VAN MEER LIMITED

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January 31, 1995

Moira River Conservation Authority
P.O. Box 698
Belleville, Ontario
K8N 5B3

Attn: Mr. Ernie Margetson P.Eng.,

RE: NOR-BELLE SUBWATERSHED PLAN,
PART LOT 3, CONC. 3,
TOWNSHIP of THURLOW

Dear Sir.

We have provided for your review and approval Nor-Belle Subwatershed Stormwater management plan.

We trust the enclosed will meet with your approval. Should you have any questions or require any further information please do not hesitate to contact our office.

Yours Truly,

Van MEER Limited

Phil Cook, P.Eng.,
PJC/
Encl.

NOR-BELLE SUBWATERSHED

STORMWATER MANAGEMENT STUDY

DRAFT REPORT

Prepared for:

Nor-Belle Developments Inc.

January 1995

Van MEER Limited
14 Bridge Street West
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1.0 INTRODUCTION

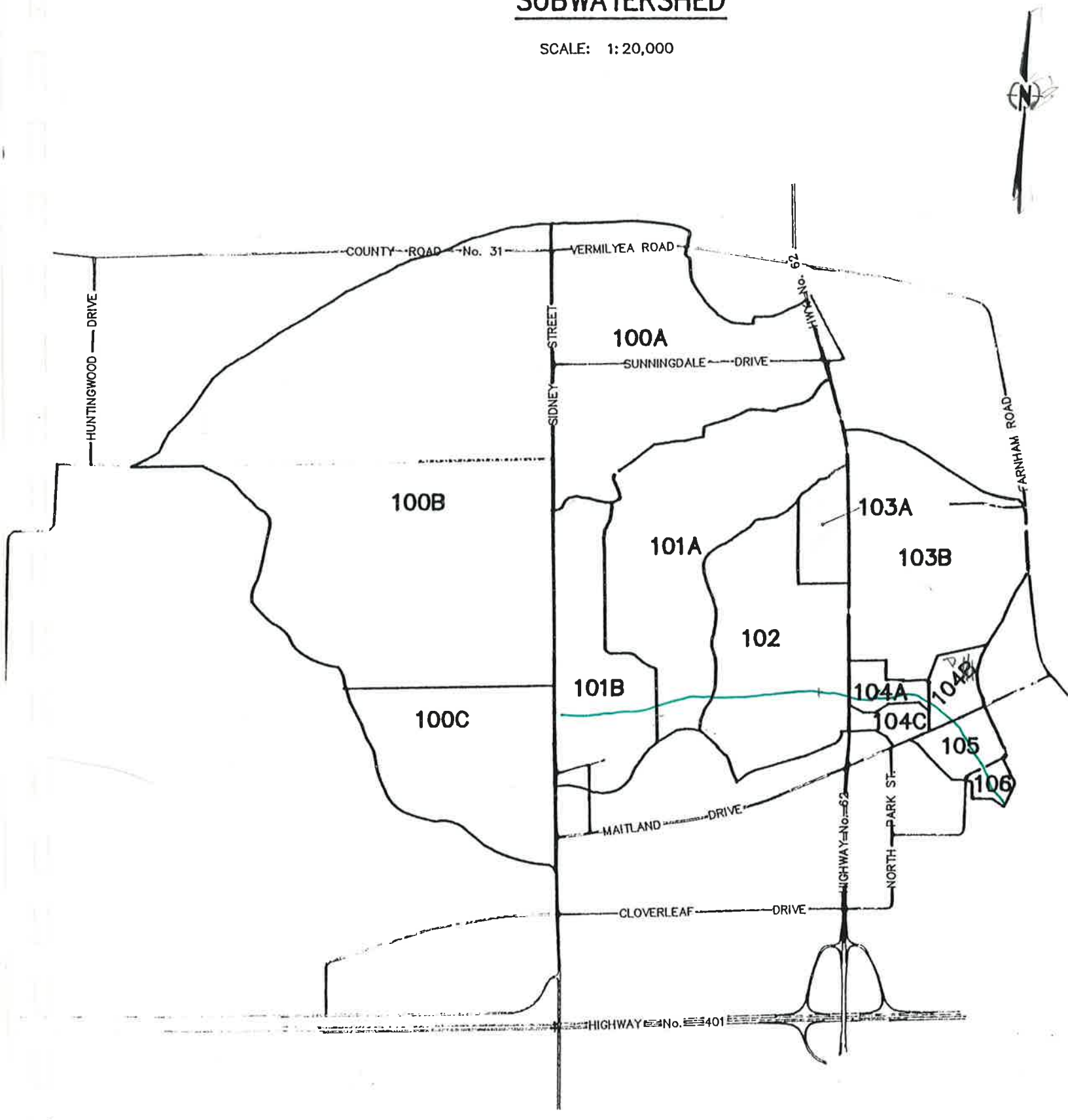
In 1991, through the Cannifton Secondary Plan, the Township of Thurlow adopted stormwater management policies to ensure that future development within the Secondary Plan area proceeds in a sustainable manner through adherence to acceptable stormwater management criteria and relevant regulatory requirements. Part 4; Section 3.2.1 of the Secondary Plan requires that prior to the development of land within any drainage basin identified on Schedule 4 to the Plan, a Master Drainage Plan be prepared by the developer on behalf of the Municipality.

In keeping with the provisions of the Cannifton Secondary Plan, Nor-Belle Developments Inc. retained Van MEER Limited to prepare a Subwatershed Plan in support of consent application B338/92, and subsequently consent application B119/94, for the development of a commercial property within what is hereinafter referred to as the Nor-Belle Subwatershed.

The Nor-Belle Subwatershed consists of an area of approximately 550 hectares which outlets into the Moira River in Cannifton. The Moira River which outlets at the City of Belleville is a major tributary to the Bay of Quinte.

NOR–BELLE SUBWATERSHED

SCALE: 1:20,000



2.0 STUDY AREA

2.1 Nor-Belle Subwatershed

The Nor-Belle Subwatershed is a 550 hectare watershed located within the Townships of Sidney and Thurlow, immediately north of the City of Belleville.

The subwatershed is bounded to the north by Vermilyea Road, (County Road No. 31), to the south by the No-Name Creek subwatershed , to the west by the Potter Creek Subwatershed and to the east by the Moira River and Farnham Road.

The Subwatershed drains in a south easterly direction where it outlets into the Moira River in Cannifton. Sidney Street and Highway No. 62 traverse the subwatershed in a north south orientation with Sidney Street the boundary between Thurlow Township to the east and Sidney Township to the west.

Approximately 250 hectares of the subwatershed is located in Sidney Township and approximately 300 hectares located in Thurlow Township.

The study area is primarily drained by a single unnamed drainage course.

2.2 Existing Drainage Course

The existing unnamed drainage course which traverses the Nor-Belle Subwatershed serves as the primary drainage source for the study area outletting directly into the Moira River.

In general, the drainage course exists in its natural state west of Highway 62 as a grassed swale. East of Highway 62, the drainage course has undergone a significant level of alteration and channelization. A portion of the eastern leg of the drainage course has been diverted underground. The drainage course has been further channelized via a system of concrete block retaining walls through the Thurlow Township Industrial Park to its outlet into the Moira River.

