SWAN LAKE COMMUNITY

ENVIRONMENTAL MANAGEMENT STUDY

TOWN OF MARKHAM

SWAN
LAKE

THE SWAN LAKE COMMUNITY

ENVIRONMENTAL MANAGEMENT STUDY

TOWN OF MARKHAM

December, 1993

PREPARED BY:

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File No. 87464

PREPARED FOR:

Swan Lake (Markham) Limited

The Swan Lake Community
Environmental Management Study

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EXECUTIVE SUMMARY

This Environmental Management Plan has been prepared to provide input to the proposed development of the Swan Lake Community located in the south central areas of Study Area 1B in the Town of Markham. This study presents a Environmental Master Plan for the rehabilitation and use of the former gravel pit and specifically addresses storm drainage design in accordance with the recommendations of the *Environmental Management and Master Servicing Plan for Future Urban Areas in the Bruce Creek, Burndenet Creek, Robinson Creek and Exhibition Creek Subwatersheds.*

Study findings and recommendations include:

- **The dominant existing feature** on site is a former gravel pit. The pit excavation has filled with groundwater and has no existing drainage outlet. Large quantities of fill with steep eroding sides have been placed adjacent the former pit. No significant plant communities have been identified in terms of composition of community type. Existing fish population within the pit are typical of warm water systems. Surface water quality conditions are excellent.

- **An environmental master plan for lake rehabilitation and use** has been prepared which demonstrates how the area will be transformed from an inactive gravel pit into diverse natural habitat for aquatic and terrestrial wildlife, with limited human access. This will be accomplished through the implementation of a variety of approaches to create fish and waterfowl habitat, preservation and enhancement of lakeshore vegetation, stabilization of fill slopes and management of access.

- **Best management practices** appropriate for implementation in the Swan Lake Community plan include the use of extended detention facilities to control runoff from a 25 mm rainfall event and release it over a 24 hour period. This will be accomplished through the creation of two wet extended detention ponds in the peripheral areas of the Lake. The ponds will outlet to off-site storm sewers.

- **Runoff control for flood control purposes** will be accomplished by directing flows in excess of the 25 mm runoff event into the Lake. The lake will store surface runoff and release it slowly into the downstream storm sewer system south of 16th Avenue. Allowances for lake fluctuations, in the order of 0.2 m for the 5 year storm and 0.5 m for the 100 year event have been incorporated into the designs of areas adjacent to the Lake.

Emergency spill? > 100 year

- **Major and minor system drainage** patterns are identified.

where is outlet?

- **An erosion and sediment control concept** has been prepared which identifies measures to capture construction generated sediment;

See 1st paragraph pg. E.6

1.0 INTRODUCTION

In 1989, the Town of Markham initiated a comprehensive planning program to develop a strategy for future growth management. Several studies were carried out to identify future urban land requirements and appropriate urban form. Recommendations of these studies, including the Municipal Housing Statement and the Urban Expansion Study, form the basis of Official Plan Amendment No. 5 (OPA 5) that presents development policies for future urban areas in the municipality.

The Study Area 1B lands, bounded by Major MacKenzie Drive, Ninth Line, 16th Avenue and the Canadian National Railway, are one of the future urban areas identified in OPA 5 (**Figure 1**). *The Area 1B Secondary Plan, Final Report*, was submitted to the Town of Markham in June 1993. This plan presents and supports the development of a residential community with open space, parks, schools, commercial cores and gathering and work places.

Within the south central portion of Study Area 1B, Swan Lake(Markham) Limited proposes an adult lifestyle residential community. This 57 hectare community responds to the demand for "empty nesters" and seniors housing anticipated in the Town of Markham's Municipal Housing Statement. The proposed development also includes 5.8 hectares of low and medium density condominium residences north of the Lake and a 2.3 ha elementary school and park site east of the Lake (**Figure 2**).

In support of draft plans of subdivision for the Swan Lake Community lands, several studies have been completed to address servicing and environmental issues. This Environmental Management Plan presents storm drainage and lake management strategies at a level of detail appropriate to support the draft plan of subdivision. It specifically addresses:

- various environmental and storm drainage design issues identified for further study in the *Environmental Management and Master Servicing Plan for the Urban Expansion Areas in the Bruce Creek, Burndenet Creek, Robinson Creek and Exhibition Creek Subwatersheds*; and,

- a strategy for the incorporation, design and management of the Lake as a focal point of the Swan Lake development. This includes lake

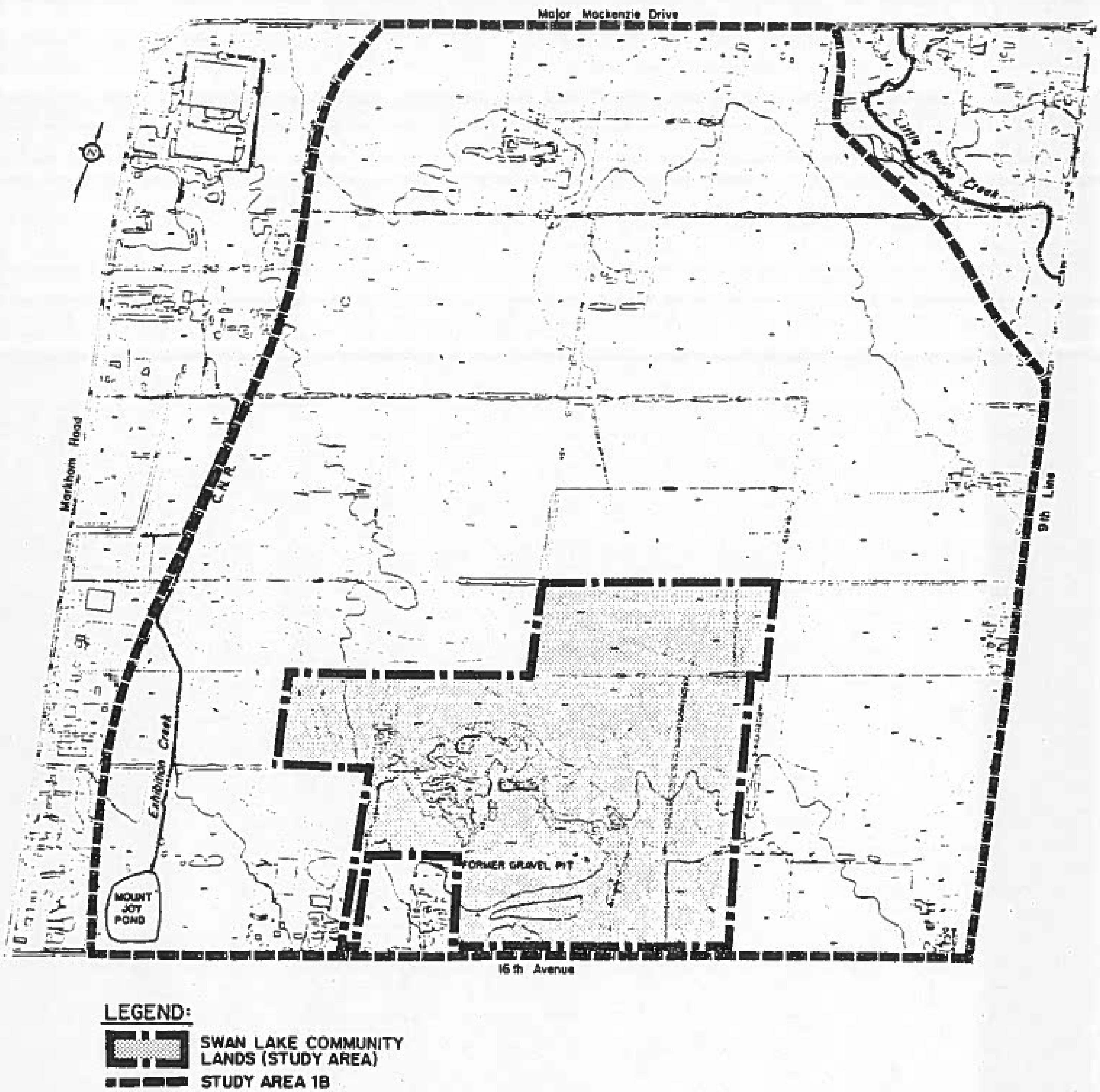

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FIGURE 1

STUDY AREA

Swan Lake

"the adult lifestyle community"

Featuring:

* a 15 acre spring fed lake with nature preserve, surrounding board walk and parks
* the village shops, services and professional suites... a restaurant on the lake
* recreational facilities include indoor and outdoor pools, tennis courts, lawn bowling, an all inclusive clubhouse and walking trails
* master putting golf course and botanical gardens with ponds, stream and walkway
* horticultural centre and greenhouses
* security gates, guardhouse maned 24 hours
* care free condominium living in single and town home bungalows, clusters and low-rise apartments, each offering a wide range of options including lofts, atriums and some customizing

Swan Park

"the medium density community overlooking Swan Lake"

Featuring:

* street and condo town homes, clusters and low-rise apartments

Note:

Base plan provided by W.J.Warren & Co.Ltd. based on preliminary layout concept.

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FIGURE 2

DEVELOPMENT CONCEPT

rehabilitation and restoration for a variety of recreational uses.

This report has been formatted to present a summary of key environmental and storm drainage findings and recommendations. Supporting technical data and analyses are provided in Appendices to the report. This report includes:

- Chapter 2.0 which presents an overview of biophysical resources onsite;
- Chapter 3.1 which describes the restoration plan for the Lake;
- Chapter 3.2 which describes the recreation facilities proposed for the Lake;
- Chapter 3.3 which describes the storm drainage plan for the site, including best management practices and major/minor system design, and; *
- Chapter 3.4 which outlines the required erosion and sediment control concepts. *

2.0 OVERVIEW OF BIOPHYSICAL RESOURCES

Qualitative biophysical surveys were conducted on the subject lands by Michael Michalski Associates on four occasions: July 29, 1987, December 1, 1992, June 29, 1993, and November 12, 1993. On the first three site visits, plant cover characteristics (i.e. composition and plant community types) of the former gravel pit environs were recorded. In addition, all wildlife species sightings and the overall wildlife habitat quality of the site were noted. On the last visit, Michael Michalski Associates mapped the specific distribution of plant communities based on compositional and physiognomic considerations, as well as on degrees and extent of site disturbance; 1993 aerial photography was used as a mapping base.

Additional information on the biological resources of the former gravel pit and surrounding area is provided in Town of Markham Natural Features Study: Phase 1 Background Report (Gore & Storrie Limited 1992).

The dominant feature onsite is the former gravel pit area that has been left inactive over the past several years. Steep, eroding slopes exist in many areas around the excavation. Plant communities around the former gravel pit are typical of early secondary successional sites, and are dominated by common indigenous and adventive plant species; large areas are covered by coarse weed communities. None of the plant communities identified for this area are significant in terms of species composition or community type.

In general, the existing vegetation provides cover, breeding and foraging habitat for wildlife species that are common to sites ranging from open and sparsely vegetated to continuous old field cover. The shoreline areas and open waters of the former gravel pit are suitable for a variety of resident and migratory shore birds and waterfowl. Fish populations area typical of warm water systems.

A summary of the history and biophysical features of the Swan Lake Community lands includes:

- **The former gravel pit** has filled with groundwater to an elevation of 208.35 m. The bottom grades are varying as per the existing topography left behind by the gravel extraction operation. Resulting water depths range from less than 1 m to greater than 4 m.

Planning Dept. - NFS and LSA conflicts with development & the concept of LSA maintained

In the early 1800s, the subject site was comprised of agricultural and vacant land. Gravel deposits were discovered during the early 1850s and used for road and rail building in the area. The rights to extract gravel were sold to the Township of Markham in 1873. The gravel extraction operations were phased out sometime later and the site became part of the Grove farm, and remained so until 1961.

In 1962, Bill Warnock and Gerald Johnson purchased the gravel pit lands from the Grove farm and resumed extraction. Groundwater was struck in about 1970 and a trench was excavated on the west side of the pit for dewatering. Resultant reduced well yields and noise and dust complaints lodged by neighbours caused the Township to close the gravel pit in 1973. The dewatering trench was backfilled and the former gravel pit filled with groundwater.

The site has received fill from construction sites in the surrounding areas since the early 1980s. Most was stockpiled around the former gravel pit. The south portion of the open pit, which in the past extended to 16th Avenue, was completely filled in.

The fill consists primarily of clean topsoil and sandy or clayey silt which may be used within the proposed development. However, some indiscriminate dumping of construction materials together with former land uses have created unacceptable fill in some localized areas. A geo-environmental investigation of these areas was undertaken by Peto MacCallum Ltd. in January 1993. Peto MacCallum has subsequently prepared a report to address Ministry of the Environment and Energy's (MOEE) concerns and allow decommissioning of the site for development.

Schedule? to completion plus MOEE sign-off

- **Topography of the Swan Lake Community lands** is gently sloping throughout the northern and eastern areas (**Drawing 2**). A large amount of fill has been placed immediately adjacent the pit. The fill on the north side has been stockpiled up to 12.0 m high with side slopes of approximately 1.5:1 (H:V). Fill along the south side has been stockpiled up to 5.0 m high between the present edge of water and 16th Avenue. These steeply piled fill areas are presently rutted and eroding into the existing ponded water.

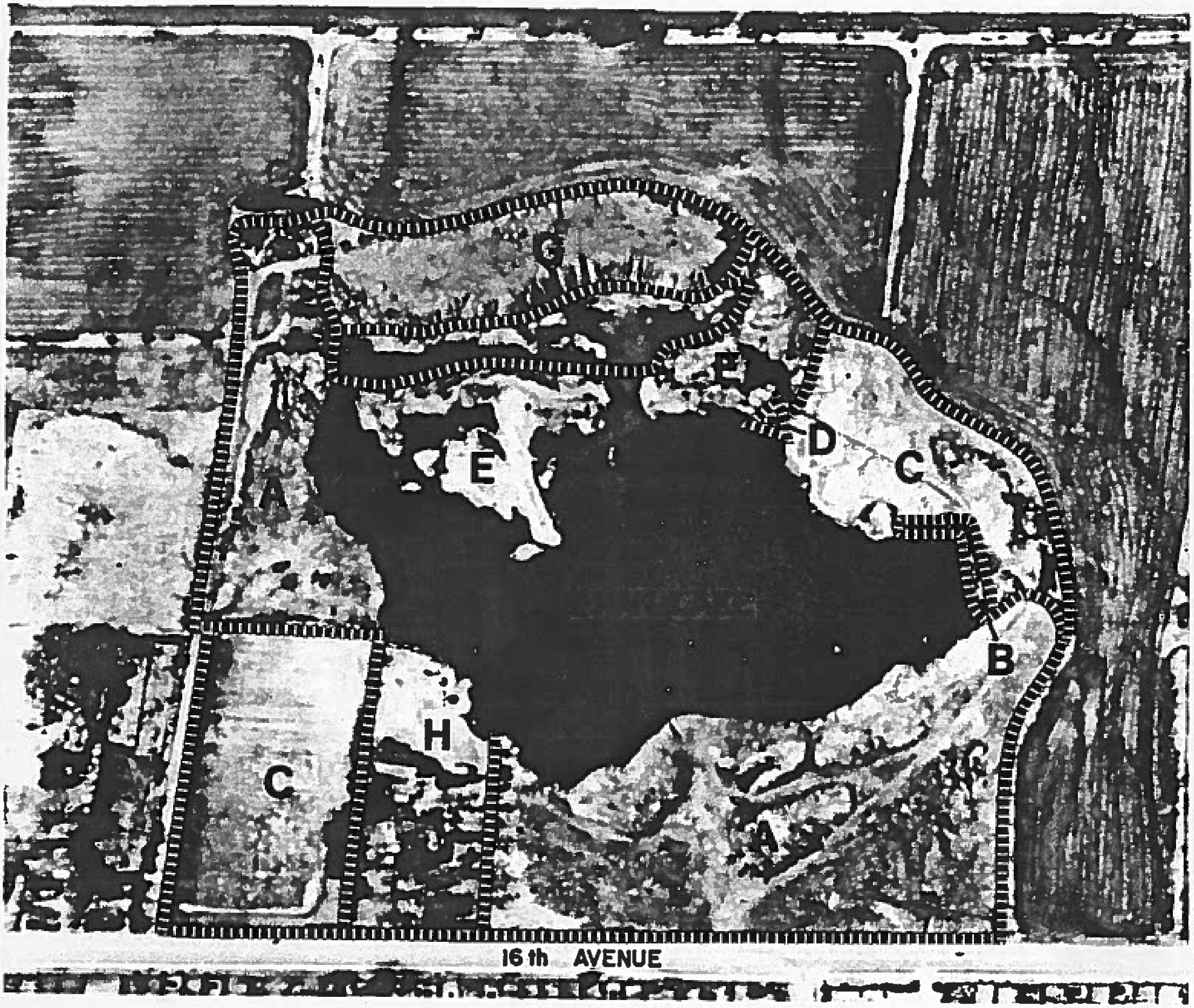
- **Terrestrial plant cover** around the former gravel pit consists predominantly of early secondary successional growth (i.e. weed communities dominated by coarse, aggressive weeds), with local occurrences of more established successional plant communities (i.e. old fields with scattered tree and shrub cover). Some marsh and wet meadow communities are also associated with the ponded water in the pit itself. The distribution of these community types is presented on **Figure 3**. Characteristics of each are discussed below and the plant species identified have been noted in **Table A-1 of Appendix A**.

  → **Area A** - This area is a weed community situated on fill material deposited around the former gravel pit. The dominant species include coarse, aggressive adventive species. The plant cover is discontinuous, with conspicuous areas of bare soil and rubble evident in many parts. Portions of the slopes fronting onto the water surface are generally steeply sloping (ie. >25%), with rubble occurring locally along the shoreline.

  → **Area B** - A narrow band of emergent aquatic marsh community occurs on a silty bottom substrate in shallow waters at the extreme eastern end of the former gravel pit. Tall shrubs are scattered throughout the community.

  → **Area C** - This well-drained upland area is in a more successionally advanced stage of development than is Area A. It is dominated by a variety of indigenous and adventive plant species typical of old fields. Cover is generally continuous and dense, with only local bare areas and disturbances. Tree and shrub species including manitoba maple and red osier dogwood occur sporadically.

  → **Area D** - This small area of wet meadow community is situated on a very gently sloping shoreline, and includes a narrow strip of sparsely-vegetated beach. It is dominated by rushes, scattered sedges, and shrubs.



LEGEND:

- A WEED COMMUNITY ON FILL
- B EMERGENT MARSH
- C OLD FIELD
- D SHORELINE WET MEADOW
- E OLD FIELD WITH SCATTERED TREE COVER
- F POORLY-DRAINED TROUGH WITH WET WINDOW, EMERGENT MARSH AND LOWLAND THICKET
- G HIGH MOUND OF SPARESELY-VEGETATED,ERODING FILL
- H RESIDENCE WITH MAINTAINED LANDSCAPE

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FIGURE 3

DISTRIBUTION OF PLANT COMMUNITIES

→ **Area E** - This area is the most topographically diverse around the former gravel pit, consisting of mounded terrain with locally very steep slopes, some of which are bare and eroding, and interspersed with areas of more subdued topography. The plant cover is similarly varied in terms of both compositional and physiognomic characteristics. The ground cover consists mainly of indigenous and adventive old field species and a variety of weeds. The area is also marked by scattered tree and shrub cover.

→ **Area F** - This area consists of a narrow, poorly-drained trough lying between high, fill-mounded areas. The varied and discontinuous plant cover includes open ponded areas, and small areas of wet meadow and emergent marsh communities, as well as varied tree and tall shrub cover; parts of this area support tall thicket stands of willow. The vegetation is dominated primarily by indigenous wetland species, including most of those species noted above for Areas B and D, and interspersed with old field species on local upland sites. Refuse was dumped in some parts of this area.

→ **Area G** - A high mound of fill material dominates the land immediately north of the former gravel pit. This area has very sparse plant cover, and is marked by very steep side slopes (i.e. >25%) with numerous, deep erosion channels. The most common plants are primarily weedy adventives.

→ **Area H** - An existing residential lot is situated at the southwest side of the former gravel pit. The immediate shoreline supports aggressive weed communities, as in Area A; however, various ornamental tree and shrub plantings and maintained landscape characterize the tableland.

→ **Area I** - With the exception of a few small areas of old field (ie. Area C), the bulk of the tablelands surrounding the former gravel pit are predominantly open and cultivated for various crops (eg. corn, soya). the margins of these cultivated fields are marked by hedgerows of varying composition and density. According to field observations and to Gore & Storrie Limited (1992), hedgerows range from more or less continuous bands of older hardwoods > 15m in height, to discontinuous cover of smaller shrubs and trees (generally 5 m to 15 m high). The hedgerows cover only a small proportion of this area and are typically heterogeneous. They include both indigenous and adventive tree and shrub species, as well as a number of old field forbs and grasses as the ground cover stratum.

- **Wildlife and wildlife habitat** was noted during four site visits. A list of wildlife species sighted has been provided in **Table A-2 of Appendix A.** Wildlife species noted include a few that are resident, as well as several that are likely migratory. Although several other species undoubtedly occur around the former gravel pit, the limited number of species that were recorded are, nevertheless, consistent with the habitat conditions available at this locality.

  The open waters and local, gently sloping shoreline areas provide suitable habitat for various waterfowl species such as Canada goose and mallard, both of which may well breed at this locality, and migratory species such as common merganser, which was only seen during the December visit. However, the majority of the existing bank conditions around the existing water level are steep and eroding. These steep banks are not suitable for waterfowl. Shallow littoral zones and bare, open areas on tablelands are frequented by killdeer and spotted sandpiper. Great blue heron feeds along the shallow littoral zone.

  The old fields on surrounding uplands provide cover for small mammals such as meadow vole, as well as foraging habitat for birds such as red-tailed hawk, American goldfinch and eastern kingbird.

- **Fisheries information** on existing fish populations within the ponded water of the former gravel pit is limited. According to Gore and Storrie (1992), the MTRCA once stocked the site with largemouth bass (*Micropterus salmoides*); This species which can be found near weed beds, logs, stumps and other sunken objects, prefers warm water less than 6 m in depth and is now apparently resident and fished by local anglers. However, several small bait and pan fish were also noted. These provide forage for the largemouth bass.

