MASTER DRAINAGE PLAN

For

TWIN VALLEY RESORT

M.D. OF WILLOW CREEK No. 26, ALBERTA

Ptn. of W $^1/_2$ Section 13-15-26-W4M
E $^1/_2$ Section 14-15-26-W4M

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Prepared for:
TWIN VALLEY RESORT LTD.

December, 2004

Project No. 386-01-01

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Dec 15, 2004

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Signature
Date DEC 15, 2004
PERMIT NUMBER: P 4625
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

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1.0 INTRODUCTION

1.1 General

Lee Maher Engineering Associates Ltd. has been retained by Twin Valley Resort Ltd. to prepare the Master Drainage Plan for the future country residential subdivision to be known as Twin Valley Resort by the newly constructed Twin Valley Reservoir near the Town of Nanton, AB, County of Willow Creek. The Plan supports the Area Structure Plan completed in October 2004 by Lee Maher Engineering.

The following issues are addressed in this report:

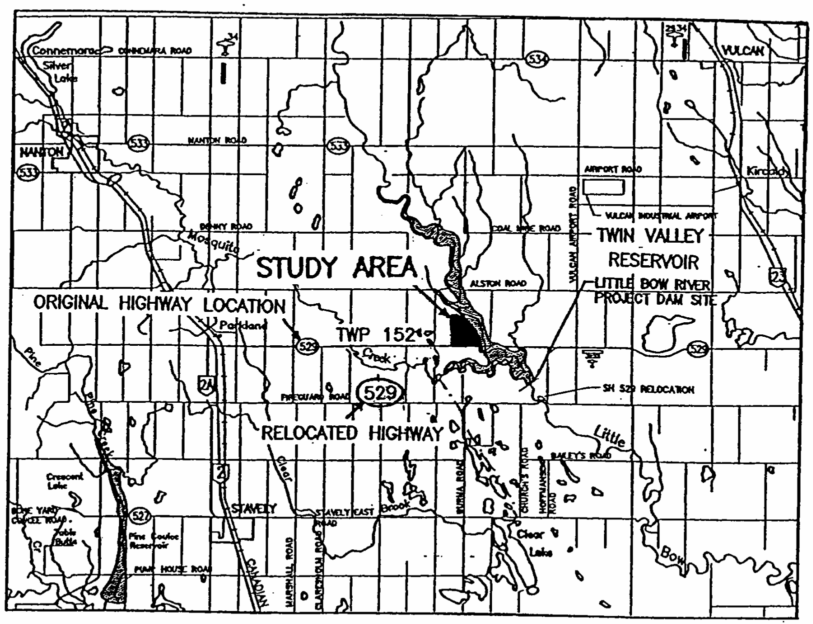
- Extent and directions of drainage flows,
- Discharge conditions,
- Preliminary design of the retention/detention system,
- Storm water quality.

1.2 Location

The legal description of the land is:

Ptn. of W$^1/_2$ Section 13-15-26-W4M, and
E$^1/_2$ Section 14-15-26-W4M

As shown in Figure 1, the study area of about 227.5 hectares is located on the west shore of the newly constructed Twin Valley Reservoir, about 10 kilometers east of Parkland and Highway #2. The Twin Valley Reservoir is a large irrigation reservoir constructed by Alberta Environment. The existing county (TWP) Road 152 bounds the study area on the south, providing an access from Highway #2. The land east of the study area adjacent to the reservoir is Government of Alberta property.



PROJECT AREA PLAN
SCALE 1:125 000

Scales: 1:125 000 — 0 1000 2500
1:250 000 — 0 3000 5000
1:4 000 000 — 0 40 80

This drawing may have been reduced. All scale notations indicated are based on 22"x34" format drawings.

FIGURE 1
LOCATION PLAN

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1.3 Proposed Development

As shown in Figure 2, the proposed development encompasses:

- 172 country residential lots - total 73.76 ha
- Common Area – total 3.03 ha
- Internal roads, pathways, and lanes - total 7.50 ha
- Central Lake Park – total 12.03 ha,
- Remainder of Section 13 – total 0.91 ha
- NW ¼ Section 14 – total 64.77 ha
- SW ¼ Section 14 – total 64.77 ha
- Range road allowance – total 3.22 ha

1.4 Physiography

The site is located adjacent to a newly created reservoir on the Little Bow River upland plain, approximately 20 metres above the original river bottom. The natural escarpment leading to the reservoir bounds the proposed development on the east. The escarpment slopes towards the reservoir at about 2% on the north and up to 10% on the south. The site is presently covered with grass with very little signs of erosion. Further to the south, within the government land, the escarpment becomes very steep and eroded.

The topography of the site and the surrounding area is gently undulating with numerous depressions and generally slopes towards the Little Bow River - Mosquito Creek channels on the east and south.

A geotechnical report was completed by G Tech Earth Sciences in September 2004. Test wells 6 meters deep indicate that an average of 300-mm of topsoil overlays silty sands, clay till and bedrock, mostly comprised of siltstone. Groundwater levels were found to be at depths between 2.64 m to 5.90 metres below the existing ground level. The test holes locations are shown in Appendix C.

The land is not presently being used for agriculture. However, an air photo taken several years ago (Appendix C) shows that with the exception of the northwest corner, the site was used for growing crops. Elevation of the site varies from 974m on the east high point to 966m within the natural low, and to 984.50m at the west high point.

1.5 Climatic Conditions

The study area is located in south central Alberta with a semiarid climate, characterized by hot dry summers and cold winters with little precipitation. The meteorological data for the Twin Valley Reservoir area applied in the WRMM model, which is being used to simulate the irrigation system operation in Southern Alberta, is as follows:

- Average annual evaporation - recorded data for Lethbridge with a factor of 0.94
  - Lake evaporation = 738 mm
  - Potential evaporation = 1027 mm
- Average annual precipitation = 438 mm derived from recorded data for Vulcan with a factor of 1.09

2.0 STORM DRAINAGE

2.1 Existing Drainage

The Twin Valley Reservoir has recently been constructed at the confluence of the Little Bow River and Mosquito Creek. A 22-meter high earth dam is located about 5 km south east of the study area. A copy of the Reservoir Area Plan prepared by AMEC Earth and Environmental Ltd. is included in Appendix C. The water level elevations for the reservoir are as follows:

- Full Supply Level (FSL) = 964.8 m
- 100-year flood level = 965.7 m
- 1000-year flood level = 967.3 m