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2.3 Existing Drainage

The headwaters of the Nor-Belle Subwatershed originate in both Sidney Township and Thurlow Township, specifically the Huntingwood Hills and County Road 31 area in Sidney and the Sunningdale Drive, County Road 31 area in Thurlow.

Storm drainage crosses Municipal boundaries in two instances. Storm water drains from Thurlow Township into Sidney Township then from Sidney Township back into Thurlow Township.

Sidney Street has created an obstruction to free drainage and has resulted in significant ponding of water on the west side of Sidney Street which remains wet throughout most of the year.

The wet area on the west side of Sidney Street drains back into Thurlow Township via four 760mm csp's and one 600mm csp. These five culverts control the peak flow rate which drain back into Thurlow Township. The storage discharge curves for these culverts is presented in Tables B-2 & B-3.

Drainage from Sidney Street is facilitated by a 3 metre wide 0.4 metre deep grassed swale which drains in an easterly direction to Highway No. 62. Due to the low capacity of the existing drainage swale and the flat slope approximately 0.2% a split flow occurs during the major storm events with approximately 1.2 m^3/s spilling southerly into the No Name Creek Subwatershed.

Stormwater flowing to Highway No. 62 encounters a 1500mm by 900mm concrete box culvert located immediately south of the Bob Clute Car Dealership. The box culvert does not have sufficient capacity to convey the 1:100 year storm event.

It has been determined that approximately 1.3 hectare metres of storm water is ponded on the west side of the Highway No. 62 culvert to an elevation of 108.0m. The extent of the ponding is identified in the Pre-Development floodplain Mapping Drawing.

The water then flows overland via a small natural channel where it is then diverted underground via 60 metres of 1.8 metre diameter steel pipe. The water resurfaces south of Maitland Drive where it is conveyed via a 3.0 metre wide, 150 metre long concrete block lined channel to its outlet into the Moira River.

There is currently no storm sewer system within the Nor-Belle Subwatershed to separate the minor storm systems from the major storm systems. As such, the minor storm drainage system consists of roadside ditches and natural and man-made swales; the major storm drainage system discharges overland following the natural topography of the area and the existing primary drainage course.

2.4 *Physiography*

The Nor-Belle Subwatershed is situated within the Napanee Plain physiographic region of Ontario. The Napanee Plain is characterized by flat to undulating limestone with limited overburden due to glacial activity in the area (Chapman and Putman, 1984).

The existing overburden material within the Drainage Basin is predominated by Solmesville, Grey-Brown Podzolic Clay to an average depth of 2.3 metres. Below the clay lies packed gravel and hardpan to an average depth of 4.0 metres; with limestone bedrock occurring at an average depth of 16 metres. All soil information was obtained from the Soils of Hastings County, South, Ontario Soil Survey Report Number 27 and the Water Well Records of the County of Hastings.

2.5 *Vegetative Environment*

The Nor-Belle Subwatershed is characterized by a progression of vegetation in subcatchment areas 101A and 101B of pasture lands, mature lowland deciduous tree stands and abandon and active farmlands to the more urbanized parts of the study area that have been cleared for development leaving only small pockets of abandon farmland and mature deciduous tree stands. It is noted that within the Subwatershed, the stands of mature deciduous trees are limited to the boundaries of active or abandon farm fields or along the existing drainage course.

2.6 *Aquatic Environment*

Information provided by the Ministry of Natural Resources indicate that there is no significant concern for fish or fish habitat within the primary drainage course for the Nor-Belle Subwatershed.

Fish migration up the drainage course from the Moira River is precluded due to a 4.0 metre difference in elevation between the Moira River and the outlet of the drainage course.

2.7 *Wetlands*

There are no ~~locally or Provincially significant~~ wetlands areas within the Nor-Belle Subwatershed. which are have been classified to date

3.0 HUMAN ENVIRONMENT

3.1 Existing Land Use & Development

As previously noted in this report, the Nor-Belle Subwatershed comprises approximately 555 hectares of land; 250 hectares located in the Township of Sidney and 305 hectares located in the Township of Thurlow.

The lands within the study area represent a mix of low density residential, small scale commercial, light industrial and agricultural land uses. Agricultural land uses account for approximately 80 % or 448 hectares of the study area.

The residential land uses, predominantly single detached dwellings, occur in small pockets in both Sidney and Thurlow Townships. Within Thurlow, the residential pockets are located along Maitland Drive, Farnham Road and Thurlow Drive. In Sidney, the residential pockets are located along Huntingwood Drive and Hastings County Road 31. Commercial land uses are primarily oriented along the Highway 62 corridor, with small scale light industrial uses concentrated on Parks Drive (Thurlow Industrial Park).

The major opportunities for development within the study area are in subcatchment areas 102, 103, 104, 105 and 106 which form part of the urban service area of the Township of Thurlow; commonly referred to as the Cannifton Secondary Plan Area.

3.2 Existing Population

The existing population for the Nor-Belle Subwatershed is approximately 409 persons. The population of the study area is broken down as follows:

Nor-Belle Subwatershed Population Breakdown
(Source: 1991 Canada Census Data)

Township	Total Population	Pop. within Study Area
Thurlow	7,267	212
Sidney	16,702	197

3.3 Municipal Planning Policies

Development within the Nor-Belle Subwatershed is regulated by the policies of the Official Plan for part of the Township of Thurlow (including the Cannifton Secondary Plan) and the Official Plan for the Township of Sidney (Figure 3.1).

(a) Official Plan for the Township of Sidney

Schedule "A" (Land Use Plan) to the Official Plan designates the lands within the study area (subcatchment areas 100 A & 100B) for predominantly Agricultural uses with small pockets of Rural land situated to the west of Huntingwood Drive.

Under the policies of the Agricultural and Rural designation, Sections 3.6 and 3.7 respectively, development within subcatchment area 100A & 100B will be limited to individual lot creation via the consent process and farm related land uses. As such, development within the Sidney Township portion of the subwatershed should not significantly increase water flows into Thurlow Township.

(b) Official Plan for part of the Township of Thurlow

The Nor-Belle Subwatershed is divided between the service area (Cannifton Secondary Plan area) and the non-service area of the Township as defined by the Official Plan.

Subcatchment areas 101A and 101B are primarily located within the non-service area of the Township along with a small portion of subcatchment area 102. Schedule "A1" to the Official Plan designates the majority of these lands as Agriculture with pockets of existing residential development being designated Rural Residential.

Development of the lands designated as Agriculture is limited to agricultural activities with limited residential lot creation in keeping with the provisions of the Ontario Food Land Guidelines and the Agricultural Code of Practice.

Notwithstanding the proximity of these lands to the urban service area, full development of these lands is not anticipated in the foreseeable future due to the supply of vacant, developable land within the boundaries of the Cannifton Secondary Plan area.

Small portions of subcatchment areas 101A, the majority of subcatchment area 102 and all of subcatchment areas 103, 104, 105 and 106 are located within the Cannifton Secondary Plan area. The

Official Plan designations for the portions of the subwatershed within the study area are a mix of residential, commercial, industrial and open space land uses.