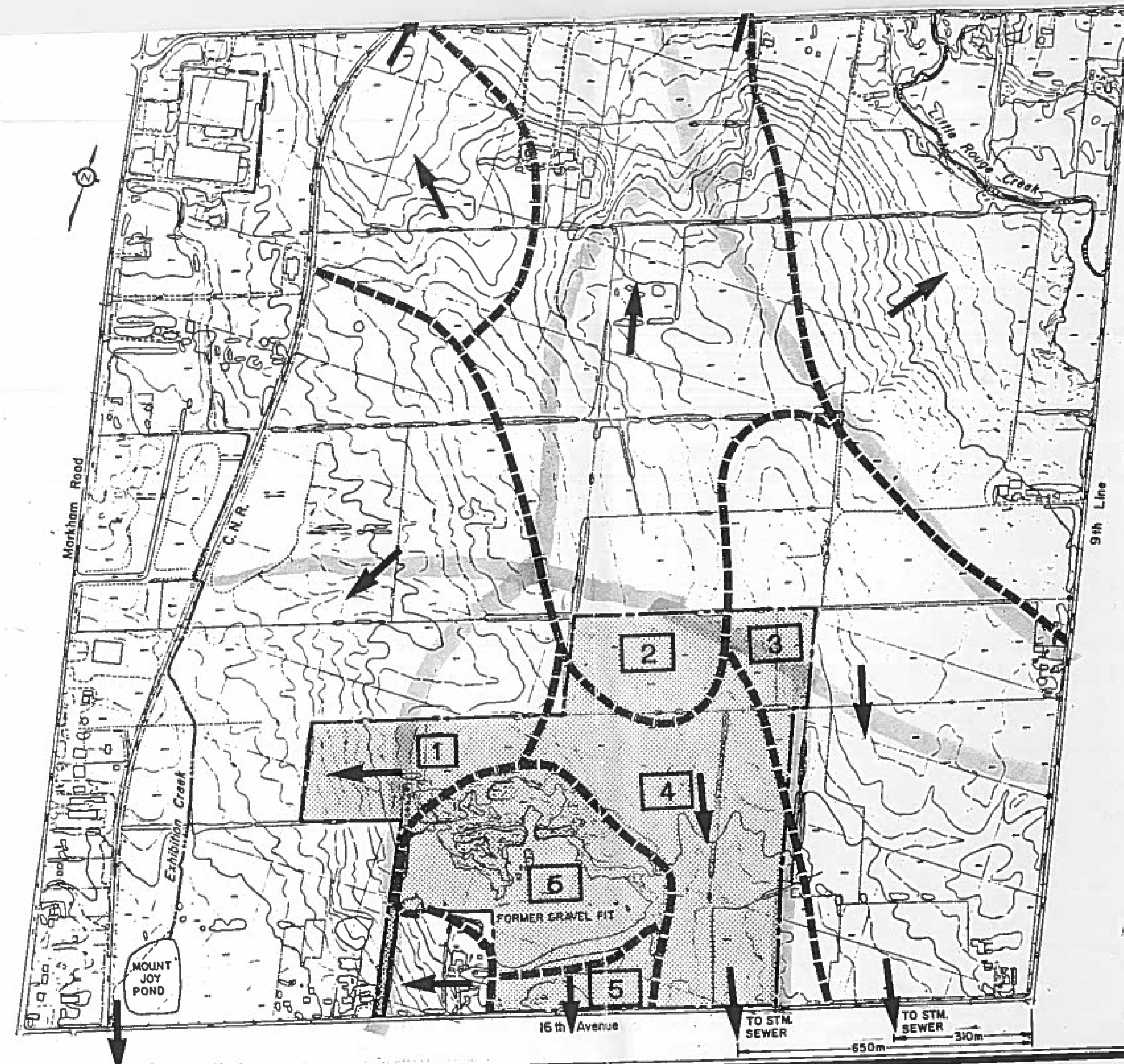
- **Six surface drainage catchments** presently drain the site (See **Figure 4**). These catchments are located within the upper portions of the Exhibition Creek watershed. The drainage areas are described below:

  → **Area #1** is a 7.9 ha agricultural area in the northwest corner of the site sheet which drains westerly through privately owned lands towards Exhibition Creek upstream of the Mount Joy Pond. A portion of this drainage originates from recent fill stockpiled on the north side of the former gravel pit.

  → **Area #2** is a 6.6 ha agricultural area located in the northern portion of the site which sheet drains northerly through privately owned lands towards the Major Mackenzie Drive. The flows are conveyed through a culvert under the road and continue north through private lands to the Little Rouge Creek.

  → **Area #3** is a 4.0 ha agricultural area located in the north east corner of the site which sheet drains south-eastwards to 16th Avenue. A storm sewer inlet has been provided east of the subject lands to accept the 2 year pre-development run-off from a 60.3 ha upstream area including and east of Area #3. An overland flow route has been provided between the houses on the south side of 16th Avenue to convey the major system flows.

  → **Area #4** is a 19.2 ha agricultural area located in the central and eastern portion of the site which sheet drains southerly towards 16th Avenue. A storm sewer inlet has been provided on the north side of 16th Avenue to accept 2 year pre-development flows from the upstream drainage area. The storm sewer inlet is located at a low point of 16th Avenue. There has been no overland flow route provided through the existing subdivision south of 16th Avenue. Therefore, any flows which exceed to the 2 year pre-development peak flows presently pond up to 0.7 m deep at 16th Avenue and then spill through the residential lots on the south side of 16th Avenue.



LEGEND:

- EXISTING DRAINAGE BOUNDARY
- DRAINAGE ROUTE
- 1 DRAINAGE AREA No.

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FIGURE 4

EXISTING DRAINAGE

→ **Area #5** is a 3.2 ha fill area located south of the former gravel pit which sheet drains directly to 16th Avenue. Drainage from 16th Avenue is directed via the storm sewer inlet described in Area #4.

→ **Area #6** is a 16.5 ha area which includes the former gravel pit and immediately adjacent fill areas. As previously discussed, the former gravel pit has filled with water to the level of the Regional Groundwater Level (Peto MacCallum Ltd., 1993). There is no surface drainage outlet from the pit. All captured rainfall either infiltrates or evaporates.

- **A preliminary soils analysis** of the area surrounding the former gravel pit entitled *Preliminary Geo-Environmental Site Investigation and Analysis*, was prepared by Peto MacCallum Ltd. in March 1993 to addresses the quality of fill material adjacent the lake. Conclusions from this report that are significant to the storm drainage analysis are:

→ that most of the reusable fill material adjacent to the former gravel pit consists of brown clayey silt with some limited sand and gravels;

→ that native soils adjacent the former gravel pit are generally comprised of a stratum of sandy silt till underlain by a major stratum of sand and gravel; and,

→ that surface water within the former gravel pit is located at what appears to be the Regional Groundwater elevation. Groundwater appears to flow from north to south or southwest.

The *Report On Existing Conditions in the Bruce Creek, Burndenet Creek, Robinson Creek, and Exhibition Creek Subwatersheds, July 1993*, prepared by Cosburn Patterson Wardman Limited, Michael Michalski Associates and Gartner Lee Limited identifies that areas immediately north of the former gravel pit may contain additional granular material associated with a buried kame deposit.

- **A detailed soils investigation** of the subject lands was completed by Peto MacCallum Ltd. in December 1993. This analysis has confirmed that:

  → the surficial site soils are predominantly very dense sandy silt till; and,

  → the stratum of sand continues at depth around the present limits of the former gravel pit; top elevation of the sand ranges from 206 m to 210.5 m; the sand is predominantly saturated.

- **Hydrogeology**

  Hydrogeological investigations were undertaken by Peto MacCallum Ltd. Their investigations indicate that:

  → Static groundwater elevations range between 207 and 209 m;

  → The Regional Groundwater table is in hydraulic continuity with the static water level in the former gravel pit; and,

  → The Regional Groundwater flow is directed southwards or southwestwards with an average hydraulic gradient of approximately 1%.

- **Subsurface Water Quality**

  → Water samples were collected from a depth of 0.25 m - 0.5 m at five locations in Swan Lake on November 26, 1993 by staff of Peto MacCallum Ltd. The results are shown in Table 1, together with provincial water quality objectives or guidelines (Ontario Ministry of the Environment 1984). Comments on the results of the data have been provided in **Appendix B**.

ok provide rational for particular parameters

Table 1

Surface Water Quality Data
Collected on November 26, 1993, from Five Stations in Swan Lake.

	Guideline	Station A	B	C	D	E
Ph	6.5 - 8.5	7.87	7.86	7.88	7.96	7.94
Alkalinity (mg/L)		118	103	118	118	130
Hardness (mg/L)		131	136	135	135	139
Nitrate nitrogen (mg/L)		<.1	<.1	0.20	<.1	<.1
Unionized ammonia nitrogen (mg/L)		0.009	0.008	0.010	0.011	0.012
Total Kjeldahl nitrogen (mg/L)		1.02	0.80	0.86	0.750	1.08
Total phosphorus (µg/L)	10-20	<5	<5	<5	11	<5
Total nitrogen/total phosphorus		222	182	214	78	224
Suspended solids (mg/L)		5	6	6	7	6
Iron (mg/L)	0.3[1]	0.287	0.259	0.284	0.248	0.228
Mercury (mg/L)	0.0002[3]	<.0002	<.0002	<.0002	<.0002	<.0002
Cadmium (mg/L)	0.0002[1]	<.0002	<.0002	<.0002	<.0002	<.0002
Nickel (mg/L)	0.025[1]	<.01	<.01	<.01	<.01	<.01
Lead (mg/L)	0.025[2]	<.002	.002	.002	<.002	<.002
Copper (mg/L)	0.005[1]	<.003	<.003	<.003	<.003	<.003
Zinc (mg/L)	0.03[1]	0.008	.019	0.026	0.012	0.011
Chromium (mg/L)	0.100[1]	<.005	<.005	<.005	<.005	<.005

	Guideline	Station A	B	C	D	E
Arsenic (mg/L)	0.100[1]	<.002	<.002	<.002	<.002	<.002
Free cyanide (mg/L)	0.005[1]	<.005	<.005	<.005	<.005	<.005
Phenols	0.001	<.001	<.001	<.001	<.001	<.001

1 Concentrations are determined on an unfiltered water sample.

2 The toxicity of lead is highly dependent on the alkalinity of the water; it declines as alkalinity increases. At alkalinities greater than 80 mg/L, the maximum concentration of lead in an unfiltered sample should be 0.025 mg/L.

3 Concentrations of total mercury in **filtered** water should not exceed 0.0002 mg/L.

In summary, water quality conditions in the Lake are excellent based on five samples collected on November 26, 1993. The lake is a relatively clear, hard water system and is insensitive to heavy acid loadings, with fish and other biota not at risk in this regard. Additionally, there is no evidence of contamination owing to heavy metals and phenolic compounds. On the basis of phosphorus concentrations, Swan Lake is nutrient-poor or oligotrophic, and is clearly phosphorus-limited.

3.0 ENVIRONMENTAL MANAGEMENT PLAN

The Environmental Management Plan has four main components that collectively provide guidance to the draft plans of subdivision for the Swan Lake Community on all storm drainage and environmental conditions. These components include:

- restoration and rehabilitation of the Lake to provide diverse natural habitat for aquatic and terrestrial wildlife;
- a recreational plan that incorporates passive use opportunities surrounding the Lake;
- implementation of Best Management Practices (BMPs) to control surface water quality and quantity to appropriate flood and erosion controls; and,
- an erosion and sediment control concept during construction.

The restoration, rehabilitation and recreation components of the Environmental Management Plan are described below. The storm drainage and erosion and sediment control concepts are addressed in **Sections 3.3** and **3.4** respectively.

3.1 Former Gravel Pit Rehabilitation

3.1.1 Restoration Objectives

In keeping with the types of habitats currently on site, and the wishes of the Town of Markham to maintain the area's natural values, considerable stretches of the former gravel pit shoreline will be maintained and enhanced within the proposed development. Overall, although no significant habitats were noted, the former gravel pit and surrounding area has good potential for rehabilitation/habitat creation to enhance existing vegetation and wildlife features. Since the banks along the existing waters edge are predominately composed of steep, eroding fill, the majority of the wet perimeter will be restored.

The proposed Lake within the former gravel pit will provide a diverse natural habitat for aquatic and terrestrial wildlife with limited human access through footpaths, paddle-boats, and isolated lake access points. This can be accomplished through the use of techniques, such as selected indigenous aquatic planting, reforestation, slope stabilization, construction management and impact mitigation.

The following environmental rehabilitation objectives were established to guide the development of the lake rehabilitation plan:

- **Preservation of Existing Vegetation**

  Existing aquatic and herbaceous and woody terrestrial vegetation will be preserved where grading permits. Selective transplanting of trees of high landscape and ecological value is proposed.

- **Habitat Creation**

  Provision of food and cover for aquatic and terrestrial life within the presently degraded environment.

- **Water Quality Enhancement**

  Improving water quality through the use of natural systems and process.

- **Shoreline Restoration**

  Protection of existing shoreline from disturbance through planting and trial system design.

An element common to each of the four environmental rehabilitation objectives is the need for the presence of vegetation in various forms. In this regard, *lakeshore restoration requires substantial plantings to provide vegetation linkages, shore line protection, sedimentation control, enhancement of local scenic quality, fish and wildlife habitat, microclimatic benefits, increased human comfort levels, reduced surface water temperature and maintenance costs, all of which will ultimately yield a distinct ecosystem that is recognizable from the surrounding landscape.* Local organics excavated during construction will be salvaged and re-used to provide a source of seeds and root masses.

It is intended that nearby residences and visitors will use the lake for educational exercises and nature interpretation. The inherent accessibility of the lake lends a higher social value to the site. A further reason for protecting and enhancing the existing lake is that this landscape feature is relatively rare in the Town of Markham.

The Environmental Master Plan (**Drawing 1**) illustrates the principle that increasing the richness of plant species composition and improving structural diversity will lead to a diverse number of habitats.

Several design initiatives depicted on the Master Plan are directed towards protection and enhancement of aquatic and wildlife habitat. Waterfowl habitat and migration routes will be enhanced through shading of the lake and the subsequent provision of food, cover and possibly lower water temperatures. The use of aquatic plant material will improve water quality and habitat.

The following specific design works are incorporated in the Environmental Master Plan.

3.1.2 Fisheries Habitat Creation

The existing ponded water within the former gravel pit appears to have some spawning, nursery and adult habitat for largemouth bass and a variety of forage and panfish species. Additional habitat will be created by:

- **Providing additional spawning sites** by introducing areas of gravel/sand to sand in localized shallow waters.

- **Laying tiles, culverts, crib structures and rubble piles** on the bottom of the lake (**Figure 5**).

- **Introducing rooted aquatic plants in shallow bays** and other near-shore areas to provide protective cover for largemouth bass and forage species as well as substrate for many invertebrates. These shallow areas should average about 1 m in depth and should not exceed 2 m. Botton material in these shallow areas should consists of soils having a substantial organic content. Although a variety of aquatic plants will eventually establish themselves in these settings, the process can be accelerated by artificially introducing these plants.

- **Creating near-shore pools** about 1.5 m deep that provide excellent protection when overhung by vegetated banks.

- **Planting brush and other vegetation along banks** of the restored Lake to create shaded areas. Insect populations associated with these areas are a prime food source for fish.

3.1.3 Waterfowl Habitat

As previously noted, the former gravel pit presently attracts some waterfowl. The existing waterfowl habitat can be enhanced by:

- **Re-shaping the shore-line edges** of the proposed Lake to ensure that the waterfowl are directed away from the lands designated for passive recreational uses into more isolated or natural areas of the lake. In this regard, waterfowl production, and wildlife diversity in general, are usually greatest in wide shoreline and near-shore zones with low grades. Banks should be no greater than 10:1 (H:V), and ideally around 20:1 (H:V). Such grades not only provide excellent loafing areas, but allow for the development of extensive food and cover areas typical of productive natural shore-lines. For example, a wide shoreline and near-shore zone

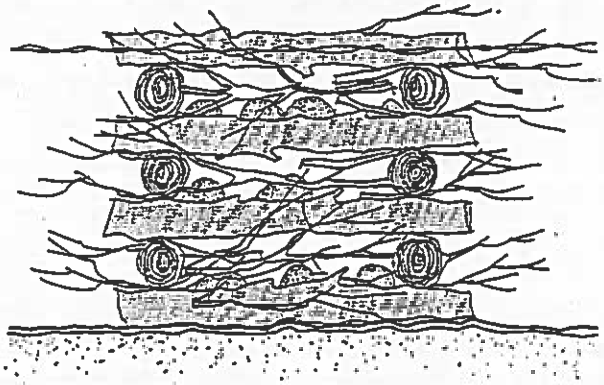


Figure 1. Cribs can substantially enhance habitat for fish, particularly panfish and bait fish, by providing both food and protection.

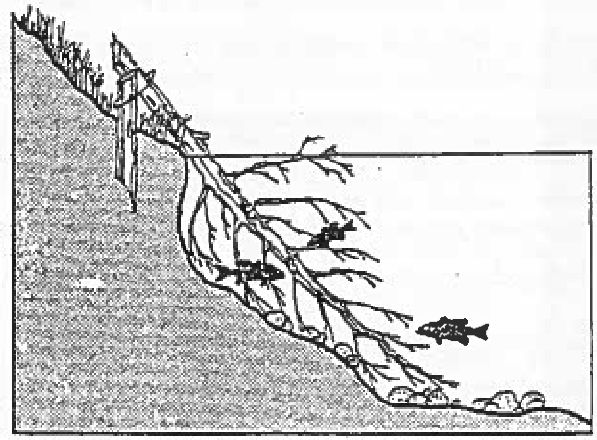
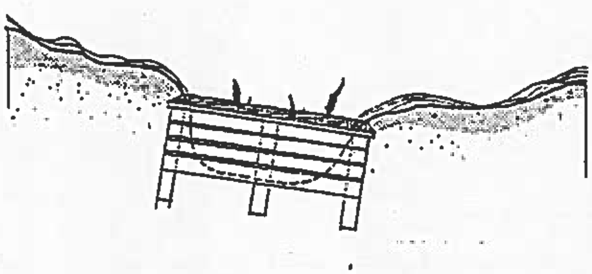
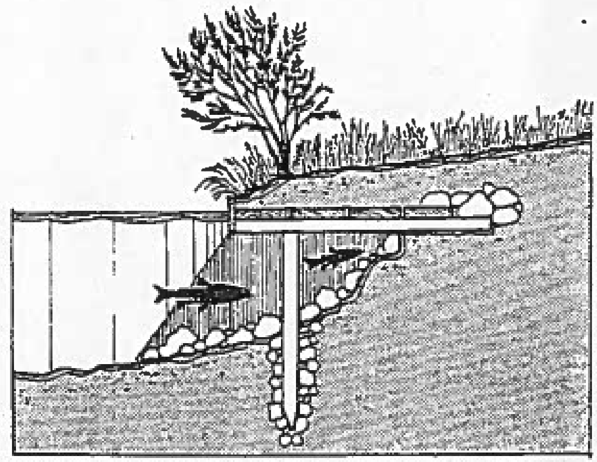


Figure 2. A simple technique to provide cover in steep drop-off bank areas.



Overhead View



Side View

Figure 3. Overhead and side views of constructed fish habitat where relatively steep littoral zones occur. The plan view shows the structure without earth and vegetation cover, which is illustrated in the profile view.

SWAN LAKE VILLAGES INC.

ENVIRONMENTAL MANAGEMENT STUDY

FIGURE 5

FISH HABITAT STRUCTURES

will support a characteristic distribution of plant communities, from wet meadow, through emergent and floating aquatic zones, to the submergent plants of waters 1.5 m or mor deep. In contrast, on 2:1 (H:V) or steeper slopes, only a limited number of aquatic plants will develop; as well, most waterfowl cannot easily cope with steep banks.

- **Developing islands** to focus waterfowl away from areas intended for human use. They not only have the affect of increasing shoreline length, but they also provide protection from most predators, particularly during nesting and moulting. To be effective, an island should have a low profile, and ideally should be either horseshoe shaped, with the open end facing away from prevailing winds, or designed as a small crowded cluster or atoll surrounding a sheltered lagoon. In either case, the sheltered zone should be shallow, with the adjacent banks graded gently to provide easy access. Islands can also be established in deep water by building floating, anchored rafts.

3.1.4 Lakeshore Restoration

The shoreline areas of the Lake will be restored and stabilized through the preservation of existing vegetation, regrading and introduction of new plantings. These initiatives include:

- **Grading of the lake shore** will be varied in grade to promote diversity and confine wildlife to appropriate riparian areas.

- **Existing trees of high landscape and/or ecological value will be preserved** as grading permits. Selective transplanting of existing riparian vegetation and trees of high landscape value will be undertaken where practical. Vegetation removal where excavations for storm water treatment ponds are required will be replaced.

  Tagging and inventory of individual trees in proposed tree preservation zones will be performed. Tree preservation plans will indicate preservation zones and specimens to be preserved as part of the design process. Details, procedures and control measures for construction activity in and around these areas will be described as a clear direction to contractors to builders. All trees and stumps which are to be removed will be fully utilized either in clipped or as mulch over the site.

- **Introduction of indigenous trees and shrubs** appropriate to lakeshore site conditions and adjacent uplands will increase compositional richness and add structural diversity favourable to wildlife, particularly for birds.

  The objective of these plantings is to put in place a foundation plant cover consisting of indigenous plant species in combinations that reflect plant communities native to southern Ontario, and that are representative of their sites of natural occurrence (i.e. littoral zone, riparian zone, etc.). The intent is to implement a low maintenance landscape that adheres to principles of natural succession and reduces areas of manicured turf grass so that the shoreline areas will develop over the long term, including colonization from existing seed sources, into habitats for indigenous flora and fauna.

  In this regard, species combinations appropriate for various sites are noted in **Table 6**;

- **The lake riparian zone will be substantially vegetated** where no boardwalks are planned to discourage disturbances resulting from large flocks of Canada Geese **(see Table C-1 in Appendix C)**.

3.1.5 Fish Stocking

As previously noted, there are excellent opportunities for creating spawning, nursery and adult habitat for largemouth bass, pumpkinseed sunfish, rock bass, and other panfish and minnow species. In addition, artificial plantings of hatchery reared largemouth bass may assist in maintaining populations at or near self sustaining levels; however, stocking of this species is not recommended until the effects of habitat restoration/enhancement are evaluated. Rainbow trout is commonly stocked in ponds north of Metropolitan Toronto. This species is mainly a stream spawner, and normally will only reproduce in ponds that have gravel bottoms, inflowing spring fed streams, or upwelling spring waters. Sites without these characteristics are unlikely to support natural reproduction and stocks would need to be maintained on a put-and-take basis. Also of importance is that the preferred summertime water temperatures for rainbow trout is between 18°C and 22°C; temperatures in the proposed Lake are likely to exceed this range in most summers, even with substantial rehabilitation of riparian areas. Accordingly, plantings of this species are not recommended, unless the presence of cold water upwellings are confirmed, or there is a recognition that artificial plantings will need to be undertaken on a regular basis.

3.1.6 Long Term Maintenance

The potential lake quality issues were identified and evaluated in terms of maintenance requirements. A detailed description of each issue is provided in **Appendix D.**

The evaluation concludes that:

- **Surface water quality** within the Lake is anticipated to remain excellent and will require virtually no long term maintenance due to the filtering action of the riparian planting and the off-line extended detention ponds.

