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TOWNSHIP OF THURLOW STORMWATER MANAGEMENT STUDY FOR NOR-BELLE DEVELOPMENTS INC.

May 1996

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Engineers and Planners

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1.0 INTRODUCTION

1.1 BACKGROUND

The Township of Thurlow (Township) recognizes development can impact negatively on the natural environment. Assessing potential impacts and implementing best management practices is of interest to the Township, who supports the efforts of the Ministries of Natural Resources (MNR), Environment & Energy (MOEE), and Municipal Affairs (MMA), and the Quinte Conservation Services Alliance (QCSA) in incorporating stormwater management into all development plans. In the past decade the public and governments have become aware of the benefits of sound ecological and natural resource management, particularly in urban areas or areas undergoing intensive development.

The Township completed the *Cannifton Secondary Plan* (the *Plan*) in February, 1991 to address the land-use and development issues in the Cannifton area. One objective of the Secondary Plan was to apply the principles of ecosystems planning whilst implementing the recommendations of the *Bay of Quinte Remedial Action Plan* (QRAP). This calls for the integration of stormwater management into sustainable urban development, by using natural drainage features, where possible. Part 4, Section 3.2.1 of the Secondary Plan, requires that lands, within the drainage basins identified on Schedule 4 - Stormwater Drainage Plan, must have a Master Drainage Plan prepared by the developer on behalf of the Municipality prior to development.

In January, 1996 Nor-Belle Developments Inc. retained The Greer Galloway Group Inc. to finalize a comprehensive stormwater management Plan for a 550 hectare subwatershed north of Maitland Drive, and satisfy any concerns voiced by the review agencies. This subwatershed, a portion of which is in Stage 2 of the Secondary Plan area, is part of the Moira River and Bay of Quinte watershed.

No earlier studies examined stormwater management for developments in this subwatershed. This study uses existing information and data from studies carried out in the adjacent Upper No Name Creek subwatershed. This study considers updated topographic and land use information, and recommends a stormwater management plan incorporating potential development (the ultimate built-out condition) meeting all relevant water management objectives. The Recommended Plan includes plan drawings of the conceptual arrangement and land requirements and an implementation strategy with phasing, cost-sharing, and monitoring details.

This report is organized into a main body and technical appendices. **All figures are presented in Appendix A**, and technical details in the appendices are summarized in the main report. Chapter 2 is a description of the study area characteristics. Chapter 3 provides information on water management objectives used to develop a stormwater management strategy. The fourth chapter discusses the floodline analysis performed for this study. The fifth, and final, chapter outlines the preferred stormwater management Plan with an implementation strategy.

1.2 STUDY OBJECTIVES

The general objectives of studying stormwater management in a subwatershed are to:

1. Analyze the hydrologic response of the drainage area to determine major drainage system requirements and the measures required to reduce risk of flood damages.

2. Identify measures to achieve the water quality standards of the "Bay of Quinte Stormwater Implementation Strategy" under ultimate development conditions.

3. Undertake environmental and engineering analyses to determine the optimum combination of stormwater management facilities, best management practices and natural preservation to achieve objectives of 1. and 2.

4. Provide preliminary engineering for the proposed works of 3. including; cost estimates, flow targets, land requirements, grading requirements and structural works, to allow the document to be used as a guideline for final design.

5. Recommend an implementation strategy including; phasing, cost-sharing, if applicable, and explicit responsibilities of Nor-Belle Developments Inc., The Township of Thurlow, and other affected land owners.

1.3 APPROACH

Greer Galloway approached the study in five tasks:

Task 1 - Review the stormwater management Study Draft Report prepared by Van MEER Ltd., January 1995.

Task 2 - Review Hydraulic Modelling for the Post-Development Scenario.

Task 3 - Revise the stormwater management Strategy.

Task 4 - Reporting and Study Conclusion.

Task 5 - Liaise with Review Agencies.

2.0 SITE CHARACTERISTICS

2.1 LOCATION

The study area, illustrated in Figure 1, lies within a larger 'subwatershed' encompassing approximately 550 hectares of land in both Thurlow (54%) and Sidney Townships (46%). This area is bounded to the north by Vermilyea Road, Upper No Name Creek Subwatershed to the south, Sidney Street to the west, and Farnham Road and the Moira River to the east. The subwatershed is located north of the City of Belleville, in the southwestern region of the Township.

2.2 EXISTING AND FUTURE LAND USE

The subwatershed (Figure 1) consists primarily of agricultural lands (80%) with pockets of single family residential development throughout, and commercial/light industrial development in the lower reaches (Highway 62 corridor to the outlet).

2.2.1 Sidney Township Official Plan

Schedule 'A' (Land Use Plan) designates the lands within the subwatershed for predominantly Agricultural uses with small pockets of Rural land situated to the west of Huntingwood Drive. Under the policies for these zones, Sections 3.6 and 3.7 respectively, development shall be limited to individual lot creation via Consent, or agricultural purposes.

2.2.2 Thurlow Township Official Plan

This subwatershed is divided between areas designated as serviced and non-serviced.

Non-service areas, in the upper catchment area, are designated in Schedule 'A1' as Agricultural with pockets of Rural Residential. These lands are limited to agricultural activities and residential lot creation, in keeping with the Ontario Food Land Guidelines and Agricultural Code of Practice.

The lower catchment area is within the Cannifton Secondary Plan area (serviced). The Secondary Plan allows for a mix of residential, industrial, commercial and open space uses.

Other policies of interest to this study include:

- → All development within the Secondary Plan area must take place on full municipal services.
- → A thirty metre Environmental Protection strip, prohibiting development or the

storage of goods, exists along the banks of the Moira River.

2.2.3 Future Use

Little change is expected in the upper catchment area which is zoned for agricultural use. In the future, development within the Cannifton Secondary Plan area is the most likely to take place. Development will include both low and medium density residential, light industrial, and general and highway commercial uses.

2.3 Existing Studies/Plans

stormwater management for the study area is controlled through the *Plan* and QRAP. No previous studies or plans have addressed the need for stormwater management within the this subwatershed. A summary of relevant guidelines, policies, and documents is presented in Appendix B.

2.4 Geology and Soils

This subwatershed is situated within the Napanee Plain physiographic region of Ontario. The region is characterized by flat to gently undulating limestone with limited overburden due to historic glacial activity in the area (Chapman and Putman, 1984).

The overburden material, or soils, is predominated by the Solmesville soil series of the Perth Family. These soils are described in "Drainage Guide for Ontario", Ontario Ministry of Agriculture and Food, 1986.

→ *Hydrologic soil group 'C',*

→ *Drainage design code 'S2Ib5'*

S — *In general, surface water gley soils are those profiles that present drainage problems related to excess water. These soils have a distinct horizon of low permeability (ie. rock) within one metre of the soil surface.*

S2 — *Overall medium texture and well structured. Soil becomes more compact with depth. Free water saturation at depths less than one metre on parent material.*

I — *Imperfectly drained - The soil moisture in excess of field capacity remains in the subsurface horizons for moderately long periods during the year.*

b	*Undulating to inclined, midslope, complex dissected landform.*
5	*Very gentle slopes, 2-5%. Soil classification slope class 3 - moderately severe limitations that restrict the range of crops or require special conservation practices or both.*

2.5 Topography

The general slope of the land is from northwest to southeast with a gradient of approximately 0.2%. The obvert of the channel closely follows the gently sloping land through the upper part of the subwatershed, but becomes incised in the limestone through its lower reaches. At its discharge point, the drain drops in a natural chute to the Moira River (also incised at this location).

2.6 Drainage/Receiving Waters

The lands at the head of the subwatershed are located in both Townships, as illustrated in Figure 2. This upper portion of the subwatershed drains via natural contours and a grassed swale, to the west and south, to culverts (four 760mm and one 600mm CSP) crossing under Sidney Street. Immediately up gradient of these culverts is an area that ponds during significant precipitation events and tends to remain saturated throughout the year. Storage-discharge curves for the five existing culverts are shown in Figure 3.

Down gradient of Sidney Street, an improved swale and dug ditch (approximately 3 metres wide and 0.4 metre deep), following the natural grade (0.2%), conveys water between Sidney Street and Highway 62. Due to the flat topography in this portion of the subwatershed, the swale overtops and spills an estimated 1.2 m^3/s into the Upper No Name Creek Subwatershed (see Figure 1).

Flow is obstructed/controlled by a poorly installed culvert under Highway 62. The obvert of this 1520 mm X 1200 mm concrete box culvert is too low, and has allowed sediment to accumulate to a depth of 270 mm. This reduction in size does not allow flow from major events to pass through unhindered, thus creating some ponding upstream of Highway 62 (see Figure 1).

Downstream of Highway 62 the low flow watercourse is confined to a series of improved or lined channels and culverts to its discharge point at the Moira River (see Figure 3).

No planned or engineered drainage system exists within this subwatershed, other than drains protecting the road subgrade. All flows are conveyed overland to the main watercourse, and subsequently to the Moira River.

The drain through the subwatershed is intermittent in nature - flow being driven by spring freshet or rain events, with little or no baseflow during the mid to late summer.

The receiving waters for this subwatershed is the Moira River. This river is controlled through a series of flow control weirs and ice booms operated by the Moira Region Conservation Authority. The nearest of these weirs is approximately 500 metres upstream of the confluence of the drain and the Moira.

The Moira River, in turn, discharges to the Bay of Quinte at the City of Belleville waterfront. Due to past development, agricultural, and resource extraction practices, the Bay is classified as an area of concern within the Great Lakes Basin and has had a remedial action plan prepared. The QRAP is summarized in Appendix B.

2.7 GROUNDWATER/SURFACE WATER USES

Groundwater is used as a potable water supply throughout the subwatershed with individual wells supplying each property. Existing pressures on drinking water quality include extraction, private septic system effluent attenuation, and agricultural practices. As there are no classified wetlands or Areas of Natural and Scientific Interest in the subwatershed, it can be surmised that no groundwater recharge zones for the deep potable aquifers are within this subwatershed.