The majority of the residentially designated land is classified as "low" density (single detached, semi-detached, triplex and townhouse dwelling units not to exceed a maximum density of 19.8 units per net hectare) with "medium" and "high" density residential lands (semi-detached, triplex, townhouse dwelling units not exceeding 44.0 units per net hectare, and low and high rise apartments not to exceed 118 units per net hectare respectively) occurring in smaller pockets.

Development adjacent to the Highway 62 corridor is limited to Highway Commercial development that caters to the travelling public, but does not include the development of regional shopping centres (ie. shopping malls). Lands located to the north and south of Maitland Drive are designated for Service Industrial and Restricted Industrial land uses respectively.

Key elements of the municipal planning policies relating to the future development of the Nor-Belle Subwatershed are summarized as follows:

(a) all development within the study area located in the urban service boundary must take place on full municipal water and sewer services;

(b) a 30 metre strip of Environmental Protection land exists to prohibit development or the storage of goods adjacent to the banks of the Moira River;

(c) the Secondary Plan states that all new development greater than 0.5 hectares requires the completion of a storm water management report that is consistent with the recommendations and conclusions of the approved Subwatershed Plan; and

(d) the majority of the land situated outside of the urban service area has been designated for agricultural use and prohibits other forms of non-agricultural development from taking place on these lands.

3.4 Transportation

The study area is traversed in a north-south direction by the Highway 62 corridor. Highway 62 serves as a connecting link between Highway 7 and Highway 401 and also serves as the primary transportation route between the communities of northern Hastings County and the City of Belleville.

Due to the development of 'big box retail' commercial operations (ie. Wal-Mart) adjacent to the Highway 401/Highway 62 interchange, in conjunction with the existing commuter traffic along Highway 62, the Ministry of Transportation plans to upgrade Highway 62 to a four or possibly five lane highway within the next five to seven years.

The redevelopment of this portion of Highway 62 should facilitate the upgrading of the existing culvert and roadside ditch system conveying water through this portion of the study area.

The south-western portion of the Nor-Belle Subwatershed is located within the "Approach Surface" of C.F.B. Trenton. The draft Department of National Defence guidelines regarding development within the surface approaches of runways limits storm water detention/retention facilities to less than one hectare in size due to potential bird hazard.

4.0 WATER MANAGEMENT OBJECTIVES

4.1 Rationale for Objectives

The rationale for the stormwater management objectives is derived from the following sources:

* the stormwater management requirements of the Moira River Conservation Authority;
* the stormwater management requirements of the Bay of Quinte Remedial Action Plan; and
* the municipal drainage standards of the Township of Thurlow (as outlined in the Cannifton Secondary Plan).

(a) Cannifton Secondary Plan

The objective of this report is to formulate a stormwater management plan to facilitate sustainable development within the Nor-Belle subwatershed area. The plan must adhere to the objectives outlined in the Cannifton Secondary Plan, summarized as follows:

* to provide protection against flooding risks through the maintenance of a zero (0) percent increase in peak run-off from pre to post development conditions;
* to identify and locate stormwater detention and retention facility requirements to ensure that future development conditions do not result in an adverse impact on water quantity and/or quality; and
* to meet the requirements of the Remedial Action Plan for the Bay of Quinte as it relates to future development.

(b) Remedial Action Plan

The Bay of Quinte Remedial Action Plan (RAP) represents the efforts of a multi-agency coordinating committee to develop recommendations to improve the water quality of the Bay of Quinte. The water quality objectives as identified in the RAP as they pertain to new development are outlined below:

* ecoli levels in stormwater being discharged to the Bay of Quinte during the body contact season (May 15 to September 15) shall not exceed 100 counts/dl (with the exception of four event exceedances); and

* suspended sediment levels discharging to the Bay of Quinte shall not exceed 25 mg/litre (with the exception of four event exceedances)

The above noted stormwater management objectives were the basis for the Nor-Belle Stormwater Management Plan.

5.0 DEVELOPMENT OF STORMWATER MANAGEMENT PLAN

5.1 Stormwater Management Approach

The stormwater management plan for the Nor-Belle subwatershed must address the requirements of stormwater quantity and quality control. In addressing these requirements the following issues were considered:

* the plan should utilize existing natural topography drainage course and wet areas;
* the plan should be economical in terms of land costs, construction costs and operation and maintenance costs, the number of facilities should be minimized;
* the plan should be suited to implementation based on the policies of the Cannifton Secondary Plan (servicing staging), existing land ownership, and natural development boundaries (ie. Gas easements); and
* the recommendations of the plan should be adaptable to implementation in phases.

5.2 Method of Analyzing System Components

The Otthymo computer model was used to determine peak flow rates and stormwater runoff volumes for existing conditions at various locations within the watershed, the drainage system schematic is shown in Appendix B, figure B-1. Peak flow rates under existing conditions at specific locations of concern are identified in table B-5.

Table B-9 identifies post development peak flow rates under two conditions. Condition 1 reflects the post development peak flow rates with no obstruction at Highway No. 62. Condition 2 reflects the post development peak flow rates with ponding occurring behind the Highway 62 culvert. Table B-10 reflects the post development peak flow rates under the proposed stormwater management plan. The tables indicate the need for stormwater management.

The Hec-2 computer model was used to determine the capacity of the existing drainage course and culverts. Floodplain mapping under existing conditions is presented in two drawings; Predevelopment Floodplain Mapping, Moira River to Highway No. 62, and Predevelopment Floodplain Mapping, Highway No. 62 to Sidney Street.

The existing culvert capacities are identified Appendix C, Table C-2. The existing culvert capacities identify the need for stormwater management

The Otthymo computer model and the Ministry of the Environment and Energy publication, Stormwater Management Practices Planning and Design Manual (MOEE, 1994) were utilized to determine the water quality options for the Nor-Belle Subwatershed.

The hydrologic and Hydraulic analysis were utilized to determine stormwater management options and storage volume requirements.

5.3 Development of Stormwater Management Options

In consideration of the water management objectives and in keeping with the approach outlined previously several SWM options were considered.

The existing storage behind the Highway No. 62 culvert under the 100 year storm event as identified in the Floodplain Mapping Drawing provides attenuation of existing conditions peak flow rates. With the constraints of the existing downstream culvert capacities the replacement of the Highway No. 62 culvert to alleviate the existing ponding was not considered to be a feasible option.

The storage created by the restriction of the Highway 62 culvert was considered to be utilized to attenuate post development peak flow rates. Several issues were consideration in utilizing the existing storage behind the Highway No. 62 culvert as follows:

* the area of land which would be affected which is presently designated for Highway Commercial and Residential development under the Township of Thurlow Official Plan and Cannifton Secondary Plan;

* the location of possible Stormwater Retention/ Detention Facilities as identified in Schedule 4 of the Cannifton Secondary Plan; and

* existing approved development plans.

It was considered that the Highway No. 62 culvert should remain to be utilized as a control structure and the storage volume created could be redirected phase by phase as development proceeds upstream to the location identified under the Cannifton Secondary Plan. The proposed SWM Plan is discussed in detail in the following section.