- **High turbidity** within the Lake is not anticipated due to the proposed bank stabilization with riparian plantings and the off-line extended detention pond.

- **Excessive aquatic vegetation** within the Lake is not anticipated due to the littoral zone bottom grades and depths.

- **Algal Blooms** (predominantly caused by high phosphorus levels) within the Lake are not anticipated due to the low ambient phosphorus conditions.

- **Fish kills** within the Lake are not anticipated due to the moderately deep character of the Lake for wintering and due to the levels of aquatic plants which are insufficient cause oxygen depletion.

- **Sedimentation** within the Lake is not anticipated due to the two off-line extended detention ponds. The ponds will require routine cleanings to maintain their operation. Cleanings are anticipated every 10 to 15 years, depending on the quantity of road sanding and catchbasin cleaning.

who will have control

Access? Cost?
↳ non toxic sediment?

See also Appendix D

See DA

3.2 Proposed Lake Area Recreation

An integral component of the future Swan Lake community is the passive use recreation opportunities which will be created through the restoration of the existing lake and adjacent lands. These activities will be available in conjunction with active use facilities such as tennis courts, a master putting golf course, lawn bowling, and indoor and outdoor swimming pools which are proposed within the future community.

Pedestrian and cyclist access to the lake will be provided through a comprehensive low environmental impact community trail system. This system will link daily activity destinations such as shopping areas, park and recreation facilities and will include a series of interest nodes. Care will be extended in the design of the trail system to ensure that sensitive aquatic and terrestrial habitat zones are not disturbed or impacted. Plant communities will be protected through the use of handrails, bridges and boardwalk sections where necessary. An elevated observation platform within a habitat protection zone will provide opportunities for nature interpretive and educational use. The proposed landscape treatment within the community will maintain and/or enhance visual access to the lake.

A principally passive use park is proposed along the south shore of the lake which will accommodate the following activities:

- nature interpretation/education centre with change rooms;
- walkway/cycleway system
- picnicing;
- hockey ice skating;
- fishing;
- paddle sports;
- free play; and
- sunning/volleyball beach use

The park site fronts on to 16th Avenue and is located at a central location within the plan area. This site optimizes the walking/cycling distances for the area to be served.

3.3 Storm Drainage Plan

The *Environmental Management and Master Servicing Plan for Urban Expansion Areas in the Bruce Creek, Burndenet Creek, Robinson Creek and Exhibition Creek Subwatersheds* was prepared for the Town of Markham in November 1993 to study environmental and storm drainage issues in these subwatersheds in support of the secondary planning exercise for future urban lands including Study area 1B. This study recommends a resource management strategy including a preferred approach to providing Best Management Practices and storm drainage systems for the Swan Lake Community.

A stormwater management plan for the Swan Lake Community lands was completed applying the recommendations of the *Environmental Management and Master Servicing Plan* together with a detailed analysis of site outlet capacities, major/minor drainage systems, quantity control and quality control requirements. This detailed stormwater management analysis is enclosed in **Appendix E.** The recommended stormwater management strategy for the Swan Lake Community is described below and shown graphically on **Drawing 2:**

- **Outlet Capacities** have been identified for the two site outlets:
  - → **Exhibition Creek** - post development to predevelopment control for the 2 through 100 year peak flows
  - → **Existing Storm Sewer South of 16th Avenue** - 2 year predevelopment flow from a 39.7 ha area north of the south 16th Avenue right-of-way (1.166 m³/s). There is no overland flow outlet.
- **The West Drainage Area** (3.6 ha School and Park Block) will be drained to the Exhibition Creek. Water quantity control to pre-development levels for the 2 through 100 year storm will be provided in an off-site pond adjacent the Exhibition Creek in conjunction with future development to the west. Water quality control will be provided in an off-site extended detention pond adjacent the Exhibition Creek in conjunction with future development to the west.

- **The North Drainage Area** (14.0 ha Residential Area) will be drained towards the north side of the Lake. Water quantity control will be provided within the Lake to a total lake release rate of 100 l/s for all storms. An emergency overflow has been located on the west side of the Lake which will drain towards Exhibition Creek. Water quality control will be provided within a wet extended detention pond with emergent plantings located on the north shore of the Lake. The extended detention pond will outlet to a foundation drain collector pipe which drains to an existing storm sewer south of 16th Avenue. Granular soils which were identified in the *Environmental Management and Master Servicing Study* as potential infiltration areas are not suitable for use within the proposed development due to their depth below the surface grades and their saturation level.

- **The East Drainage Area** (24.6 ha Residential Area) will be drained towards the east side of the Lake. Water quantity control will be provided within the Lake with a total lake release rate of 100 l/s for all storms. Regional storm ponding fluctuation will be 1.1 m. An emergency overflow has been located on the west side of the Lake which will drain towards Exhibition Creek. Water quality control will be provided within a wet extended detention pond with emergent plantings located on the east shore of the Lake. The extended detention pond will outlet to a foundation drain collector pipe which drains to an existing storm sewer south of 16th Avenue.

- **The South Drainage Area** (2.2 ha Residential Area) will be drained directly into the existing storm sewer on the south side of 16th Avenue. Water quantity control will not be required since the 100 year peak runoff is less than the existing storm sewer design capacity. Water quality control will be provided by soft BMP measures such as draining rooftops to pervious areas and the use of grassed rear yard swales.

- **The East Rear Yard Area** (1.3 ha Residential Rear Yard Area) will ultimately be drained off-site to the east via a proposed adjacent north-south road to an additional existing storm sewer and overland flow route on the south side of 16th Avenue located 310 m west of Ninth Line. This area may not be drained to the Lake due to the relative grades between the east limit of subdivision and the Lake. Water quantity control will not be required since the proposed drainage area to the east is significantly less than the existing area, and since the 1.3 ha consist of primarily pervious rear yard areas. Interim drainage will continue to the existing outlets prior to future development east of the Swan Lake Community .

- **16th Avenue Right-of-Way** (2.1 ha Pavement and Boulevard) will continue to be drained to the existing storm sewer south of 16th Avenue. Quantity control will be required to limit the right-of-way runoff to the 2 year predevelopment rates for which the existing storm sewer was designed. Control can be provided through surface ponding or underground storage.

3.4 Erosion and Sediment Control Concept

A preliminary erosion and sediment control concept was prepared in accordance with the "*Guidelines on erosion and Sediment Control for Urban Construction Sites, Ministry of the Environment 1987*". The erosion potential for the site has been evaluated by assessing the slope gradient, slope length, and soil characteristics. This analysis is located in **Appendix G**.

Based on the analysis of the site conditions in **Appendix G**, the following measures will be reviewed at the detailed design stage to finalize preferred sediment control measures to be installed and maintained during construction:

- a temporary sediment control fence will be placed adjacent all property limits subject to direct drainage prior to grading;

- a temporary sediment control fence will be placed around all topsoil stockpile locations;

- a temporary sediment control fence will be placed around the former gravel pit during site grading works;

- several temporary rock check dams will be provided along all drainage swales;

- temporary sedimentation ponds will be designed and graded to provide 125 m^3 of storage per hectare of drainage area ;

- a Temporary sedimentation ponds to be located outside of the former gravel pit;

- A temporary rock mud mat will be provided at all construction entrances to avoid trucks tracking sediments onto adjacent streets;

- Temporary sediment control will be provided on both the street and rear lot catchbasins;

- All proposed open space areas will be restored with topsoil and seed upon completion of grading; and,

- a disturbed slopes in excess of 10 % will be restored with either topsoil and sod or topsoil, seed and an erosion control matting.

All temporary erosion and sediment control measures will be routinely inspected and repaired during construction. Temporary controls will not be removed until the area they serve are restored and stable.

Following completion of final grading the site will be restored with topsoil and seed or sod. If specific lots or blocks are left temporarily undeveloped, they will be seeded to stabilize the soils. The proposed extended detention facilities will provide continued sediment control by attenuating the 25 mm rainfall run-off for 24 hours. The extended detention ponds outfall will bypass the proposed Lake and outlet to the Mintleaf subdivision storm sewer south of 16th Avenue.

In conclusion, all reasonable measures will be taken to ensure the sediment transport from the site due to stormwater run-off will be minimized both during and following construction. Erosion and Sediment Control Plans detailing the design and location of each facility will be submitted together with the detailed design drawings for the subdivision upon approval of the stormwater management concepts.

4.0 CONCLUSION/RECOMMENDATIONS

Study conclusions and recommendations include:

- **That the dominant existing feature** on site is a former gravel pit. The pit excavation has filled with groundwater and has no existing drainage outlet. Large quantities of fill with steep eroding sides have been placed adjacent the former pit. No significant plant communities have been identified in terms of composition of community type. Existing fish population within the pit are typical of warm water systems. Surface water quality conditions are excellent.

- **That an Environmental Master Plan** was prepared to demonstrate how the former gravel pit will be restored, rehabilitated and used for recreation purposes. This plan includes numerous initiatives that will rehabilitate fish and waterfowl habitat, stabilize slopes, revegetate shoreline areas and incorporate passive recreation uses around the Lake.

- **That runoff control** is required within the Swan Lake Community for flood control and erosion control purposes.

- **That in accordance with recommendations of the *Environmental Management and Master Servicing Plan for Future Urban Areas in the Bruce Creek, Burndenet Creek, Robinson Creek and Exhibition Creek Subwatersheds***, appropriate BMPs for incorporation into the development plan were reviewed.

- **That soils** within the site subcatchment are confirmed to be dense, sandy silt till; their low permeability makes large scale infiltration of surface runoff unfeasible.

- **That water** quality conditions in the Lake are excellent based on 5 samples collected on November 26, 1993. In this regard, it is a relatively clear, hard water system, which is insensitive to heavy acid loadings. There is no evidence of contamination owing to heavy metals or phenolic compounds. In terms of trophic state, the Lake is nutrient-poor, or oligotrophic and is clearly phosphorous limited.

- **That appropriate BMPs** for use include extended detention facilities, the discharge of roof leaders to pervious surfaces and the use of localized grass swales. The extended detention facilities are proposed for two inlet bay areas in the east and north portions of the gravel pit. Outflows from these facilities discharge into an existing storm sewer system south of 16th Avenue through the Mintleaf subdivision.

- **That water quality** conditions in the Lake will not be diminished in the long term given the BMPs proposed. Some minor impacts may result during construction, particularly during less frequent rainfall events, and until the drainage areas to the Lake have been landscaped and stabilized.

- **That conceptual major and minor system drainage** design was completed to identify drainage areas and routes.

- **That erosion and sediment control measures** must be implemented during construction to retain construction generated sediments onsite. Measures for further review at the detailed design stage are suggested.

- **That the recommended extended detention pond is exempt from the Environmental Assessment Act** since it is a private work and not designated as a Schedule C undertaking.

- **That all draft plan study requirements** identified in the Environmental Management and Master Servicing Plan have been addressed.

APPENDIX 'A'

Biophysical Inventories

APPENDIX 'A'

Biophysical Inventories

Table A-1

Existing Vegetation

Area A	ragweed (*Ambrosia artemisiifolia*), Queen Anne's lace (*Daucus carota*), white sweet clover (*Melilotus alba*), common burdock (*Arctium minus*), hound's tongue (*Cynoglossum officinale*), soapwort (*Saponaria officinalis*), thistle (*Cirsium arvense*), barnyard grass (*Echinochloa crusgalli*), common dock (*Rumex crispus*) Canada goldenrod (*Solidago canadensis*) reed canary grass (*Phalaris arundinacea*).
Area B	narrow-leaved cattail (*Typha angustifolia*), giant reed (*Phragmites australis*), various sedges (*Carex spp.*), rushes (*Juncus effusus, Juncus dudleyi*), spike rush (*Eleocharis acicularis, Eleocharis erythropoda*), variegated horsetail (*Equisetum variegatum*), soft-stem bulrush (*Scirpus validus*), willowherb (*Epilobium ciliatum*), arrowhead (*Sagittaria sp.*), water horehound (*Lycopus americanus*), and aster (*Aster lanceolatus*) willow shrubs (*Salix eriocephala*)
Area C	including Canada goldenrod, heath aster (*Aster ericoides*), New England aster (*Aster novae-angliae*), couch grass (*Agropyron repens*), vetch (*Vicia cracca*), St. John's wort (*Hypericum perforatum*), goat's beard (*Tragopogon pratensis*), awnless brome grass (*Bromus inermis*), common milkweed (*Asclepias syriaca*), strawberry (*Fragaria virginiana*), butter-and-eggs (*Linaria vulgaris*) Manitoba maple (*Acer negundo*) red-osier dogwood (*Cornus stolonifera*)
Area D	varieigated harsetail (*Equisetum variegatum*), rushes (*Juncus spp.*), sedges (*Carex spp.*), aster (*Aster lanceolatus*) Willow (*Salix eriocepahala*), red osier dogwood (*Cornus stolonifera*)
Area E	catnip (*Nepeta cataria*), hound's tongue (*Cynoglossum officinale*), motherwort (*Leonurus cardiaca*), common burdock (*Arctium minus*) Manitoba maple (*Acer negundo*), Tatarian honeysuckle (*Lonicera tatarica*), raspberry (*Rubus strigosus*), and red-osier dogwood (*Cornus stolonifera*).

Area F	Same Area B and D
Area G	yellow rocket, colt's-foot (*Tussilago farfara*), white sweet clover (*Melilotus alba*), Canada goldenrod (*Solidago canadensis*)
Area H	Same as Area A
Area I	ash (*Franxinus americana*), green ash (*Franxinous pennsylvanica*), sugar maple (*Acer saccharum*), basswood (*Tilia americana*), hawthorn (*Crataegus spp*), Manitoba maple (*Acer negundo*), white elm (*ulmus americana*) Tatarian honeysuckle (*Lonicera tatarica*), choke cherry (*Prunus virginiana*) common buckthorn (*Rhamus cathartica*), lilac (*Syringa vulgaris*), raspberry (*Rubus strigosus*), elderberry (*Sambucus pubens*), redo-osier dogwood (*Cornus stolonifera*)

Table A-2

Wildlife Species Sighted And Their Habitats Of Occurrence

Common Name	Scientific Name	Habitat
Birds: great blue heron Canada goose herring gull	 *Ardea herodias* *Branta canadensis* *Largus argentatus*	 shoreline and open waters
mallard common merganser	*Anas platyrhynchos* *Mergus merganser*	open waters
red-tailed hawk killdear	*Buteo jamaicencis* *Charadrius vociferus*	old field shoreline and bare upland sites
spotted sandpiper	*Actitis macularia*	shoreline
rock dove mourning dove	*Columbia livia* *Zenaida macroura*	bare upland areas bare upland areas
eastern kingbird	*Tyrannus tryannus*	old field-treed areas
American crow	*Corvus brachyrhynchos*	bare areas and old field
red-winged blackbird	*Agelaius phoeniceus*	marsh, old field and weed communities
American goldfinch	*Carduelis tristis*	old field

Common Name	Scientific Name	Habitat
Mammals:		
eastern cottontail	*Sylvilagus flouridanus*	old field
meadow vole	*Microtus pennsylvanicus*	old field

APPENDIX 'B'

Surface Water Quality Analysis

APPENDIX 'B'

Surface Water Quality Analysis

Alkalinity is a measure of a system's carbonate-bicarbonate capacity to buffer or neutralize water against acidification. If a lake has a high alkalinity level, it can resist pH changes caused by acid inputs. Lakes having low alkalinities can experience Ph depressions during the spring snowmelt or following heavy rains, times when large acid loads can enter a lake. A lake with zero alkalinity is an acid lake. A negative alkalinity reading means that it contains mineral acidity; such lakes usually have a Ph less than 5.0, and if they have any fish at all, it will be a hardy, acid-tolerant species like yellow perch. As a lake acidifies, sensitive species such as bass and trout will probably not reproduce, although some adult fish may still survive until they die of old age or other causes.

The neutralizing capacity of a lake is dependent on a number of factors. For example, lakes in limestone regions usually have a very high alkalinity, since bicarbonate alkalinity results as limestone slowly dissolves in water. Alkalinity can also be generated in soils; accordingly, groundwater and soil runoff inputs to some lakes can be an important supply of neutralizing capacity. In some cases, alkalinity levels can be reduced by naturally occurring acids; such acids are formed during the decomposition of leaves and other organic material. The presence of these acids is usually observed as a brown colouration in water, and can be quite noticeable in areas with extensive swamps or bogs. Examples of lakes with large amounts of acid neutralizing capacity are the Great Lakes, the Kawarthas, the Rideaus, and lakes on Manitoulin Island and throughout the Niagara Escarpment. Lakes on the Canadian Shield typically have low acid neutralizing capacities. This region is underlain by granite, and has many exposed rock outcrops; granite is insoluble and supplies little alkalinity. The soils are usually shallow and sandy or acidic; these soils are not the result of acid deposition, but are formed by the decomposition of organic material such as forest litter. Runoff from these soils do not contribute any neutralizing capacity to lakes, so that most lakes on the Shield have low alkalinity levels.

Swan Lake with alkalinity values exceeding 100 mg/L would be classified as a level five lake according to the Ministry of the Environment and Energy, meaning it is not sensitive to acid loadings and is capable of withstanding heavy acid loadings during spring runoff without biological damage. Such lakes contain sufficient buffering capacity to neutralize acid rain for an indefinite period of time.

Hardness, is the term used to describe how readily soap lathers in water. Calcium and magnesium ions form a scum or precipitate with soap; accordingly, when these ions are present in excess, extra soap must be used. Thus, hardness is essentially a measure of the concentration of calcium and magnesium ions in water. Values exceeding 130 mg/L for Swan Lake (Table 1) indicate hard water conditions.

Ph is the chemical short form referring to the concentration of hydrogen ions in a solution. The more hydrogen ions, the lower is the pH, and vice versa. Because the pH scale is a logarithmic scale, there is a tenfold difference between one number and the next one to it. Therefore, a drop in pH from 8 to 7 indicates that the acidity is ten times greater at pH 7 than it is at pH 8; from 8 to 6, it is one hundred times greater, and so on. Guidelines of pH based on recreational uses of surface waters have been set by the Ministry of the Environment (1984); in this regard, the pH should be within the range of 6.5 and 8.5. For protecting aquatic life, the Ministry has no specific guideline or objective; however, in general, the pH of water should not vary beyond the range of pH 6.5 - 9.0 (**Canadian Water Quality Guidelines** 1987). As noted in Table 1, the pH of Swan Lake complies with both sets of objectives/guidelines.

Suspended solids, in water results from particles such as clay, silt, organic matter, plankton, and other microscopic organisms. While generally non-toxic to aquatic organisms, high levels can reduce photosynthesis of submerged, rooted aquatic vegetation and algae, which may, in turn, suppress fish productivity (Ontario Ministry of the Environment 1979). In this regard, the European Inland Fisheries Advisory Committee (1965) indicated that temporarily high concentrations of suspended solids (i.e., >400 mg/L) should be prevented in rivers where good fisheries are to be maintained, even though several thousand milligrams of solids per litre may not kill fish during exposure of several hours or days. In a comprehensive study of the effects of salmonids (arctic grayling), McLeay et al (1984) found that at suspended solids >100 mg/L, fish growth was depressed and feeding responses slowed. At concentrations of 300 mg/L and greater, fish were displaced downstream, oxygen uptake rates were increased, and tolerance to a toxicant was reduced. Because suspended solids can vary substantially in surface waters, federal guidelines limit variation to 10% from a seasonally adjusted norm for a given water body; there are no provincial objectives or guidelines. For waters which average less than 100 mg/L suspended solids, the **Canadian Water Quality Guidelines** (1987) permit up to 10 mg/L variation, since good to moderate fisheries can be maintained at concentrations less than 100 mg/L. As shown in Table 1, suspended solids in Swan Lake were well below the above noted concentrations, and would not impair resident fish stocks or undermine related habitat.

Phosphorus is a non-metallic element which occurs in dissolved and particulate, organic and inorganic forms in water. In a chemically combined state (the elemental form is rare), it is virtually non-toxic to aquatic life. It is the principal nutrient causing eutrophication, and is part of the cycle of nature. However, this element is also present in human and domesticated animal wastes, farm and industrial waste water, and a variety of products, such as soaps and fertilizers, that end up in sanitary and storm sewage or runoff.

As well, human activities result in increased levels of phosphorus in the airborne particles that settle or fall with precipitation onto lake surfaces. Other human actions, particularly the clearing of forests and vegetation, reduce the ability of the lands around lakes to retain phosphorus, resulting in further increases in phosphorus discharges to water. Nutrients other than phosphorus (nitrogen, carbon, silica and manganese) are also necessary for plant growth, but they are generally available in adequate supply; as well, they can only be used by algae and weeds if sufficient phosphorus is available.

The most obvious effects of increased levels of phosphorus in lakes are more algae and weeds, less clear water, and in some cases reduced habitat for cold water fish species. These changes are generally considered to be undesirable, although it should be emphasized that native aquatic weeds are part of a healthy, productive lake ecosystem, and, like much else in nature, should not be viewed as intrinsically bad, even though they may physically interfere with certain recreational activities such as swimming, boating, and fishing. The effects of increased phosphorus loadings are generally not detectable from one year to the next, but if they are permitted to increase unabated, they can be noticed from one decade to the next, and can be very significant over a generation or a lifetime.

It is the Ministry of the Environment's management objective to limit phosphorus inputs to surface waters in order to protect recreational use potential and fish habitat. The Ministry's publication **Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment** (1984) includes in its phosphorus guidelines for lakes the following:

> "Current scientific evidence is insufficient to develop a firm objective at this time. Accordingly, the following phosphorus concentrations should be considered as general guidelines which should be supplemented by site specific studies:
>
> To avoid nuisance concentrations of algae in lakes, average total phosphorus concentrations for the ice-free period should not exceed 20 ug/L;
>
> A high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration for the ice-free period of 10 ug/L or less. This should apply to all lakes naturally below this

value;

Excessive plant growth in rivers and streams should be eliminated at a total phosphorus concentration below 30 μg/L."

According to data collected on November 26, 1993, the total phosphorus concentrations in Swan Lake were less than 5 μg/L, except for Station D, at which a concentration of 11 μg/L was recorded. These data suggest nutrient-poor or oligotrophic conditions.

Ammonia nitrogen, enters surface waters directly from municipal and industrial effluents, agricultural runoff and atmospheric precipitation. Indirectly, it can also input, via chemical and biological transformation of nitrogenous material in soil and water, nitrogen fixation of dissolved oxygen in water, and excretion of ammonia by biota. Aquatic ammonia is in constant equilibrium with its ionized ammonium form, a relationship which is highly temperature and pH dependent. Un-ionized ammonia is the form most toxic to aquatic biota, and the Ministry of the Environment and Energy has indicated that concentrations should not exceed 0.02 mg/L for the protection of aquatic life (Ministry of the Environment 1984). Transformation of the November 26th ammonia readings in Table 1 to the un-ionized form by incorporating temperature and pH effects generated values which were less than the Ministry's objective.