Surface water flows in the drain are 'flashy' in nature, only reacting to runoff events. For this reason, the drain is not considered a reliable water supply. The Moira River may be used by riparian landowners as a source of irrigation water for landscaping and gardens, but this is unconfirmed.

2.8 SITE CONSTRAINTS

Physical constraints in the subwatershed include flat topography, existing culverts, and channelized sections of the drain through the lower reaches. Further constraints relate to zoning, visibility of commercial establishments, Township standards, and property ownership.

3.0 FORMULATION OF ALTERNATIVE APPROACHES

Alternative stormwater management approaches for the subwatershed have been formulated by applying the methods described in Appendices C and D, and by considering the following:

1. Location opportunities and space availability along the existing drainage ditches for construction of stormwater ponds.

2. The proposed land use in the development areas and the opportunities for rooftop and/or parking-lot storage for on-site flow attenuation.

A description of recognized stormwater management controls is presented in Appendix D.

3.1 Facility Location Opportunities and Constraints

A number of opportunities exist in the subwatershed for siting stormwater management pond(s) or wetland facilities. Constraints on siting of facilities relate primarily to the expected layout of the drainage system, topography, property ownership, perceived development opportunities, and existing land use plans. These are accounted for in defining opportunities. The following points should be noted:

1. Centralized stormwater management facilities should be located within the areas indicated in Schedule 4 of the *Plan*.

2. Most of the western part of the subwatershed is agricultural, including some lands suitable for a stormwater management facility.

3. Existing commercial and light industrial lands will not be required to implement on-site stormwater management controls. Voluntary control may be solicited.

4. The culvert under Highway 62 is the prime flow constraint for the upper catchment area.

5. The lower part of the catchment does not require flow control due to the proximity of the subwatershed to the Bay of Quinte.

3.2 METHOD OF PRELIMINARY SIZING OF SYSTEM COMPONENTS

Details of the hydrologic, hydraulic analyses, and pond sizing are in Appendix E.

The hydrologic analyses provide preliminary estimates of the size of the primary stormwater management, detention/retention facilities (i.e. ponds or wetlands).

1. Estimation of Active Storage Requirements

As described in Appendix E, the OTTHYMO model was used to determine the active storage requirements (ie. "detention:" volumes) needed at facility locations to control downstream peak flows to target levels presented earlier.

A. Meteorologic Analysis

Analysis of data was originally performed by Van MEER Limited, and is presented in Appendix D. Further analysis was beyond the scope of this revision.

B. Pre-Development Parameters

Analysis of the existing, pre-development conditions for the study area were originally performed by Van MEER Limited; further analysis was beyond the scope of this revision.

C. Post-Development Parameters

Hydrologic analyses, presented in Appendix D, were originally prepared by Van MEER Limited using OTTHYMO-89. Staff of the QCSA have indicated that the results of this modelling were representative of future development conditions.

2. Estimation of Treatment Level Requirements

At the stormwater management facilities, treatment will primarily be by the hydraulic residence time resulting from a permanent pool volume held within the facility. Preliminary size of these pool volumes (*ie.* retention volumes) have been based on the recent publication "Stormwater Management Practices Planning and Design Manual" (MOEE, 1994). These guidelines allow estimation of the permanent pool volume required per hectare of service area, to achieve any one of four levels of treatment (as indicated by solids removal). Preliminary pool size has been based on the most stringent level (Level I) intended to achieve average annual solids removal of 80%.

3. Design Concept for Ditches

The recommended concept is for the ditches to be designed using a 'natural channel design' method. This will help to minimize net impacts on the local environment and provide potential for local enhancement of aquatic or riparian habitats which are highly disturbed. The bed of the low-flow channel could be lined with cobbles and stones to minimize erosion potential while improving physical diversity and aquatic habitat potential. The channel banks and side slopes can be stabilized with plantings including grasses, sedges, shrubs, and aquatic species. To enable use of the channel floodway as parkland, some areas of turf grass could be incorporated within the landscape plan.

Erosion protection and channel stability must be addressed in the subsequent design of the ditches. Along the reach from Highway 62 to the Moira River existing topography may require sections where average channel slopes are likely to exceed 1% (depending on final alignment selected). This situation has the potential to cause flow velocities capable of causing local erosion problems unless erosion protection measures are in place. Velocity control measures (*ie.* energy gradient control) could be used to assist with erosive power control. Within the context of a natural form of channel design this could possibly take the form of pool-riffle sequences along the ditch to help reduce flow velocities, dissipate flow energy and provide increased aquatic habitat potential.

3.3 Basis For Stormwater Management Approach

The methods used to carry out preliminary size estimates of the three stormwater management facility alternatives are outlined below. An integral part of each alternative is the inclusion of on-site controls for all future commercial and industrial development.

On-site are recommended for two reasons:

1. They have become standard practice in the design of buildings and landscaping for commercial and industrial properties.
2. Without these controls, the required storage facilities will be significantly larger, requiring more land and higher construction costs.

Supporting discussion is presented in Appendix E.

The plan consists of single, centralized stormwater management facilities, with source flow controls included in proposed commercial/industrial development areas. There are few opportunities for locating stormwater management facilities, therefore only one alternative has been developed for consideration.

Mechanical treatment has not been included here. This form of water quality treatment is recognized as being very effective (Gore & Storrie, 1994), however, the initial capital cost, and ongoing operation and maintenance costs are unacceptable to the Township. Any opportunity to provide passive treatment was considered acceptable.

3.4 Evaluation of Control Strategies

Lot level controls are most practical in commercial/industrial zones where rooftop storage and parking lot ponding will likely provide adequate detention to control flows to pre development levels. Past experience and stormwater management research suggest that water quality treatment will also be required for effluent originating from paved areas.

In residential areas, lot level controls rely on ponding and/or infiltration for managing stormwater. Ponding in swales or yards, in residential areas, has proven to be unpopular with homeowners and is difficult to protect from future landscaping. In the case of this subwatershed, the fine textured soils and thin overburden preclude the use of infiltration techniques.

Flow through the main drain of this subwatershed is currently controlled by several road crossings and culverts. As noted above, the soils are not amenable to the use of infiltration techniques, therefore conveyance controls will have little beneficial effect for quantity control. Water quality may be maintained by promoting vegetation in the drain and floodplain.

End-of-pipe controls tend to be the last resort for stormwater management planners, and also the most popular. These facilities allow a municipality to concentrate their resources and efforts on one, or more, specific locations rather than having to police and maintain systems/facilities crossing many properties.

This centralized-type of facility allows for quantity and quality control to take place in one site. They can be readily designed and constructed to provide adequate storage for large events, and can also be configured to provide water quality polishing for the 'first flush' or lesser events. Quantity control is normally provided through ponding, while quality treatment can be performed 'naturally' or mechanically.

Natural water quality polishing involves the use of existing wet areas and floodplains or constructed wetlands. Extended contact with vegetation enhances nutrient removal, while extended flow time allows for increased bacteria die-off.

The last, last resort of stormwater management planners is to recommend mechanical treatment at the outlet of a pond. Sediment removal is required to treat nutrient contamination and irradiation (ultra violet) or chemical treatment is used for bacteria control. The initial capital cost for each of these processes is considerable, and operation and maintenance can be difficult, specialized, and costly.

4.0 FLOODLINE ANALYSIS

Staff from the Moira Region Conservation Authority have advised that the modelling originally performed by Van MEER Limited, although not rigorous, adequately depicts the existing flood regime.

Post development hydraulic analysis, for the 100-year event, was revised for the study area upstream of Highway 62 through the use of the United States Army Corps of Engineers', Hydrologic Engineering Centre, computer model 'HEC-2 Water Surface Profiles, September 1990'. There are no records of recent major flooding, other than anecdotal for the study area. The 100-year water surface elevations computed by HEC-2 were used in combination with available topographic mapping to estimate the floodlines. These are illustrated on the accompanying floodplain maps.

A summary of the results from this modelling are presented in Appendix E.

5.0 IMPLEMENTATION STRATEGY

5.1 Stormwater Management Plan

The stormwater management approach closely follows that proposed by Van MEER Limited, but includes lot level (on-site) and conveyance system controls. for water quality

5.1.1 Review of Van MEER Limited Draft Report

The draft report proposed the implementation of two, possibly three ponds within this subwatershed. The first two ponds are expected to be located in the areas designated on Schedule 4 of the *Plan* as possible stormwater retention/detention facilities. The third pond would be located between Parks and Maitland Drives in the Cannifton Industrial Park.

The first pond (Pond 1) requires an active storage volume of 14,000 m^3 with an outlet controlled to pre-development peak flow for the inlet of the Highway 62 culvert. This pond has been the prime subject of this review and will be described in more detail later in this report.

The second pond (Pond 2), will be located in an existing, naturally wet area between Farnham Road and Highway 62, and will provide both water quantity control and quality treatment. The m³. The contributing area includes 15 hectares of highway commercial and 66 hectares of residentially zoned lands. Permanent storage was estimated from the MOEE guidelines (MOEE, 1994). The 1.6 hectare area shown on Schedule 4 of the *Plan* will require minor berming and control structures to provide adequate storage.

The final pond (Pond 3), is proposed as a 5,500 m³ water quality treatment facility which would treat effluent from subcatchments 104 and 105 (22 ha of highway commercial, service and restricted industrial). Its location, between Parks and Maitland Drives, utilizes an existing wet area within the 100 year floodplain. Through channel and pond inlet design, flows greater than those from the water quality design storm will be routed past the pond, directly to the Moira River.

As an alternative to the third pond, an ultra violet treatment facility, located at the Moira River, was proposed. This facility would be sized to accommodate a flow of 770 ℓ/s.