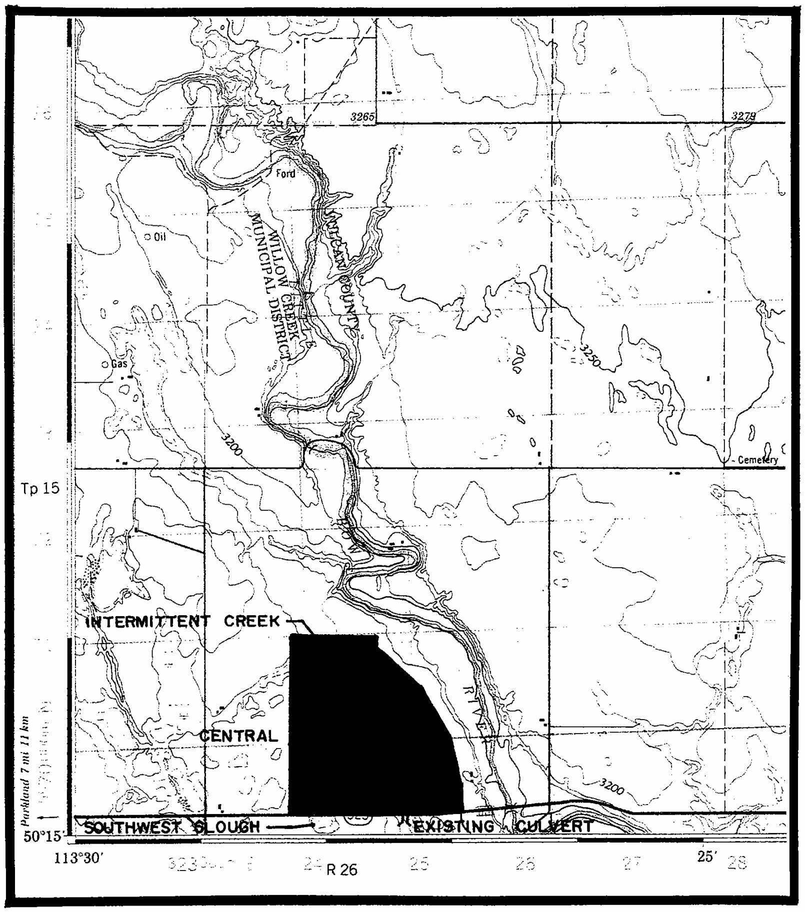
The general drainage system in the vicinity of the proposed Twin Valley Resort development is shown in Figure 3. The major drainage features and their drainage basins are shown in Figure 4. These are:

- Basin A Existing parcel presently contributing receiving runoff to the Twin Valley reservoir, area of 37.2 ha.
- Basin B Central depressional area which discharges to the Mosquito Creek (presently Twin Valley Reservoir) through the existing culvert, area of 120.8 ha.

  The existing 750mm diameter CSP culvert in TWP Road 152 is partially filled with soil, indicating the actual level of ponding in the slough when the discharge to the south occurs. The surveyed elevations of the culvert are as follows:

  N INV = 966.33

  S INV = 966.39
- Basin C Northwest parcel, which contains a creek that flows intermittently, drains depressional lows west of the study area. The northwest corner of the study area drains to this creek, area of 37.9 ha.
- Basin D Southwest parcel which is self-contained, with no discharge route. It drains the southwest corner of the site, area of 32.3 ha.



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SCALE: 1:50 000

FIGURE 3
DRAINAGE FEATURES

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FIGURE 3.DWG

2.2 Post Development Drainage

The proposed drainage system for the Twin Valley Resort development is shown in Figure 5. The following assumptions were developed for the future storm drainage design:

1) The proposed Central Lake Park located within an existing low area, will receive the runoff from the majority of the residential development, from the land set aside for effluent irrigation and from the portion of the Reserved Land.
2) Two proposed storm ponds connected by a brook, to be constructed within the Central Lake Park, will provide water quality enhancement within their permanent volumes. A circulation pump will circulate the water flow between these two storm ponds, thereby aerating the stored water.
3) The runoff resulting from up to a 100-year storm will be stored within the Central Lake Park above the permanent ponds and the adjacent land, which will create "active storage".
4) The excess runoff from active storage will discharge through the existing culvert at the pre-development rates based on the pre-development drainage boundary and the actual capacity of the existing culvert.
5) A control structure will be constructed upstream of the existing culvert to restrict the flow to the pre-development flow rate.
6) Runoff from the Effluent Irrigated Land, which may contain elevated nutrient contents, will pass through a wetland before entering the storm ponds. This will protect the permanent ponds from excessive eutrophication.
7) A cutoff ditch will be constructed along the proposed drainage boundary between the Effluent Irrigated Land and the Intermittent Creek to prevent any overland runoff or subsurface flow generated by the effluent irrigated area from entering the existing watercourse in the northwest. The flow will be directed to the wetland.

8) The western portion of the Reserved Land will continue discharging to the existing Southwest Slough.

9) The proposed residential development will drain overland through roads, paths and lanes to the proposed storm ponds in the Central Lake Park. The flow depths and velocities will conform to the AENV standards.

10) Drainage from the backyards adjacent to the reservoir is proposed to drain to the reservoir as overland drainage.

3.0 DESIGN CRITERIA & METHODOLOGY

The following calculations will be performed in order to provide flood protection, improve the quality of storm water leaving the development and to determine the required water to supplement the existing storm pond.

a) Determine the pre-development 100-year discharge rate based on the natural drainage boundary of the Central Parcel and the existing natural storage within this catchment.

b) Calculate the detention volume required for a 100-year storm.

c) Calculate the permanent pond volume required for water quality enhancement purposes.

d) Determine the size of the natural wetland and the cutoff ditch for the Effluent Irrigated Land.

e) Determine the annual hydrologic water budget using the evaporation and precipitation data and input this data into the Qualhymo model.

4.0 COMPUTER MODELLING

4.1 Model Applied

A hydrologic analysis to determine the required volume of detention in the storm ponds was carried out in accordance with the Alberta Environment Stormwater Management Design Guidelines. The INTERHYMO computer program, of a single event storm model, was used in calculations of active storage volumes, permanent pond storage volume and peak flows in some critical locations in the developed area.

4.2 Design Storm

The Chicago distribution design storm was applied in the modelling. The storm frequency and duration used varied according to the modelling purpose:

- 24-hour duration, 100-year return period storm in dry storage volume required
- 24-hour, 2-year return period storm in permanent pond storage volume required

The IDF data for the Nanton area was obtained from the "Rainfall Frequency Atlas for Canada", 1985 and the following values were used in the development of the design storm for the study area:

- 100-year, 24 hour storm – total rainfall 89.35 mm, (Calgary, 89.4 mm), design storm for Calgary was used
- 2-year, 24 hour storm – total rainfall 41.8 mm (Calgary 37.2 mm)

4.3 Model Parameters

The input data for the Interhymo model includes drainage areas and land surface characteristics. The model parameters were selected as follows:

4.3.1 Drainage areas

The division into drainage subcatchments to calculate the active 100-year storage volume and the permanent pond volumes is marked on Figure 5. The pre-development catchment boundaries are marked in Figure 4. The summary of drainage areas used in pre and post-development modelling are summarized in Table 4.1.