Total Kjeldahl nitrogen is a measure of ammonia plus organic nitrogen. This latter parameter is not a concern to aquatic life or human health, so no guidelines have been proposed; its role is mainly related to the supply of ammonia resulting from the hydrolysis of organic compounds. Concentrations in Swan Lake are quite typical of other good quality southern Ontario streams and lakes.

Nitrate nitrogen, is the principal form of nitrogen in natural waters, and results from the complete oxidation of other nitrogen compounds, particularly ammonia. A numerical limit has not been established by the Province of Ontario for nitrates in surface waters, although it is recognized that elevated levels may contribute to nuisance vascular and algal plant growth; as noted below, nitrogen does not limit plant growth in Myers Lake. Nitrate nitrogen is not toxic to fish at concentrations normally found in lakes and streams; in this regard, toxicity information provided in the **Canadian Water Quality Guidelines** (1987), indicate an acute lethal concentration of 5,800 mg/L for chinook salmon and 6,000 mg/L for rainbow trout, and some mortality of rainbow trout eggs at concentrations as low as 5 mg/L. As noted in Table 1, nitrate nitrogen levels were always substantially lower than above-noted concentrations.

Total nitrogen to total phosphorus ratios, less than 10 indicate nitrogen limitation, whereas ratios greater than 10 reveal a phosphorus limited system. The average ice-free total nitrogen to total phosphorus ratio for Swan Lake was 184, confirming that phosphorus is the key element limiting trophic conditions.
Heavy metals (iron, mercury, cadmium, nickel, lead, copper, zinc, chromium, arsenic, and free cyanide) were detected at all five sampling sites; however, concentrations were always less than the Ministry of the Environment and Energy's objectives.

Phenols should not exceed 0.001 mg/L to protect against the tainting of edible fish flesh; as noted in Table 1, concentrations at the five sampling sites were less than this limit.

APPENDIX 'C'

Proposed Vegetation

APPENDIX 'C'

Proposed Vegetation

Table C-1

<u>Open Waters: 0.5 m to 1.5 m deep</u>	
pond lily	*Nuphar variegatum*
water lily	*Nymphaea odorata*
pondweed	*Potamogeton richardsonii*
pondweed	*Potamogeton pectinatus*
<u>Lake margins and waters to 0.75 m deep</u>	
bur-reed	*Sparganium eurycarum*
sweet flag	*Acorus calamus*
soft-stem bulrush	*Scirpus validus*
<u>Lake margins and waters to 0.75 m deep</u>	
bur-reed	*Sparganium eurycarum*
sweet flag	*Acorus calamus*
soft-stem bulrush	*Scirpus validus*
<u>Shores and waters to 0.5 m deep</u>	
narrow-leaved cattail	*Typha angustifolia**
wide-leaved cattail	*Typha latifolia*
giant reed	*Phragmites australis**
river bulrush	*Scirpus fluviatilis*
<u>Shores and waters to 0.25 m deep</u>	
blue flag	*Iris veriscolor*
pickerelweed	*Pontedaria cordata*
arrowhead	*Sagittaria latifolia*
water plantain	*Alisma plantago-aquatica*

Lake riparian zone	
bulrush	*Scirpus atrovirens*
bulrush	*Scirpus cyperinus*
rush	*Juncus effusus*
spike rush	*Eleocharis palustris*
reed canary grass	*Phalaris arundinacea**
sedges	*Carex lacustris**
Joe-Pye-weed	*Eupatorium maculatum*
rice cutgrass	*Leersia oryzoides*
marsh milkweed	*Asclepias incarnata*
ninebark	*Physocarpus opulifolius*
red-osier dogwood	*Cornus stolonifera**
nannyberry	*Viburnum lentago*
highbush cranberry	*Viburnum trilobum*
willow	*Salix eriocephala**
Lower slopes near shore	
eastern white cedar	*Thuja occidentalis*
black willow	*Salix nigra*
silver maple	*Acer saccharinum*
red maple	*Acer rubrum*
green ash	*Fraxinus pennsylvanica*
bur oak	*Quercus macrocarpa*
red-osier dogwood	*Cornus stolonifera**
nannyberry	*Viburnum lentago*
highbush cranberry	*Viburnum trilobum*
Upper slopes	
white pine	*Pinus strobus*
red oak	*Quercus rubra*
white oak	*Quercus alba*
ironwood	*Ostrya virginiana*
basswood	*Tilia americana*
white ash	*Fraxinus americana*
white birch	*Betula papyrifera*
sugar maple	*Acer saccharum*
gray dogwood	*Cornus racemosa*
witch hazel	*Hamamelis virginiana*
choke cherry	*Prunus virginiana*
servicberry	*Amelanchier arborea*
beaked hazel	*Corylus cornuta*
elderberry	*Sambucus canadensis*

* - indicates species already on site

APPENDIX 'D'

Long Term Maintenance

APPENDIX 'D'

Long Term Maintenance

As with all surface waters that are downgradient from development and which receive overland drainage and treated stormwater runoff, some problems may occur from time to time. However, these are expected to be negligible given the present excellent water quality conditions of the Lake, and the BMP's that are proposed within the Swan Lake Community.

In the paragraphs below, potential Lake quality issues are identified and evaluated in terms of maintenance requirements.

1. Surface Water Quality

For most rainfall events, the only overland flow to the Lake will relate to sheet flow from the lake's immediate shoreline environment, and not from the majority of the developed watershed. As indicated in **Section 3.1,** naturalization of most of the lake's riparian shoreline will effectively filter and assimilate nutrients, suspended solids and other "pollutants" present in overland runoff draining directly to the lake, meaning negligible water quality impacts.

OK

The two stormwater detention ponds will attenuate in excess of 80% of the suspended solids, bacteria, etc. in stormwater from the developed area of the watershed, with discharge to the stormwater system south of 16th Avenue for all rainfall events. During rainfall events greater than 25 mm, runoff volumes in excess of the quality pond's storage capacity will be directed to the lake. Under no circumstances will stormwater be discharged untreated from the site.

calcs? reference

See pg. E.10

The above measures will virtually eliminate long term impacts of accelerated enrichment and diminished lake aesthetics.

2. Turbidity

Turbid water seldom kills fish, although it may slow growth, affect flesh taste, and impair aesthetics. As well, high turbidity may prevent growth of desirable floating and submerged aquatic vegetation. With the high content of clays and silts found in the littoral zone of the Lake, there is some potential for this problem in localized unrestored areas. However, such problems are not anticipated, given the extent of bank and bottom stabilization that is proposed with various riparian, emergent, submergent, and open-water plants.

3. **Excessive Aquatic Vegetation**

Although vascular aquatic plants are essential components of good fisheries habitat, excessive growths can use up dissolved oxygen, impair pond aesthetics, and interfere with recreational activities such as angling, canoeing and paddleboating. The best way to control growth is to make certain that physical habitat and light conditions are not optimal. Such opportunities are available with the restoration program proposed for the Lake. In this regard, the near-shore bottom substrates will be contoured in some areas to sustain growths of emergent and submergent plants (ie. in natural and remote areas); in contrast, much of the littoral zone will have a relatively steep grade below the lake's standing surface level, meaning little to no plant material. **Accordingly, offensive growths of aquatic plants are not considered problematic for the lake, meaning no long-term maintenance/management liabilities.**

4. **Algal Blooms**

Algae are tiny microscopic plants which grow naturally in lakes. An algal bloom is a dense concentration of such plants. Most algal blooms in Ontario lakes consist either of diatoms or blue-green algae. Diatom blooms usually occur in the late spring or early summer, an can turn the water slightly brown; however, they do not create the scums and odours normally associated with blue-green blooms. In fact, diatom blooms often occur without being noticed by lake users. In contrast, blue-green blooms can cause a greater problem for lake users because they are subject to concentration by wind action and scum formation. This scum may be blown into shallow areas and onto exposed shorelines, thereby making the lake's edge appear to be covered with blue-green paint. When these shoreline accumulations die and decompose, the resulting odour can be unpleasant. The best solution is to locate the source of the problem, which is almost always phosphorus, and reduce its access to the system. **With respect to the Lake, its ambient phosphorus concentrations are very low (ie. about 5 ug/l), an well below levels normally associated with algal blooms (ie. >20 ug/l). Given the low levels and BMP's described earlier, the likelihood of periodic algal blooms is remote.**

5. **Fish Kills**

Oxygen depletion problems are most common in later winter, when decomposition of the previous years' vegetation uses up much of the dissolved oxygen that fish need. Most kills occur in shallow bays which are cut off from the main lake or pond by ice; in these instances, fish cannot move from an area low in oxygen to more suitable waters. Also, there can be summer fish kills in shallow, very weedy ponds, at night when oxygen consumed by plant respiration counterbalances daytime oxygen produced by photosynthesis, and on calm, cloudy days when photosynthesis and aeration are low.

Summer and winter kills from inadequate dissolved oxygen can usually be avoided by ensuring that substantial areas of the pond are 2 m to 3 m in depth, which is the present situation in the Lake, and by ensuring sufficient depth so that fish can move from shallow embayments into the main pond. Dissolved oxygen can be added directly to ponds with a surface aerator or a small compressor and air diffuser line. As well, winter dissolved oxygen levels can sometimes be increased, particularly on smaller ponds, by clearing the ice to allow light penetration and photosynthesis; however the benefits often may not be worth the considerable effort involved. **The moderately deep character of the lake will be sufficient to offset winter fish kills, while the best management practices described above will maintain plant biomass (ie. algal and emergent and submergent vascular aquatics) at levels that are insufficient to cause oxygen depletion.**

6. **Undesirable Fish**

Overpopulation of a particular species of fish can occur in a lake, either by a preferred species (largemouth bas or bluegills), the presence of a few large predatory fish (rainbow trout), or an abundance of coarse fish such as suckers, carp, creek chub, or bullheads. Reclamation can be achieved either by draining, or using a fish toxicant, or a combination of both methods. Rotenone is the normal compound used to kill fish. A permit from the Ministry of the Environment and Energy is needed for any use of rotenone.

7. **Sedimentation**

Sedimentation within the Lake will be related primarily to the state of the adjacent banks and the quantity of suspended solids in surface run-off entering the water. In this regard, the quantity of suspended solids in urban surface water fun-off directly proportional to the frequency of street sweeping, catchbasin cleaning, and quantity of winter sanding (largest source). The restoration plan for the Lake is to stabilize its existing eroding banks with various plantings. In addition, off-line extended detention ponds are proposed to allow settling of suspended solids. **Since all sources of suspended solids are to be eliminated, there will be no significant sedimentation.**

The extended detention facility which are specifically designed to settle out solids from surface run-off will require occasional cleaning and maintenance to ensure their efficient operation. The frequency of maintenance will relate to the level of street sweeping, catchbasin cleaning and winter sanding. Since extended detention facilities are relatively new to the area, maintenance histories are not available. However, regular sediment removal within the ponds is anticipated every 10 to 15 years, given clean-out following all construction activities. The ponds should be cleaned once two thirds of the sediment design storage has been filled. Maintenance roadways are provided to each facility to facilitate cleaning.

APPENDIX 'E'

Stormwater Management Details

APPENDIX 'E'

Stormwater Management Details

E. Storm Drainage Plan

E.1 Previous Study Recommendations

The *Environmental Management and Master Servicing Plan For Urban Expansion Areas in the Bruce Creek, Burndenet Creek, Robinson Creek and Exhibition Creek Subwatersheds* was prepared for the Town of Markham in November 1993 to study environmental and storm drainage in support of the secondary planning exercise for future urban lands, including Study Area 1B. This study recommends a resource management strategy for developing areas in the Exhibition Creek subwatershed including a preferred approach to providing best management practices and storm drainage systems for the Swan Lake Community.

The Swan Lake Community falls within Area 29, identified in the previous study. Recommendations made for the management of surface water in this subarea are summarized in **Table E-1**.

Based on an evaluation of several storm drainage alternatives, the use of the former gravel pit area for both water quality and quantity control was recommended. As well, recommendations were made to discharge roof leaders to grassed areas and review the feasibility of localized use of grass swales.

The *Environmental Management and Master Servicing Plan* recommended that subsequent studies in support of draft plans of subdivision complete the activities noted in **Table E-1**. This Environmental Management Study for the Swan Lake Community has addressed each of these items.

Table E-1

Summary of BMP and Storm Drainage Recommendations

(Source - Environmental Management Servicing Plan for Urban Expansion Areas in the Bruce Creek, Burndenet Creek, Robinson Creek and Exhibition Creek Subwatershed)

AREA 29 **Exhibition Creek Subwatershed - Study Area 1B**
• The first flush portion of the minor system flows are to be directed to extended detention facilities. Extended detention storage may be provided by using a berm to create offline embayments within the existing Reesor Pond *. The design of this arrangement must be compatible with the Town of Markham's future plans for the pond.
• The extended detention cell is to be sized to accommodate the runoff volume from a 2 hour duration 25 mm rainfall event on the service area. This design volume is to be released over minimum period of 24 hours.
• Flows from the extended detention cells are to be discharged into the foundation drain collector system that ultimately outlets to the existing storm sewer in the Mintleaf subdivision.
• Major system flows to be discharged uncontrolled into Reesor Pond which will provide quantity storage. Release from the pond is to be to the Mintleaf storm sewer. The total release rate is not to exceed the downstream capacity.
• The Reesor Pond currently has no outlet. An emergency overflow must be designed to convey flows out of the pond in the case of extreme storm conditions.

* The Reesor Pond is the ponded water within the former gravel pit.

E.2 Best Management Practice (BMP) Review

The use of wet extended detention facilities to provide stormwater quality control for the Swan Lake Community lands was conceptually selected based on a comprehensive evaluation by the *Environmental Management & Master Servicing Plan in the Bruce Creek, Burndenet Creek, Robinson Creek, and Exhibition Creek Subwatersheds, Volume 5 (1993)*. The selection of this type of Best Management Practice (BMP) was confirmed to be appropriate by the more detailed soils, land use and grading information available.

In this regard, Peto MacCallum Ltd. has recently completed a detailed soils investigation of the Swan Lake Community lands. This investigation has found that, as expected, the surficial soil across the majority of the site is predominately dense sandy silt till. The granular kame deposit which was identified in the Town of Markham's *Environmental Management and Master Servicing Plan, Volume 1*, was found to be saturated and at considerable depth below the proposed grades. Therefore, infiltration based BMPs will not be appropriate for the Swan Lake Community lands.

Proposed site layout and grading information generally provided the identical situation as assumed in the overall Environmental Management and Master Servicing Plan. The site will essentially be divided into two large drainage basins; one draining to the north side of the former gravel pit and one draining to the east side. Therefore, based on the detailed soils and site layout/grading information, the proposed extended detention facilities are appropriate for use in this area.

However, detailed analysis of the site grading shows that a small 2.2 ha area may not be drained to the proposed Lake due to the relative grades between 16th Avenue and the proposed lake. Based on the small size of this area, it's relatively impervious soils and the drainage outlet to existing storm sewer, soft BMP measures such as roof leaders to pervious areas and grassed swales have been recommended for this portion of the site. In this regard, the Town of Markham design standards require a minimum slope of 2% along all grassed swales. However, in this 2.2 ha, the use of shallower swales (*approximately 1%*) is recommended to promote additional attenuation and filtering of surface run-off. The expected removal efficiency of a well designed and maintained conventional grassed swale is projected to be 70% for total suspended solids, 30 % for total phosphorus, 25 % for total nitrogen and 50% to 90 % for trace metals (*A Current Assessment of Urban Best Management Practices, T. Schueler, P. Kumble, M. Heraty, March 1992*).

Grassed swales along the roadways are not compatible with this proposed development due to the number and close proximity of driveways.

E.3 Outlet Capacities

Area 29 currently drains predominantly to either the former gravel pit, to a storm sewer inlet on 16th Avenue roughly 650 m west of 9th Line, from the west drainage area or to the Exhibition Creek. Conditions and capacities of these outlets include:

- **The 16th Avenue storm sewer** inlet was designed to accept a 2 year pre-development peak flow of 1.166 m^3/s from a 39.7 ha area north of the 16th Avenue south right-of-way limit. Since there has been no allowance made for overland flows to the south of 16th Avenue, all post development flows from north of 16th Avenue must be controlled to the 1.166 m^3/s peak flow. Previous stormwater management studies in support of the development south of 16th Avenue have identified the former gravel pit as an attenuation pond location to control the flows north of 16th Avenue to the specified rates.

- **The former gravel pit has no outlet.** Captured water either infiltrates or evaporates. The proposed lake will have a restricted outfall to the 16th Avenue storm sewer.

- **The west drainage area** sheet drains across private property to the Exhibition Creek. Post Development flows must be controlled to the pre-development level for the 2 through 100 year peak flows. This control will ultimately be provided by an off-site stormwater management pond adjacent the Exhibition Creek.

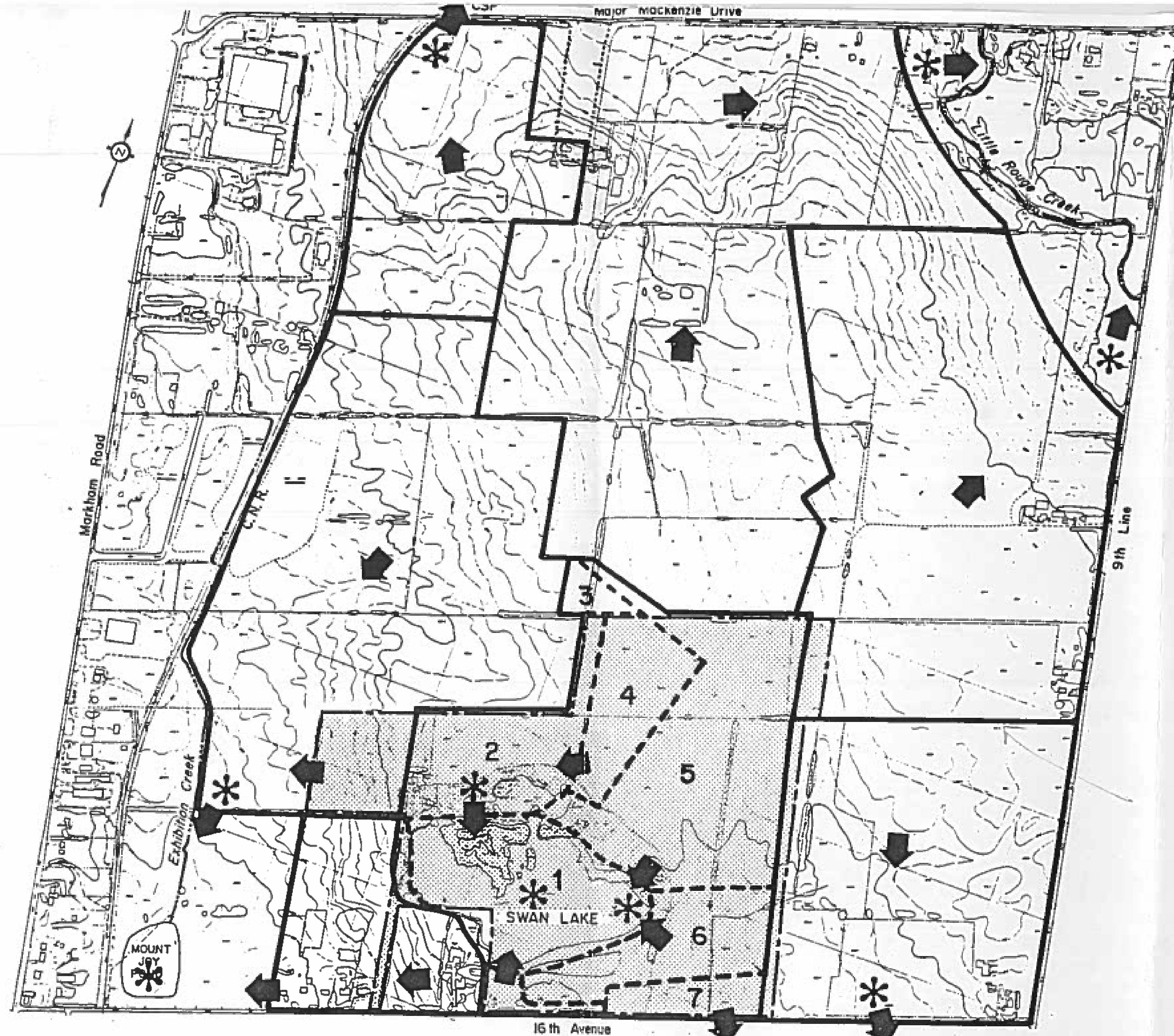
An additional storm sewer inlet is located on 16th Avenue approximately 310 m west of Ninth Line. This inlet was designed to drain the 2 year pre-development flows from a 60.7 ha area north of the South 16th Avenue right-of-way limit (see **Drawing 2**). An overland flow route to the south has also been provided at this location.

E.4 Major/Minor System Design

The proposed overland flow and storm sewer drainage routes within the Villages of Swan Lake are shown on **Drawing 2.** As shown, the site is divided into four drainage basins; north, south, east and west.

- **The north and east drainage basins** drain to the extended detention ponds and the Lake. Since the Lake will be required to provide stormwater runoff quantity control, the site must be graded to convey overland drainage to the lake. As shown by the existing grades, the site will require a significant amount of fill to drain the north and east areas in this direction. To minimize fill requirements;

    → the storm sewers in these areas are designed with a minimum grade and cover to minimize the required fill on the site.
    As a result of the shallow storm sewers, a foundation drain collection system will be required to provide protection for the basements which are below the obverts of the proposed storm sewer system. As shown



LEGEND:

- EXTERNAL DRAINAGE BOUNDARY
- DRAINAGE DIRECTION
- PROPOSED STORMWATER MANAGEMENT FACILITY
- INTERNAL DRAINAGE BOUNDARY
- SWAN LAKE COMMUNITY LANDS (STUDY AREA)

SWAN LAKE VILLAGES INC.

ENVIRONMENTAL MANAGEMENT STUDY

FIGURE E-1

PROPOSED EXTERNAL DRAINAGE

on **Drawing 2**, the foundation drain collector will outlet to the existing storm sewer south of 16th Avenue which is located well below the basement elevations.

→ road grades (overland flow routes) will be "sawtoothed" along the longer streets. This concept will create localized low points up to a maximum of 0.15 m deep which will fill and overtop during a high intensity storm.

- **The south drainage area** is too low to be drained to the Lake. Therefore, storm sewers and overland flow routes will convey stormwater run-off directly to the existing storm sewer south of 16th Avenue.

- **The west drainage area** is also too low to be drained towards the Lake. Therefore, these lands will be drained to Exhibition Creek in conjunction with future external development (**Figure E-1**).

- **External drainage areas** to the Swan Lake Community lands include one small area north of the site which will be drained through the site to the Lake (**Figure E-1**).