5.1.2 Revised Pond 1

QCSA concerns about creating an impoundment up gradient from the Nor-Belle Development Inc. lands prompted this revision of the Draft Report. The Draft Report indicated that a 1.4 hectare impoundment would be created immediately west of Lot 3, Concession 3. This location would require that lands not already within the floodplain be included in the ponded area. QSCA staff were concerned about the legal issue of ponding water outside of the floodplain, and requested that an alternative be investigated.

Further hydraulic analysis (HEC-2) was performed to determine if the pond could be accommodated within the existing 100 year floodplain, without the loss of highway commercial property. The results of this analysis are included in Appendix E, with the conclusion that, yes, the pond could be accommodated in the west ½ of Lot 3, Concession 3. The installation of 1880 mm X 1260 mm corrugated steel pipe arches under the new roads for the commercial development would control post-development flows to existing conditions for the box culvert under Highway 62. The impoundment created behind the westernmost culvert would include approximately half of the developable lands (currently within the 100 year floodplain). There may be a future opportunity to deepen this pond, through berming and excavation, to allow development of some of the residential lands in west ½ Lot 3, Concession 3.

5.2 Regulatory Approvals

It is a recommendation of this report that the most effective way to implement this plan is to proceed with the project as a municipal drain, following the requirements of the *Drainage Act*. Any projects proceeding in this way are exempt from the requirements of the *Environmental*

Assessment Act, R.S.O. 1990, c. E.18 as amended, the *Environmental Protection Act, R.S.O. 1990, c E.19 as amended* (PART VIII, s 74(h)), and the *Ontario Water Resources Act, R.S.O. 1990, c. O.40 as amended* (s 53(6)(e)).

Should the project be undertaken through an alternate process, regulatory approvals will be needed for the implementation of the stormwater management strategy including:

1. *Ontario Water Resources Act* approval will be required for the stormwater management ponds and Certificates of Approval will be issued by the Ontario Ministry of Environment & Energy based on approval of the final facility designs. The Certificates will specify stormwwater quality compliance requirement such as specific targets for bacteria and suspended solids concentration in facility effluent and will likely also specify monitoring required to demonstrate compliance.

2. Alteration to Waterway and Fill and Construction Regulations (*Conservation Authorities Act*) approval will be required for the stormwater ponds. These approvals are administered by the Quinte Conservation Services Alliance.

3. *Lakes and Rivers Improvement Act* approval of impoundment and outlet control works associated with stormwater ponds. These approvals are administered by the Ministry of Natural Resources. Approval applications require detailed design information.

4. Encroachment Permits from the Ministry of Transportation, since the works are nearby, two major highways, and may impact upon Provincially owned lands.

5. Transport Canada permits for the establishment of ponds within the CFB Trenton flight control zone.

5.3 Final Design and Environmental Assessment Requirements

This study has provided planning-level estimates of the stormwater storage volumes required at both facilities to ensure adequate stormwater treatment, to meet QRAP guidelines, and control of peak flows up to the 100-year return period. The estimated pond volumes are based on fully developed residential and industrial/commercial lands.

Implementation of the stormwater strategy requires final design analysis and detailed design of the recommended stormwater ponds, ditches and culvert improvements, and final determination of phasing requirements and cost apportionment, consistent with *Drainage Act* requirements.

Detailed design of the various components of the stormwater strategy will be needed to apportion costs, proceed to construction, obtain agency comments, and to allow proposed land developments to proceed.

5.3.1 Stormwater Treatment Facilities

The design process for the ponds should follow the framework of a Schedule B Class Environmental Assessment for Municipal Water and Wastewater Project (June 1993), even though implementation will be through the *Drainage Act*. This report will serve as a support document fulfilling Phase I (Problem/Need Identification) and most of Phase II (Selection of Preferred Alternative) of the process. By following this process, the Township would assure public participation and a greater level of acceptance.

Design of the stormwater ponds will include:

1. Detailed site layout and grading plans provide storage volumes.

2. Detailed design of inlet and outlet control structures to regulate storage levels and peak water levels.

3. Preparation of landscaping plans, and detailing of other design features such as access roads and fencing.

It is emphasized that further hydrologic and hydraulic analyses will likely be required, at the final design stage, to optimize the size and operation of the facilities.

5.2.2 Channels/Ditches

The existing floodway and channels directing flow to the Moira River should not be changed or 'improved' other than to reduce bank erosion. Ditches within development areas should be designed to detain low flow thus reducing erosion and increasing vegetation contact time.

It is recommended that the design of any channels utilize a 'natural' approach such as placement of root wads and establishment of dense vegetation to maintain channel stability, as opposed sole reliance on more traditional techniques such as gabions and imported rip-rap stone. Where velocity and erosion control is a concern, the natural design approach could include the creation of pool-riffle sequences to help control velocities and create local aquatic habitat.

As an example, the channel beds could be lined with cobbles and stones to minimize erosion potential and improved physical diversity and habitat potential. The banks and side slopes can be stabilized with plantings including grasses, sedges, shrubs, and aquatic species. To allow use of the channel floodways as parkland, some areas of turf grass could be incorporated within the overall landscape plan.

5.2.2.1 Estimation of Land Area Requirements

The surface area of the ponds is estimated as follows:

Pond 1 - 1.40 hectares,
Pond 2 - 1.61 hectares, and
Pond 3 - 0.50 hectare.

Adequate land will be required for maintenance purposes and containment berms. Since Pond 1 and Pond 3 are located alongside roadways, access can be directly from the road, and no land allowance will be necessary. Pond 2 may, depending on future development layout, require an easement in favour of the Township for maintenance access.

The following factors must also be considered:

1. Maintenance access along some ditches may be needed for routine inspection, debris removal and repair of any erosion problems. Vehicle access should be possible along at least one side.

2. A vegetated buffer should be maintained along each side of the ditches to minimize direct pollutant washoff from adjacent development sites.

To allow conveyance channels, other than road ditches, room for adequate capacity, maintenance access, and opportunities for velocity-control and erosion-control measures, a minimum ditch corridor width of 15 metres is recommended throughout the subwatershed.

5.3 Implementing Source Controls

The recommended stormwater management strategy calls for the following on-site controls within the development areas:

1. Residential source controls to ensure that roof and foundation drainage is diverted onto grassed areas, as opposed to being drained onto paved areas or directly connected to the storm sewer.

2. Industrial and commercial on-site controls to ensure roof top storage on flat-roofed buildings, along with catch basin inlet controls in parking areas, to restrict

peak outflow rates.

3. Water quality can also be improved through the following actions:
   - → The Township adopt a 'Poop-and-scoop' By-law.
   - → Regular parking lot sweeping, not cutting grass shorter than 75 millimetres, and spill response training and materials be adopted by area industrial and commercial land users.

These must be included in new development site plans to provide the required performance for peak flow control and stormwater treatment.

5.4 PHASING

Phasing is an important aspect to implementation, since facilities must precede land development, but should be implemented only when land development will proceed. Phasing of facilities must also recognize that development within the subwatershed is likely to extend over a number of years, as individual land developers proceed.

There is no immediate need for the Township to implement this stormwater management plan. The majority of components in this plan are connected to development outside of the Cannifton Secondary Plan area.

The initial impoundment for Pond 1 will be created as an integral part of the Nor-Belle Development. Possible future changes in the configuration of this pond should take place when the residential lands are developed.

Pond 2 will be required prior to the development of the lands north of the Nor-Belle development and the Trans-Northern Pipeline (area 103).

Pond 3 would be constructed when the lands north of Maitland Drive are considered for development or redevelopment.

5.5 COST SHARING

Cost sharing for the stormwater management works is an important concern. An equitable cost-sharing arrangement for the major components is necessary. The Township is expected to own and operate the stormwater facilities; this requires an equitable method to apportion costs to all benefitting landowners.

It is recommended costs be allocated in proportion to the volume of storm-event runoff generated by the respective tributary areas and on the basis of tributary drainage area in relation to the runoff characteristics of each subcatchment.

5.6 Overall Implementation Strategy

Based on the requirements of the final design, phasing, and cost-sharing, an overall implementation strategy can be summarized as outlined in Table 5.1. This strategy fits the Schedule B Class Environmental Assessment process for Water and Wastewater projects. Throughout design and implementation, the Class Environmental Assessment process may be used as a guide. This ensures sound decision making based on all costs.

Should the Township proceed with this project as a municipal drain, the requirements of the *Drainage Act* take precedence over the requirements of the *Environmental Assessment Act*, *Environmental Protection Act*, and the *Ontario Water Resources Act*. Therefore, this document presents the stormwater management requirements of the Cannifton Secondary Plan, and the design criteria for the municipal drain.