6.0 Stormwater Management Plan

The proposed stormwater management plan incorporates two ponds with an option for a third pond. The location of the ponds are identified in the Post Development Drainage Area drawing. Pond 1 and Pond 2 are proposed to be located within the area designated for stormwater facilities as indicated in Schedule 4 of the Cannifton Secondary Plan. Pond 3 is proposed to be located between Parks Drive and Maitland Drive in the Thurlow Industrial Park.

a) Pond 1

Pond 1 is proposed as a stormwater quantity pond requiring 14,000 cubic metres of storage volume. Pond 1 is required to allow the development of post development drainage areas 102 while maintaining predevelopment peak flow rates to the Highway No. 62 culvert.

The pond is proposed to utilize the existing topography with no earth excavation. Pond 1 will be formed by creating a restriction to flow with a control structure located at the limits of the Cannifton secondary plan. Preliminary design indicates that Pond 1 will require a stage storage discharge curve as identified in Appendix B, Table-B7. The Post Development Floodplain Mapping Drawing identifies the extent of the ponding. The hydraulics of the resultant backwater are discussed further in Appendix C.

b) Pond 2

Pond 2 is proposed to be utilized for both stormwater quantity and quality control with volume requirements of 13,000 and 8,200 cubic metres respectively (see Table 6.1).

Pond 2 will receive stormwater runoff from 15 hectares of highway commercial land and a total of 66 hectares of residential land, post development catchment areas 103A, 103B and 103C. From the MOEE table it was determined that the total storage volume required for wetlands under level one protection would be 8200 cubic metres.

Pond 2 is proposed to utilize the existing natural wet area between Highway No. 62 and Farnham Road and is proposed to be retained as a permanent wet area.

The existing wet area as identified on the Pre Development Drainage Area plan comprises approximately 1.6 hectares in surface area. The proposed water quality wet area would require minor berming and control structures to effectively utilize the existing wet area.

c) Pond 3

The options outlining the requirements for Pond 3, are identified in Tables 6.1 and 6.2. The requirement for Pond 3 is based on water quality considerations of natural or physical disinfection.

Pond 3 will receive stormwater runoff from 22 hectares of highway commercial service industrial and restrictive industrial lands, post development catchment areas 104, and 105. From the MOEE table it was determined that the total storage volume required for wet ponds under level one protection would be 5500 cubic metres.

Pond 3 is proposed to be located within the existing low wet area between Parks Drive and Maitland Drive within the limits of the existing 1:100 year floodplain. Pond 3 would be developed as a wet pond and utilized to address stormwater quality.

A preliminary review indicates that a 5500 cubic metre pond could be constructed within the area delineated as the existing 1:100 year flood line between Parks Drive and Maitland Drive with minimal earth excavation and berming.

TABLE 6.1 OPTION 1 NATURAL DISINFECTION				
	Quantity volume cm	Quality volume cm	Total volume cm	Land Area reqd. ha.
POND ONE	14,000	0	14,000	4.0
POND TWO	13,000	8,200	21,200	1.6
POND THREE	0	5,500	5,500	1.0
TOTAL	27,000	13,700	40,700	6.6

TABLE 6.2 OPTION 2 PHYSICAL DISINFECTION				
	Quantity volume cm	Quality volume cm	Total volume cm	Land Area reqd. ha.
POND ONE	14,000	0	14,000	4.0
POND TWO	13,000	0	13,000	1.6
POND THREE	0	0	0	0
TOTAL	27,000	0	27,000	5.6

6.1 Water Quality Options

a) Natural Disinfection

Option 1 examines the storage volume required to obtain water quality effluent consistent with the RAP guidelines utilizing natural processes.

The water quality pond size requirements were based on the Stormwater Management Practices Planning and Design Manual (MOEE, 1994). The MOEE manual identifies storage volume requirements per hectare for percent impervious based on four levels of protection to the receiving watercourse. Due to the close proximity of the Nor-Belle Subwatershed to the Bay of Quinte protection level 1 was selected as the basis for the water quality requirement.

The MOEE Storage Volume Requirement Table is reproduced on the following page.

b) Physical Disinfection

Option 2 examines the requirements to obtain water quality effluent consistent with the RAP guidelines utilizing ultra violet disinfection processes.

It was determined utilizing the Otthymo computer model that the water quality event storm generates approximately 770 l/s of runoff at the Moira River.

A single ultra violet treatment system located at the outlet to the Moira River can be designed to meet the water quality requirements for the entire Nor-Belle Subwatershed.

Table 4.1 Water Quality Storage Requirements based on Receiving Waters					
Protection Level	BMP Type	Storage Volume (m^3/ha) for Impervious Level			
		35 %	55 %	70 %	85 %
Level 1	Infiltration	25	30	35	40
	ED Wetlands	80	105	120	140
	ED Wet Pond	140	190	225	250
	Dry Pond (Batch)	140	190	210	235
Level 2	Infiltration	20	20	25	30
	ED Wetlands	60	70	80	90
	ED Wet Pond	90	110	130	150
	Dry Pond (Batch)	60	80	95	110
Level 3	Infiltration	20	20	20	20
	ED Wetlands	60	60	60	60
	ED Wet Pond	60	75	85	95
	Dry Pond (Batch)	40	50	55	60
	ED Dry Pond	90	150	200	240
Level 4	Infiltration	15	15	15	15
	ED Wetlands	60	60	60	60
	ED Wet Pond	60	60	60	65
	Dry Pond (Batch)	25	30	35	40
	ED Dry Pond	35	50	60	70

* For wetlands and wet ponds all of the storage, except for 20 m^3/ha, in Table 4.1 represents the permanent pool volume. The 20 m^3/ha represents extended detention storage.

7.0 IMPLEMENTATION AND PHASING

As noted in Section 5.1, the approach to stormwater management should be suited to implementation based on the Cannifton Secondary Plan servicing staging policies and should be adaptable to implementation in phases.

The SWM study was initiated by Nor-Belle Developments Inc. in support of consent application B338/92 and B119/94.

This section will discuss the specific SWM requirements for the development of the Nor-Belle holdings, and the staging of the SWM plan in general.

Phase One of the Nor-Belle Development holdings, as it relates to this SWM plan, constitutes those lands designated as highway commercial; more specifically the development plans prepared by Greer Galloway & Associates, for Part of Lot 3, Concession 3. It is proposed that the service roads and drainage easements be constructed in accordance with the Greer Galloway drawings (with revisions by Van Meer Limited to reflect the SWM requirements.)

A zero increase in peak flow rates from the development of the highway commercial lands will be achieved by over controlling on the upstream side of the most westerly service road. The control will create temporary ponding. The temporary ponding will be largely contained within the Nor-Belle holdings to the west to an elevation of 108.30m (as identified as Phase 1 ponding elevation in the Post Development Floodplain Mapping drawing).

As development of the residential lands occur, a control structure will be located at the west property limits of the Nor-Belle holdings. The creation of Pond 1 and alleviating the temporary ponding created from Phase one of the proposed development.

The MOEE manual recomends that 40 m^3/ha of stormwater be ponded and infiltrated for highway commercial development.

Storm water quality requirements for the development of Phase one are to be addressed for each lot under site plan control as per section 41 of the Planning Act.

It is anticipated that future development pressures will most likely occur along Maitland Drive as Stage 1 services are provided.

The SWM plan has allowed for the redevelopment of post development areas 104, 105 & 106 with no water quantity controls.