E.5 Quantity Control

The post-development flows from subarea 29 were calculated using the OTTHYMO computer model (**Appendix F** for output and modelling parameters). The results of this analysis have been analyzed below for each drainage area.

- **Drainage to the Lake - East and West Drainage Areas**

  As shown in **Drawing 2**, a total drainage area of 52 ha (both north and east areas) will be conveyed towards the Lake. Piped and overland flows in excess of the 25 mm rainfall runoff will be conveyed into the Lake at 3 locations for attenuation. As previously described, the former gravel pit has no existing drainage outlet and all inflows either evaporate or infiltrate. In order to ensure a constant water level and positive drainage of the Lake, a gravity outlet must be provided at the normal water elevation. Due to the downstream drainage constraints of the 16th Avenue storm sewer of 1.166 m^3/s, the Lake release rate will be restricted to 100 l/s. This restricted outlet rate will require essentially all stormwater runoff to the Lake to be attenuated since it is well below the post development runoff rates.

In addition to the controlled outlet from the Lake, an emergency overflow was provided along the west shore at an elevation of 210.3 m (**see Drawing 2**). In the event of a severe storm in excess of Hurricane Hazel, the ponded water within the Lake will spill out of the west side via an overland flow easement to the north-south collector road. The spill will be directed southwards along this road to 16th Avenue and then to the Exhibition Creek.

Table E-2 below summarizes the drainage and attenuation characteristics of the Lake. The stage/storage/discharge relationships shown below in **Table E-3**.

Table E-2

Swan Lake - Drainage and Attenuation Characteristics

Storm	Peak Inflow (m^3/s)	Peak Outflow (m^3/s)	Storage (m^3)	Elevation (m)	Fluctuation (m)	Draw Down Time* (hrs)
25 mm	0.0	0.00	0	208.35	0.00	0
2 Year	3.9	0.03	8880	208.50	0.15	14
5 Year	6.6	0.04	13080	208.57	0.22	22
25 Year	11.3	0.05	20440	208.70	0.35	37
100 Year	16.3	0.06	28860	208.85	0.50	49
Regional	5.9	0.10	68610	209.51	1.17	110

* includes 5500 m^3/day seepage (Peto MacCallum Ltd., March 1993)

Table E-3

Swan Lake Stage/Storage/Discharge Characteristics

Stage (m)	Storage (m^3)	Discharge (m^3/s)
208.35	0	0.00
209.35	58,000	0.09
210.35	122,000	0.13

- **Uncontrolled Drainage into Subarea 30 - Drainage to the East**

As shown on **Drawing 2,** a 1.3 ha area of the east basin, consisting primarily of rear lots and a portion of the east/west site entrance road will drain to the east. This area slopes away from the Lake to match the existing grades along the east property limit. Runoff will ultimately drain to the future north-south roadway along the east property line. This roadway will be drained via a storm sewer to the existing storm sewer inlet 310 m west of 9th Line.

A 4.0 ha area of the Swan Lake Community lands is presently tributary to the 16th Avenue storm sewer inlet located 310 m west of Ninth Line (**Figure E-4**). Therefore the 1.3 ha area consisting primarily of rearyard areas will continue draining uncontrolled to that outlet.

- **16th Avenue Right-of-Way Drainage Area**

The existing storm sewer adjacent to the Swan Lake Community lands south of the 16th Avenue right-of-way was designed to accommodate a 39.7 ha area with a 2 year pre-development peak flow of 1.166 m^3/s. A 2.07 ha area of the 16th Avenue right-of-way presently drains uncontrolled to the existing storm sewer. Based on a pro-rated area, the 16th Avenue drainage contribution must be controlled to it's proportionate share of 0.053 l/s total flow. Therefore, the 16th Avenue storm sewer system must be retrofitted by the Town of Markham to provide this level of control through inlet controls and attenuation facilities.

- **South Area - Uncontrolled Drainage**

As shown in **Drawing 2,** a 2.2 ha drainage area located adjacent 16th Avenue was graded to drain towards 16th Avenue.

The allowable release rate into the 16th Avenue storm sewer from the South Area was calculated to be 851 l/sec as follows:

1166 l/s	(total allowable inlet south of 16th Avenue R.O.W for 39.7 ha)
- 53 l/s	(proportionate release rate for 16th Avenue storm sewers based on a pro rated area basis - 2 ha of R.O.W)
- 12 l/s	(north extended detention pond release rate)
- 19 l/s	(west extended detention pond release rate)
- 132 l/s	(foundation drain collector release rate @ 0.075 l/s/unit)
- 100 l/s	(proposed swan lake maximum release rate)
851 l/s	(South Area allowable release rate)

The post development peak stormwater run-off rates from the South Area are provided below in **Table E-4.**

Table E-4

South Area
Post Development Peak Flows

Storm	Flow (m^3/s)
2 Year	180
5 Year	330
25 Year	580
100 Year	840
Regional	270

As shown above, all post development flows from the 2.2 ha South Area are less than the 851 l/s allowable release rate. Therefore, **no stormwater quantity control is required for the South Area.**

- **West Area**

The west area has no present outlet other than sheet drainage across private lands to the Exhibition Creek. Post development control for the 100 year peak flows to predevelopment levels will be provided for this area in conjunction with future development of adjacent lands. As shown in **Figure E-5**, an off-site stormwater management facility has been proposed adjacent the Exhibition Creek to service this area.

E.6 Quality Control

Two wet extended detention ponds will be required within the Swan Lake Community lands to accommodate the proposed site layout and required grading. As shown on **Drawing 2**, a 14 ha area will be directed to the North pond located between the proposed road and the nature reserve island; a 25 ha area will be directed to the east pond which is located within the east limit of the former gravel pit, between the proposed road and lake.

- **Pond Volumes**

  The wet extended detention ponds were designed to attenuate the stormwater run-off generated by a 2 hour duration, 25 mm rainfall. Run-off volumes were calculated with the OTTHYMO hydrology model (**Appendix F**). The resulting rainfall runoff volumes from the developed areas are 1,070 m^3 to the north pond and 1,665 m^3 to the east pond.

- **Pond Layout**

  The conceptual grading of the north and east ponds is shown on the appended Master Plan (**Drawing 1**). The pond berms have been graded with varying slopes between 3:1 and 5:1 (H:V) to provide a naturalized variable appearance within each facility. A sediment forebay has been provided at the storm sewer inlets. This feature will concentrate larger sediments to facilitate future maintenance. A shallow area (varying between 0.3 to 0.1 m deep) with emergent aquatic plantings will be provided at the pond outfall. This feature will provide both varying natural habitat and nutrient uptake. A maintenance access has been provided from the adjacent road to each pond at a maximum grade of 10%.

- **Flow Splitters**

  As shown on **Drawing 2,** storm sewer flows will be conveyed to the north pond via one inlet and to the east pond via two inlets. A flow splitter will be constructed immediately upstream of each pond outfall to direct the 25 mm storm run-off directly to the extended detention ponds. A weir within the flow splitters will be constructed with a crest elevation at the maximum extended detention ponding elevation. Therefore, any storm flows in addition to the pond volumes will bypass the ponds and enter the proposed Lake for flood control attenuation.

- **Pond Fluctuation**

The normal water surface elevation within the extended detention facilities will be maintained at the present groundwater regulated ponding elevation of 208.35 m. The ponds will be graded to allow a maximum of 0.8 and 0.5 m fluctuation within the east and north ponds respectively during a 25 mm rainfall. Fluctuation within the ponds will be minimal due to the relatively shallow and gradually graded storm sewers adjacent to the ponds.

As noted in the *Interim Stormwater Quality Control Guidelines for New Development, MOEE, May 1991*, the 25 mm rainfall is a relatively infrequent event. Ninety percent (90%) of daily precipitation events are less than 15 mm. The majority of precipitation events are less than 5 mm (approximately 87%). The associated ponding volumes and fluctuations for these rainfall events are shown below in **Table E-5.**

Table E-5

Extended Detention Pond Volumes and Fluctuation

Rainfall Depth (mm)	North Pond	North Pond	East Pond	East Pond
	Volume (m^3)	Fluctuation (m)	Volume (m^3)	Fluctuation (m)
25 mm	1070	0.5	1665	0.8
15 mm	460	0.2	678	0.3
5 mm	120	0.1	175	0.1

- **Stormwater Runoff Quality Benefits**

Monitoring studies of conventional wet ponds as published in "*A Current Assessment of Urban Best Management Practices, March 1992, T. Schueler, P. Kumble, M. Heraty*" have shown significant water quality benefits. Reported removal rates include 50% to 90 % total suspended solids, 30% to 90% phosphorus, 40% to 80% removal of soluble nutrients and moderate to high removals of trace metals, coliforms, and organic matter.

Although not well documented, the provision of extended detention and shallow areas for emergent plant growth are believed to improve the effectiveness of conventional wet ponds by:

- → reducing the resuspension of particulates through the use of deep pools at outlets;
- → settling finer particles through increased detention times;
- → stabilizing deposited sediments by plant growths; and,
- → providing additional nutrient uptake during the growing season.

- **Functional Relationship with the Lake**

The normal surface water elevation within the ponds and the Lake will be maintained at the present elevation within the former gravel pit. Peto MacCallum Ltd. has established this surface water elevation to be coincident with the adjacent groundwater elevation.

All stormwater inflows to the extended detention ponds will be outlet to the foundation drain collection system which ultimately drains to the storm sewers south of 16th Avenue. Therefore, water quality conditions of the Lake will not be impacted by site stormwater run-off.

As shown on **Drawing 1**, the grading and vegetation of the proposed Lake and adjacent ponds will be similar to maintain continuity.

APPENDIX 'F'

OTTHYMO Models

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     *
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     *         DATE         :October 29, 1993
     *
     *         AUTHOR       :SMS
     *
     *         DESCRIPTION  :Analysis of Swan Lake ponding characteristics
     *                      :Roof areas directed to pervious areas
     *
     *
     *         STORM        :5mm, 15mm, 25mm, 2 hour, 10 min time steps
     *                      :2,5,25,100 chicago storms, 4 hour duration,10 mi
     *                      :Regional Storm
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     *  COMMAND                 PURPOSE
     * 1:   *NEWPAGE        GENERATES PAGE BREAK CHARACTER FOR PRINTER
     * 2:   *PUNCH          CREATES A SEPARATE FILE CONTAINING A STORED
     *                      HYDROGRAPH IN A FORMAT WITH OTTHYMO
     * 3:   *EX PLOT        CREATES A SEPARATE HYDROGRAPH FILE WITH THE FLOW
     *                      STORED IN A COLUMNAR FASHION. USED TO TRANSFER
     *                      TO AN EXTERNAL PROGRAM FOR HIGH QUALITY PLOTTING
     * 4:   *MODIFY         CREATES A SEPARATE FILE CONTAINING A HYDROGRAPH
     *                      IN THE STORE HYD FORMAT. THE HYDROGRAPH IS
     *                      ALTERED BY TRANSFERRING ALL FLOW GREATER THAN A
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     START              START TIME OF RAINFALL  0.0 HOURS
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     * Area 1
     *
     COMPUTE URBHYD     ID  1  HYD 100 TIME STEP 0.1667 HR   AREA 11.0 HA
                        CKK 1  XIMP  0.54 TIMP 0.58  RAINFALL INTERVALS *12*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 271 M   MNI 0.015
                        SLP 1.00 %  LGP 271 M   MNP 0.25
                          mm\hr WITH A TEN MIN TIME STEP
                         1.6   1.6   1.6   2.4   5.1   4.6
                         3.3   2.6   2.4   1.6   1.6   1.6
        UNIT PEAK =      .074 CMS
        PEAK INTENSITY(RAIN EXCESS) =      4.60 MM/HR
        STORAGE COEFF. SC =     17.35 MINS
```

} Town of Markham

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     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

     UNIT PEAK =      .002 CMS
     PEAK INTENSITY(RAIN EXCESS) =       .03 MM/HR
     STORAGE COEFF. SC =  750.91 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    5.89

     TOTAL RAINFALL =      5.00 MM

     PEAK DISCHARGE =        .050 CMS  RUNOFF VOLUME =     1.89 MM   TIME TO PEA

     RUNOFF VOLUMETRIC COEFFICIENT =    .38

*
* Area 2
*
COMPUTE URBHYD         ID  2  HYD 110 TIME STEP 0.1667 HR   AREA 6.0 HA
                       CKK 1  XIMP  0.28 TIMP 0.56  RAINFALL INTERVALS *12*
                       FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR   F 0 MM
                       DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                       SLI 1.00 %  LGI 200 M  MNI 0.015
                       SLP 1.00 %  LGP 200 M  MNP 0.25
                       RAINFALL CODE  -1
     UNIT PEAK =      .085 CMS
     PEAK INTENSITY(RAIN EXCESS) =      4.60 MM/HR
     STORAGE COEFF. SC =   14.46 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

     UNIT PEAK =      .003 CMS
     PEAK INTENSITY(RAIN EXCESS) =       .03 MM/HR
     STORAGE COEFF. SC =  625.79 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    5.94

     TOTAL RAINFALL =      5.00 MM

     PEAK DISCHARGE =        .015 CMS  RUNOFF VOLUME =      .98 MM   TIME TO PEA

     RUNOFF VOLUMETRIC COEFFICIENT =    .20

*
* Area 3
*
COMPUTE URBHYD         ID  3  HYD 120 TIME STEP 0.1667 HR   AREA 1.5 HA
                       CKK 1  XIMP  0.28 TIMP 0.56  RAINFALL INTERVALS *12*
                       FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR   F 0 MM
                       DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                       SLI 1.00 %  LGI 100 M  MNI 0.015
                       SLP 1.00 %  LGP 100 M  MNP 0.25
                       RAINFALL CODE  -1
     UNIT PEAK =      .110 CMS
     PEAK INTENSITY(RAIN EXCESS) =      4.60 MM/HR
     STORAGE COEFF. SC =    9.54 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

     UNIT PEAK =      .004 CMS
     PEAK INTENSITY(RAIN EXCESS) =       .03 MM/HR
     STORAGE COEFF. SC =  412.87 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    5.96

     TOTAL RAINFALL =      5.00 MM

     PEAK DISCHARGE =        .004 CMS  RUNOFF VOLUME =      .98 MM   TIME TO PEA

     RUNOFF VOLUMETRIC COEFFICIENT =    .20

*
*  Area 4
*
COMPUTE URBHYD         ID  4  HYD 130 TIME STEP 0.1667 HR   AREA 6.5 HA
                       CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *12*
                       FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR   F 0 MM
                       DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                       SLI 1.00 %  LGI 208 M  MNI 0.015
                       SLP 1.00 %  LGP 208 M  MNP 0.25
                       RAINFALL CODE  -1
     UNIT PEAK =      .083 CMS
     PEAK INTENSITY(RAIN EXCESS) =      4.60 MM/HR
     STORAGE COEFF. SC =   14.80 MINS
```

```
     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      6.00

     UNIT PEAK =       .003 CMS
     PEAK INTENSITY(RAIN EXCESS) =        .03 MM/HR
     STORAGE COEFF. SC =   640.69 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      5.94

     TOTAL RAINFALL =       5.00 MM

     PEAK DISCHARGE =        .012 CMS   RUNOFF VOLUME =        .70 MM   TIME TO P

     RUNOFF VOLUMETRIC COEFFICIENT =    .14

 *
 * Add flows to North Quality pond (14 ha total drainage area)
 *
 ADD HYD              NEW ID  2  HYD NO  140   ADD ID  2 TO ID  3
     PEAK FLOW =          .019 CMS      RUNOFF VOLUME =        .98 MM       TIME T
0           ADD HYD        ID=2       HYD NO=140      ID I=2          ID II=3
 ADD HYD              NEW ID  2  HYD NO  150   ADD ID  2 TO ID  4
     PEAK FLOW =          .031 CMS      RUNOFF VOLUME =        .85 MM       TIME T
0           ADD HYD        ID=2       HYD NO=150      ID I=2          ID II=4
 *
 * North Quality Pond
 *
 *
 * Area 5
 *
 COMPUTE URBHYD            ID  3   HYD 160 TIME STEP 0.1667 HR   AREA 19.0 HA
                           CKK 1   XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *12*
                           FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                           DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                           SLI 1.00 %  LGI 356 M  MNI 0.015
                           SLP 1.00 %  LGP 356 M  MNP 0.25
                           RAINFALL CODE  -1
     UNIT PEAK =       .066 CMS
     PEAK INTENSITY(RAIN EXCESS) =       4.60 MM/HR
     STORAGE COEFF. SC =    20.44 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      6.00

     UNIT PEAK =       .002 CMS
     PEAK INTENSITY(RAIN EXCESS) =        .03 MM/HR
     STORAGE COEFF. SC =   884.46 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      5.79

     TOTAL RAINFALL =       5.00 MM

     PEAK DISCHARGE =        .030 CMS   RUNOFF VOLUME =        .70 MM   TIME TO P

     RUNOFF VOLUMETRIC COEFFICIENT =    .14

 *
 * Area 6
 *
 COMPUTE URBHYD            ID  4   HYD 170 TIME STEP 0.1667 HR   AREA 6.1 HA
                           CKK 1   XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *12*
                           FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                           DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                           SLI 1.00 %  LGI 202 M  MNI 0.015
                           SLP 1.00 %  LGP 202 M  MNP 0.25
                           RAINFALL CODE  -1
     UNIT PEAK =       .084 CMS
     PEAK INTENSITY(RAIN EXCESS) =       4.60 MM/HR
     STORAGE COEFF. SC =    14.55 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      6.00

     UNIT PEAK =       .003 CMS
     PEAK INTENSITY(RAIN EXCESS) =        .03 MM/HR
     STORAGE COEFF. SC =   629.53 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      5.94

     TOTAL RAINFALL =       5.00 MM

     PEAK DISCHARGE =        .011 CMS   RUNOFF VOLUME =        .70 MM   TIME TO P

     RUNOFF VOLUMETRIC COEFFICIENT =    .14
```

```
*
* Add flows to East Quality pond (25.1 ha total drainage area)
*
ADD HYD                  NEW ID  3   HYD NO  180   ADD ID  3 TO ID  4
   PEAK FLOW =             .041 CMS        RUNOFF VOLUME =     .70 MM      TIME T
          ADD HYD             ID=3      HYD NO=180      ID I=3          ID II=4
*
* East Quality Pond
*
*
*
* Area 7
*
COMPUTE URBHYD             ID  4  HYD 190 TIME STEP 0.1667 HR   Area 2.2 ha
                           CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *12*
                           FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
                           DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                           SLI 1.00 %  LGI 121 M  MNI 0.015
                           SLP 1.00 %  LGP 121 M  MNP 0.25
                           RAINFALL CODE  -1
    UNIT PEAK =     .103 CMS
    PEAK INTENSITY(RAIN EXCESS) =      4.60 MM/HR
    STORAGE COEFF. SC =   10.70 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

    UNIT PEAK =     .004 CMS
    PEAK INTENSITY(RAIN EXCESS) =       .03 MM/HR
    STORAGE COEFF. SC =  462.89 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    5.95

    TOTAL RAINFALL =      5.00 MM

    PEAK DISCHARGE =       .004 CMS  RUNOFF VOLUME =      .70 MM  TIME TO PEA

    RUNOFF VOLUMETRIC COEFFICIENT =   .14

***************************************************************************
**                           15 mm / 2 hour storm
***************************************************************************
*
* Area 1
*
COMPUTE URBHYD             ID  1  HYD 100 TIME STEP 0.1667 HR   AREA 11.0 HA
                           CKK 1  XIMP  0.54 TIMP 0.58  RAINFALL INTERVALS *12*
                           FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
                           DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                           SLI 1.00 %  LGI 271 M  MNI 0.015
                           SLP 1.00 %  LGP 271 M  MNP 0.25
                             mm\hr WITH A TEN MIN TIME STEP
                            4.8   4.8   4.8   7.2   15.3  13.8
                             9.9   7.8   7.2   4.8   4.8   4.8
    UNIT PEAK =     .103 CMS
    PEAK INTENSITY(RAIN EXCESS) =     15.30 MM/HR
    STORAGE COEFF. SC =   10.73 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

    UNIT PEAK =     .002 CMS
    PEAK INTENSITY(RAIN EXCESS) =       .03 MM/HR
    STORAGE COEFF. SC =  750.91 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    5.89

    TOTAL RAINFALL =     15.00 MM

    PEAK DISCHARGE =       .213 CMS  RUNOFF VOLUME =     7.29 MM  TIME TO PEA

    RUNOFF VOLUMETRIC COEFFICIENT =   .49

*
* Area 2
*
COMPUTE URBHYD             ID  2  HYD 110 TIME STEP 0.1667 HR   AREA 6.0 HA
                           CKK 1  XIMP  0.28 TIMP 0.56  RAINFALL INTERVALS *12*
                           FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
                           DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                           SLI 1.00 %  LGI 200 M  MNI 0.015
                           SLP 1.00 %  LGP 200 M  MNP 0.25
                           RAINFALL CODE  -1
    UNIT PEAK =     .114 CMS
    PEAK INTENSITY(RAIN EXCESS) =     15.30 MM/HR
```

```
     STORAGE COEFF. SC =    8.94 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

     UNIT PEAK =     .003 CMS
     PEAK INTENSITY(RAIN EXCESS) =       .03 MM/HR
     STORAGE COEFF. SC =  625.79 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    5.94

     TOTAL RAINFALL =    15.00 MM

     PEAK DISCHARGE =      .062 CMS  RUNOFF VOLUME =    3.78 MM  TIME TO P

     RUNOFF VOLUMETRIC COEFFICIENT =    .25

 *
 * Area 3
 *
 COMPUTE URBHYD          ID  3  HYD 120 TIME STEP 0.1667 HR   AREA 1.5 HA
                         CKK 1  XIMP  0.28 TIMP 0.56  RAINFALL INTERVALS *12*
                         FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                         DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                         SLI 1.00 %  LGI 100 M  MNI 0.015
                         SLP 1.00 %  LGP 100 M  MNP 0.25
                         RAINFALL CODE  -1
     UNIT PEAK =     .139 CMS
     PEAK INTENSITY(RAIN EXCESS) =     15.30 MM/HR
     STORAGE COEFF. SC =    5.90 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

     UNIT PEAK =     .004 CMS
     PEAK INTENSITY(RAIN EXCESS) =       .03 MM/HR
     STORAGE COEFF. SC =  412.87 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    5.96

     TOTAL RAINFALL =    15.00 MM

     PEAK DISCHARGE =      .016 CMS  RUNOFF VOLUME =    3.78 MM  TIME TO P

     RUNOFF VOLUMETRIC COEFFICIENT =    .25

 *
 *  Area 4
 *
 COMPUTE URBHYD          ID  4  HYD 130 TIME STEP 0.1667 HR   AREA 6.5 HA
                         CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *12*
                         FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                         DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                         SLI 1.00 %  LGI 208 M  MNI 0.015
                         SLP 1.00 %  LGP 208 M  MNP 0.25
                         RAINFALL CODE  -1
     UNIT PEAK =     .113 CMS
     PEAK INTENSITY(RAIN EXCESS) =     15.30 MM/HR
     STORAGE COEFF. SC =    9.15 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

     UNIT PEAK =     .003 CMS
     PEAK INTENSITY(RAIN EXCESS) =       .03 MM/HR
     STORAGE COEFF. SC =  640.69 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    5.94

     TOTAL RAINFALL =    15.00 MM

     PEAK DISCHARGE =      .048 CMS  RUNOFF VOLUME =    2.70 MM  TIME TO P

     RUNOFF VOLUMETRIC COEFFICIENT =    .18

 *
 * Add flows to North Quality pond (14 ha total drainage area)
 *
 ADD HYD               NEW ID  2  HYD NO  140  ADD ID  2 TO ID  3
     PEAK FLOW =         .078 CMS     RUNOFF VOLUME =     3.78 MM     TIME T
          ADD HYD           ID=2      HYD NO=140      ID I=2          ID II=3
 ADD HYD               NEW ID  2  HYD NO  150  ADD ID  2 TO ID  4
     PEAK FLOW =         .126 CMS     RUNOFF VOLUME =     3.28 MM     TIME T
          ADD HYD           ID=2      HYD NO=150      ID I=2          ID II=4
 *
 * North Quality Pond
```

```
*
*
* Area 5
*
COMPUTE URBHYD          ID  3  HYD 160 TIME STEP 0.1667 HR   AREA 19.0 HA
                        CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *12*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 356 M  MNI 0.015
                        SLP 1.00 %  LGP 356 M  MNP 0.25
                        RAINFALL CODE  -1
    UNIT PEAK =      .093 CMS
    PEAK INTENSITY(RAIN EXCESS) =     15.30 MM/HR
    STORAGE COEFF. SC =    12.64 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

    UNIT PEAK =      .002 CMS
    PEAK INTENSITY(RAIN EXCESS) =       .03 MM/HR
    STORAGE COEFF. SC =   884.46 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    5.79

    TOTAL RAINFALL =     15.00 MM

    PEAK DISCHARGE =       .131 CMS  RUNOFF VOLUME =     2.70 MM  TIME TO PEA

    RUNOFF VOLUMETRIC COEFFICIENT =    .18

*
* Area 6
*
COMPUTE URBHYD          ID  4  HYD 170 TIME STEP 0.1667 HR   AREA 6.1 HA
                        CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *12*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 202 M  MNI 0.015
                        SLP 1.00 %  LGP 202 M  MNP 0.25
                        RAINFALL CODE  -1
    UNIT PEAK =      .114 CMS
    PEAK INTENSITY(RAIN EXCESS) =     15.30 MM/HR
    STORAGE COEFF. SC =     8.99 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

    UNIT PEAK =      .003 CMS
    PEAK INTENSITY(RAIN EXCESS) =       .03 MM/HR
    STORAGE COEFF. SC =   629.53 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    5.94

    TOTAL RAINFALL =     15.00 MM

    PEAK DISCHARGE =       .045 CMS  RUNOFF VOLUME =     2.70 MM  TIME TO PEA

    RUNOFF VOLUMETRIC COEFFICIENT =    .18

*
* Add flows to East Quality pond (25.1 ha total drainage area)
*
ADD HYD                NEW ID  3  HYD NO  180   ADD ID  3 TO ID  4
    PEAK FLOW =          .176 CMS      RUNOFF VOLUME =      2.70 MM      TIME TO
           ADD HYD          ID=3      HYD NO=180      ID I=3          ID II=4
*
* East Quality Pond
*
*
*
* Area 7
*
COMPUTE URBHYD          ID  4  HYD 190 TIME STEP 0.1667 HR   Area 2.2 ha
                        CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *12*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 121 M  MNI 0.015
                        SLP 1.00 %  LGP 121 M  MNP 0.25
                        RAINFALL CODE  -1
    UNIT PEAK =      .132 CMS
    PEAK INTENSITY(RAIN EXCESS) =     15.30 MM/HR
    STORAGE COEFF. SC =     6.61 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00
```

```
     UNIT PEAK =      .004 CMS
     PEAK INTENSITY(RAIN EXCESS) =      .03 MM/HR
     STORAGE COEFF. SC =  462.89 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      5.95

     TOTAL RAINFALL =     15.00 MM

     PEAK DISCHARGE =       .017 CMS  RUNOFF VOLUME =     2.70 MM   TIME TO I

     RUNOFF VOLUMETRIC COEFFICIENT =   .18

*******************************************************************************
**                           25 mm / 2 hour storm
*******************************************************************************
*
* Area 1
*
COMPUTE URBHYD          ID  1  HYD 100 TIME STEP 0.1667 HR   AREA 11.0 HA
                        CKK 1  XIMP  0.54 TIMP 0.58  RAINFALL INTERVALS *12*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 271 M  MNI 0.015
                        SLP 1.00 %  LGP 271 M  MNP 0.25
                          mm\hr WITH A TEN MIN TIME STEP
                         8.0  8.0  8.0  12.0  25.5  23
                         16.5 13.0  12.0  8.0  8.0  8.0
     UNIT PEAK =      .116 CMS
     PEAK INTENSITY(RAIN EXCESS) =    25.50 MM/HR
     STORAGE COEFF. SC =     8.75 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      6.00

     UNIT PEAK =      .002 CMS
     PEAK INTENSITY(RAIN EXCESS) =      .03 MM/HR
     STORAGE COEFF. SC =  750.91 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      5.89

     TOTAL RAINFALL =     25.01 MM

     PEAK DISCHARGE =       .367 CMS  RUNOFF VOLUME =    12.69 MM   TIME TO I

     RUNOFF VOLUMETRIC COEFFICIENT =   .51

*
* Area 2
*
COMPUTE URBHYD          ID  2  HYD 110 TIME STEP 0.1667 HR   AREA 6.0 HA
                        CKK 1  XIMP  0.28 TIMP 0.56  RAINFALL INTERVALS *12*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 200 M  MNI 0.015
                        SLP 1.00 %  LGP 200 M  MNP 0.25
                        RAINFALL CODE  -1
     UNIT PEAK =      .127 CMS
     PEAK INTENSITY(RAIN EXCESS) =    25.50 MM/HR
     STORAGE COEFF. SC =     7.29 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      6.00

     UNIT PEAK =      .021 CMS
     PEAK INTENSITY(RAIN EXCESS) =     5.00 MM/HR
     STORAGE COEFF. SC =   75.66 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      5.99

     TOTAL RAINFALL =     25.01 MM

     PEAK DISCHARGE =       .111 CMS  RUNOFF VOLUME =     8.48 MM   TIME TO I

     RUNOFF VOLUMETRIC COEFFICIENT =   .34

*
* Area 3
*
COMPUTE URBHYD          ID  3  HYD 120 TIME STEP 0.1667 HR   AREA 1.5 HA
                        CKK 1  XIMP  0.28 TIMP 0.56  RAINFALL INTERVALS *12*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 100 M  MNI 0.015
                        SLP 1.00 %  LGP 100 M  MNP 0.25
                        RAINFALL CODE  -1
```

```
    UNIT PEAK =      .149 CMS
    PEAK INTENSITY(RAIN EXCESS) =     25.50 MM/HR
    STORAGE COEFF.  SC =      4.81 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    UNIT PEAK =      .031 CMS
    PEAK INTENSITY(RAIN EXCESS) =      5.00 MM/HR
    STORAGE COEFF.  SC =     49.92 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     5.99

    TOTAL RAINFALL =     25.01 MM

    PEAK DISCHARGE =       .029 CMS  RUNOFF VOLUME =     8.48 MM   TIME TO P

    RUNOFF VOLUMETRIC COEFFICIENT =    .34

*
*  Area 4
*
COMPUTE URBHYD         ID  4  HYD 130 TIME STEP 0.1667 HR   AREA 6.5 HA
                       CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *12*
                       FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                       DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                       SLI 1.00 %  LGI 208 M  MNI 0.015
                       SLP 1.00 %  LGP 208 M  MNP 0.25
                       RAINFALL CODE  -1
    UNIT PEAK =      .125 CMS
    PEAK INTENSITY(RAIN EXCESS) =     25.50 MM/HR
    STORAGE COEFF.  SC =      7.46 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    UNIT PEAK =      .021 CMS
    PEAK INTENSITY(RAIN EXCESS) =      4.95 MM/HR
    STORAGE COEFF.  SC =     77.76 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     5.99

    TOTAL RAINFALL =     25.01 MM

    PEAK DISCHARGE =       .087 CMS  RUNOFF VOLUME =     6.63 MM   TIME TO P

    RUNOFF VOLUMETRIC COEFFICIENT =    .27

*
* Add flows to North Quality pond (14 ha total drainage area)
*
ADD HYD               NEW ID  2  HYD NO  140   ADD ID  2 TO ID  3
    PEAK FLOW =          .139 CMS      RUNOFF VOLUME =     8.48 MM      TIME T
           ADD HYD          ID=2      HYD NO=140      ID I=2         ID II=3
ADD HYD               NEW ID  2  HYD NO  150   ADD ID  2 TO ID  4
    PEAK FLOW =          .226 CMS      RUNOFF VOLUME =     7.62 MM      TIME TO
           ADD HYD          ID=2      HYD NO=150      ID I=2         ID II=4
*
* North Quality Pond
*
*
* Area 5
*
COMPUTE URBHYD         ID  3  HYD 160 TIME STEP 0.1667 HR   AREA 19.0 HA
                       CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *12*
                       FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
                       DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                       SLI 1.00 %  LGI 356 M  MNI 0.015
                       SLP 1.00 %  LGP 356 M  MNP 0.25
                       RAINFALL CODE  -1
    UNIT PEAK =      .106 CMS
    PEAK INTENSITY(RAIN EXCESS) =     25.50 MM/HR
    STORAGE COEFF.  SC =     10.30 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    UNIT PEAK =      .015 CMS
    PEAK INTENSITY(RAIN EXCESS) =      4.95 MM/HR
    STORAGE COEFF.  SC =    107.34 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     5.99

    TOTAL RAINFALL =     25.01 MM

    PEAK DISCHARGE =       .240 CMS  RUNOFF VOLUME =     6.63 MM   TIME TO PEA
```