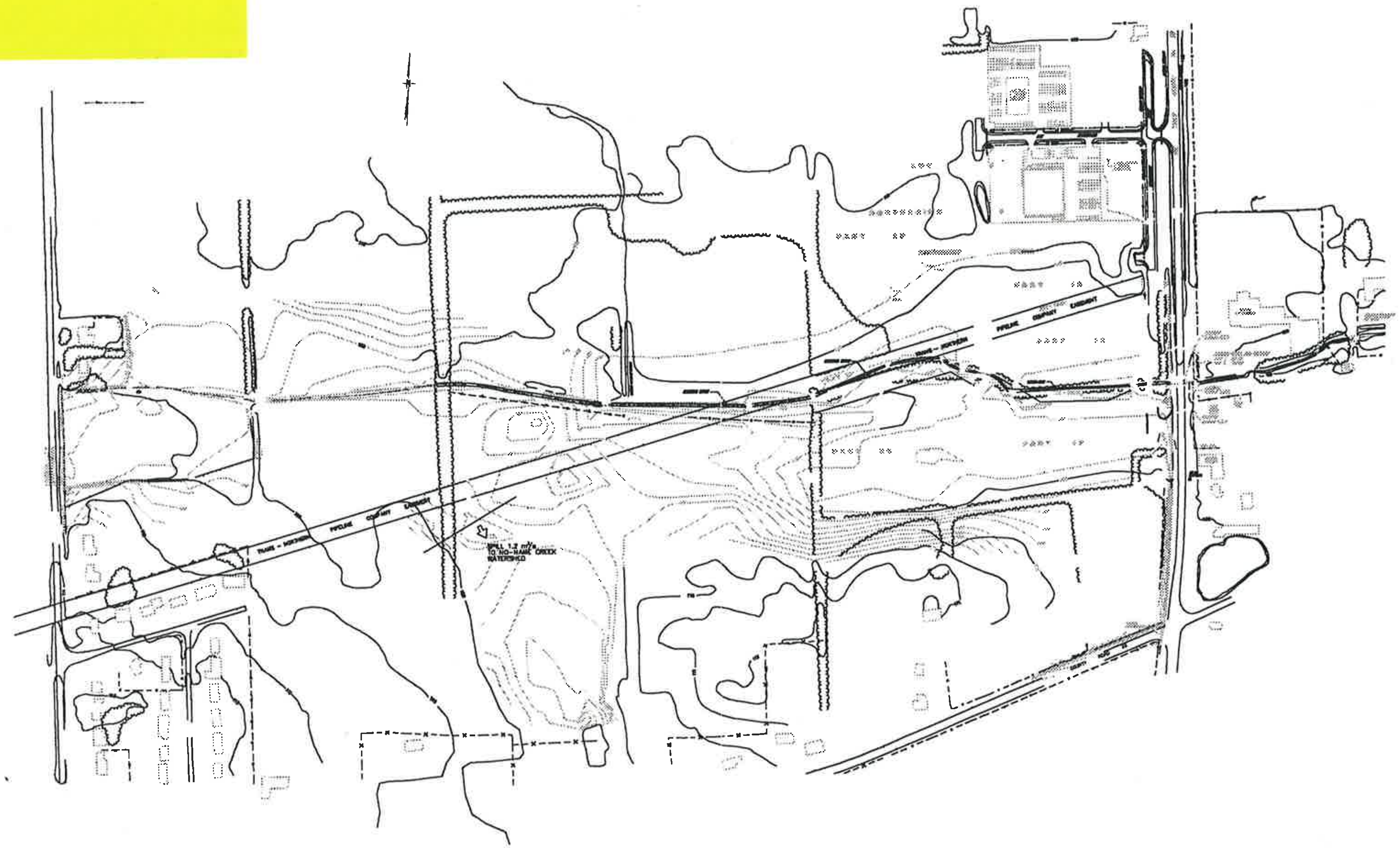
Table 5.2 Recommended Implementation Strategy

Phase	Tasks
1. Preliminary Facility Design	→ Prepare designs for two stormwater management ponds and associated conveyance works following the Schedule B Class Environmental Assessment process for Municipal Water and Wastewater Projects. → Finalize timing for construction. → Design monitoring programme.
2. Finalize Design and Acquire Agency Approvals	→ Revise designs to reflect final facility layout. → Prepare final cost estimates and cost sharing. → Acquire Approvals.
3. Construct Facilities	→ Tender project and proceed to construction.
4. Monitoring Programme	→ Implement monitoring programme to satisfy MOEE requirements, if any.
5. System Improvements (if required)	→ Assess effectiveness of stormwater management facilities and implement modifications, if required.

APPENDICES

APPENDIX A
FIGURES

Appendix A



The Greer Galloway Group Inc.
Engineers + Planners

Peterborough
Bancroft
Belleville
Courtice
Pembroke

Project Name

NOR–BELLE DEVELOPMENTS INC.

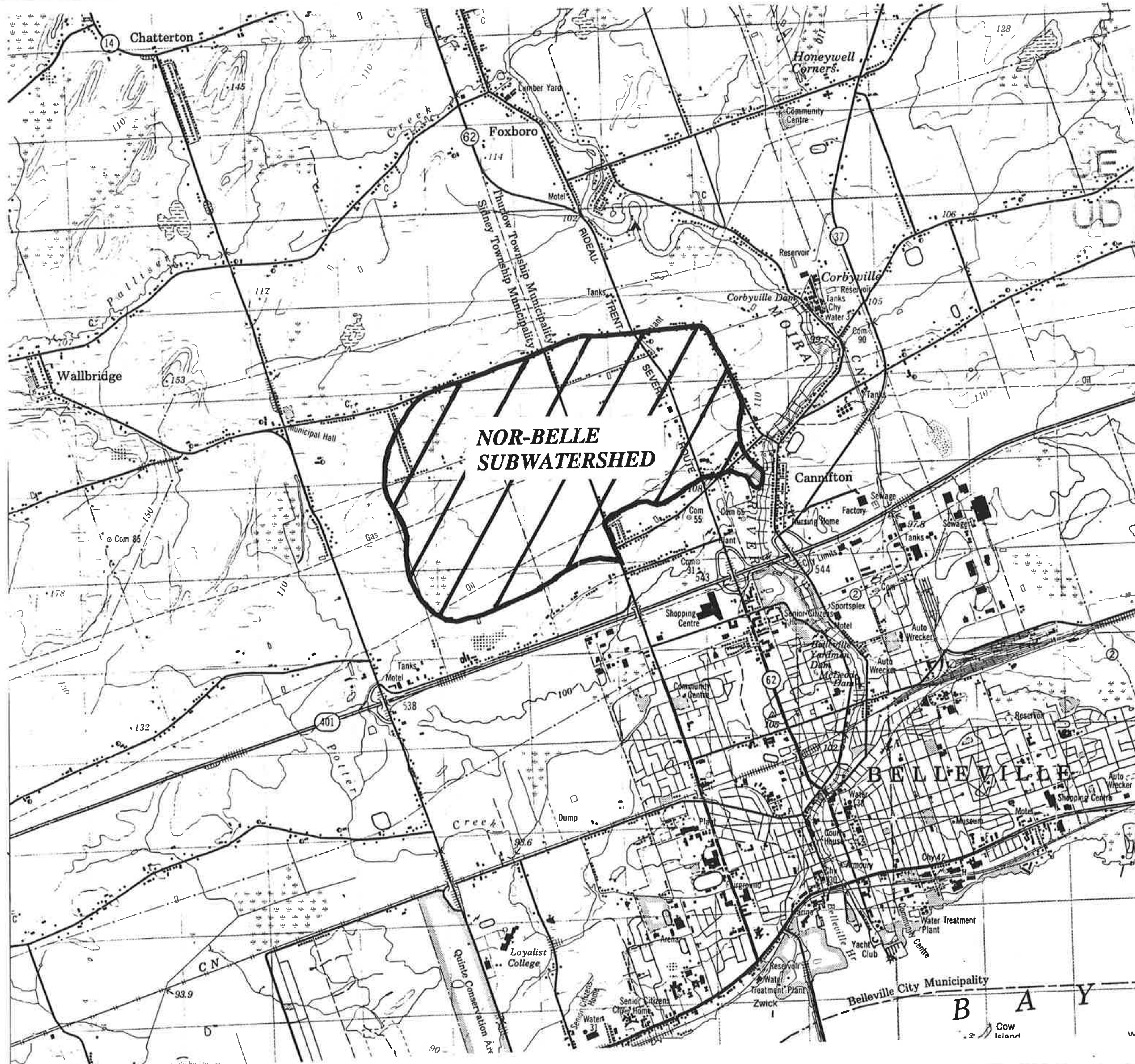
STORMWATER MANAGEMENT STUDY

Drawing Name

STUDY AREA

Scale	
NTS	
Drawn By	Date
RKT	05/96
Checked By	Date
–	–
Printed	
05/96	
Project Number	Drawing Number
95–B–5914	FIGURE 1

5914FIG1.DWG



THE GREER GALLOWAY GROUP INC.
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PETERBOROUGH
BANCROFT
BELLEVILLE
COURTICE
PEMBROKE

PROJECT NAME

NOR–BELLE DEVELOPMENTS INC.