4.3.2 Imperviousness Ratio

- **Residential development**:
  Average lot size = 4050 m^2, (1 acre)
  Average area of building + ½ of adjacent road + parking space = 500 m^2
  Total imperviousness ratio (TIMP) = 0.12
  Directly connected area XIMP = 0.05

- **Road allowance:**
  Total width = 15m
  Paved width = 7m
  Total imperviousness ratio (TIMP) = 0.47
  Directly connected area XIMP = 0.47 as the roads will be of dished type

- **Lanes and pathways:** TIMP = 0 47, XIMP = 0.20

- **Bottom of permanent pond**: impervious, TIMP = XIMP = 0.99

4.3.3 CN Value

The geotechnical report as completed by G Tech Earth Sciences Corp in September 2004, describes the soils as follows:

- Topsoil of thickness of 0.30m consisting of loamy, medium brown organic soil
- Silty, clayey and gravelly sands 1.28m to 5.94m in thickness
- Clay till found between the sand layer and bedrock in all locations
- Bedrock was generally encountered at depths between 3.35m and 6.10m below existing ground levels.

Following the SCS TR 55 the Hydrologic Soil Group was assessed as moderately to high pervious "B". The corresponding CN value is 61 for AMC II (antecedent moisture condition) and for lawn and natural vegetation cover in good condition. As the imperviousness ratio for one acre residential development sites is too low to use the modelling subroutine for urban land "Standyd" of the Interhymo Model, the "Nashyd" subroutine was used with the CN increased to 68 (SCS TR 55).

The CN value for the Central Lake Park Area was increased to 64, as in this area the soils are expected to be less pervious. This applies to the low portion of the Effluent Irrigation Lands, resulting in a general CN increase to 64.

4.3.3 Initial Abstraction

Impervious surface Ia =1.6 mm
Pervious surface Ia was calculated using the Should equation Ia = $S^{0.55}$, 16.4 mm for pasture and lawns, 13.9 mm residential lots.

4.3.5 Model Schematic

The schematic for storm pond volume calculations is included in Figure 1-A in Appendix B.

Table 4.3.5.1 Summary of Modelling Parameters

Catchment Name	Area in Ha	CN	Impervious ratio (TIMP/XIMP)	Initial abstraction (mm)
POST-Development Modelling				
Reserved Land incl. Road ROW	33.49	61	0	16.4
Effluent Irrigated Land Incl. ROW	50.45	64	0	15.3
Roads (incl. paths and lanes)	7.55	61	0.47/0.30	1.6 / 16.4
Residential lots (excluding roads)	75.20	68	n/a	13.9
Central Lake Park	12.03	64	0.33	0.1 / 15.3
Total area to Central Lake	**178.72**			
PRE-Development Modelling				
Central Parcel	18.00	80	0	9.8
Undeveloped Land	102.80	61	0	16.4
Total pre-development	**120.80**			

4.4 Pond Discharge

The storm pond will discharge through an existing culvert. As this culvert has been partially filled with sediment, we propose to maintain its present opening and its capacity as a maximum allowable discharge from the study area. To prevent the culvert washout during major floods, an outlet structure containing a gated outlet and a discharge regulating orifice will be constructed upstream of the existing culvert.

The maximum discharge based on the opening area of the existing culvert and the water elevation above the invert is 300 L/s. This value will be adopted as the maximum (100-year) discharge rate from the study area. The unit 100-year maximum discharge rates are as follows:

- Pre-development = 2.40 L/s/ha
- Post-development = 1.62 L/s/ha

The post-development storage outlet rating curve has been developed with the assumption that the 0.42m diameter orifice is installed in the outlet structure constructed upstream of the existing culvert and that the maximum flood water depth above the culvert inlet is 1.0 m.

Table 4.4.1 Pond discharge rating curve in post-development

Active Depth (m)	Elevation (m)	Active Volume (m^3)	Discharge (m^3/s)
0.00	966.33	0.00	0.000
0.30	966.63	2263.00	0.107
0.50	966.83	10600.00	0.185
0.75	967.08	28700.00	0.250
0.93	967.26	34000.00	0.288
1.00	967.33	36600.00	0.302

Table 4.4.2 Pond discharge rating curve in pre-development

Active Depth (m)	Elevation (m)	Active Volume (m^3)	Discharge (m^3/s)
0.00	966.33	0.00	0.000
0.3	966.63	6900	0.109
0.5	966.83	10380	0.244

5.0 STORMWATER QUALITY

5.1 Water Quality Constituents Generated in the Study Area

- Sediment, TSS: The amount of sediment that will be generated within the residential development area. Due to the low population density and large lot sizes, the sediment content entering the storm ponds should be negligible. Any sediment entering the proposed pond should settle out.
- Nitrogen: The amount of nitrogen washed out from fertilizer applied in the residential development area should not be significant. It is expected that due to the large size of the lots, the majority of the land will be left in a natural state or planted with trees and bushes. However elevated nitrogen amounts can be washed out from the Effluent Irrigated Land if a storm occurs soon after an effluent application. Permanent ponds are not effective in removal of nitrogen since organic nitrogen is easily converted to soluble ammonia nitrogen, nitrate and nitrite. Therefore we propose to use wetlands, which are capable of reducing soluble pollutants. The wetlands will be located in the lowest point of the Effluent Irrigated Land, upstream from the storm pond.
- Phosphorus: Both permanent ponds and wetlands are very effective in the removal of phosphorus. Also, since the levels of phosphorous loading in the wastewater are not very high, the phosphorus is effectively immobilized in most soils at shallow depths.
- Potassium, BOD, pathogens and heavy metals, if they occur in the runoff, will be removed in the wetlands or in the permanent pond.

5.2 Permanent Pond

The proposed storm pond, consisting of two separate permanent ponds connected by a brook as shown in Figure 6, will be located in the Central Lake Park. The maximum depth of the permanent ponds will be 2.5 m. Based on

AENV Guidelines the minimum pond capacity for the water quality purpose is equal to the runoff volume generated during a 25-mm, 24-hour storm. However, because of the highly pervious soils and the majority of site left undeveloped, this storm would have produced an insignificant runoff volume. Therefore a 2-year storm (which is recommended in the City of Calgary Guidelines) was used as input into the Interhymo model (Appendix B) resulting in the volume required to be 9986 m^3. The pond parameters are summarized in Table 6.1, Chapter 6.

A circulation pump installed at the lower (south) pond will circulate the water between the permanent ponds. Besides the visual benefits of flowing water, this will aerate the storm ponds, preventing water stagnation and anaerobic conditions. The FSL, or permanent water level, in the ponds varies by 0.3 m, the North pond being at 966.65, the South pond at 966.35, allowing gravity flow between the ponds.

The need for the permanent ponds lining will be determined at the detailed design stage.

5.3 Wetland

Wetlands are highly effective means of removing pollutants from urban runoff. The removal mechanisms include sedimentation, absorption, filtration and biological uptake. As the main water quality concern for the proposed development is the possibility of an excessive nutrient generation, we propose to use and maintain the existing wetland upstream of the storm ponds to control nutrients, especially the organic nitrogen.

The depressional land immediately upstream of the proposed storm ponds, which is a natural wetland, will be used in the same function in the proposed development. Only limited construction should be required. At present, we propose to construct a ditch that will act as a conveyance for runoff from the north. A low berm (elevation about 967.20m) will also be built to separate the wetland from the proposed storm pond to aid in maintaining an optimum water depth.