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    RUNOFF VOLUMETRIC COEFFICIENT =     .27

 *
 * Area 6
 *
 COMPUTE URBHYD                ID  4  HYD 170 TIME STEP 0.1667 HR   AREA 6.1 HA
                               CKK 1  XIMP   0.20 TIMP 0.51  RAINFALL INTERVALS *12*
                               FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                               DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                               SLI 1.00 %  LGI 202 M  MNI 0.015
                               SLP 1.00 %  LGP 202 M  MNP 0.25
                               RAINFALL CODE  -1
    UNIT PEAK =      .126 CMS
    PEAK INTENSITY(RAIN EXCESS) =      25.50 MM/HR
    STORAGE COEFF. SC =     7.33 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    UNIT PEAK =      .021 CMS
    PEAK INTENSITY(RAIN EXCESS) =      4.95 MM/HR
    STORAGE COEFF. SC =    76.40 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     5.99

    TOTAL RAINFALL =      25.01 MM

    PEAK DISCHARGE =       .082 CMS  RUNOFF VOLUME =     6.63 MM   TIME TO P

    RUNOFF VOLUMETRIC COEFFICIENT =     .27

 *
 * Add flows to East Quality pond (25.1 ha total drainage area)
 *
 ADD HYD                    NEW ID  3  HYD NO  180   ADD ID  3 TO ID  4
    PEAK FLOW =           .322 CMS        RUNOFF VOLUME =     6.63 MM       TIME T
0          ADD HYD           ID=3       HYD NO=180      ID I=3          ID II=4
 *
 * East Quality Pond
 *
 *
 *
 * Area 7
 *
 COMPUTE URBHYD                ID  4  HYD 190 TIME STEP 0.1667 HR   Area 2.2 ha
                               CKK 1  XIMP   0.20 TIMP 0.51  RAINFALL INTERVALS *12*
                               FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                               DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                               SLI 1.00 %  LGI 121 M  MNI 0.015
                               SLP 1.00 %  LGP 121 M  MNP 0.25
                               RAINFALL CODE  -1
    UNIT PEAK =      .143 CMS
    PEAK INTENSITY(RAIN EXCESS) =      25.50 MM/HR
    STORAGE COEFF. SC =     5.39 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    UNIT PEAK =      .028 CMS
    PEAK INTENSITY(RAIN EXCESS) =      4.95 MM/HR
    STORAGE COEFF. SC =    56.18 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     5.99

    TOTAL RAINFALL =      25.01 MM

    PEAK DISCHARGE =       .030 CMS  RUNOFF VOLUME =     6.64 MM   TIME TO P

    RUNOFF VOLUMETRIC COEFFICIENT =     .27
 ***********************************************************************
 **                            2 year storm
 ***********************************************************************
 *
 * Area 1
 *
 COMPUTE URBHYD                ID  1  HYD 100 TIME STEP 0.1667 HR   AREA 11.0 HA
                               CKK 1  XIMP   0.54 TIMP 0.58  RAINFALL INTERVALS *24
                               FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 I
                               DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                               SLI 1.00 %  LGI 271 M  MNI 0.015
                               SLP 1.00 %  LGP 271 M  MNP 0.25
                                    MM/HR WITH A TEN MINUTE TIME STEP
                                  3.251    3.556    3.962    4.521    5.309    6.553
```

```
                      8.941   16.916   78.816   20.980   13.005    9.881
                      8.153    7.010    6.198    5.588    5.105    4.724
                      4.394    4.115    3.886    3.683    3.505    3.353
    UNIT PEAK =      .142 CMS
    PEAK INTENSITY(RAIN EXCESS) =      78.82 MM/HR
    STORAGE COEFF.  SC =     5.57 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    UNIT PEAK =      .031 CMS
    PEAK INTENSIITY(RAIN EXCESS) =      21.88 MM/HR
    STORAGE COEFF.  SC =    50.29 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     5.99

    TOTAL RAINFALL =     39.24 MM

    PEAK DISCHARGE =       1.178 CMS   RUNOFF VOLUME =    22.95 MM   TIME TO PEA

    RUNOFF VOLUMETRIC COEFFICIENT =    .58

*
* Area 2
*
COMPUTE URBHYD          ID  2  HYD 110 TIME STEP 0.1667 HR   AREA 6.0 HA
                        CKK 1  XIMP  0.28 TIMP 0.56  RAINFALL INTERVALS *24*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 200 M  MNI 0.015
                        SLP 1.00 %  LGP 200 M  MNP 0.25
                        RAINFALL CODE  -1
    UNIT PEAK =      .150 CMS
    PEAK INTENSITY(RAIN EXCESS) =      78.82 MM/HR
    STORAGE COEFF.  SC =     4.64 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    UNIT PEAK =      .055 CMS
    PEAK INTENSITY(RAIN EXCESS) =      73.87 MM/HR
    STORAGE COEFF.  SC =    25.76 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    TOTAL RAINFALL =     39.24 MM

    PEAK DISCHARGE =        .508 CMS   RUNOFF VOLUME =    18.91 MM   TIME TO PEA

    RUNOFF VOLUMETRIC COEFFICIENT =    .48

*
* Area 3
*
COMPUTE URBHYD          ID  3  HYD 120 TIME STEP 0.1667 HR   AREA 1.5 HA
                        CKK 1  XIMP  0.28 TIMP 0.56  RAINFALL INTERVALS *24*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 100 M  MNI 0.015
                        SLP 1.00 %  LGP 100 M  MNP 0.25
                        RAINFALL CODE  -1
    UNIT PEAK =      .163 CMS
    PEAK INTENSITY(RAIN EXCESS) =      78.82 MM/HR
    STORAGE COEFF.  SC =     3.06 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    UNIT PEAK =      .076 CMS
    PEAK INTENSITY(RAIN EXCESS) =      73.87 MM/HR
    STORAGE COEFF.  SC =    17.00 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    TOTAL RAINFALL =     39.24 MM

    PEAK DISCHARGE =        .149 CMS   RUNOFF VOLUME =    18.91 MM   TIME TO PEA

    RUNOFF VOLUMETRIC COEFFICIENT =    .48

*
* Area 4
*
COMPUTE URBHYD          ID  4  HYD 130 TIME STEP 0.1667 HR   AREA 6.5 HA
                        CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *24*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
```

```
                    DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                    SLI 1.00 %  LGI 208 M  MNI 0.015
                    SLP 1.00 %  LGP 208 M  MNP 0.25
                    RAINFALL CODE  -1
   UNIT PEAK =      .149 CMS
   PEAK INTENSITY(RAIN EXCESS) =    78.82 MM/HR
   STORAGE COEFF. SC =     4.75 MINS

   SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

   UNIT PEAK =      .054 CMS
   PEAK INTENSITY(RAIN EXCESS) =    73.52 MM/HR
   STORAGE COEFF. SC =    26.43 MINS

   SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

   TOTAL RAINFALL =     39.24 MM

   PEAK DISCHARGE =        .462 CMS   RUNOFF VOLUME =     16.63 MM   TIME TO I

   RUNOFF VOLUMETRIC COEFFICIENT =     .42

*
* Add flows to from North side
*
ADD HYD              NEW ID  2  HYD NO  140   ADD ID  2 TO ID  3
   PEAK FLOW =         .658 CMS      RUNOFF VOLUME =     18.91 MM       TIME T
0         ADD HYD        ID=2        HYD NO=140       ID I=2           ID II=3
ADD HYD              NEW ID  2  HYD NO  150   ADD ID  2 TO ID  4
   PEAK FLOW =        1.120 CMS      RUNOFF VOLUME =     17.85 MM       TIME T
0         ADD HYD        ID=2        HYD NO=150       ID I=2           ID II=4
*
* Area 5
*
COMPUTE URBHYD          ID  3  HYD 160 TIME STEP 0.1667 HR   AREA 19.0 HA
                        CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *24
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 I
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 356 M  MNI 0.015
                        SLP 1.00 %  LGP 356 M  MNP 0.25
                        RAINFALL CODE  -1
   UNIT PEAK =      .133 CMS
   PEAK INTENSITY(RAIN EXCESS) =    78.82 MM/HR
   STORAGE COEFF. SC =     6.56 MINS

   SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

   UNIT PEAK =      .041 CMS
   PEAK INTENSITY(RAIN EXCESS) =    73.52 MM/HR
   STORAGE COEFF. SC =    36.48 MINS

   SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

   TOTAL RAINFALL =     39.24 MM

   PEAK DISCHARGE =      1.141 CMS   RUNOFF VOLUME =     16.63 MM   TIME TO I

   RUNOFF VOLUMETRIC COEFFICIENT =     .42

*
* Area 6
*
COMPUTE URBHYD          ID  4  HYD 170 TIME STEP 0.1667 HR   AREA 6.1 HA
                        CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *24
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 I
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 202 M  MNI 0.015
                        SLP 1.00 %  LGP 202 M  MNP 0.25
                        RAINFALL CODE  -1
   UNIT PEAK =      .150 CMS
   PEAK INTENSITY(RAIN EXCESS) =    78.82 MM/HR
   STORAGE COEFF. SC =     4.67 MINS

   SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

   UNIT PEAK =      .054 CMS
   PEAK INTENSITY(RAIN EXCESS) =    73.52 MM/HR
   STORAGE COEFF. SC =    25.97 MINS

   SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

   TOTAL RAINFALL =     39.24 MM
```

```
     PEAK DISCHARGE =        .437 CMS  RUNOFF VOLUME =   16.63 MM  TIME TO P
     RUNOFF VOLUMETRIC COEFFICIENT =   .42
 *
 * Add flows to from east side
 *
 ADD HYD                NEW ID  3  HYD NO  180   ADD ID  3 TO ID  4
     PEAK FLOW =         1.579 CMS     RUNOFF VOLUME =     16.63 MM        TIME T
            ADD HYD          ID=3     HYD NO=180      ID I=3          ID II=4
 *
 * Add total flows to Swan Lake
 *
 ADD HYD                NEW ID  2  HYD NO  185   ADD ID  2 TO ID  3
     PEAK FLOW =         2.698 CMS     RUNOFF VOLUME =     17.07 MM        TIME T
            ADD HYD          ID=2     HYD NO=185      ID I=2          ID II=3
 ADD HYD                NEW ID  2  HYD NO  185   ADD ID  1 TO ID  2
     PEAK FLOW =         3.876 CMS     RUNOFF VOLUME =     18.36 MM        TIME T
            ADD HYD          ID=2     HYD NO=185      ID I=1          ID II=2
 *
 * Swan Lake routing
 *
 ROUTE RESERVOIR         OUTFLOW ID 6  HYD 187 INFLOW ID 2
                         OUTFLOW (CMS) STORAGE (HA-M)
                             0.0          0.0000
                             0.03         0.8400
                             0.04         1.2800
                             0.05         2.2000
                             0.06         2.9000
                             0.10         6.5000
                             0.13        12.2000
     PEAK DISCHARGE =         .0311 CMS   RUNOFF VOLUME=  8.4355 MM
 *
 *
 * Area 7
 *
 COMPUTE URBHYD          ID  4  HYD 190 TIME STEP 0.1667 HR   Area 2.2 ha
                         CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *24*
                         FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
                         DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                         SLI 1.00 %  LGI 121 M  MNI 0.015
                         SLP 1.00 %  LGP 121 M  MNP 0.25
                         RAINFALL CODE  -1
     UNIT PEAK =      .161 CMS
     PEAK INTENSITY(RAIN EXCESS) =      78.82 MM/HR
     STORAGE COEFF. SC =     3.43 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

     UNIT PEAK =      .069 CMS
     PEAK INTENSITY(RAIN EXCESS) =      73.52 MM/HR
     STORAGE COEFF. SC =    19.09 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

     TOTAL RAINFALL =     39.24 MM

     PEAK DISCHARGE =        .182 CMS  RUNOFF VOLUME =   16.63 MM  TIME TO PEA

     RUNOFF VOLUMETRIC COEFFICIENT =   .42

 *
 ************************************************************************
 **                              5 year storm
 ************************************************************************
 *
 * Area 1
 *
 COMPUTE URBHYD          ID  1  HYD 100 TIME STEP 0.1667 HR   AREA 11.0 HA
                         CKK 1  XIMP  0.54 TIMP 0.58  RAINFALL INTERVALS *24*
                         FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                         DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                         SLI 1.00 %  LGI 271 M  MNI 0.015
                         SLP 1.00 %  LGP 271 M  MNP 0.25
                             MM/HR WITH A TEN MINUTE TIME STEP
                              3.429    3.581    4.039    4.674    5.613    7.112
                             10.185   21.615  112.370   27.762   15.748   11.430
                              9.144    7.696    6.680    5.944    5.385    4.928
                              4.547    4.216    3.962    3.734    3.531    3.353
     UNIT PEAK =      .148 CMS
     PEAK INTENSITY(RAIN EXCESS) =     112.37 MM/HR
     STORAGE COEFF. SC =     4.83 MINS
```