STORMWATER MANAGEMENT STUDY

DRAWING NAME

SUBWATERSHED AREA

SCALE	
NTS	
DRAWN BY	DATE
RKT	05/96
CHECKED BY	DATE
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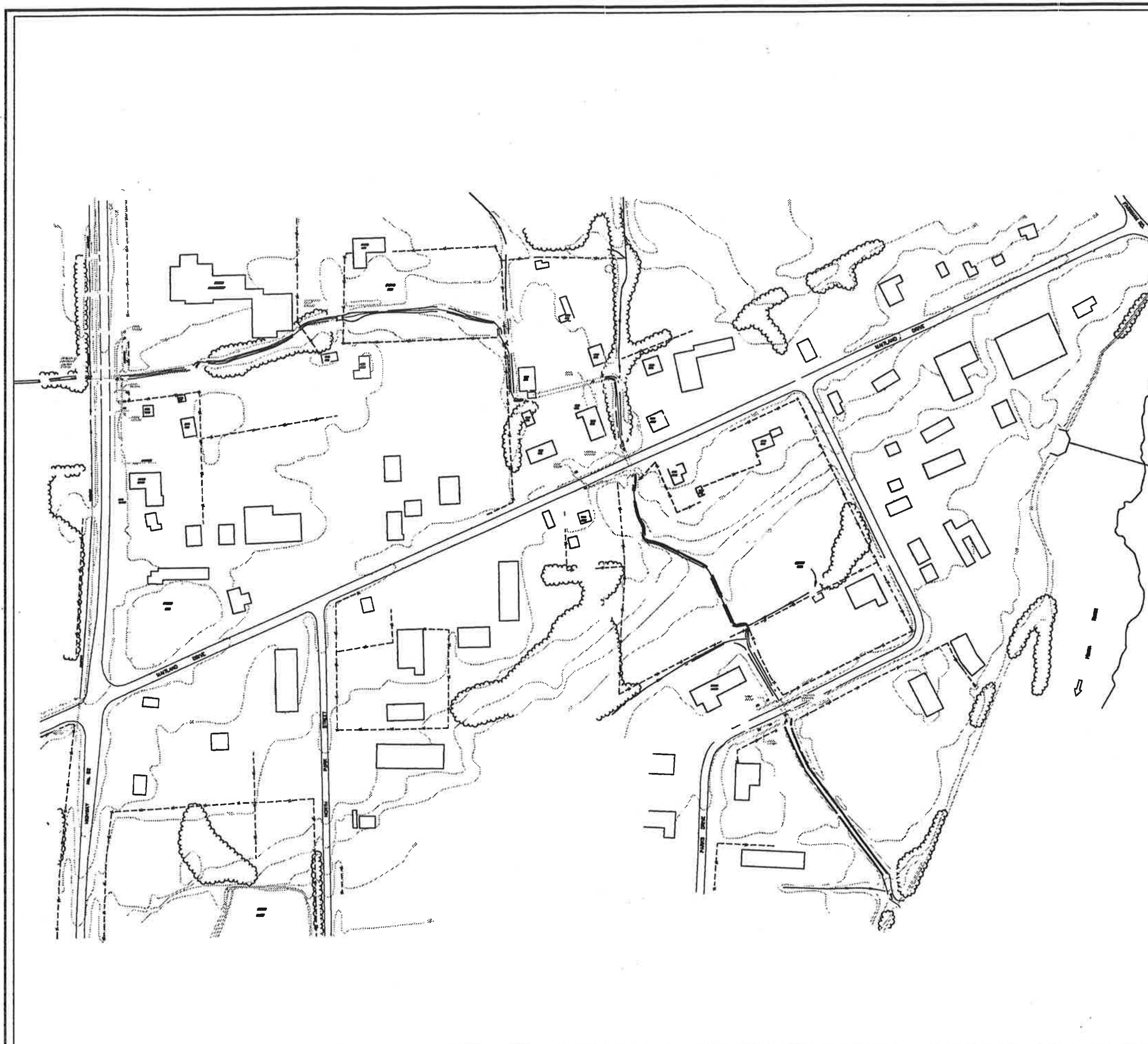
PRINTED	
05/96	
PROJECT NUMBER	DRAWING NUMBER
95–B–5914	FIGURE 2

5914FIG1.DWG



THE GREER GALLOWAY GROUP INC.
ENGINEERS + PLANNERS

PETERBOROUGH
BANCROFT
BELLEVILLE
COURTICE
PEMBROKE

PROJECT NAME

NOR-BELLE DEVELOPMENTS INC.

STORMWATER MANAGEMENT STUDY

DRAWING NAME

AREA DOWNSTREAM OF HIGHWAY 62

SCALE

NTS

DRAWN BY	DATE
RKT	05/96

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05/96

PROJECT NUMBER	DRAWING NUMBER
95-B-5914	FIGURE 3

5914FIG3.DWG

APPENDIX B
OVERVIEW OF PREVIOUS STUDIES/REPORTS

APPENDIX B
OVERVIEW OF PREVIOUS STUDIES/REPORTS

Several studies of the hydrology and hydraulics of the Upper No Name Creek watershed and the catchment area subject of this study have been completed in the last 20 years. These were summarized for the Upper No Name Creek Subwatershed Study, and those summaries are repeated here with emphasis on information relevant to this study.

B.1 EXCERPTS FROM: "Nor-Belle Subwatershed Stormwater Management Plan", Draft Report by Van MEER Limited, 1995 (unedited)

"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 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 (see Figure 5.1). Peak flow rates under existing conditions at specific locations of concern are identified in (Table 5.1).

Table 5.1 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

(Table 5.2) 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 5.3) reflects the post development peak flow rates under the proposed stormwater management plan. The tables indicate the need for stormwater management.

identify the need for stormwater management.

Table 5.4 Structure Performance Data

Location HEC-2 Sec. No.	Description	Peak Flow	Capacity (M³S)
Parks Drive Sect. No. 4	Twin 1.83m x 1.22m CSPA	Pre7.83 Post7.45	9.0
Maitland Drive Sect. No. 11	2.66m x 1.66m Concrete Box	Pre7.13 Post6.53	9.0
Gravel Parking Lot Sect. No. 14	1.82m dia Steel Pipe	Pre6.46 Post5.78	5.0
Farm Crossing Sect. No. 19	1.45m x 1.14m Concrete Bridge	Pre3.13 Post3.86	3.2
Highway No. 62 Sect. No. 23	1.52m x 0.93m Concrete Box	Pre2.89 Post3.30	3.0

The Otthymo computer model and the Ministry of 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

Table 5.2 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 5.3 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

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 in (Table 5.4). The existing culvert capacities 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 i 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 2 ... 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."

"*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 (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 and 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 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 base 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."

"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."

B.2 BELLEVILLE WATER MANAGEMENT STUDY (Crysler and Lathem, 1997)

This study identified areas prone to flooding during the 1:100 year regional storm and made recommendations to mitigate flooding. The study considered the catchment area subject of this study and the No Name Creek watershed, under the land use conditions existing at the time.

The United States Department of Agriculture, Soil Conservation Service (SCS) curve number model was used to generate peak flows, and the HEC-2 model to estimate flood prone areas. The study concluded, for the upper basin of the No Name Creek watershed (north of Tracey Street) detention basins were required to reduce regional storm flows to a level that could be accommodated in the Tracey Street storm sewer (sized for approximately the 1:5 year storm). Storage basins were recommended immediately upstream of Highway 401, and immediately downstream of Bell Boulevard on the Upper No Name Creek.

B.3 BELLEVILLE FLOODPLAIN MAPPING STUDY (Ministry of Natural Resources, 1982)

This study included HYMO and HEC-II modelling of No Name Creek to generate floodlines and to develop a plan to reduce flooding potential. Only existing land use conditions were considered.

The peak flows generated in this study were lower than the Crysler and Lathem (1977) study, which did not consider the available storage north of Highway 401. The recommended remedial work for the Upper No Name Creek basin was a variation on one of Crysler and Lathem's proposed solutions and included a detention pond upstream of Highway 401, channelization of the creek downstream of the 401 to connect with the existing channel and a swale to carry excess flow from the upper basin to Tracey Street, then into another swale to route flow back into the creek in the lower basin.

B.4 REPORT ON STORMWATER MANAGEMENT FOR THE NORTHWEST BELLEVILLE AREA (Gore & Storrie, 1986)

A stormwater management study was conducted for the City of Belleville, for the entire No Name Creek watershed. Expansion of the Quinte Mall was approved on the condition controls be enforced to control post-development peak flows to pre-development levels. This was achieved by surface detention on the parking lot and rooftop.

Required criteria to be met were flood controls for the 1:100 year regional storm, control of runoff to pre-development levels, maintenance of the existing storage north of Highway 401, and control of flows north of the 401 by developers to ensure no increase in flows from existing levels.

OTTHYMO was the hydrologic model used in this study. The Chicago distribution was used to derive a 1:5 year synthetic storm of 3 hours in duration. For analysis of flood control, the regional storm was applied, which is a 12 hour duration 1:100 year storm following the SCS Type II distribution. The model incorporated existing storage north of the 401, at the Quinte Mall, and upstream of the Tracey Street storm sewer. Storage volumes were estimated based on topographic information. The capacity of the Tracey Street storm sewer was found to be 3.5 m* at its inlet at Lemoine Street (outlet of Upper No Name Creek). With 1986 land use conditions, the modelling indicated the storm sewer had sufficient capacity for the 1:5 year flows, and would have less than 10% surcharge at 1:100 year flows, when existing storage upstream of Tracey Street is taken into consideration. Peak flows generated in this study are provided in Appendix ?. Flows were in reasonable agreement with the previous MNR (1982) study, except for outflows from the existing beaver pond north of Highway 401. The 1986 Gore and Storrie study computed available storage based on 1:2000 scale mapping, not available at the time of the MNR study.

The proposed development considered in this study included only the industrial and commercial developments south of the 401. No development north of the Highway was considered. The analysis assumed a drainage channel would be maintained through the proposed industrial development from the 401 to Bell Boulevard and the existing channel south of Bell Boulevard to the storm sewer inlet would be maintained. A detention facility was recommended at Tracey Street to control runoff from severe storms, to allow the Tracey Street Storm sewer to provide the outlet for all runoff events from the Upper No Name Creek basin. No major flows from Upper No Name Creek would therefore be routed to the southern portion of the No Name Creek watershed. The storage volume required in the detention facility, to eliminate surcharge in the storm sewer at future land use conditions for the 1:100 year storm, was estimated at 6,200 m^3.

B.5 UPDATE REPORT ON STORMWATER MANAGEMENT FOR THE NORTHWEST BELLEVILLE AREA (Gore & Storrie, 1990)

Between 1986 and 1990, parts of the No Name Creek watershed were developed, resulting in land use changes and higher imperviousness. The 1986 OTTHYMO model was modified to reflect the changes, and storage requirements adjusted. The study also considered development north of Highway 401.

At the ultimate land use conditions known at the time of the update study, it was estimated the existing storage north of the 401 would have to be increased to 16,000 m* for the 1:100 year event, an increase of 6,000 m*. South of the 401, the storage requirements at Tracey Street to maintain the storm sewer as an outlet for the 1:100 year event was increased to 10,700 m^3.

B.6 NO NAME CREEK STORMWATER MANAGEMENT STUDY (Falcone Smith, 1990)

The hydrology of the Upper No Name Creek watershed, for the developers of the Belleville Home Centre and the Congress Centre, was the subject of this study. It was focused on stormwater management strategies affecting these developments. The study area included all drainage to the Tracey Street storm sewer at Lemoine Street, as well as some analysis which was extended to include contributing areas along the length of Tracey Street to estimate the carrying capacity of the storm sewer all the way to the Moira River.