The proposed land set aside for wetlands will be approximately 2.95 ha and will incorporate an existing small pond (about 1.8m deep and a capacity of 200m^3), a shallow marsh of varying depth (0.8m to 0.3m) and at the southern end, the natural pond (about 1.0m deep). The wetland will receive runoff from the Effluent Irrigated Land, a portion of the residential development and a portion of the Reserve Land. Its total dead storage capacity is approximately 9,000m^3, which based on the Urban Wetlands Seminar Manual by Richard R. Horner, might serve a contributing urban area of 220 ha during a 2-year storm, twice the area which will actually discharge to the wetland.

Sine the wetland currently exists naturally, there should be no need to line the wetland.

A buffer of bushes and trees should be provided along the wetland boundaries, especially along the residential backyards. The water level variations will be low, as the excess flow will spill through a berm and into the North pond. Only during major events (100-year storm) will there will be water backed up from the Feature Park ponds to an elevation of about 967.35.

5.4 Detention Storage

The surface runoff from the majority of the site will collect in the storm ponds of the Central Lake Park. The minor storm event will be kept within the FSL of the storm ponds and wetland, while the major storm event runoff will accumulate above the storm pond's FSL up to 1.0 metre in depth, inundating an area of about 4.5 ha. The runoff stored in the ponds will be gradually released through the outlet structure and then the existing culvert to the southern extension of the slough. The 2-year storm volume will be released at the allowable rate of 120 l/s (0.67 l/s/ha), and its volume stored for at least 24 hours within the existing ponds, as required by the AENV guidelines.

5.5 Water Budget

5.5.1 Budget Parameters

The need to supply make up water to the storm ponds, the wetland and for irrigation within the study area should be calculated from the water balance.

Average annual supply volume = E + Gin – R – Gout – S

Where:

E	= Evaporation from the water body surface, annual value 738 mm
R	= Runoff resulting from average precipitation, annual value 438 mm
Gin	= Groundwater recharge
Gout	= Groundwater discharge
S	= Storage change

Of the above equation parameters:

- Storage change can be assumed to be zero

- Evaporation loss from the water surface is being calculated using the average annual lake evaporation
- Average annual total runoff from the study area is being calculated using the continuous simulation model QHM over the period of 35 years
- Groundwater discharge/recharge relationship, which does play an important role in the water budget has not been researched sufficiently as yet. Groundwater readings conducted in September 2004 after the wet summer and fall found the lowest elevations along the reservoir escarpment, on average at 964.7 and the highest in the northwest corner of the site at 971.01 which illustrates that the ground water moves from west to east. The ground water elevation in the TH 13, located closest to the Feature Park is 966.06, equal to the free water surface elevation at the time of the measurements. The large slough area marked on the topographical map (drafted in 1976), Figure 3 indicates that historically a high ground water level might have occurred in this area. However, since then, the climate has changed resulting in many water bodies in Alberta drying up. Another unknown factor is the influence of the newly constructed reservoir on groundwater fluctuations. Therefore for the time being it is assumed that infiltration losses and groundwater recharge add up to zero.

5.5.2 Budget Calculation

- Input data that was entered into the Qualhymo model is the precipitation recorded at the Calgary International Airport in hourly time steps during the period of 1960 to 1994
- The model schematic is included in Figure B-1. The min / max storage parameters were determined for an average CN (63) value for the entire Central Lake catchment area
- Evapotranspiration losses are included in the model. The monthly evapotranspiration data for Lethbridge was used with a coefficient of 0.94

- The average annual precipitation and runoff was obtained by dividing the total precipitation and runoff values calculated by the model by 35 years. As the average annual precipitation from the model is only 272 mm, versus a total of 438mm, a ratio of 1.6, the resulting runoff of 18,686m^3 was adjusted to 30,300m^3
- The annual evaporation loss for the water surface of 4.35 ha is 32,103m^3

Therefore in an average year, approximately 2000m^3 of make up water per year will be required to supplement the storm ponds and wetlands when infiltration losses are not considered. The final needs for the make up water can be determined when the groundwater influence is better known. This make up water will be obtained from the newly constructed reservoir.

5.6 Discharge to Reservoir Embankment

We propose to discharge runoff from the back half of the lots adjacent to the escarpment, onto the escarpment. The naturally vegetated escarpment is sufficiently long and its slope quite shallow (2% to 10%), is much less than the maximum allowable, to provide high quality biological filtration prior to the runoff entering the reservoir. The slope vegetation should be protected and preserved. Any runoff that occurs will provide moisture needed for the vegetation on east facing slopes.

The runoff is expected to reach the escarpment as distributed flow, with the majority of the flow being subsurface. Any flow concentration that might cause erosion in steeper portions of the escarpment should be prevented by the introduction of flow spreaders and/or by the erection of environmental berms. The escarpment should be inspected annually.

6.0 RESULTS - SUMMARY

6.0 RESULTS - SUMMARY

The printouts of the input/output data files for the Interhymo model simulations are located in Appendix A. The results are shown in Figures 5, 6 and 7.

Table 6.1 Results Summary

PARAMETER	VALUE
Lake drainage area (ha)	178.72
Permanent pond volume required (m^3)	9,986
100-year active volume required (m^3):	35,760
Unit detention required in permanent storage (m^3/ha):	53
Unit detention in active storage (m^3/ha):	200
Maximum permanent depth up to FSL (m):	2.50
Maximum active (100-year) storage depth (m):	1.00
Maximum rate of discharge (m^3/s):	0.290
Unit max. discharge rate (l/s/ha):	1.60
Minimum Freeboard (m):	0.15
Permanent water elevation PWL - South Pond	966.35
Permanent water elevation PWL – North Pond	966.65
100-year water elevation HWL	967.35
Minimum Freeboard elevation	967.50
Wetland dead storage (m3):	9000
Wetland FSL	967.20
Wetland 100-year elevation	967.35

7.0 CONCLUSIONS AND RECCOMMENDATIONS

1. The Master Drainage Plan has been prepared in accordance with the Stormwater Management Guidelines for the Province of Alberta, 1999
2. Generally, land development increases impervious surface cover resulting in higher peak flows and surface runoff volumes. However the proposed development, with large lots and a significant area left in the natural stage, will have a minor impact on the hydrology of the area
3. The discharge rate from the proposed development, which naturally drains towards the south, will be reduced to pre-development rates, maximum of 290 L/s for a 100-year flood event
4. The runoff quality enhancement controls will be through the use of wet ponds and wetlands
5. The two proposed wet ponds will have a capacity significantly exceeding volume required based on the AENV guideline. Additionally, the runoff will be aerated by circulating the water between the two wet ponds
6. The natural wetland north and west from the proposed development will be preserved and maintained with a minimum amount of construction. The wetland will remove nutrients before the runoff enters the storm ponds
7. The make-up water to supplement the storm pond and wetlands storage, and for irrigation of the Common Ground Park will be supplied from the Twin Valley Reservoir