Water quality concerns for the development of areas 104 and 105 will require the construction of Pond 3. A storm sewer system should be constructed with the redevelopment of these lands to convey the minor storm drainage to proposed water quality Pond 3.

Pond 2 will be required at such time as Stage 2 services are provided to coincide with development proposals. At this time the existing 900mm csp under Highway No. 62 will require upgrading in order to accommodate post development peak flow rates from subcatchment areas 103A and 103B. A culvert with the capacity to convey 3.15 m^3/s will be required.

A PRECIPITATION

A.1 Design Storm

A single event design storm was utilized as precipitation input to the Otthymo model from which peak flows were generated. Three different design storms were modeled to determine which storm generated the highest peak flows within the watershed. The three design storms are listed below:

* the Atmospheric Environment Service (AES) Type II - 12 hour duration;
* the Hydroteck distribution - 1 hour duration; and
* the Soil Conservation Service (SCS) Type II - 12 hour duration;

The 12 hour SCS Type-II distribution with a 30 minute time step was determined to be the optimum design storm for modelling the runoff response of the watershed as identified in Table A-1

TABLE A-1
COMPARISON OF PEAK FLOWS GENERATED FROM DESIGN STORMS

LOCATION	AES 12-HOUR	HYDROTECH 1-HOUR	SCS 12-HOUR
Moira River	3.01	6.11	8.13
Parks Drive	2.98	6.02	7.83
Maitland Drive	2.93	5.74	7.13
1.8m Dia Steel Pipe	2.92	5.02	6.46
Highway No. 62	2.18	2.94	5.21
Sidney Street	0.76	0.45	1.02

Meteorological information was obtained from the Atmospheric Environment Service rainfall intensity -duration frequency values for Belleville station number 6150689.

A.2 Water Quality Storm

The water quality event storm was derived from the analysis prepared by Gore & Storrie Limited, from the Upper No Name Creek Stormwater Management Study.

Gore & Storrie analyzed 28 years of rainfall record for the Quinte Area for the recreational season (May 15 to September 15). The precipitation data set was analyzed to determine specific rainfall events based on various inter event times.

Gore & Storrie selected a six hour inter-event period and generated a rain event magnitude distribution for all 28 years. The average rainfall summer was determined to be 1968.

Van Meer Limited reviewed the precipitation data for the summer of 1968 and identified the rainfall events based on a six hour inter event time. The events were ranked in order of magnitude. The fifth largest event was utilized as the design storm event to be used in the water quality analysis. The water quality storm event generates a total precipitation volume of 22.4mm, shown in the following table.

Time (hours)	precip. (mm/hr)
1	0.0
2	0.0
3	7.9
4	4.3
5	1.8
6	1.0
7	0.0
8	0.0
9	0.3
10	6.1
11	1.0
12	0.0

The above noted quality event storm was input into the Otthymo model of future conditions to determine the water quality peak flow rate for the Nor-Belle subwatershed. It was determined that the water quality event generated a peak flow rate at the Moira River of 770 litres/ second.

B HYDROLOGIC ANALYSIS

B.1 Otthymo Model Setup

The OTTHYMO 1989, version"B", hydrologic computer model was used for the analysis of the hydrologic response of the Nor-Bell Subwatershed. Otthymo is an event based water quantity model designed to develop and simulate stormwater management and flood control plans. The Otthymo 89 model was developed from the preceding models HYMO (Williams and Hann, USDA, 1973) and OTTHYMO (Wisner and P'ng, University of Ottawa, 1983).

Otthymo is capable of generating hydrographs from various subcatchments, adding them and routing them through channels, natural reservoirs or proposed stormwater ponds.

In the development of the computer model, the watershed was discritized into subcatchments based on natural topography, existing and proposed land uses.

Discritization was achieved from examination of 1:5000 scale topographic mapping prepared from aerial photographs taken by Airborne Sensing in the fall of 1993. The topographic mapping was supplemented with extensive field survey, site inspection, and Municipal planning documents.

Flow data was not available for the Nor-Belle subwatershed from which to calibrate the computer model. Conservative input parameters were selected from published literature and the Otthymo users manual.

The Nash unit hydrograph was used to simulate the runoff response from the Nor-Bell subwatershed. The Nash subroutine uses the curve number (CN) procedure for computing rainfall losses and the conceptual model of a cascade of "N" linear reservoirs to develop the peak flow at specific times. The initial abstraction and time to peak are functions of the catchment physiographic characteristics.

The peak discharge increases with N and decreases with Tp, measurements in Ontario indicate that an average N of 3, should be used mainly for rural areas. Urbanized highway commercial and industrial lands have been modeled with 5 linear reservoirs, and residential lands have been modeled with the assumption of 4 linear reservoirs. For initial abstractions, 2.5 mm was used for impervious areas, 5mm for residential areas and 8mm for agricultural areas.

B.2 Existing Conditions

The Soil Conservation Service Curve Number hydrologic soil group C was used as the basis of determining the curve number for the various catchments. An area weighted value was calculated based upon existing land use and pervious area coverage to determine the CN parameter for each subcatchment. Existing subcatchment Curve Number values are presented in the following table:

TABLE B-1
SOIL CONSERVATION SERVICES CURVE NUMBER
EXISTING CONDITIONS

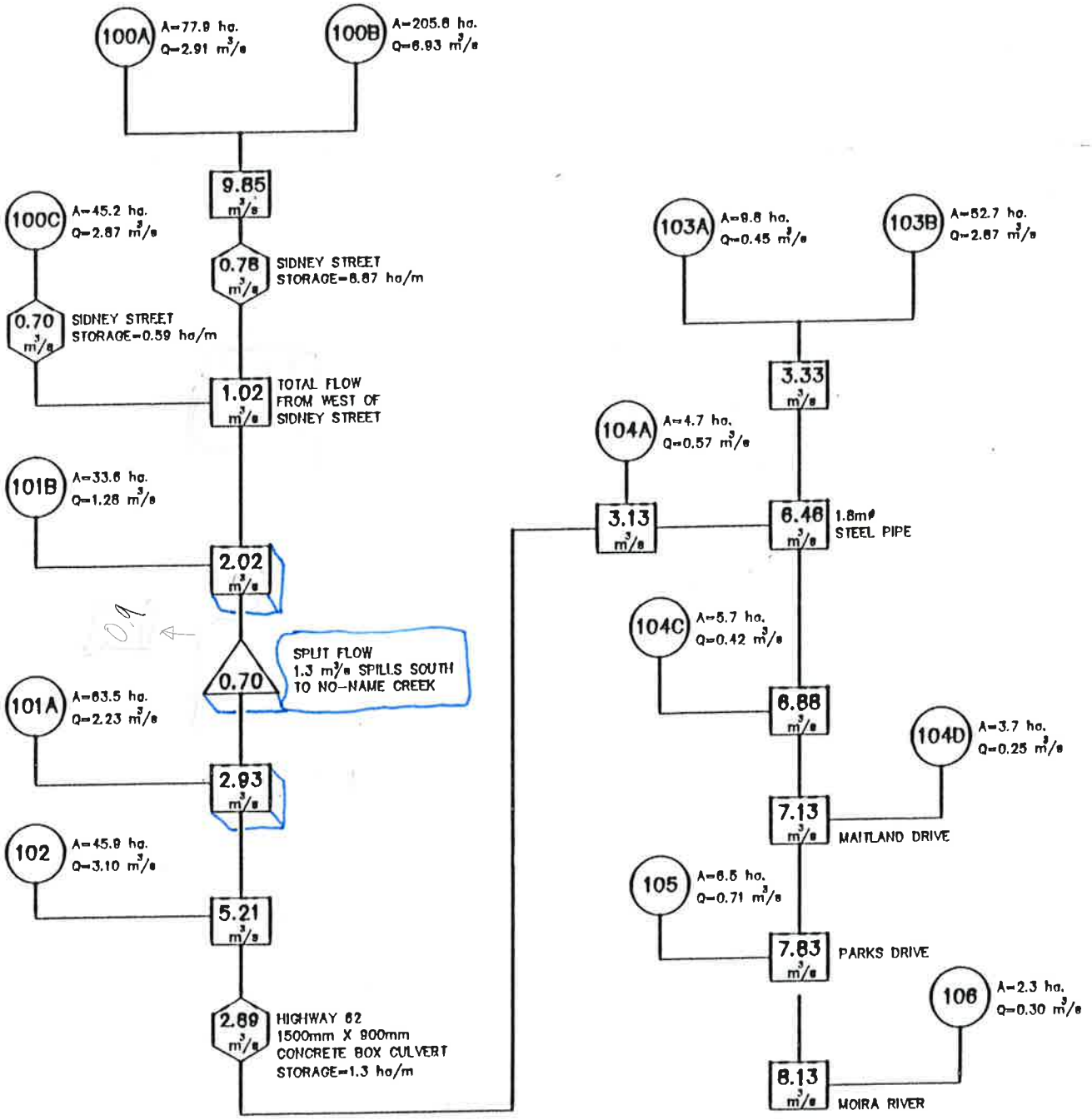
Sub-Catchment	Curve Number
100a	82
100b	82
100c	82
101a	82
101b	82
102	83.3
103a	87.4
103b	82.
104a	92.2
104c	83
104d	83.5
105	30% imp
106	43% imp

The existing development model schematic is shown in Figure D-1.

NOR-BELLE SUBWATERSHED

100 YEAR SCHEMATIC

PRE-DEVELOPMENT



Site inspection and field survey indicate drainage flowing from Thurlow Township on the north east side of Sidney Street (sub-catchment 100A) to Sidney Township on the west side of Sidney Street (sub-catchment 100B), via two 600mm csp's and one 900mm csp. Stormwater runoff is then ponded in an existing low wet area on the west side of Sidney Street approximately 21 hectares in surface area. The existing natural storage area is drained by three 760mm csp's under Sidney Street located south of the natural gas compressor station which direct runoff back into Thurlow Township.

Verified

TABLE B-2 STORAGE DISCHARGE CURVE Sidney Street Sub-Catchment 100b			
(Z-Z₀)	STORAGE (ha/m)	ΔS	DISCHARGE (m^3/s)
0	0	2.12	0
0.1	2.12	2.12	0.048
0.2	4.24	2.12	0.198
0.3	6.36	2.12	0.435
0.4	8.48	2.12	0.723
0.5	10.60	2.12	1.017
0.6	12.72		1.278

I think he means ha·m / s

$$A = \frac{dS}{dZ} = \frac{\Delta S}{\Delta S} = \frac{2.12}{0.1} = 21.2$$

A = 21.2 ha

Sub-catchment 100C or 100 as indicated in the No-Name Creek Stormwater Management Study is approximately 45 hectares in size and drains to an existing low wet area on the west side of Sidney Street approximately 7 hectares in surface area. The existing natural wet area drains from west to east under Sidney Street via one 760mm csp and one 600mm csp. The storage discharge curves are presented in the tables B-3 and B-4.

TABLE B-3
STORAGE DISCHARGE CURVE
Sidney Street Sub-Catchment 100c

STORAGE (ha/m)	DISCHARGE (m^3/s)
0	0
0.10	0.029
0.20	0.118
0.30	0.259
0.40	0.431
0.50	0.607
0.60	0.762

$$A = \frac{\Delta S}{\Delta Z} = \frac{0.1}{.6} = 7\ ha$$

Storm water runoff from the west side of Highway No. 62 ponds behind the existing 1500mm x 900mm concrete open footing box culvert. The existing culvert lacks sufficient capacity to convey the 100 year peak flow rate. The storage discharge curve used in the Otthymo reservoir routing model is presented in the following table.

TABLE B-4
STORAGE DISCHARGE CURVE
Highway No. 62 Sub-Catchment 102

Z	STORAGE (ha/m)	DISCHARGE (m^3/s)
107.0	0	0
107.2	0.01	1.20
107.4	0.02	1.80
107.6	0.03	2.25
107.8	0.33	2.70
108.0	1.41	3.00
108.2	3.16	3.15

Top of 900 mm box culvert.

Peak flow rates at various specific locations within the subwatershed are identified in the following table:

TABLE B-5
PEAK FLOWS - EXISTING CONDITIONS
@ Specific Locations

Location	Peak Flow 1: 100 Year
Moira River	8.13
Parks Drive	7.83
Maitland Drive	7.13
1.8m Dia Steel Pipe	6.46
Highway No. 62	5.21
Sidney Street	1.02

B.3 Future Conditions

The Soil Conservation Service Curve Number for future conditions was determined based upon proposed land use as outlined in the Cannifton Secondary Plan. The Thurlow Township Zoning By-Laws were used to determine the maximum allowable percent impervious for a specific land used. An area weighted value was calculated based upon the above noted criteria to determine the CN parameter for each subcatchment. Existing subcatchment Curve Number values are presented in the following table:

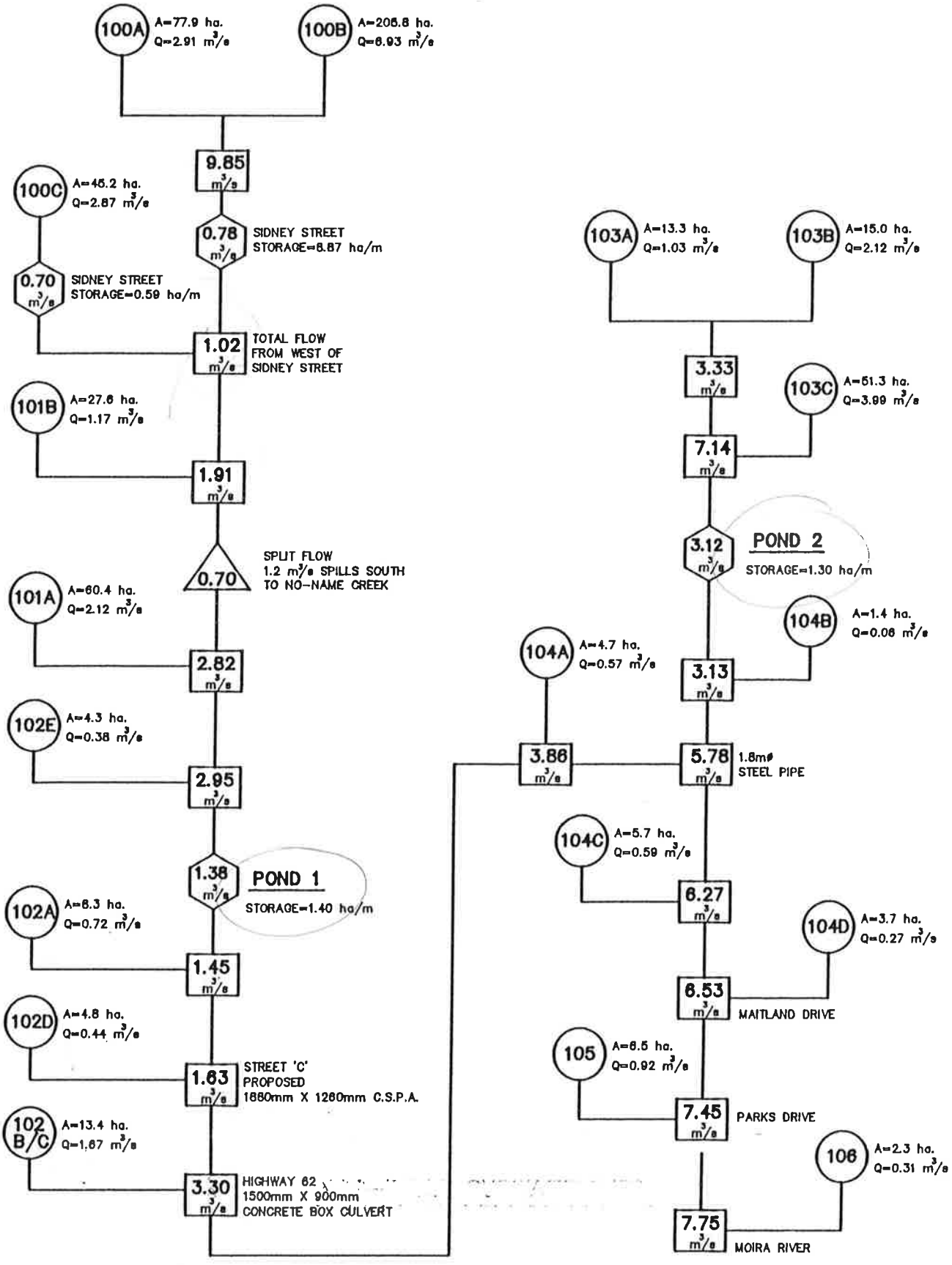
TABLE B-6	
Sub-Catchment	Curve Number
100a	82
100b	82
100c	82
101a	82
101b	82
102a	83.7
102b	93.6
102c	93.6
102d	84.7
102e	84.7
103a	83.7
103b	93.6
103c	84.4
104a	92.2
104b	92.2
104c	92.2
104d	92.2
105	59% imp
106	46% imp

The future development model schematic is presented in Figure B-2.

NOR-BELLE SUBWATERSHED

100 YEAR SCHEMATIC

POST DEVELOPMENT



Management of stormwater runoff from future development will adhere to the proposed locations for stormwater management ponds as per the Cannifton Secondary Plan for two of the three proposed ponds. Pond1 is proposed to be located west of Highway No. 62 within the existing agricultural lands as indicated in the Secondary Plan, Pond2 is proposed to be located on the west side of Highway No. 62 within the existing low wet area as indicated in the Secondary Plan and Pond3 is recommended to be located within the existing flooded area on the upstream side of Parks drive rather than in the McFarland Quarry as indicated in the secondary Plan.

Stormwater Pond1 and Pond2 are proposed to be water quantity ponds; Pond3 is proposed to be utilized for water quality only.

The storage discharge curves are presented in the following tables;

TABLE B-7
STORAGE DISCHARGE CURVE
Pond-1 west of Highway No. 62

STAGE	STORAGE (ha/m)	DISCHARGE (m^3/s) 1.0m dia CSP
108.2	0	0
108.3	0.516	1.05
108.4	1.265	1.20
108.5	1.421	1.40

TABLE B-8
STORAGE DISCHARGE CURVE
Pond-2 east of Highway No. 62

STORAGE (ha/m)	DISCHARGE (m^3/s)
0	0
0.60	1.60
0.90	2.80
1.30	3.20
1.60	3.50

TABLE B-9
PEAK FLOWS - FUTURE CONDITIONS 1:100 YEAR EVENT
@ Specific Locations

Location	NO SWM CONTROLS CONDITION 1	NO SWM CONTROLS CONDITION 2
Moira River	15.08	9.84
Parks Drive	14.77	9.53
Maitland Drive	8.62	8.62
1.8m Dia Steel Pipe	7.77	7.77
Highway No. 62	5.25	5.25
Sidney Street	1.02	1.02

TABLE B-10
PEAK FLOWS - FUTURE CONDITIONS WITH SWM CONTROLS
@ Specific Locations

Location	Peak Flow 1: 100 Year
Moira River	7.75
Parks Drive	7.45
Maitland Drive	6.53
1.8m Dia Steel Pipe	5.78
Highway No. 62	3.30
Sidney Street	1.02

An increase in peak flow rates created from the development of the Nor-Belle Developments highway commercial holdings is proposed to be controlled by an 1880mm x 1260mm CSPA located within the westerly service road. The restriction created by the proposed culvert will create a temporary ponding requiring a volume of 1.8 hectare metres. This volume will create a water surface elevation of approximately 108.30m. The backwater effects of the temporary ponding are discussed further in the hydraulic section of this report.

C HYDRAULICS ANALYSIS

C.1 Hec-2 Model Setup

A hydraulic analysis has been completed for the section of the watercourse from its outlet at the Moira River to Highway No. 62 and from Highway No. 62 through the agricultural lands to the east side of Sidney Street. The watercourse has been analyzed to determine the capacity for conveyance of the pre and post-development 100 year peak flow rate. The resultant floodlines have been identified on the Flood Plain Mapping drawings provided with this report.

The floodline, or water surface elevation for the 100 year return frequency event, is a function of the design flow, the ability of the channel, flood plain and bridge crossings to convey the flows. In order to determine the water surface elevations, a detailed hydraulic analysis must be carried out.

The Hec-2 computer program (Hydrologic Engineering Center 1991) was utilized to determine the hydraulic capacity of the Nor-Belle watercourse and associated structures. The program requires the development of a hydraulic model of the study reach. The model requires the input of geometric cross sections which represent the watercourse, floodway, culvert parameters and peak flow rates at specific locations.

A detailed field survey was conducted to obtain representative channel cross sections and to ascertain information required to analyze the performance characteristics of the hydraulic structures.

All structures from the Moira River to Sidney Street were located with elevations based on geodetic benchmarks.

The special culvert and special bridge methods of the Hec-2 program were utilized to determine the hydraulic characteristics of the various water crossings. The assumption of subcritical flow was made to determine the flow characteristics of the main channel and floodplain. Critical depth was assumed at section one and was used as the starting water surface elevation.

The model input and output files have been provided in a separate appendix for review.