The MIDUSS model was used for the hydrologic assessment, with model discretization and input parameters used by Gore and Storrie (1986, 1990). A slightly different 1:5 year storm hydrograph was used, with 15 minute time steps, instead of 5. The same 1:100 year storm was used.

A hydraulic analysis was conducted of the entire Tracey Street storm sewer, which considered flows captured at Lemoine Street, as well as at numerous catchbasins located along Tracey Street from Lemoine Street to the Moira River. The flow from Upper No Name Creek is dominant, but the other inflows are significant, and limit the flow which can be accepted at Lemoine Street without producing surcharging. Considering the inflows all along the storm sewer as well as from Upper No Name Creek, the maximum elevation of hydraulic grade line at Lemoine Street was found to be 92.5 m, corresponding to an inflow rate of 3.5 m*/s. This implies a modest degree of surcharge, not considered to be a problem.

Analyses showed that at existing land use conditions, the Tracey Street storm sewer has sufficient capacity to prevent flooding, however any development between Tracey Street and Highway 401 will result in increased flooding potential. Stormwater management measures will therefore be required in parallel with development.

Several land use scenarios were analyzed in the study. Stormwater Management measures considered included an on-line detention pond at Tracey Street, with and without on-site detention storage. Pond sizing assumed attenuation of peak flows to pre-development levels from the future development north of the 401 would be implemented. The required pond volume for the fully developed condition was found to be 8,600 m* for the 1:100 year event.

The study considered the use of on-site detention storage as an alternative or supplement to the on-line pond. Both rooftop and parking lot storage on the commercial developments were modeled. Both of these types of storage are currently employed at the Quinte Mall, which reduces the 1:100 year peak flow by 80%. The impact of on-site storage at the Belleville Home Centre and Congress developments on the required volume in the on-line pond was assessed. The result was a significant reduction in volume of the pond to 5,400 m^3. A centralized on-line pond would still be required, however, even with on-site controls. The study recommended this be designed as a dual purpose water quantity and quality control facility.

B.7 UPPER NO NAME CREEK STORMWATER MANAGEMENT STUDY (Gore & Storrie, 1995)

Certain sections of this report are of somewhat greater significance to the current study than others. The sections which provide a more through understanding of the general area are summarized below.

B.7.1 Meteorologic Data

Data for this study was acquired from the Atmospheric Environment Service of Environment Canada. A nearly complete record, from 1960 through 1990, was available for station # 6150689 - Belleville Water Treatment Plant. This data was analyzed to prepare design storms for event modelling and, with supplementary data from neighbouring stations, was also analyzed to prepare a continuous input file.

Potential evaporation was estimated through data acquired from the AES station (# 6158733) at Pearson International Airport, Toronto.

B.7.2 Vegetation Communities

The climax forest was dominated by sugar maple. White elm, silver and red maple and cedar likely occupied the low ground. White cedar occurs where it is invading old pastures (Chapman and Putnam, 1984).

Vegetation communities, illustrated in the report, categorized the vegetation communities into Environmental Constraint Zones, from 1 to 5. Zone 1 is a Water Dominant or Related area. An objective of the Bay of Quinte Remedial Action Plan is to achieve no net loss of Zone 1 areas. The remaining four Zones are: Special Wooded Areas (Zone 2), Wooded Areas (Zone 3), Old Field Regeneration (Zone 4), and Modified Areas (Zone 5).

There were no locally or provincially significant wetlands in the catchment area.

B.7.3 Flora

The Upper No Name Creek Stormwater Management Study Draft Report reports a total of 132 species in the watershed. The terrain in the catchment area has been extensively disturbed and many non-native species such as orchard grass, awnless brome and common buckthorn are abundant. Non-native species readily colonize disturbed ground. Several uncommon species, which are species found at between 10 and 100 stations within its physiographic region, were found in the Upper No Name Creek Watershed but all were from the area around the beaver ponds.

Only one rare species, purple willow-herb, was found in the Upper No Name Creek Watershed. This species, according to Gore and Storrie Limited, is fairly common in the region occurring in many disturbed habitats. Willow-herbs can be difficult to identify, and the species has likely been overlooked (Wasylbakowsky, Natural Heritage Information Centre, Peterborough, Ontario).

B.7.4 Wildlife

All animals found in the Upper No Name Creek Watershed were common to abundant winter residents of agricultural and successional land and small woodlands in eastern Ontario. Some, such as coyote, beaver and white-tailed deer, are adaptable and continue to occupy small natural habitat areas on the edges of expanding urban areas. These species also demonstrate problems caused by wildlife in cities.

Beaver appear to have been numerous in the Upper No Name Creek study area in the past. No fresh signs of beaver were seen during the 1994 field visit in the Upper No Name Creek watershed and none were evident in the catchment area subject of this study. Beaver were observed during the field survey in December 1993, in the marshy area south of Highway 401. Trapping was also noticed.

B.7.5 Water Quality Data

In 1994 the Moira River Conservation Authority conducted a water quality data collection programme for the Upper No Name Creek. Sampling results were also available from 1993. Appendix A contains tables of all water quality data available. The data, provided in the Upper No Name Creek Stormwater Management Study Draft Report, are assumed to be representative for this study.

Water quality sampling data were collected from spring to fall, 1993. Wet or dry weather sampling conditions were not identified, but elevated bacteria levels measured on June 7, July 5 and August 4 suggest wet weather. Water quality sampling for three dry weather periods was conducted during 1994. Dry weather bacteria, suspended solids and nutrients were low.

A 2.6 mm (0.1 in.) rainfall event preceded the one wet weather event in June of 1994 but no flow information was collected at the time. The water quality data shows the bacteria levels are greater than the dry weather values. The *escherichia coliform* concentrations are elevated but are an order of magnitude less than typical wet weather stormwater concentrations.

The 1994 field program results show bacteriological contamination during wet weather in the Upper No Name Creek watershed, particularly in the more developed areas south of Highway 401. The *e. coli* concentrations in the creek, in the order of 5,000 to 7,000 no/dl, indicate a problem level of bacteriological contamination from stormwater. Bacteria levels as high as those observed in Upper No Name Creek impact on bacteria loadings to the Moira River and the Bay of Quinte and may contribute to beach pollution.

APPENDIX C
WATER MANAGEMENT OBJECTIVES

APPENDIX C
WATER MANAGEMENT OBJECTIVES

This section outlines urban runoff control requirements for the catchment area.

C.1 BASIS FOR STORMWATER MANAGEMENT TARGETS

The stormwater management targets applicable to the catchment area are based on:

1. The policies of the Ontario Ministry of the Environment and Energy, with respect to protection of surface water quality.

2. Stormwater management requirements developed for the Bay of Quinte Stormwater Management Implementation Area as part of the Bay of Quinte Remedial Action Plan.

3. Water management policies and requirements of the Moira River Conservation Authority, with respect to flood and erosion control.

4. Drainage service requirements and municipal drainage design standards of the Township of Thurlow.

C.2 SUMMARY OF CURRENT POLICIES AND REGULATIONS

The following summarize policies and regulations affecting stormwater management planning for the catchment area.

C.2.1 Land Drainage Requirements: Level of Service

The main purpose of an urban drainage system is to provide an acceptable level of service, which translates into a minimum risk to personal safety and minimum inconvenience from runoff. These level of service objectives are summarized as:

1. Protect buildings from regional storm flood damage (i.e. 100-year return period for catchment area).

2. Protect basements from regional storm flooding (i.e. 100-year return period hydraulic grade line must be below foundation drains; alternatively provide a sump pump to the foundation drain).

3. No unsafe ponding on roadway surfaces for 5-year return period runoff events and the extent and duration of ponding on residential or commercial lots must be

kept to an acceptable minimum.

These land drainage objectives are best achieved through the application of the Major-Minor stormwater management concept of urban drainage design required by Section 3.2.2 of the Townships Secondary Plan. This concept is based on a drainage system composed of two interconnected sub-systems:

1. Minor or Convenience System - designed to minimize inconveniences to pedestrians and motorists by accommodating the runoff form the 5-year return period. It may consist of roof gutters, rainwater leaders, swales, street gutters, catchbasins, and storm sewers.

2. Major System For Flood Protection - the route followed by storm runoff when the minor system is inoperative or inadequate designed to provide a low risk to life and property from severe runoff events. It may consist of swales, roadways, channels, and other overland flow routes, including natural streams and valleys. This system will function whether or not it has been planned or designed and whether or not development is located wisely with respect to it. The Major and Minor systems are not necessarily separate because they may share some elements. For instance, a swale or creek may be designed to handle both flood flows.

In the catchment area the drainage system consists of a man-made ditch system. These are the primary drainage collectors, with the final outlet being the Moira River. There is no continuous or engineered major overland flow system. Major flood flow would follow existing ditches and flow to the River.

C.2.2. Erosion Control Requirements

The erosion control target is to not make existing erosion problems within the study area and downstream any worse. This is enforced by the Moira River Conservation Authority and the Ministry of Natural Resources when approvals for works under the Lakes and Rivers Improvement Act or the Fill and Alteration to Waterway Regulations are requested. Erosion control minimizes risk to adjacent properties and helps ensure the protection of downstream aquatic habitat.

C.2.3 Water Quality Protection

Requirements for controlling the impact of development on water resources stem from:

1. The policies and objectives established by the Ontario Ministry of the Environment and Energy for the protection of surface water and groundwater quantity and quality.

2. Policies and requirements of the Ontario Ministry of Natural Resources for protection of aquatic habitat under the Federal Fisheries Act.

3. Local interpretations of the Provincial policy developed from study and investigation of specific problems encountered in the area. The stormwater management guidelines developed for the Bay of Quinte is an example.