APPENDIX A

INTERHYMO Model I/O Files

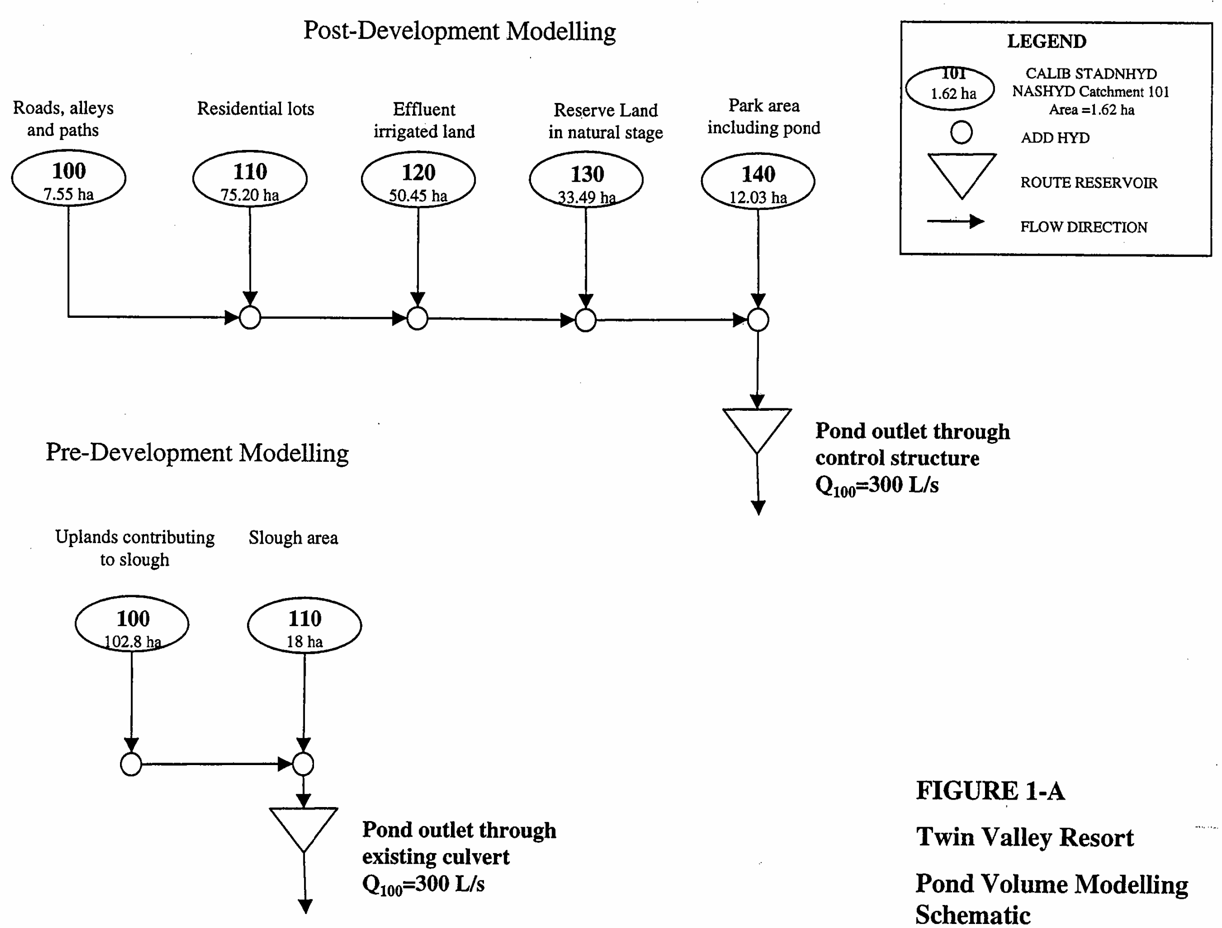

FIGURE 1-A

Twin Valley Resort

Pond Volume Modelling Schematic

```
2
*       Twin Valley Resort
*       Master Drainage Plan
*       Stormwater pond Capacity
*       Design Storm: Chicago, 1 in 100 year, 24 hour duration
*       October 2004
*       EL
*
START               TIME= 0.0  IUNITS= 2
*
*  derive a 24 hour Chicago storm
CHICAGO STORM       IUNITS=2 TD=24 HOURS R=0.333 SDT=15 MIN ICASE=1
                    A= 663.1 B=1.87 C=0.712
*****************************************************************
* POST DEVELOPMENT RUNOFF
* Roads/paths
CALIB STANDHYD      ID=1  NHYD=100   DT=5 min  AREA=7.55 HA
                    XIMP=.30 TIMP=.47 DWF=0 LOSS=2 CN=61
                    PERVIOUS DPSP=16.4 MM SLOPE=2% LGP=20 M MNP=0.25 SCP=0
                    IMPERVIOUS DPSI=1.6 MM SLOPE=0.6% LGI=40 M MNI=0.013 SCI=0
                    END=-1
* Residential area  (building density 1 per acre)
CALIB NASHYD        ID=2  NHYD=110  DT=5 min  AREA= 75.20 ha  DWF=0  CN=68
                    IA=13.9 mm  N=2.5 TP=0.30 hr  -1
*
ADD HYD             ID=3 NHYD=1010 IDONE=1 IDTWO=2
*
*Irrigated land
CALIB NASHYD        ID=4  NHYD=120  DT=5 min  AREA= 50.45 ha  DWF=0  CN=64
                    IA=15.3 mm  N=2.5 TP=0.55 hr  -1
* Reserved land
CALIB NASHYD        ID=5  NHYD=130  DT=5 min  AREA= 33.49 ha  DWF=0  CN=61
                    IA=16.4 mm  N=2.5 TP=0.45 hr  -1
*
ADD HYD             ID=6 NHYD=1020 IDONE=3 IDTWO=4
*
ADD HYD             ID=7 NHYD=1030 IDONE=6 IDTWO=5
*
* Park Area including lakes
CALIB STANDHYD      ID=8  NHYD=140   DT=5 min  AREA=12.03 HA
                    XIMP=.33 TIMP=.33 DWF=0 LOSS=2 CN=64
                    PERVIOUS DPSP=15.3 MM SLOPE=2% LGP=20 M MNP=0.25 SCP=0
                    IMPERVIOUS DPSI=0.1 MM SLOPE=0.1% LGI=40 M MNI=0.013 SCI=0
                    END=-1
*
ADD HYD             ID=9 NHYD=1040 IDONE=8 IDTWO=7
*
ROUTE RESERVOIR     ID=10 NHYD=1000 IDIN=9 DT=5 min
                    Discharge  Storage
                        0.0      0.0
                        0.107    0.23
                        0.185    1.06
                        0.250    2.87
                        0.302    3.875   -1
**********************************************************
* PRE-DEVELOPMENT RUNOFF
CALIB NASHYD        ID=1  NHYD=200  DT=5 min  AREA= 102.8 ha  DWF=0  CN=61
                    IA=16.4 mm  N=2.5 TP=0.70 hr  -1
*
* Wetland Area
CALIB NASHYD        ID=2  NHYD=210  DT=5 min  AREA=18 ha  DWF=0  CN=86
                    IA=10 mm  N=2.5 TP=0.20 hr  -1
*
ADD HYD             ID=3 NHYD=2010 IDONE=1 IDTWO=2
*
ROUTE RESERVOIR     ID=4 NHYD=2020 IDIN=3 DT=5 min
                    Discharge  Storage
                        0.0      0.0
                        0.109    0.69
                        0.244    1.04
                        0.297    1.80 -1
**********************************************************
*
FINISH
```