CROSS SECTION #	DESCRIPTION	100 YEAR WSEL (m)
5	0+125 upstream of Parks Drive	100.55
6	0+188 upstream of Parks Drive	101.19
7	0+238 upstream of Parks Drive	103.55
8	0+277 upstream of Parks Drive	103.95
9	0+290 downstream face 2660mm x 1660mm	104.04
11	0+314 upstream face 2660mm x 1660mm	105.16
12	0+364 upstream of Maitland Drive	105.12
13	0+376 downstream of 1800mm pipe	105.31
14	0+443 upstream face 1800mm pipe	105.90
15	0+493 upstream of 1800mm pipe	105.94
16	0+559 upstream of 1800m pipe	105.99
17	0+605 downstream of 1450mm x 1140mm	106.02
18	0+634 downstream face 1450mm x 1140mm	106.24
19	0+639 upstream face 1450mm x 1140mm	106.91
20	0+674 upstream of 1450mm x 1140mm	106.97
21	0+755 downstream of Highway No. 62	107.27
22	0+819 downstream face Highway No. 62	107.46
23	0+843 upstream face Highway No. 62	* 108.0
24	1+015 upstream of Highway No. 62	* 108.0
25	1+167 upstream of Highway No. 62	* 108.0
26	1+314 upstream of Nor-belle holdings	108.23
27	1+469 agricultural lands	108.35
28	1+612 agricultural lands	109.07
29	1+848 agricultural lands	109.07

* water surface elevation controlled by reservoir routing

C.2 Analysis of Culvert Capacities

There are five structures which cross the Nor-Belle watercourse from its outlet at the Moira River to Highway 62. The structures will be discussed as they proceed upstream from the Moira River.

The first structures encountered are twin corrugated steel pipe arches located at Parks Drive. The twin culverts, 1830mm x 1220mm in size, have a capacity of 9.0 cms.

The next structure upstream at Maitland Drive, is a single 2660mm x 1660mm concrete box culvert with a capacity of 9.0 cms

Located behind Dougs Heating, under the gravel parking lot, there is approximately 60 metres of 1800mm diameter steel pipe which appears to be constructed from steel cylinders with the tops and bottoms cut off and laid end to end.

The fourth structure appears to be a home made formed and poured concrete bridge with an open gravel bottom. The bridge is 1450mm wide by 1140mm high and provides access to the barn on the north side of the watercourse.

The culvert at Highway No 62 is a 1520mm x 1200mm concrete box culvert with an open bottom. However, the culvert is inundated with silt such that there is only an effective flow depth of 930mm.

The structure performance data is provided in the following table.

TABLE C-2
STRUCTURE PERFORMANCE DATA

LOCATION HEC-2 SEC. NO.	DESCRIPTION	PEAK FLOW	CAPACITY (M^3S)
PARKS DRIVE SECT. NO. 4	TWIN 1.83m x 1.22m CSPA	PRE 7.83 POST 7.45	9.0
MAITLAND DRIVE SECT. NO. 11	2.66m x 1.66m CONCRETE BOX	PRE 7.13 POST 6.53	9.0
GRAVEL PARKING LOT SECT. NO. 14	1.82m dia STEEL PIPE	PRE 6.46 POST 5.78	5.0
FARM CROSSING SECT. NO. 19	1.45m x 1.14m CONCRETE BRIDGE	PRE 3.13 POST 3.86	3.2
HIGHWAY NO. 62 SECT. NO. 23	1.52m x 0.93m CONCRETE BOX	PRE 2.89 POST 3.30	3.0

Hydraulic analysis has been conducted to determine the capacity of the culverts under the 100 year peak flow for existing and proposed future development conditions.

The above table indicates that both Parks Drive and Maitland Drive culverts have sufficient capacity to convey both the existing and proposed 100 year peak flow rates. The 1800mm diameter steel pipe under the gravel parking lot lacks sufficient capacity to convey either the existing or the proposed future 100 year peak flow rates and overtopping of the parking lot will occur.

The farm crossing is overtopped during post development conditions. However due to the low level of service provided by the crossing and given the low risk to life or property this crossing is satisfactory at this time.

The concrete box culvert at Highway No. 62 lacks sufficient capacity to convey the existing or proposed 100 year peak flow rates. The existing peak flow rate to the culvert has been calculated to be 5.21 m^3/s. Utilizing the stage discharge curve identified in table B-4 and the Otthymo computer model it was determined that 1.3 hectare metres of storage was created upstream of the culvert. Given the depth of ponding, the release rate from

the culvert under existing conditions was determined to be 2.89 m^3/s. Under proposed post development conditions, with pond-1 controlling the release rate to the Highway No. 62 culvert, the culvert will require a concrete headwall to increase the capacity to the proposed release rate of 3.3 m^3/s.

The following table identifies the post development flood elevations.

TABLE C-3		
CROSS	DESCRIPTION	100 YEAR
5	0+125 upstream of Parks Drive	100.55
6	0+188 upstream of Parks Drive	101.17
7	0+238 upstream of Parks Drive	103.53
8	0+277 upstream of Parks Drive	103.94
9	0+290 downstream face 2660mm x 1660mm	104.01
11	0+314 upstream face 2660mm x 1660mm	105.04
12	0+364 upstream of Maitland Drive	105.01
13	0+376 downstream of 1800mm pipe	105.27
14	0+443 upstream face 1800mm pipe	105.88
15	0+493 upstream of 1800mm pipe	105.92
16	0+559 upstream of 1800m pipe	105.97
17	0+605 downstream of 1450mm x 1140mm	106.01
18	0+634 downstream face 1450mm x 1140mm	106.32
19	0+639 upstream face 1450mm x 1140mm	106.92
20	0+674 upstream of 1450mm x 1140mm	107.01
21	0+755 downstream of Highway No. 62	107.36
22	0+819 downstream face Highway No. 62	107.38
23	0+843 upstream face Highway No. 62	107.70
24	0+849 downstream face 1880mm x 1260mm	107.65
25	0+872 upstream face 1880mm x 1260mm	107.83
26	0+953 proposed drainage easement	108.05

27	1+041 downstream face 1880mm x 1260mm	108.05
28	1+063 upstream face 1880mm x 1260mm	108.09
29	1+667 proposed drainage easement	108.00
30	1+314 proposed Pond-1	*108.50
31	1+469 proposed Pond-1	*108.50
32	1+612 agricultural lands	109.08
33	1+848 agricultural lands	109.08

* water surface elevation controlled by Pond-1

The hydraulic analysis, supported by field inspection, revealed a split flow. Stormwater from the Nor-Belle Subwatershed spills south into the No-Name Creek Subwatershed. The split flow occurs along the fence row at the Gas Easement, approximately 1.2 m^3/s and 0.70 m^3/s flow into the No-Name Creek and Nor-Belle drainage courses respectively.

Phase 1 development of the Nor-Belle Development highway commercial holdings with control provided by an 1800mm x 1260mm cspa at the westerly service road, creates a temporary ponding largely contained within the Nor-Belle Developmepments holdings to an elevation of 108.30. The backwater effects of the proposed temporary ponding are dissipated within the subsequent upstream section, (pre-development section number 27) with an increase in water surface elevation from 108.35 to 108.36.

The backwater effects of proposed Pond1 are minimal with an increase in water surface elevation from 109.07 to 109.08 as identified in Tables C-1 and C-3.