C.2.3.1. Provincial Policies

The Provincial policies and objectives are contained in the Ministry of the Environment and Energy publication Water Management: Goals, Policies, Objectives and Implementation Procedures. This so-called 'Blue Book' sets out specific water-quality objectives and policies for attaining the overall goal of ensuring the surface waters of the Province are of a quality satisfactory for aquatic life and recreation.

The Province's objectives for protecting surface water quality for aquatic habitat are consistent with the objectives of the Federal Fisheries Act, which requires discharges to water bodies not have any harmful effect on fish habitats. The Canadian Water Quality Guidelines (Canadian Council of Environmental and Resources Ministers, 1987) provides a scientific basis for establishing specific impact-control targets for protecting aquatic habitat.

C.2.3.2. The Bay of Quinte Remedial Action Plan Guidelines

Within the Bay of Quinte watershed the Provincial objectives have been interpreted in the Bay of Quinte Remedial Action Plan. The Bay of Quinte Stormwater Management Implementation Area guidelines for stormwater quality control have been developed by the Inter-Agency Storm Water Management Working Committee (Ministry of the Environment and Energy, 1993). The water quality performance objectives are that stormwater discharges to existing watercourses meet the following requirements for protecting recreational water quality in the Bay of Quinte:

> *Escherichia coli (EC) level in stormwater discharges to be 100 no/Dl or less (from May 15 to September 15). The Ministry of the Environment and Energy will allow up to four separate event exceedances of these bacteriological criteria to occur each swimming season.*
>
> *An additional guideline is total suspended solids should be below 25 mg/L (from May 15*

to September 15).

The rationale is that summertime coliform bacteria control is needed to protect the Bay for recreational use. By keeping discharge suspended solids levels to 25 mg/L, a high degree of removal will be assured. Since a wide range of pollutants are directly associated with suspended solids, it follows that a good degree of overall stormwater quality control will be assured. The Bay of Quinte Stormwater Guidelines give limits for additional parameters related to protection of aquatic life. These generally conform with the Ministry of the Environment and Energy Provincial Water Quality Objectives.

C.3 STORMWATER CONTROL TARGETS

The policies and guidelines summary can be used directly or interpreted to provide a set of targets for stormwater management in catchment area.

C.3.1 Stormwater Quality Targets

Problems become apparent when stormwater management goals and regulatory targets are compared with expected impacts of future development within the catchment area.
Recent research shows runoff from urban areas carries a number of contaminants of potential concern, including coliform bacteria (e.g. e. coli), heavy metals, hydrocarbons, chlorides, and suspended sediment. It is expected runoff from residential, commercial or industrial areas contains contaminants at concentrations and loadings with potential impact on receiving waterbodies. In particular, it is expected that without satisfactory source control and/or runoff treatment, e. coli levels will be higher than 100 no/dl at the point of discharge to the receiving water body (i.e. at the storm sewer outfall). It is also expected suspended solids levels will be above the 25 mg/L target, and a range of contaminants (including bacteria) will be associated with those sediments. Recent Ontario research on die-off and persistence of coliform bacteria in surface water systems indicates sediment resuspension may play a role in creating higher coliform levels during runoff events. Therefore, coliform bacteria control is needed not only in wet weather but also during dry weather to ensure sediment-bound bacteria levels are not maintained by dry-weather inputs. The water quality target can be stated as:

> *Drainage systems for new urban development must be designed to adequately control pollutant loads delivered to catchment area. In particular, e. coli and suspended solids concentrations in discharges to Moira River must be controlled to comply with the Bay of Quinte guidelines: e. coli must be below 100 no/dl from May 15 to September 15 (with allowance of four event exceedances), and Suspended Solids levels must be controlled to 25 mg/L.*

Meeting these targets implies adequate stormwater quality control will be provided for compliance with all existing policies and regulations for surface water quality protection.

C.3.2 Targets For Control of Peak Flows

For this study, the targets for control of peak flows have been set as outlined in Table 2. The 100-year targets are based on maintaining the predevelopment peak flow.

C.3.3 Erosion Control Targets

The objective of no increase in erosion can be achieved in two ways, control the future flow so there is no increase in the erosive power. This requires the stormwater management system be designed to not increase the duration of erosive flowrates and velocities. minimizing erosion can also be achieved by designing the conveyance system to increase resistance to erosion wherever an increase in erosive power is expected.

There are no substantial erosion concerns in the catchment area. However, as the area is developed, there may be potential for an increase in the erosive power in the ditches. The flow attenuation provided by the stormwater management system will help control this impact, by reducing peak flow during all runoff events. However, even if designed to control peak flows to present levels for all return periods from 2 to 100 years, the stormwater control system will not likely provide full control of erosive power. This reflects the fact that the *duration* of erosive flowrates is likely to increase, due to the increased volume of runoff associated with increased watershed imperviousness.

The target for stormwater management planning should be:

> *No increase in the duration with which flowrate or velocity exceeds the threshold at which erosion begins (i.e. control of excessive erosive impulse, as defined by Lorant, 1982).*

This can be achieved through additional stormwater flow attenuation (sometimes referred to as overcontrol), or through increasing the erosive threshold by increasing the resistance of the conveyance channel (i.e. through structural reinforcement or natural or bioengineering techniques). Both approaches should be considered.

C.4 SUMMARY

The stormwater control targets have been formulated during this study to guide the formulation and evaluation of specific options for the overall stormwater management system for the catchment area. The targets require:

1. Summertime control of bacteria levels in discharges to the Moira River to below 100 *e. coli* per 100 mL, with the allowances of up to four event exceedances.

2. Control of 100-year peak flowrates.

3. Consideration of flow-control or stream-channel protection measures to ensure control of erosion along the roadside ditches.

APPENDIX D
FORMULATION OF STORMWATER MANAGEMENT PLAN

APPENDIX D
FORMULATION OF ALTERNATIVES

The first step in formulating alternative approaches to stormwater management was to review the literature for general alternativesand measures that mey provide controls which meet the criteria.

D.1 OVERVIEW OF APPROACH

In June, 1994, the Ministry of Environment & Energy published the "Stormwater Management Practices Planning and Design Manual" which provides technical guidance for practitioners of SWM planning, design, and review. This manual summarizes current approaches to stormwater management, from lot level controls through to the preparation of watershed plans. Any level of control, or combination of controls, may be considered as an alternative for stormwater management.

The manual suggests a hierarchy of preferred stormwater management practices:

1. Lot Level (Source) Controls
2. Conveyance Controls
3. End-of-pipe Controls

D.2 LOT LEVEL (SOURCE) CONTROLS

Lot level controls do one or more of the following:

1. Control the volume of surface runoff from a development site.
2. Control the rate of surface runoff from a development site.
3. Control the pollutants transported by runoff from a development site.

Ideally, contamination of runoff is avoided prior to 'disposal'. This is a difficult task to achieve since there is a wide variety and number of possible sources of contamination. Also, a substantial portion of urban pollutant washoff occurs from roadway surfaces.

D.2.1 Alternative Lot Level Controls

Source control measures which reduce runoff volume, rate, and contamination include:

I. Runoff rate and volume:

   A. Rooftop storage with gradual release to the drainage system.
   B. Catchbasin inlet controls such as flow restrictions, resulting in temporary

ponding in parking lots, grassed areas, and roads.

The above two alternatives are commonly recommended for use in commercial/industrial zones.

C. Use of lot-by-lot infiltration measures such as:
   1. grassed swales.
   2. infiltration trenches, possibly including perforated pipe systems.
   3. diversion of rooftop runoff onto grassed areas.
D. Storage tanks or cisterns to provide temporary storage and gradual release to the drainage system.
E. Porous pavements to reduce direct runoff from paved areas

II. Source controls of runoff contamination include:

A. Intensive sweeping/vacuuming of roads and parking lots
B. Housekeeping measures in industrial areas such as:
   i. covering of chemical storage areas, garbage dumpsters, etc.,
   ii. litter control, and
   iii. spill control and containment.
C. Pet control by-laws.
D. Control or elimination of the use of fertilizers, pesticides, and herbicides
E. Public education and awareness, including measures such as signage on all stormwater inlets.

D.2.2 Evaluation of Lot Level Controls

Factors affecting the feasibility, acceptability, and practicality of source control options include:

1. Catchment Physiography and Seasonal Weather - Soil types, water table elevation, and surficial geology may render infiltration-type measures impractical within localized study areas. Seasonal weather changes (spring and fall saturation and winter frost conditions) may reduce the effectiveness of some alternatives and render them unfeasible, or to only limited, seasonal use.

2. Type of Existing and Proposed Development - The type and extent of development, development controls, and site drainage system requirements, may add constraints to the level of control achievable. For example, municipal drainage standards may discourage frequent ponding on private or public lands. If the road standards require curbs with catchbasins and storm sewers, source control of the pollutants (sediments, trace metals, hydrocarbons) wash-off will be difficult.

3. Control Objectives - The objectives for control of runoff quality and quantity will have direct impacts on the suitability of control measures. The suitability of source

controls to meet the objectives will determine whether these controls are adequate in and of themselves. On their own, source controls may not be sufficient to meet site specific criteria for floe velocity, flow rate, and/or erosive potential.

The lot level control options can be evaluated based on their known effectiveness, practicality, and feasibility. *Table D3 reviews source control measures for controlling runoff volume and rate and Table D4 evaluates methods of run-off pollution control.*

D.2.3 Performance Review

When assessing of the feasibility of lot level controls it should be recognized that:

I. Sources of bacterial pollution are numerous and widespread. Pitt (1983) provides a review of possible sources (present and active) within an urban area. The net impact of these sources is difficult to predict, therefore control, and the reason(s) for coliform bacteria persistence in the natural water environment are not fully understood. It is not reasonable to expect source controls alone can meet the current Quinte Remedial Action Plan requirement that coliform levels in summertime runoff discharge to the Moira River be below 100 **e.coli** per 100 ml.

