11          .07
                                                          *TOTALS*
     PEAK FLOW       (cms)=        .13          .05            .18 (iii)
     TIME TO PEAK    (hrs)=       3.42         3.58           3.42
     RUNOFF VOLUME    (mm)=      80.92        53.53          69.94
     TOTAL RAINFALL   (mm)=      81.52        81.52          81.52
     RUNOFF COEFFICIENT   =        .99          .66            .86


       (i) CN PROCEDURE SELECTED FOR RAINFALL LOSSES:
            CN*   =  76.0    Ia = Dep. Storage  (Above)
      (ii) COMPUTATIONAL TIME STEP SHOULD BE SMALL OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------


--------------------
| ADD HYD   (1012) |
|   9 +  2 =  1    |          AREA     QPEAK     TPEAK      R.V.
--------------------          (ha)     (cms)     (hrs)      (mm)
```

```
          ID1= 9 (2003):   461.84     2.73    14.50    44.17
        + ID2= 2 (1084):     4.31      .21     3.33    69.94
          =================================================
          ID = 1 (1012):   466.15     2.73    14.50    44.41

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| ADD HYD   (1013) |
|   1 +  3 =  2    |          AREA     QPEAK     TPEAK      R.V.
--------------------          (ha)     (cms)     (hrs)      (mm)
          ID1= 1 (1012):   466.15     2.73    14.50    44.41
        + ID2= 3 (1085):     3.78      .18     3.42    69.94
          =================================================
          ID = 2 (1013):   469.93     2.73    14.50    44.62

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
*                   Basin 108abc Portion of 108 uncontrolled
--------------------
| CALIB            |
| STANDHYD  (1086) |   Area     (ha)=  23.91
|ID= 3 DT= 5.0 min |   Total Imp(%)=  80.00   Dir. Conn.(%)=  60.00
--------------------
                                IMPERVIOUS    PERVIOUS (i)
     Surface Area      (ha)=      19.13          4.78
     Dep. Storage      (mm)=        .60          2.50
     Average Slope      (%)=        .60          5.00
     Length             (m)=     700.00         35.00
     Mannings n            =       .013          .250

     Max.eff.Inten.(mm/hr)=      21.19         28.00
                over (min)       20.00         10.00
     Storage Coeff.  (min)=      17.80 (ii)    23.74 (ii)
     Unit Hyd. Tpeak (min)=      20.00         25.00
     Unit Hyd. peak  (cms)=        .06           .05
                                                             *TOTALS*
     PEAK FLOW       (cms)=        .82           .32            1.11 (iii)
     TIME TO PEAK    (hrs)=       3.58          4.67            3.67
     RUNOFF VOLUME    (mm)=      80.92         53.53           69.96
     TOTAL RAINFALL   (mm)=      81.52         81.52           81.52
     RUNOFF COEFFICIENT   =        .99           .66             .86


       (i) CN PROCEDURE SELECTED FOR RAINFALL LOSSES:
             CN*   =  76.0     Ia = Dep. Storage  (Above)
      (ii) COMPUTATIONAL TIME STEP SHOULD BE SMALL OR EQUAL
           THAN THE STORAGE COEFFICIENT.
```

```
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (1014) |
|   2 +  3 =  1    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
          ID1= 2 (1013):   469.93     2.73    14.50    44.62
        + ID2= 3 (1086):    23.91     1.11     3.67    69.96
          ==================================================
          ID = 1 (1014):   493.84     2.73    14.50    45.85

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
*                   Basin 108h Portion of 108 uncontrolled
--------------------
| CALIB            |
| STANDHYD  (1087) |   Area    (ha)=   1.47
|ID= 2 DT= 5.0 min |   Total Imp(%)=  80.00   Dir. Conn.(%)=  60.00
--------------------
                             IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       1.18          .29
     Dep. Storage     (mm)=        .60         2.50
     Average Slope     (%)=        .60         5.00
     Length            (m)=     125.00        35.00
     Mannings n           =       .013         .250

     Max.eff.Inten.(mm/hr)=      21.19        28.00
                over (min)      10.00        10.00
     Storage Coeff.  (min)=       6.33 (ii)   12.26 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=        .19          .09
                                                          *TOTALS*
     PEAK FLOW       (cms)=        .05          .02             .07 (iii)
     TIME TO PEAK    (hrs)=       3.33         3.42            3.33
     RUNOFF VOLUME    (mm)=      80.92        53.53           69.92
     TOTAL RAINFALL   (mm)=      81.52        81.52           81.52
     RUNOFF COEFFICIENT   =        .99          .66             .86


       (i) CN PROCEDURE SELECTED FOR RAINFALL LOSSES:
             CN*   =  76.0    Ia = Dep. Storage  (Above)
      (ii) COMPUTATIONAL TIME STEP SHOULD BE SMALL OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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```
| ADD HYD    (1015) |
|   1 +  2 =  3     |          AREA     QPEAK     TPEAK      R.V.
--------------------           (ha)     (cms)     (hrs)      (mm)
          ID1= 1 (1014):     493.84      2.73     14.50     45.85
        + ID2= 2 (1087):       1.47       .07      3.33     69.92
          ==================================================
          ID = 3 (1015):     495.31      2.73     14.50     45.92

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
*                   Basin 108i Portion of 108 uncontrolled
--------------------
| CALIB             |
| STANDHYD  (1087)  |   Area     (ha)=    1.43
|ID= 2 DT= 5.0 min  |   Total Imp(%)=  65.00   Dir. Conn.(%)=  45.00
--------------------
                                    IMPERVIOUS    PERVIOUS (i)
     Surface Area      (ha)=            .93           .50
     Dep. Storage      (mm)=            .60          2.50
     Average Slope      (%)=            .60          5.00
     Length             (m)=         100.00         35.00
     Mannings n            =           .013          .250

     Max.eff.Inten.(mm/hr)=           21.19         19.56
                over (min)            10.00         10.00
     Storage Coeff.  (min)=            5.54 (ii)    13.86 (ii)
     Unit Hyd. Tpeak (min)=            5.00         15.00
     Unit Hyd. peak  (cms)=             .20           .08
                                                                *TOTALS*
     PEAK FLOW       (cms)=             .04           .02           .06 (iii)
     TIME TO PEAK    (hrs)=            3.25          4.25          3.25
     RUNOFF VOLUME    (mm)=           80.92         48.78         63.18
     TOTAL RAINFALL   (mm)=           81.52         81.52         81.52
     RUNOFF COEFFICIENT   =             .99           .60           .78


       (i) CN PROCEDURE SELECTED FOR RAINFALL LOSSES:
            CN*   =  76.0    Ia = Dep. Storage  (Above)
      (ii) COMPUTATIONAL TIME STEP SHOULD BE SMALL OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD    (1016) |
|   2 +  3 =  1     |          AREA     QPEAK     TPEAK      R.V.
--------------------           (ha)     (cms)     (hrs)      (mm)
          ID1= 2 (1087):       1.43       .06      3.25     63.18
        + ID2= 3 (1015):     495.31      2.73     14.50     45.92
```

```
          ==================================================
          ID = 1 (1016):   496.74     2.73    14.50    45.98

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
--------------------
| SAVE HYD  (1016) |   AREA        (ha)= 496.74
| ID= 1   PCYC=*** |   QPEAK      (cms)=   2.73 (i)
| DT= 5.0 min      |   TPEAK      (hrs)=  14.50
--------------------   VOLUME      (mm)=  45.98
  Filename: NBel100.TXT
  Comments: Peak Outflow

     (i)  PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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 FINISH
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