```
    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    UNIT PEAK =      .044 CMS
    PEAK INTENSITY(RAIN EXCESS) =     61.37 MM/HR
    STORAGE COEFF. SC =     33.29 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    TOTAL RAINFALL =     48.46 MM

    PEAK DISCHARGE =     1.867 CMS   RUNOFF VOLUME =    31.39 MM   TIME TO P

    RUNOFF VOLUMETRIC COEFFICIENT =     .65

*
* Area 2
*
COMPUTE URBHYD          ID  2  HYD 110 TIME STEP 0.1667 HR   AREA 6.0 HA
                        CKK 1  XIMP  0.28 TIMP 0.56  RAINFALL INTERVALS *24*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 200 M  MNI 0.015
                        SLP 1.00 %  LGP 200 M  MNP 0.25
                        RAINFALL CODE  -1
    UNIT PEAK =      .156 CMS
    PEAK INTENSITY(RAIN EXCESS) =    112.37 MM/HR
    STORAGE COEFF. SC =      4.03 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    UNIT PEAK =      .066 CMS
    PEAK INTENSITY(RAIN EXCESS) =    132.74 MM/HR
    STORAGE COEFF. SC =     20.38 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    TOTAL RAINFALL =     48.46 MM

    PEAK DISCHARGE =      .871 CMS   RUNOFF VOLUME =    27.42 MM   TIME TO P

    RUNOFF VOLUMETRIC COEFFICIENT =     .57

*
* Area 3
*
COMPUTE URBHYD          ID  3  HYD 120 TIME STEP 0.1667 HR   AREA 1.5 HA
                        CKK 1  XIMP  0.28 TIMP 0.56  RAINFALL INTERVALS *24*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 100 M  MNI 0.015
                        SLP 1.00 %  LGP 100 M  MNP 0.25
                        RAINFALL CODE  -1
    UNIT PEAK =      .166 CMS
    PEAK INTENSITY(RAIN EXCESS) =    112.37 MM/HR
    STORAGE COEFF. SC =      2.66 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    UNIT PEAK =      .089 CMS
    PEAK INTENSITY(RAIN EXCESS) =    132.74 MM/HR
    STORAGE COEFF. SC =     13.44 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    TOTAL RAINFALL =     48.46 MM

    PEAK DISCHARGE =      .258 CMS   RUNOFF VOLUME =    27.42 MM   TIME TO P

    RUNOFF VOLUMETRIC COEFFICIENT =     .57

*
* Area 4
*
COMPUTE URBHYD          ID  4  HYD 130 TIME STEP 0.1667 HR   AREA 6.5 HA
                        CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *24*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 208 M  MNI 0.015
                        SLP 1.00 %  LGP 208 M  MNP 0.25
                        RAINFALL CODE  -1
    UNIT PEAK =      .155 CMS
    PEAK INTENSITY(RAIN EXCESS) =    112.37 MM/HR
    STORAGE COEFF. SC =      4.12 MINS
```

```
     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

     UNIT PEAK =      .065 CMS
     PEAK INTENSITY(RAIN EXCESS) =   132.17 MM/HR
     STORAGE COEFF. SC =    20.90 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

     TOTAL RAINFALL =     48.46 MM

     PEAK DISCHARGE =       .827 CMS   RUNOFF VOLUME =    25.05 MM   TIME TO PEA

     RUNOFF VOLUMETRIC COEFFICIENT =    .52

 *
 * Add flows to from North side
 *
ADD HYD                NEW ID  2  HYD NO  140   ADD ID   2 TO ID  3
     PEAK FLOW =         1.129 CMS     RUNOFF VOLUME =     27.42 MM       TIME T
            ADD HYD         ID=2      HYD NO=140     ID I=2          ID II=3
ADD HYD                NEW ID  2  HYD NO  150   ADD ID   2 TO ID  4
     PEAK FLOW =         1.956 CMS     RUNOFF VOLUME =     26.32 MM       TIME T
            ADD HYD         ID=2      HYD NO=150     ID I=2          ID II=4
 *
 * Area 5
 *
COMPUTE URBHYD          ID  3  HYD 160 TIME STEP 0.1667 HR   AREA 19.0 HA
                        CKK 1  XIMP  0.20 TIMP 0.51   RAINFALL INTERVALS *24*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 356 M  MNI 0.015
                        SLP 1.00 %  LGP 356 M  MNP 0.25
                        RAINFALL CODE  -1
     UNIT PEAK =      .141 CMS
     PEAK INTENSITY(RAIN EXCESS) =   112.37 MM/HR
     STORAGE COEFF. SC =      5.69 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

     UNIT PEAK =      .050 CMS
     PEAK INTENSITY(RAIN EXCESS) =   132.17 MM/HR
     STORAGE COEFF. SC =    28.85 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

     TOTAL RAINFALL =     48.46 MM

     PEAK DISCHARGE =      2.032 CMS   RUNOFF VOLUME =    25.05 MM   TIME TO PEA

     RUNOFF VOLUMETRIC COEFFICIENT =    .52

 *
 * Area 6
 *
COMPUTE URBHYD          ID  4  HYD 170 TIME STEP 0.1667 HR   AREA 6.1 HA
                        CKK 1  XIMP  0.20 TIMP 0.51   RAINFALL INTERVALS *24*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 202 M  MNI 0.015
                        SLP 1.00 %  LGP 202 M  MNP 0.25
                        RAINFALL CODE  -1
     UNIT PEAK =      .156 CMS
     PEAK INTENSITY(RAIN EXCESS) =   112.37 MM/HR
     STORAGE COEFF. SC =      4.05 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

     UNIT PEAK =      .066 CMS
     PEAK INTENSITY(RAIN EXCESS) =   132.17 MM/HR
     STORAGE COEFF. SC =    20.54 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

     TOTAL RAINFALL =     48.46 MM

     PEAK DISCHARGE =       .783 CMS   RUNOFF VOLUME =    25.05 MM   TIME TO PEA

     RUNOFF VOLUMETRIC COEFFICIENT =    .52

 *
 * Add flows to from east side
 *
```

```
   ADD HYD              NEW ID  3  HYD NO  180   ADD ID  3 TO ID  4
       PEAK FLOW =         2.815 CMS       RUNOFF VOLUME =      25.05 MM       TIME T
0              ADD HYD            ID=3      HYD NO=180      ID I=3          ID II=4
   *
   * Add total flows to Swan Lake
   *
   ADD HYD              NEW ID  2  HYD NO  185   ADD ID  2 TO ID  3
       PEAK FLOW =         4.770 CMS       RUNOFF VOLUME =      25.50 MM       TIME T
0              ADD HYD            ID=2      HYD NO=185      ID I=2          ID II=3
   ADD HYD              NEW ID  2  HYD NO  185   ADD ID  1 TO ID  2
       PEAK FLOW =         6.637 CMS       RUNOFF VOLUME =      26.79 MM       TIME T
0              ADD HYD            ID=2      HYD NO=185      ID I=1          ID II=2
   *
   * Swan Lake routing
   *
   ROUTE RESERVOIR         OUTFLOW ID 6   HYD 187 INFLOW ID 2
                           OUTFLOW (CMS)  STORAGE (HA-M)
                               0.0         0.0000
                               0.03        0.8400
                               0.04        1.2800
                               0.05        2.2000
                               0.06        2.9000
                               0.10        6.5000
                               0.13       12.2000
       PEAK DISCHARGE =         .0403 CMS  RUNOFF VOLUME= 11.7996 MM
   *
   *
   * Area 7
   *
   COMPUTE URBHYD          ID  4   HYD 190 TIME STEP 0.1667 HR   Area 2.2 ha
                           CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *24*
                           FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                           DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                           SLI 1.00 %  LGI 121 M  MNI 0.015
                           SLP 1.00 %  LGP 121 M  MNP 0.25
                           RAINFALL CODE  -1
       UNIT PEAK =      .164 CMS
       PEAK INTENSITY(RAIN EXCESS) =    112.37 MM/HR
       STORAGE COEFF. SC =    2.98 MINS

       SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

       UNIT PEAK =      .082 CMS
       PEAK INTENSITY(RAIN EXCESS) =    132.17 MM/HR
       STORAGE COEFF. SC =   15.10 MINS

       SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

       TOTAL RAINFALL =     48.46 MM

       PEAK DISCHARGE =        .327 CMS  RUNOFF VOLUME =    25.05 MM   TIME TO P

       RUNOFF VOLUMETRIC COEFFICIENT =    .52

   *
   **********************************************************************************
   **                             25 year storm
   **********************************************************************************
   *
   * Area 1
   *
   COMPUTE URBHYD          ID  1   HYD 100 TIME STEP 0.1667 HR   AREA 11.0 HA
                           CKK 1  XIMP  0.54 TIMP 0.58  RAINFALL INTERVALS *24*
                           FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                           DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                           SLI 1.00 %  LGI 271 M  MNI 0.015
                           SLP 1.00 %  LGP 271 M  MNP 0.25
                             MM/HR WITH A TEN MINUTE TIME STEP
                             4.496     4.978     5.613     6.452     7.696     9.703
                            13.640    27.686   158.852    35.077    20.599    15.240
                            12.319    10.439     9.144     8.153     7.391     6.782
                             6.274     5.842     5.486     5.182     4.902     4.648
       UNIT PEAK =      .154 CMS
       PEAK INTENSITY(RAIN EXCESS) =    158.85 MM/HR
       STORAGE COEFF. SC =    4.21 MINS

       SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

       UNIT PEAK =      .055 CMS
       PEAK INTENSITY(RAIN EXCESS) =    119.22 MM/HR
       STORAGE COEFF. SC =   25.53 MINS

       SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00
```

```
     TOTAL RAINFALL =     66.11 MM
     PEAK DISCHARGE =      2.914 CMS  RUNOFF VOLUME =    46.53 MM   TIME TO PEA
     RUNOFF VOLUMETRIC COEFFICIENT =    .70

*
* Area 2
*
COMPUTE URBHYD           ID  2  HYD 110 TIME STEP 0.1667 HR   AREA 6.0 HA
                         CKK 1  XIMP  0.28 TIMP 0.56  RAINFALL INTERVALS *24*
                         FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
                         DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                         SLI 1.00 %  LGI 200 M  MNI 0.015
                         SLP 1.00 %  LGP 200 M  MNP 0.25
                         RAINFALL CODE  -1
     UNIT PEAK =      .160 CMS
     PEAK INTENSITY(RAIN EXCESS) =   158.85 MM/HR
     STORAGE COEFF. SC =     3.51 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

     UNIT PEAK =      .078 CMS
     PEAK INTENSITY(RAIN EXCESS) =   229.76 MM/HR
     STORAGE COEFF. SC =    16.36 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

     TOTAL RAINFALL =     66.11 MM

     PEAK DISCHARGE =      1.482 CMS  RUNOFF VOLUME =    42.63 MM   TIME TO PEA

     RUNOFF VOLUMETRIC COEFFICIENT =    .64

*
* Area 3
*
COMPUTE URBHYD           ID  3  HYD 120 TIME STEP 0.1667 HR   AREA 1.5 HA
                         CKK 1  XIMP  0.28 TIMP 0.56  RAINFALL INTERVALS *24*
                         FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
                         DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                         SLI 1.00 %  LGI 100 M  MNI 0.015
                         SLP 1.00 %  LGP 100 M  MNP 0.25
                         RAINFALL CODE  -1
     UNIT PEAK =      .168 CMS
     PEAK INTENSITY(RAIN EXCESS) =   158.85 MM/HR
     STORAGE COEFF. SC =     2.31 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

     UNIT PEAK =      .103 CMS
     PEAK INTENSITY(RAIN EXCESS) =   229.76 MM/HR
     STORAGE COEFF. SC =    10.80 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

     TOTAL RAINFALL =     66.11 MM

     PEAK DISCHARGE =       .439 CMS  RUNOFF VOLUME =    42.63 MM   TIME TO PEA

     RUNOFF VOLUMETRIC COEFFICIENT =    .64

*
* Area 4
*
COMPUTE URBHYD           ID  4  HYD 130 TIME STEP 0.1667 HR   AREA 6.5 HA
                         CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *24*
                         FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
                         DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                         SLI 1.00 %  LGI 208 M  MNI 0.015
                         SLP 1.00 %  LGP 208 M  MNP 0.25
                         RAINFALL CODE  -1
     UNIT PEAK =      .159 CMS
     PEAK INTENSITY(RAIN EXCESS) =   158.85 MM/HR
     STORAGE COEFF. SC =     3.59 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

     UNIT PEAK =      .076 CMS
     PEAK INTENSITY(RAIN EXCESS) =   228.98 MM/HR
     STORAGE COEFF. SC =    16.77 MINS
```

APPENDIX 'G'

Erosion and Sediment Control Measures Analysis

```
     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      6.00
     TOTAL RAINFALL =     66.11 MM
     PEAK DISCHARGE =      1.460 CMS  RUNOFF VOLUME =    39.96 MM   TIME TO P
     RUNOFF VOLUMETRIC COEFFICIENT =    .60
 *
 * Add flows to from North side
 *
 ADD HYD              NEW ID  2  HYD NO  140   ADD ID  2 TO ID  3
     PEAK FLOW =        1.921 CMS    RUNOFF VOLUME =     42.63 MM       TIME T
0           ADD HYD        ID=2      HYD NO=140      ID I=2             ID II=3
 ADD HYD              NEW ID  2  HYD NO  150   ADD ID  2 TO ID  4
     PEAK FLOW =        3.380 CMS    RUNOFF VOLUME =     41.39 MM       TIME T
0           ADD HYD        ID=2      HYD NO=150      ID I=2             ID II=4
 *
 * Area 5
 *
 COMPUTE URBHYD         ID  3  HYD 160 TIME STEP 0.1667 HR   AREA 19.0 HA
                        CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *24*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                        DPSI 1.5 DPSP 4.7 STI  0.00 STP 0.00
                        SLI 1.00 %  LGI 356 M  MNI 0.015
                        SLP 1.00 %  LGP 356 M  MNP 0.25
                        RAINFALL CODE  -1
     UNIT PEAK =      .147 CMS
     PEAK INTENSITY(RAIN EXCESS) =    158.85 MM/HR
     STORAGE COEFF. SC =     4.96 MINS
     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      6.00
     UNIT PEAK =      .060 CMS
     PEAK INTENSITY(RAIN EXCESS) =    228.98 MM/HR
     STORAGE COEFF. SC =    23.16 MINS
     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      6.00
     TOTAL RAINFALL =     66.11 MM
     PEAK DISCHARGE =      3.582 CMS  RUNOFF VOLUME =    39.96 MM   TIME TO P
     RUNOFF VOLUMETRIC COEFFICIENT =    .60
 *
 * Area 6
 *
 COMPUTE URBHYD         ID  4  HYD 170 TIME STEP 0.1667 HR   AREA 6.1 HA
                        CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *24*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                        DPSI 1.5 DPSP 4.7 STI  0.00 STP 0.00
                        SLI 1.00 %  LGI 202 M  MNI 0.015
                        SLP 1.00 %  LGP 202 M  MNP 0.25
                        RAINFALL CODE  -1
     UNIT PEAK =      .160 CMS
     PEAK INTENSITY(RAIN EXCESS) =    158.85 MM/HR
     STORAGE COEFF. SC =     3.53 MINS
     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      6.00
     UNIT PEAK =      .077 CMS
     PEAK INTENSITY(RAIN EXCESS) =    228.98 MM/HR
     STORAGE COEFF. SC =    16.48 MINS
     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      6.00
     TOTAL RAINFALL =     66.11 MM
     PEAK DISCHARGE =      1.382 CMS  RUNOFF VOLUME =    39.96 MM   TIME TO P
     RUNOFF VOLUMETRIC COEFFICIENT =    .60
 *
 * Add flows to from east side
 *
 ADD HYD              NEW ID  3  HYD NO  180   ADD ID  3 TO ID  4
     PEAK FLOW =        4.965 CMS    RUNOFF VOLUME =     39.96 MM       TIME T
0           ADD HYD        ID=3      HYD NO=180      ID I=3             ID II=4
 *
 * Add total flows to Swan Lake
 *
 ADD HYD              NEW ID  2  HYD NO  185   ADD ID  2 TO ID  3
```

```
    PEAK FLOW =       8.345 CMS      RUNOFF VOLUME =     40.47 MM     TIME TO
           ADD HYD         ID=2      HYD NO=185      ID I=2          ID II=3
ADD HYD                NEW ID  2  HYD NO  185   ADD ID  1 TO ID  2
    PEAK FLOW =      11.259 CMS      RUNOFF VOLUME =     41.80 MM     TIME TO
           ADD HYD         ID=2      HYD NO=185      ID I=1          ID II=2
*
* Swan Lake routing
*
ROUTE RESERVOIR          OUTFLOW ID 6  HYD 187 INFLOW ID 2
                         OUTFLOW (CMS) STORAGE (HA-M)
                             0.0        0.0000
                             0.03       0.8400
                             0.04       1.2800
                             0.05       2.2000
                             0.06       2.9000
                             0.10       6.5000
                             0.13      12.2000
    PEAK DISCHARGE =          .0483 CMS  RUNOFF VOLUME= 15.4389 MM
*
*
* Area 7
*
COMPUTE URBHYD           ID  4  HYD 190 TIME STEP 0.1667 HR   Area 2.2 ha
                         CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *24*
                         FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR   F 0 MM
                         DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                         SLI 1.00 %   LGI 121 M   MNI 0.015
                         SLP 1.00 %   LGP 121 M   MNP 0.25
                         RAINFALL CODE  -1
    UNIT PEAK =      .166 CMS
    PEAK INTENSITY(RAIN EXCESS) =   158.85 MM/HR
    STORAGE COEFF. SC =     2.59 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

    UNIT PEAK =      .095 CMS
    PEAK INTENSITY(RAIN EXCESS) =   228.98 MM/HR
    STORAGE COEFF. SC =    12.12 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

    TOTAL RAINFALL =     66.11 MM

    PEAK DISCHARGE =         .578 CMS  RUNOFF VOLUME =   39.96 MM   TIME TO PEA

    RUNOFF VOLUMETRIC COEFFICIENT =   .60

*
*******************************************************************************
**                            100 year storm
*******************************************************************************
*
* Area 1
*
COMPUTE URBHYD           ID  1  HYD 100 TIME STEP 0.1667 HR   AREA 11.0 HA
                         CKK 1  XIMP  0.54 TIMP 0.58  RAINFALL INTERVALS *24*
                         FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR   F 0 M
                         DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                         SLI 1.00 %   LGI 271 M   MNI 0.015
                         SLP 1.00 %   LGP 271 M   MNP 0.25
                           MM/HR WITH A TEN MINUTE TIME STEP
                           4.496    5.055    5.817    6.833    8.407   11.074
                          16.866   41.072  205.918   54.559   28.169   19.279
                          14.834   12.116   10.312    9.017    8.026    7.239
                           6.604    6.096    5.664    5.283    4.978    4.699
    UNIT PEAK =      .158 CMS
    PEAK INTENSITY(RAIN EXCESS) =   205.92 MM/HR
    STORAGE COEFF. SC =     3.79 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

    UNIT PEAK =      .063 CMS
    PEAK INTENSITY(RAIN EXCESS) =   184.48 MM/HR
    STORAGE COEFF. SC =    21.44 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

    TOTAL RAINFALL =     83.75 MM

    PEAK DISCHARGE =       4.093 CMS  RUNOFF VOLUME =   63.56 MM   TIME TO P

    RUNOFF VOLUMETRIC COEFFICIENT =   .76
```

```
*
* Area 2
*
COMPUTE URBHYD          ID  2  HYD 110 TIME STEP 0.1667 HR   AREA 6.0 HA
                        CKK 1  XIMP  0.28 TIMP 0.56  RAINFALL INTERVALS *24*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 200 M  MNI 0.015
                        SLP 1.00 %  LGP 200 M  MNP 0.25
                        RAINFALL CODE  -1
    UNIT PEAK =       .163 CMS
    PEAK INTENSITY(RAIN EXCESS) =   205.92 MM/HR
    STORAGE COEFF. SC =    3.16 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    UNIT PEAK =       .085 CMS
    PEAK INTENSITY(RAIN EXCESS) =   318.16 MM/HR
    STORAGE COEFF. SC =   14.36 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    TOTAL RAINFALL =      83.75 MM

    PEAK DISCHARGE =       2.126 CMS  RUNOFF VOLUME =    59.71 MM   TIME TO P

    RUNOFF VOLUMETRIC COEFFICIENT =    .71

*
* Area 3
*
COMPUTE URBHYD          ID  3  HYD 120 TIME STEP 0.1667 HR   AREA 1.5 HA
                        CKK 1  XIMP  0.28 TIMP 0.56  RAINFALL INTERVALS *24*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 100 M  MNI 0.015
                        SLP 1.00 %  LGP 100 M  MNP 0.25
                        RAINFALL CODE  -1
    UNIT PEAK =       .168 CMS
    PEAK INTENSITY(RAIN EXCESS) =   205.92 MM/HR
    STORAGE COEFF. SC =    2.09 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    UNIT PEAK =       .111 CMS
    PEAK INTENSITY(RAIN EXCESS) =   318.16 MM/HR
    STORAGE COEFF. SC =    9.48 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    TOTAL RAINFALL =      83.75 MM

    PEAK DISCHARGE =        .625 CMS  RUNOFF VOLUME =    59.71 MM   TIME TO P

    RUNOFF VOLUMETRIC COEFFICIENT =    .71

*
* Area 4
*
COMPUTE URBHYD          ID  4  HYD 130 TIME STEP 0.1667 HR   AREA 6.5 HA
                        CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *24*
                        FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                        DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                        SLI 1.00 %  LGI 208 M  MNI 0.015
                        SLP 1.00 %  LGP 208 M  MNP 0.25
                        RAINFALL CODE  -1
    UNIT PEAK =       .162 CMS
    PEAK INTENSITY(RAIN EXCESS) =   205.92 MM/HR
    STORAGE COEFF. SC =    3.24 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    UNIT PEAK =       .084 CMS
    PEAK INTENSITY(RAIN EXCESS) =   317.37 MM/HR
    STORAGE COEFF. SC =   14.72 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     6.00