II. Source control of bacteria, nutrients, and sediment washoff is also difficult due to the nature of the existing and expected drainage systems in the catchment area. Source control of pollutant wash-off from large commercial and industrial parking areas and from curbed roadways is difficult. Roadway washoff is difficult to control without frequent street sweeping/vacuuming. The effectiveness of street sweeping was examined by Pitt (1983) who concluded it may reduce fecal coliform discharges by up to 20%, but that 10% is more likely. Pitt (1983) notes these marginal improvements would only be associated with major increases in street cleaning expenditures.

III. Education programs in the area provide the public with an awareness of the impact of domestic sources and activities, including pet litter, landscape maintenance (use of fertilizers and herbicides, etc.), and car washing/maintenance on areas draining onto roadways. Because the impact is difficult to predict, little reliance can be placed on the effectiveness of education.

The following conclusions can be made:

I. Source controls alone may not adequately control runoff pollution. Source control measures to reduce runoff pollution are likely to be of limited effectiveness in dealing with suspended sediments, coliform bacteria, and phosphorous.

II. Rooftop storage and catchbasin inlet controls can provide substantial benefits in flow reduction (and some volume reduction) and should be continued and implemented wherever practical.

III. Centralized runoff collection or treatment facilities may be needed to provide treatment prior to discharge to the Moira River.

IV. Since on-site or source control measures may not provide the full amount of flow attenuation needed, some form of centralized runoff detention may be needed within the subwatershed to control peak flows.

The development of a conceptual stormwater management alternative focusses on providing centralized runoff detention and treatment within the catchment area. Opportunities to provide source flow control via rooftop and parking lot storage and drainage of rooftop runoff onto grassed areas are considered crucial to all alternatives developed here.

D.3 CONVEYANCE CONTROLS

The only conveyance controls likely to be effective in this subwatershed are 'naturally' designed channels. These channels can offer the ability to detain flow, reduce erosive velocities, and, with good vegetation, reduce the concentration of nutrients and bacteria to the downstream environment. The actual water quality treatment ability of these controls is intangible, but should not be disregarded. As with lot level controls, conveyance controls should be implemented as part of the overall stormwater management plan.

D.4 CENTRALIZED STORMWATER MANAGEMENT FACILITIES

Centralized stormwater management facilities are engineered detention or retention facilities located within, or alongside, the drainage system of a subwatershed. For this subwatershed they may have to be designed to provide water quality treatment as well as flow detention. The overall treatment process will have to be designed to meet the stringent *e. coli* control target.

D.4.1 Centralized Treatment Options

Table D5 lists the options for centralized treatment of runoff from developed areas and an assessment of how each of these options can be designed to accommodate runoff storage for flow control. The table also includes an assessment of the level of bacteria load reduction expected from the treatment process and its adaptability to direct effluent disinfection via a physical or chemical wastewater disinfection process.

D.4.2 Evaluation

There are a number of considerations entering into the evaluation of options besides those on Table D5 including:

D.4.2.1 Passive Systems

I. Centralized runoff treatment should occur at a minimum number of facilities, thus minimizing construction costs and the complexity of operation and maintenance.

II. Ponds and wetlands are easiest to design to include significant storage for the downstream flow control. In this subwatershed, where there are opportunities along the existing drainage system to locate ponds, the preferred approach is to use detention ponds to temporarily hold runoff and allow its gradual release. Combination retention/detention ponds or wetlands providing both water quality treatment and flow control are the most favourable options.

III. Constructed wetlands need adequate tributary area to ensure there is enough water year round. A rule-of-thumb is that a constructed wetland should be at least 1-2% of its drainage area, and that a minimum tributary area of 10 hectares is preferred (Schueler, 1992).

D.4.2.2 Active/Mechanical Systems

IV. Vortex separators are manufactured wastewater treatment devices. Their performance is dependent on the physical characteristics of the sediment (particle sizes and mass) carried by the runoff. They are best suited to small scale end-of-pipe applications, but have been tested in larger applications. Performance in a stormwater treatment system may be variable depending on flow and sediment concentration. Used alone, these devices may provide adequate solids removal to meet treatment targets, but are costly to install (particularly where sanitary sewers are not available for sediment disposal), and require routine maintenance (if syphoning at wet well is required). Since sewage treatment capacity has a finite allocation limit, which is currently committed, and stand alone systems require post-event service, vortex separators will not be considered as possible alternatives for this subwatershed.

V. Filtration systems can only be installed at the outlet of a settling pond since pre-treatment is needed to remove coarse and medium textured sediment. Filtration systems also require regular inspection and maintenance, based on sediment concentration and runoff volume and would only be viewed as an option for providing improved treatment of effluent from an initial settling facility. This alternative has also been discounted for use in this subwatershed due to initial capital costs and the requirement for routine maintenance.

Pond and/or wetland facilities are likely the most appropriate centralized runoff detention and treatment for the catchment area.

D.4.2.3 Disinfection Technology

The temporal variation in bacterial loadings and natural die-off mechanisms means that natural processes may not be adequate for bacteria removal in some cases. If passive systems cannot achieve the water quality objectives, some form of direct disinfection may be required. A number of options have been applied to effluent disinfection of municipal wastewater; these are:

1. Chlorination/Dechlorination
2. Chlorine Dioxide
3. Bromine Chloride
4. Ozone
5. Ultra Violet Light

Ultra violet disinfection has advantages in stormwater applications (Gore & Storrie, 1994). It is a relatively simple process requiring short contact time, has good bactericidal and virucidal properties, and does not create known hazardous by-products. Comparing capital and operating costs of the various disinfection options also indicates ultra violet irradiation is the most cost effective. This process, like filtration, is installed at the outlet of a detention/settling pond.

As there is adequate land available for stormwater management facilities in the subwatershed, the need for disinfection should be negligible. Ultra-violet treatment will only be considered as an alternative of last resort.

D.4.3 PREFERRED APPROACH TO CENTRALIZED STORMWATER MANAGEMENT

The preferred methods and approach to centralized stormwater management in the subwatershed are summarized as follows:

I. Centralized treatment and flow control can best be achieved through the use of wet pond/wetland facilities providing stormwater treatment by natural settling and bacteria die off. Secondary removal by biological uptake of nutrients by aquatic vegetation should also be encouraged.

II. The overall system should:

   A. Minimize the number of facilities.
   B. Facilitate phasing as upstream development proceeds.
   C. Facilitate cost sharing and implementation.

D.5 CONCLUSION

The semi-urban nature of this subwatershed, and lack of established development, allows the Township to implement a stormwater management plan that incorporates a variety control measures. To this end it is recommended that the following controls be included in the alternative approaches under consideration.

→ Lot level controls be required for all undeveloped commercial/industrial/community properties. These controls should also be encouraged for land undergoing redevelopment.
→ Foundation drains and roof leaders from residences be discharged to rear yard swales.
→ Regular parking lot sweeping, dust control, waste disposal/containment, and yard maintenance be encouraged for all properties (voluntary compliance).
→ Swales and ditches be designed to provide flow attenuation with up to 12 to 24 hours ponding.
→ Conveyance channels be designed to reduce erosive velocities, and promote contact time with vegetation.
→ Wet pond(s) and/or wetland(s) be located near the Moira River to provide flow attenuation and water quality treatment. It is likely, over the long term, that stormwater conveyance from this subwatershed will be through a piped sewer system, therefore these facilities should be sized to provide all attenuation and treatment needs.

APPENDIX E
HYDROLOGY/HYDRAULICS

APPENDIX E
HYDROLOGIC ANALYSIS

Hydrology was originally performed by Van MEER Limited. Appendix A from the "Nor-Belle Subwatershed Stormwater Management Plan", Draft Report, is reproduced here, unedited.

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 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 the 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 rankedin 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) ans 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.

Discritiztion 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 characterisitics.

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 exisitng 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
EXISITNG 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 exisitng development model schematic is shown in Figure D-1.

Site inspection and field survey indicate that 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.

TABLE B-2 STORAGE DISCHARGE CURVE Sidney Street Sub-Catchment 100b	
STORAGE (ha/m)	DISCHARGE (m^3/s)
0	0
2.12	0.048
4.24	0.198
6.36	0.435
8.48	0.723
10.60	1.017
12.72	1.278

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

Strom water runoff from the west side of Highway No. 62 ponds behind the exisitng 1500mm x 900mm concrete open footing box culvert. The exisitng 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		
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

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

TABLE B-5 PEAK FLOWS - EXISITNG 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. Exixting 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.

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 exisitng agricultural lands as indicated in the Secondary Plan, Pond2 is proposed to be located on the west side of Highway No. 62 within the exisitng low wet area as indicated in the Secondary Plan and Pond3 is recommended to be located within the exisitng flooded area on the upstream side of Parks drive rather than in the McFarland Quarry as indicated in the secondary Plan.

Stormwater management 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 (m3/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 crossing 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 Centre 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 for 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 1140mm	106.02
18	0+634 downstream face 1450mm x 1140mm	106.24
19	0+639 upstream face of 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	PRE7.83 POST7.45	9.0
MAITLAND DRIVE SECT. NO. 11	2.66m x 1.66m CONCRETE BOX	PRE7.13 POST6.53	9.0
GRAVEL PARKING LOT SECT. NO. 14	1.82m dia STEEL PIPE	PRE6.46 POST5.78	5.0
FARM CROSSING SECT. NO. 19	1.45m x 1.14m CONCRETE BRIDGE	PRE3.13 POST3.86	3.2
HIGHWAY NO. 62 SECT. NO. 23	1.52m x 0.93m CONCRETE BOX	PRE2.89 POST3.30	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 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 postdevelopment 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 meters 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 m3/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 inxcrease the capacity to the proposed release rate of 3.3 m^3/s.

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.