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

       OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    I N T E R H Y M O
      O   O    T      T    H   H   Y Y   MM MM  O   O   * * * 1989b * * *
      O   O    T      T    HHHHH    Y    M M M  O   O
      O   O    T      T    H   H    Y    M   M  O   O
       OOO     T      T    H   H    Y    M   M   OOO    E-9516061302198

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  EXCLUSIVE USE TO : E. Lipowska

  Input   filename: twin100.dat
  Output  filename: twin100.out
  Summary filename: twin100.sum


DATE: 10-10-2004                         TIME: 17:58:09

COMMENTS: ___________________________________________________________

--------------------------------------------------------------------------
*        Twin Valley Resort
*        Master Drainage Plan
*        Stormwater pond Capacity
*        Design Storm: Chicago, 1 in 100 year, 24 hour duration
*        October 0 2004
*        EL
*
  ***************************
  ** SIMULATION NUMBER:   1 **
  ***************************

*
*  derive a 24 hour Chicago storm
--------------------
| CHICAGO STORM    |     IDF curve parameters: A= 663.100
| Ptotal= 89.67 mm |                           B=   1.870
--------------------                           C=    .712
                         used in:    INTENSITY =  A / (t + B)^C

                         Duration of storm   = 24.00 hrs
                         Storm time step     = 15.00 min
                         Time to peak ratio =    .33
```

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
.25	1.11	6.25	3.27	12.25	2.77	18.25	1.48
.50	1.13	6.50	3.67	12.50	2.66	18.50	1.46
.75	1.16	6.75	4.21	12.75	2.56	18.75	1.43
1.00	1.19	7.00	4.99	13.00	2.47	19.00	1.41
1.25	1.22	7.25	6.24	13.25	2.39	19.25	1.39
1.50	1.26	7.50	8.71	13.50	2.31	19.50	1.36
1.75	1.29	7.75	17.31	13.75	2.24	19.75	1.34
2.00	1.33	8.00	88.69	14.00	2.17	20.00	1.32
2.25	1.37	8.25	21.72	14.25	2.11	20.25	1.30
2.50	1.42	8.50	12.91	14.50	2.05	20.50	1.29
2.75	1.47	8.75	9.62	14.75	1.99	20.75	1.27
3.00	1.52	9.00	7.81	15.00	1.94	21.00	1.25
3.25	1.58	9.25	6.66	15.25	1.89	21.25	1.23
3.50	1.64	9.50	5.84	15.50	1.85	21.50	1.22
3.75	1.71	9.75	5.23	15.75	1.81	21.75	1.20
4.00	1.78	10.00	4.75	16.00	1.77	22.00	1.19
4.25	1.87	10.25	4.37	16.25	1.73	22.25	1.17
4.50	1.97	10.50	4.05	16.50	1.69	22.50	1.16
4.75	2.08	10.75	3.78	16.75	1.66	22.75	1.14
5.00	2.20	11.00	3.56	17.00	1.62	23.00	1.13
5.25	2.34	11.25	3.36	17.25	1.59	23.25	1.12
5.50	2.51	11.50	3.19	17.50	1.56	23.50	1.10
5.75	2.72	11.75	3.03	17.75	1.53	23.75	1.09
6.00	2.96	12.00	2.90	18.00	1.51	24.00	1.08

```
--------------------------------------------------------------------------
*****************************************************************
```

```
* POST DEVELOPMENT RUNOFF
* Roads/paths
--------------------
| CALIB              |
| STANDHYD  (0100) |   Area     (ha)=    7.55
|ID= 1 DT= 5.0 min |   Total Imp(%)=  47.00   Dir. Conn.(%)=  30.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area      (ha)=       3.55          4.00
     Dep. Storage      (mm)=       1.60         16.40
     Average Slope      (%)=        .60          2.00
     Length             (m)=      40.00         20.00
     Mannings n            =       .013          .250

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

                              IMPERVIOUS    PERVIOUS (i)
     Max.eff.Inten.(mm/hr)=      88.69         35.67
                over (min)        5.00         10.00
     Storage Coeff.  (min)=       1.80 (ii)     8.84 (ii)
     Unit Hyd. Tpeak (min)=       5.00         10.00
     Unit Hyd. peak  (cms)=        .32           .12
                                                          *TOTALS*
     PEAK FLOW       (cms)=        .56           .28          .82 (iii)
     TIME TO PEAK    (hrs)=       8.00          8.08         8.00
     RUNOFF VOLUME    (mm)=      88.07         29.81        47.28
     TOTAL RAINFALL   (mm)=      89.67         89.67        89.67
     RUNOFF COEFFICIENT   =        .98           .33          .53

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  61.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------
* Residential area  (building density 1 per acre)
--------------------
| CALIB              |
| NASHYD     (0110) |   Area     (ha)=  75.20   Curve Number    (CN)= 68.0
|ID= 2 DT= 5.0 min |   Ia       (mm)=  13.90   # of Linear Res.(N)= 2.50
--------------------   U.H. Tp(hrs)=     .30

     Unit Hyd Qpeak  (cms)=   8.181

     PEAK FLOW       (cms)=   2.262 (i)
     TIME TO PEAK    (hrs)=   8.250
     RUNOFF VOLUME    (mm)=  29.323
     TOTAL RAINFALL   (mm)=  89.665
     RUNOFF COEFFICIENT   =    .327

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

------------------------------------------------------------------------------
*


--------------------
| ADD HYD   (1010) |
|   1 + 2 = 3      |          AREA     QPEAK     TPEAK      R.V.
--------------------          (ha)     (cms)     (hrs)      (mm)
          ID1= 1 (0100):      7.55       .82      8.00     47.28
        + ID2= 2 (0110):     75.20      2.26      8.25     29.32
          ===============================================
          ID = 3 (1010):     82.75      2.57      8.25     30.96

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------
*
*Irrigated land
--------------------
| CALIB              |
| NASHYD     (0120) |   Area     (ha)=  50.45   Curve Number    (CN)= 64.0
|ID= 4 DT= 5.0 min |   Ia       (mm)=  15.30   # of Linear Res.(N)= 2.50
--------------------   U.H. Tp(hrs)=     .55

     Unit Hyd Qpeak  (cms)=   2.994
```

```
     PEAK FLOW        (cms)=     .849 (i)
     TIME TO PEAK     (hrs)=    8.667
     RUNOFF VOLUME     (mm)=   25.444
     TOTAL RAINFALL    (mm)=   89.665
     RUNOFF COEFFICIENT   =      .284