    TOTAL RAINFALL =      83.75 MM

    PEAK DISCHARGE =       2.133 CMS  RUNOFF VOLUME =    56.98 MM   TIME TO P

    RUNOFF VOLUMETRIC COEFFICIENT =    .68
```

```
*
* Add flows to from North side
*
ADD HYD              NEW ID  2   HYD NO  140   ADD ID  2 TO ID  3
    PEAK FLOW =       2.751 CMS    RUNOFF VOLUME =    59.71 MM      TIME T
           ADD HYD       ID=2      HYD NO=140      ID I=2        ID II=3
ADD HYD              NEW ID  2   HYD NO  150   ADD ID  2 TO ID  4
    PEAK FLOW =       4.884 CMS    RUNOFF VOLUME =    58.44 MM      TIME T
           ADD HYD       ID=2      HYD NO=150      ID I=2        ID II=4
*
* Area 5
*
COMPUTE URBHYD        ID  3  HYD 160 TIME STEP 0.1667 HR   AREA 19.0 HA
                      CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *24*
                      FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
                      DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                      SLI 1.00 %  LGI 356 M  MNI 0.015
                      SLP 1.00 %  LGP 356 M  MNP 0.25
                      RAINFALL CODE  -1
    UNIT PEAK =     .152 CMS
    PEAK INTENSITY(RAIN EXCESS) =   205.92 MM/HR
    STORAGE COEFF. SC =     4.47 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

    UNIT PEAK =     .066 CMS
    PEAK INTENSITY(RAIN EXCESS) =   317.37 MM/HR
    STORAGE COEFF. SC =    20.32 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

    TOTAL RAINFALL =     83.75 MM

    PEAK DISCHARGE =      5.265 CMS  RUNOFF VOLUME =    56.97 MM   TIME TO PEA

    RUNOFF VOLUMETRIC COEFFICIENT =   .68

*
* Area 6
*
COMPUTE URBHYD        ID  4  HYD 170 TIME STEP 0.1667 HR   AREA 6.1 HA
                      CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *24*
                      FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
                      DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                      SLI 1.00 %  LGI 202 M  MNI 0.015
                      SLP 1.00 %  LGP 202 M  MNP 0.25
                      RAINFALL CODE  -1
    UNIT PEAK =     .163 CMS
    PEAK INTENSITY(RAIN EXCESS) =   205.92 MM/HR
    STORAGE COEFF. SC =     3.18 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

    UNIT PEAK =     .085 CMS
    PEAK INTENSITY(RAIN EXCESS) =   317.37 MM/HR
    STORAGE COEFF. SC =    14.47 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    6.00

    TOTAL RAINFALL =     83.75 MM

    PEAK DISCHARGE =      2.019 CMS  RUNOFF VOLUME =    56.98 MM   TIME TO PEA

    RUNOFF VOLUMETRIC COEFFICIENT =   .68

*
* Add flows to from east side
*
ADD HYD              NEW ID  3   HYD NO  180   ADD ID  3 TO ID  4
    PEAK FLOW =       7.284 CMS    RUNOFF VOLUME =    56.98 MM      TIME T
           ADD HYD       ID=3      HYD NO=180      ID I=3        ID II=4
*
* Add total flows to Swan Lake
*
ADD HYD              NEW ID  2   HYD NO  185   ADD ID  2 TO ID  3
    PEAK FLOW =      12.167 CMS    RUNOFF VOLUME =    57.50 MM      TIME TO
           ADD HYD       ID=2      HYD NO=185      ID I=2        ID II=3
ADD HYD              NEW ID  2   HYD NO  185   ADD ID  1 TO ID  2
    PEAK FLOW =      16.260 CMS    RUNOFF VOLUME =    58.83 MM      TIME T
           ADD HYD       ID=2      HYD NO=185      ID I=1        ID II=2
*
* Swan Lake routing
```

```
*
ROUTE RESERVOIR          OUTFLOW ID 6  HYD 187 INFLOW ID 2
                         OUTFLOW (CMS) STORAGE (HA-M)
                             0.0           0.0000
                             0.03          0.8400
                             0.04          1.2800
                             0.05          2.2000
                             0.06          2.9000
                             0.10          6.5000
                             0.13         12.2000
    PEAK DISCHARGE =          .0598 CMS  RUNOFF VOLUME= 18.6511 MM
*
* Area 7
*
COMPUTE URBHYD           ID  4  HYD 190 TIME STEP 0.1667 HR   Area 2.2 ha
                         CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *24*
                         FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                         DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                         SLI 1.00 %  LGI 121 M  MNI 0.015
                         SLP 1.00 %  LGP 121 M  MNP 0.25
                         RAINFALL CODE  -1
    UNIT PEAK =      .168 CMS
    PEAK INTENSITY(RAIN EXCESS) =   205.92 MM/HR
    STORAGE COEFF. SC =    2.34 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      6.00

    UNIT PEAK =      .104 CMS
    PEAK INTENSITY(RAIN EXCESS) =   317.37 MM/HR
    STORAGE COEFF. SC =   10.64 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      6.00

    TOTAL RAINFALL =    83.75 MM

    PEAK DISCHARGE =        .839 CMS  RUNOFF VOLUME =    56.98 MM  TIME TO P

    RUNOFF VOLUMETRIC COEFFICIENT =   .68

*
*************************************************************************
**                             Regional Storm
*************************************************************************
*
* Area 1
*
COMPUTE URBHYD           ID  1  HYD 100 TIME STEP 0.25 HR   AREA 11.0 HA
                         CKK 1  XIMP  0.54 TIMP 0.58  RAINFALL INTERVALS *48*
                         FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                         DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                         SLI 1.00 %  LGI 271 M  MNI 0.015
                         SLP 1.00 %  LGP 271 M  MNP 0.25
                         REGIONAL STORM WITH REDUCTION FACTOR OF ONE
                         MM / HR WITH A FIFTEEN MINUTE TIME STEP
                         6.35  6.35  6.35  6.35  4.32  4.32  4.32  4.32
                         6.35  6.35  6.35  6.35 12.7   12.7  12.7  12.7
                        16.76 16.76 16.76 16.76 12.7   12.7  12.7  12.7
                        23.11 23.11 23.11 23.11 12.7   12.7  12.7  12.7
                        12.7  12.7  12.7  12.7  52.83 52.83 52.83 52.83
                        37.85 37.85 37.85 37.85 12.7   12.7  12.7  12.7
    UNIT PEAK =      .102 CMS
    PEAK INTENSITY(RAIN EXCESS) =    52.83 MM/HR
    STORAGE COEFF. SC =    6.54 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      4.00

    UNIT PEAK =      .037 CMS
    PEAK INTENSITY(RAIN EXCESS) =    44.66 MM/HR
    STORAGE COEFF. SC =   37.81 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      4.00

    TOTAL RAINFALL =   211.07 MM

    PEAK DISCHARGE =       1.331 CMS  RUNOFF VOLUME =   151.49 MM  TIME TO P

    RUNOFF VOLUMETRIC COEFFICIENT =    .72

*
* Area 2
*
COMPUTE URBHYD           ID  2  HYD 110 TIME STEP 0.25 HR   AREA 6.0 HA
                         CKK 1  XIMP  0.28 TIMP 0.56  RAINFALL INTERVALS *48*
```

```
                          FO 76.2   MM/HR   FC 13.2   MM/HR   DCAY 4.14 /HR   F 0 M
                          DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                          SLI 1.00 %   LGI 200 M   MNI 0.015
                          SLP 1.00 %   LGP 200 M   MNP 0.25
                          RAINFALL CODE   -1
     UNIT PEAK =      .106 CMS
     PEAKK INTENSITY(RAIN EXCESS) =     52.83 MM/HR
     STORAGE COEFF. SC =      5.45 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     4.00

     UNIT PEAK =      .050 CMS
     PEAK INTENSITY(RAIN EXCESS) =     73.25 MM/HR
     STORAGE COEFF. SC =     25.85 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     4.00

     TOTAL RAINFALL =    211.07 MM

     PEAK DISCHARGE =        .737 CMS   RUNOFF VOLUME =   144.53 MM   TIME TO P

     RUNOFF VOLUMETRIC COEFFICIENT =     .68

 *
 * Area 3
 *
COMPUTE URBHYD            ID   3   HYD 120 TIME STEP 0.25 HR    AREA 1.5 HA
                          CKK 1    XIMP   0.28 TIMP 0.56   RAINFALL INTERVALS *48*
                          FO 76.2   MM/HR   FC 13.2   MM/HR   DCAY 4.14 /HR   F 0 M
                          DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                          SLI 1.00 %   LGI 100 M   MNI 0.015
                          SLP 1.00 %   LGP 100 M   MNP 0.25
                          RAINFALL CODE   -1
     UNIT PEAK =      .112 CMS
     PEAK INTENSITY(RAIN EXCESS) =     52.83 MM/HR
     STORAGE COEFF. SC =      3.59 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     4.00

     UNIT PEAK =      .066 CMS
     PEAK INTENSITY(RAIN EXCESS) =     73.25 MM/HR
     STORAGE COEFF. SC =     17.05 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     4.00

     TOTAL RAINFALL =    211.07 MM

     PEAK DISCHARGE =        .192 CMS   RUNOFF VOLUME =   144.55 MM   TIME TO P

     RUNOFF VOLUMETRIC COEFFICIENT =     .68

 *
 * Area 4
 *
COMPUTE URBHYD            ID   4   HYD 130 TIME STEP 0.25 HR    AREA 6.5 HA
                          CKK 1    XIMP   0.20 TIMP 0.51   RAINFALL INTERVALS *48*
                          FO 76.2   MM/HR   FC 13.2   MM/HR   DCAY 4.14 /HR   F 0 M
                          DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                          SLI 1.00 %   LGI 208 M   MNI 0.015
                          SLP 1.00 %   LGP 208 M   MNP 0.25
                          RAINFALL CODE   -1
     UNIT PEAK =      .106 CMS
     PEAK INTENSITY(RAIN EXCESS) =     52.83 MM/HR
     STORAGE COEFF. SC =      5.58 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     4.00

     UNIT PEAK =      .049 CMS
     PEAK INTENSITY(RAIN EXCESS) =     73.05 MM/HR
     STORAGE COEFF. SC =     26.49 MINS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =     4.00

     TOTAL RAINFALL =    211.07 MM

     PEAK DISCHARGE =        .777 CMS   RUNOFF VOLUME =   137.11 MM   TIME TO P

     RUNOFF VOLUMETRIC COEFFICIENT =     .65

 *
 * Add flows to from North side
 *
ADD HYD                 NEW ID  2  HYD NO  140   ADD ID  2 TO ID  3
```

```
        PEAK FLOW =          .929 CMS      RUNOFF VOLUME =   144.54 MM       TIME T
 0             ADD HYD         ID=2      HYD NO=140     ID I=2            ID II=3
    ADD HYD                NEW ID  2  HYD NO  150    ADD ID   2 TO ID  4
        PEAK FLOW =         1.706 CMS      RUNOFF VOLUME =   141.09 MM       TIME T
 0             ADD HYD         ID=2      HYD NO=150     ID I=2            ID II=4
    *
    * Area 5
    *
    COMPUTE URBHYD              ID  3  HYD 160 TIME STEP 0.25 HR   AREA 19.0 HA
                                CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *48*
                                FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                                DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                                SLI 1.00 %  LGI 356 M  MNI 0.015
                                SLP 1.00 %  LGP 356 M  MNP 0.25
                                RAINFALL CODE  -1
        UNIT PEAK =       .097 CMS
        PEAK INTENSITY(RAIN EXCESS) =     52.83 MM/HR
        STORAGE COEFF. SC =     7.70 MINS

        SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      4.00

        UNIT PEAK =       .038 CMS
        PEAK INTENSITY(RAIN EXCESS) =     73.05 MM/HR
        STORAGE COEFF. SC =    36.57 MINS

        SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      4.00

        TOTAL RAINFALL =    211.07 MM

        PEAK DISCHARGE =       2.121 CMS  RUNOFF VOLUME =  137.09 MM   TIME TO P

        RUNOFF VOLUMETRIC COEFFICIENT =    .65

    *
    * Area 6
    *
    COMPUTE URBHYD              ID  4  HYD 170 TIME STEP 0.25 HR   AREA 6.1 HA
                                CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *48*
                                FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 M
                                DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                                SLI 1.00 %  LGI 202 M  MNI 0.015
                                SLP 1.00 %  LGP 202 M  MNP 0.25
                                RAINFALL CODE  -1
        UNIT PEAK =       .106 CMS
        PEAK INTENSITY(RAIN EXCESS) =     52.83 MM/HR
        STORAGE COEFF. SC =     5.48 MINS

        SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      4.00

        UNIT PEAK =       .050 CMS
        PEAK INTENSITY(RAIN EXCESS) =     73.05 MM/HR
        STORAGE COEFF. SC =    26.03 MINS

        SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =      4.00

        TOTAL RAINFALL =    211.07 MM

        PEAK DISCHARGE =        .731 CMS  RUNOFF VOLUME =  137.10 MM   TIME TO P

        RUNOFF VOLUMETRIC COEFFICIENT =    .65

    *
    * Add flows to from east side
    *
    ADD HYD                NEW ID  3  HYD NO  180    ADD ID   3 TO ID  4
        PEAK FLOW =         2.852 CMS      RUNOFF VOLUME =   137.09 MM       TIME T
 0             ADD HYD         ID=3      HYD NO=180     ID I=3            ID II=4
    *
    * Add total flows to Swan Lake
    *
    ADD HYD                NEW ID  2  HYD NO  185    ADD ID   2 TO ID  3
        PEAK FLOW =         4.558 CMS      RUNOFF VOLUME =   138.52 MM       TIME T
 0             ADD HYD         ID=2      HYD NO=185     ID I=2            ID II=3
    ADD HYD                NEW ID  2  HYD NO  185    ADD ID   1 TO ID  2
        PEAK FLOW =         5.889 CMS      RUNOFF VOLUME =   141.37 MM       TIME T
 0             ADD HYD         ID=2      HYD NO=185     ID I=1            ID II=2
    *
    * Swan Lake routing
    *
    ROUTE RESERVOIR             OUTFLOW ID 6  HYD 187 INFLOW ID 2
                                OUTFLOW (CMS) STORAGE (HA-M)
                                    0.0         0.0000
                                    0.03        0.8400
```

```
                              0.04        1.2800
                              0.05        2.2000
                              0.06        2.9000
                              0.10        6.5000
                              0.13       12.2000
    PEAK DISCHARGE =           .1019 CMS   RUNOFF VOLUME= 45.0687 MM
*
*
* Area 7
*
COMPUTE URBHYD            ID  4  HYD 190 TIME STEP 0.25 HR   Area 2.2 ha
                          CKK 1  XIMP  0.20 TIMP 0.51  RAINFALL INTERVALS *48*
                          FO 76.2  MM/HR  FC 13.2  MM/HR  DCAY 4.14 /HR  F 0 MM
                          DPSI 1.5 DPSP 4.7 STI 0.00 STP 0.00
                          SLI 1.00 %  LGI 121 M  MNI 0.015
                          SLP 1.00 %  LGP 121 M  MNP 0.25
                          RAINFALL CODE  -1
    UNIT PEAK =     .111 CMS
    PEAK INTENSITY(RAIN EXCESS) =     52.83 MM/HR
    STORAGE COEFF. SC =    4.03 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    4.00

    UNIT PEAK =     .062 CMS
    PEAK INTENSITY(RAIN EXCESS) =     73.05 MM/HR
    STORAGE COEFF. SC =   19.14 MINS

    SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =    4.00

    TOTAL RAINFALL =    211.07 MM

    PEAK DISCHARGE =       .275 CMS  RUNOFF VOLUME =  137.11 MM  TIME TO PEA

    RUNOFF VOLUMETRIC COEFFICIENT =   .65

FINISH
```

Extended Detention Discharge Calculation

Avg. Storage Elevation *(m)*	Outlet Invert *(m)*	Working El. of Orifice *(m)*	Operating Head *(m)*	Cd	Orifice Diameter *(m)*	Orifice Discharge *(m3/s)*
149.80	148.40	148.51	1.29	0.62	0.125	0.038

TABLE 1

SLOPE GRADIENT CLASSES

Slope* %	Description
0 - 10	Gentle
10 - 15	Moderate
Over 15	Steep

* Vertical distance : horizontal distance between two contours

TABLE 2

SLOPE LENGTH CLASSES

Length *	Description
under 70 metres	Moderate
over 70 metres	Long

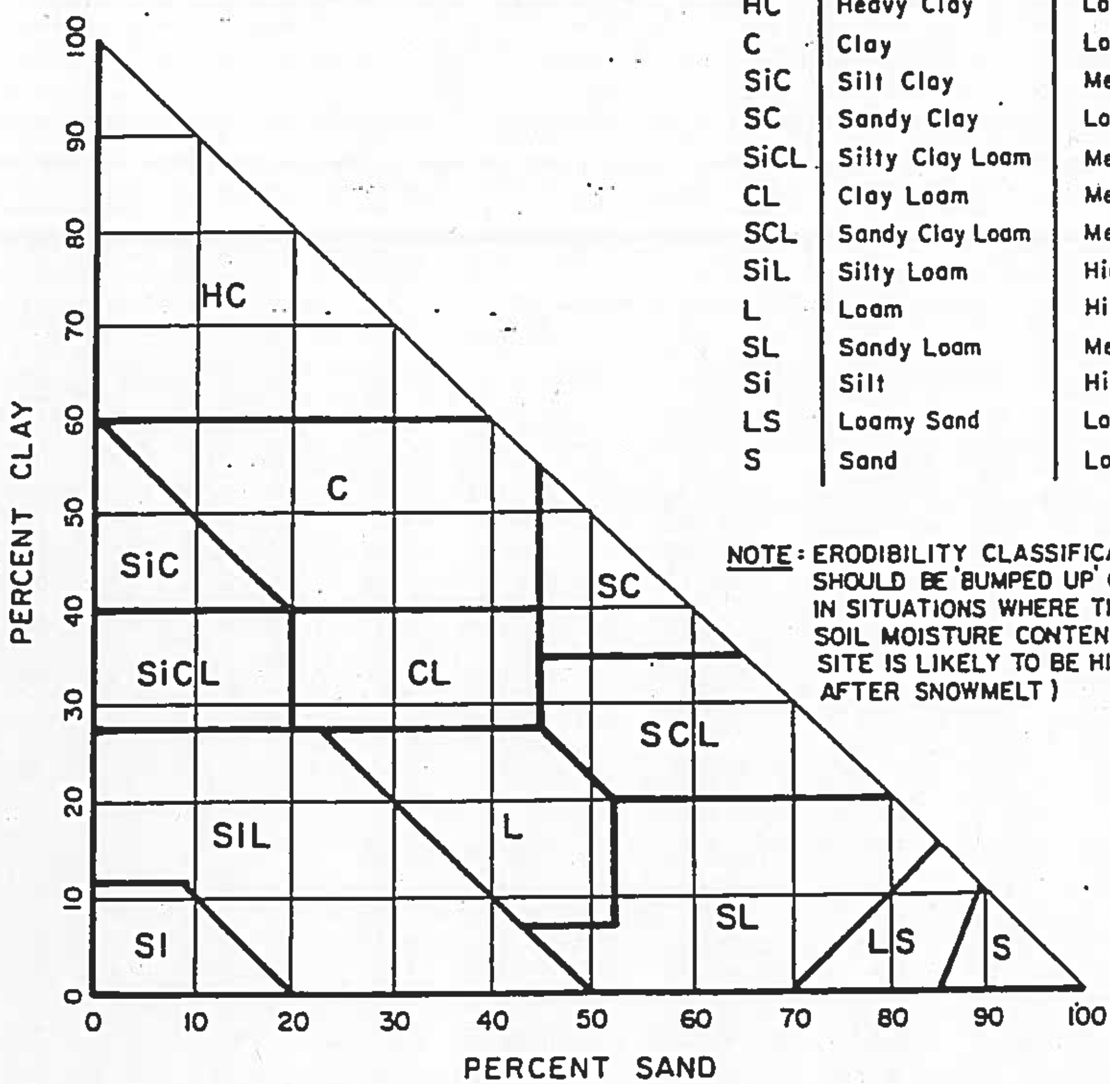
* slope length measured down the slope face

TABLE 3

SOIL ERODIBILITY

KEY	SOIL TYPE	SOIL ERODIBILITY (K)
HC	Heavy Clay	Low
C	Clay	Low
SiC	Silt Clay	Medium
SC	Sandy Clay	Low
SiCL	Silty Clay Loam	Medium
CL	Clay Loam	Medium
SCL	Sandy Clay Loam	Medium
SiL	Silty Loam	High
L	Loam	High
SL	Sandy Loam	Medium
Si	Silt	High
LS	Loamy Sand	Low
S	Sand	Low

NOTE: ERODIBILITY CLASSIFICATIONS (K) SHOULD BE 'BUMPED UP' ONE CLASS IN SITUATIONS WHERE THE INITIAL SOIL MOISTURE CONTENT OF THE SITE IS LIKELY TO BE HIGH. (ie AFTER SNOWMELT)



SOIL TEXTURE CLASSES. PERCENTAGES OF CLAY AND SAND IN THE MAIN TEXTURAL CLASSES OF SOIL; THE REMAINDER OF EACH CLASS IS SILT.

SOIL TEXTURE NOMOGRAPH

EROSION POTENTIAL

TOPOGRAPHIC CLASSES		SOIL ERODIBILITY CLASS ③		
GRADIENT ①	LENGTH ②	LOW	MEDIUM	HIGH
GENTLE	MODERATE	LOW	LOW	MODERATE
	LONG	LOW	MODERATE	HIGH
MODERATE	MODERATE	LOW	MODERATE	HIGH
	LONG	MODERATE	HIGH	HIGH
STEEP	MODERATE	MODERATE	HIGH	HIGH
	LONG	MODERATE	HIGH	HIGH

EROSION POTENTIAL

TABLE 5

DEGREE OF EROSION AND SEDIMENT CONTROL

Site Erosion Potential	Impacts on Downstream Water Uses	Degree of Erosion and Sediment Control
Low	Negligible	Good Housekeeping measures only
	Yes	Consider sedimentation pond(s)
Moderate	Negligible	Erosion and sediment controls
	Yes	Erosion controls and sedimentation pond(s)
High	Negligible	Erosion and sediment controls
	Yes	All flows to on-site sedimentation pond(s)

APPENDIX 'H'

References

APPENDIX [illegible]

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APPENDIX 'H'

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APPENDIX 'G'

Erosion and Sediment Control Measures

Is this part of a Topsoil Permi Applic

The following preliminary erosion and sediment control concept has been prepared in accordance with "*The Guidelines on Erosion and Sediment Control for Urban Construction Sites, MOEE 1987*".

The existing and proposed slope gradient of the site are between 0 and 10 %. Therefore as shown on **Table 1** the gradient is classified as "gentle". The average length of slope is over 70 m long and is therefore classified as "long" in **Table 2.** The soil conditions are predominantly sandy clay loam as determined by Peto MacCallum Ltd. an by the Ontario soil Survey report No. 19. As shown in the soil Texture Nomograph in **Table 3** this material has a "medium" soil erodability classification. The erosion potential of the site as determined in **Table 4** which combines the above data, has been rated as "moderate".

Based on the above evaluation, and the potential impact of sediment laden water to the Exhibition Creek and Reesor Pond, **Table 5** recommends the use of erosion controls and sedimentation ponds.