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

-------------------------------------------------------------------------------
* Reserved land
--------------------
| CALIB              |
| NASHYD    (0130)   |   Area     (ha)=  33.49   Curve Number    (CN)= 61.0
|ID= 5 DT= 5.0 min   |   Ia       (mm)=  16.40   # of Linear Res.(N)= 2.50
--------------------     U.H. Tp(hrs)=     .45

     Unit Hyd Qpeak  (cms)=    2.429

     PEAK FLOW        (cms)=     .551 (i)
     TIME TO PEAK     (hrs)=    8.500
     RUNOFF VOLUME     (mm)=   22.758
     TOTAL RAINFALL    (mm)=   89.665
     RUNOFF COEFFICIENT   =      .254

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

-------------------------------------------------------------------------------
*

--------------------
| ADD HYD   (1020)   |
|   3 +  4 =  6      |         AREA     QPEAK     TPEAK      R.V.
--------------------           (ha)     (cms)     (hrs)      (mm)
          ID1= 3 (1010):      82.75      2.57      8.25     30.96
        + ID2= 4 (0120):      50.45       .85      8.67     25.44
          ===============================================
          ID = 6 (1020):     133.20      3.21      8.25     28.87

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
*

--------------------
| ADD HYD   (1030)   |
|   6 +  5 =  7      |         AREA     QPEAK     TPEAK      R.V.
--------------------           (ha)     (cms)     (hrs)      (mm)
          ID1= 6 (1020):     133.20      3.21      8.25     28.87
        + ID2= 5 (0130):      33.49       .55      8.50     22.76
          ===============================================
          ID = 7 (1030):     166.69      3.70      8.33     27.64

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
*
* Park Area including lakes
--------------------
| CALIB              |
| STANDHYD  (0140)   |   Area      (ha)=   12.03
|ID= 8 DT= 5.0 min   |   Total Imp(%)=   33.00    Dir. Conn.(%)=   33.00
--------------------

                              IMPERVIOUS      PERVIOUS (i)
     Surface Area      (ha)=        3.97          8.06
     Dep. Storage      (mm)=         .10         15.30

     Average Slope      (%)=         .10          2.00
     Length             (m)=       40.00         20.00
     Mannings n           =         .013          .250

     Max.eff.Inten.(mm/hr)=        88.69         21.78
                over (min)         5.00         15.00
     Storage Coeff.   (min)=        3.09 (ii)    11.65 (ii)
     Unit Hyd. Tpeak  (min)=        5.00         15.00
     Unit Hyd. peak   (cms)=         .27           .09
                                                              *TOTALS*
     PEAK FLOW        (cms)=         .97           .29          1.17 (iii)
     TIME TO PEAK     (hrs)=        8.00          8.17          8.00
     RUNOFF VOLUME     (mm)=       89.57         25.46         46.61
```

```
    TOTAL RAINFALL   (mm)=       89.67         89.67          89.67
    RUNOFF COEFFICIENT   =        1.00           .28            .52

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

      (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN*  =  64.0     Ia = Dep. Storage  (Above)
     (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
          THAN THE STORAGE COEFFICIENT.
    (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
*

--------------------
| ADD HYD   (1040) |
|  8 + 7 = 9       |          AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
         ID1= 8 (0140):      12.03     1.17     8.00    46.61
       + ID2= 7 (1030):     166.69     3.70     8.33    27.64
         ================================================
         ID = 9 (1040):     178.72     4.16     8.25    28.92

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
*
--------------------
| RESERVOIR (1000) |
| IN= 9---> OUT=10 |
| DT=  5.0 min     |     OUTFLOW    STORAGE  |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)  |   (cms)     (ha.m.)
                           .000       .000   |    .250      2.870
                           .107       .230   |    .302      3.875
                           .185      1.060   |    .000       .000

                               AREA     QPEAK     TPEAK       R.V.
                               (ha)     (cms)     (hrs)       (mm)
    INFLOW : ID= 9 (1040)    178.72      4.16      8.25      28.92
    OUTFLOW: ID=10 (1000)    178.72       .29     24.08      28.74

                 PEAK   FLOW   REDUCTION [Qout/Qin](%)=  6.890
                 TIME SHIFT OF PEAK FLOW        (min)=950.000
                 MAXIMUM  STORAGE   USED       (ha.m.)=  3.576

--------------------------------------------------------------------------------
**********************************************************
* PRE-DEVELOPMENT RUNOFF
--------------------
| CALIB            |
| NASHYD    (0200) |   Area     (ha)= 102.80   Curve Number    (CN)= 61.0
|ID= 1 DT= 5.0 min |   Ia       (mm)=  16.40   # of Linear Res.(N)= 2.50
--------------------   U.H. Tp(hrs)=     .70

    Unit Hyd Qpeak  (cms)=   4.793

    PEAK FLOW       (cms)=   1.279 (i)
    TIME TO PEAK    (hrs)=   8.917
    RUNOFF VOLUME    (mm)=  22.772
    TOTAL RAINFALL   (mm)=  89.665
    RUNOFF COEFFICIENT   =    .254

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

--------------------------------------------------------------------------------
*
* Wetland Area
--------------------
| CALIB            |
| NASHYD    (0210) |   Area     (ha)=  18.00   Curve Number    (CN)= 86.0
|ID= 2 DT= 5.0 min |   Ia       (mm)=  10.00   # of Linear Res.(N)= 2.50
--------------------   U.H. Tp(hrs)=     .20

    Unit Hyd Qpeak  (cms)=   2.937

    PEAK FLOW       (cms)=   1.552 (i)
    TIME TO PEAK    (hrs)=   8.083
    RUNOFF VOLUME    (mm)=  52.081
    TOTAL RAINFALL   (mm)=  89.665
    RUNOFF COEFFICIENT   =    .581
```

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

-----------------------------------------------------------------------------
*

--------------------
| ADD HYD   (2010) |
|  1 +  2 =  3     |          AREA     QPEAK    TPEAK      R.V.
--------------------          (ha)     (cms)    (hrs)      (mm)
          ID1= 1 (0200):    102.80     1.28      8.92     22.77
        + ID2= 2 (0210):     18.00     1.55      8.08     52.08
          ============================================
          ID = 3 (2010):    120.80     2.09      8.25     27.14

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-----------------------------------------------------------------------------
*

--------------------
| RESERVOIR (2020) |
| IN= 3---> OUT= 4 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                           .000        .000   |     .244      1.040
                           .109        .690   |     .297      1.800

                                AREA      QPEAK      TPEAK        R.V.
                                (ha)      (cms)      (hrs)        (mm)
    INFLOW : ID= 3 (2010)     120.80       2.09       8.25       27.14
    OUTFLOW: ID= 4 (2020)     120.80        .29      17.92       26.73

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)= 14.022
                  TIME SHIFT OF PEAK FLOW          (min)=580.000
                  MAXIMUM  STORAGE   USED        (ha.m.)=  1.749

-----------------------------------------------------------------------------
*********************************************************
*

FINISH
=============================================================================
```

□

```
2
*       Twin Valley Resort
*       Master Drainage Plan
*       Permanent Pond Capacity
*       Design Storm: Chicago, 1 in 2 year, 24 hour duration
*       October 2004
*       EL
*
START               TIME= 0.0  IUNITS= 2
*
*  derive a 24 hour Chicago storm
CHICAGO STORM       IUNITS=2 TD=24 HOURS R=0.333 SDT=15 MIN ICASE=2
                    (Time, intensity) 15,29.39 30,17.43 60,10.25 120,7.76
                                      360,3.93, 720,2.7 1440,1.76 -1
*****************************************************************
* POST DEVELOPMENT RUNOFF
* Roads/paths
CALIB STANDHYD      ID=1  NHYD=100   DT=5 min  AREA=7.55 HA
                    XIMP=.30 TIMP=.47 DWF=0 LOSS=2 CN=61
                    PERVIOUS DPSP=16.4 MM SLOPE=2% LGP=20 M MNP=0.25 SCP=0
                    IMPERVIOUS DPSI=1.6 MM SLOPE=0.6% LGI=40 M MNI=0.013 SCI=0
                    END=-1
* Residential area  (building density 1 per acre)
CALIB NASHYD        ID=2  NHYD=110  DT=5 min  AREA= 75.20 ha  DWF=0  CN=68
                    IA=13.9 mm  N=2.5 TP=0.30 hr  -1
*
ADD HYD             ID=3 NHYD=1010 IDONE=1 IDTWO=2
*
*Irrigated land
CALIB NASHYD        ID=4  NHYD=120  DT=5 min  AREA= 50.45 ha  DWF=0  CN=64
                    IA=15.3 mm  N=2.5 TP=0.55 hr  -1
* Reserved land
CALIB NASHYD        ID=5  NHYD=130  DT=5 min  AREA= 33.49 ha  DWF=0  CN=61
                    IA=16.4 mm  N=2.5 TP=0.45 hr  -1
*
ADD HYD             ID=6 NHYD=1020 IDONE=3 IDTWO=4
*
ADD HYD             ID=7 NHYD=1030 IDONE=6 IDTWO=5
*
* Park Area including lakes
CALIB STANDHYD      ID=8  NHYD=140   DT=5 min  AREA=12.03 HA
                    XIMP=.33 TIMP=.33 DWF=0 LOSS=2 CN=64
                    PERVIOUS DPSP=15.3 MM SLOPE=2% LGP=20 M MNP=0.25 SCP=0
                    IMPERVIOUS DPSI=0.1 MM SLOPE=0.1% LGI=40 M MNI=0.013 SCI=0
                    END=-1
*
ADD HYD             ID=9 NHYD=1040 IDONE=8 IDTWO=7
*
COMPUTE VOLUME      ID=9 Strate =-100 RELRATE=0.000001
*
ROUTE RESERVOIR     ID=10 NHYD=1000 IDIN=9 DT=5 min
                    Discharge  Storage
                        0.0     0.0
                        0.107   0.23
                        0.185   1.06
                        0.250   2.87
                        0.302   3.875   -1
FINISH
□
```

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

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO     I N T E R H Y M O
       O   O    T      T    H   H   Y Y   MM MM  O   O   * * * 1989b * * *
       O   O    T      T    HHHHH    Y    M M M  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO     E-9516061302199
```



```
  Input   filename: twin2y.dat
  Output  filename: twin2y.out
  Summary filename: twin2y.sum


DATE: 10-10-2004                     TIME: 18:05:24

COMMENTS: ______________________________________________________

---------------------------------------------------------------------------
*        Twin Valley Resort
*        Master Drainage Plan
*        Permanent Pond Capacity
*        Design Storm: Chicago, 1 in 2 year, 24 hour duration
*        October 2004
*        EL
*
  ****************************
  ** SIMULATION NUMBER:   1 **
  ****************************

*
*  derive a 24 hour Chicago storm
--------------------
| CHICAGO STORM    |     IDF curve parameters: A= 145.751
| Ptotal= 41.09 mm |                           B=   1.502
--------------------                           C=    .611
                         used in:   INTENSITY =  A / (t + B)^C

                         Duration of storm  = 24.00 hrs
                         Storm time step    = 15.00 min
                         Time to peak ratio =   .33

                     The CORRELATION coefficient is =  .9973
```

TIME (min)	INPUT INT. (mm/hr)	TAB. INT. (mm/hr)
15.	29.39	26.28
30.	17.43	17.71
60.	10.25	11.77
120.	7.76	7.76
360.	3.93	3.99
720.	2.70	2.61
1440.	1.76	1.71

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
.25	.68	6.25	1.72	12.25	1.50	18.25	.87
.50	.70	6.50	1.90	12.50	1.44	18.50	.86
.75	.71	6.75	2.13	12.75	1.40	18.75	.85
1.00	.73	7.00	2.46	13.00	1.35	19.00	.84
1.25	.74	7.25	2.98	13.25	1.31	19.25	.83
1.50	.76	7.50	3.94	13.50	1.28	19.50	.82
1.75	.78	7.75	6.92	13.75	1.24	19.75	.80
2.00	.80	8.00	26.28	14.00	1.21	20.00	.79
2.25	.82	8.25	8.38	14.25	1.18	20.25	.78
2.50	.84	8.50	5.47	14.50	1.15	20.50	.77
2.75	.87	8.75	4.28	14.75	1.13	20.75	.77
3.00	.89	9.00	3.60	15.00	1.10	21.00	.76
3.25	.92	9.25	3.15	15.25	1.08	21.25	.75
3.50	.95	9.50	2.82	15.50	1.06	21.50	.74

```
         3.75      .99 |  9.75     2.56 | 15.75     1.04 | 21.75      .73
         4.00     1.03 | 10.00     2.37 | 16.00     1.02 | 22.00      .72
         4.25     1.07 | 10.25     2.20 | 16.25     1.00 | 22.25      .72
         4.50     1.11 | 10.50     2.07 | 16.50      .98 | 22.50      .71
         4.75     1.17 | 10.75     1.95 | 16.75      .96 | 22.75      .70
         5.00     1.23 | 11.00     1.85 | 17.00      .95 | 23.00      .69
         5.25     1.30 | 11.25     1.76 | 17.25      .93 | 23.25      .69
         5.50     1.37 | 11.50     1.68 | 17.50      .92 | 23.50      .68
         5.75     1.47 | 11.75     1.61 | 17.75      .90 | 23.75      .67
         6.00     1.58 | 12.00     1.55 | 18.00      .89 | 24.00      .67


-----------------------------------------------------------------------------
*****************************************************************
* POST DEVELOPMENT RUNOFF
* Roads/paths
--------------------
| CALIB              |
| STANDHYD  (0100)  |   Area    (ha)=   7.55
|ID= 1 DT= 5.0 min  |   Total Imp(%)=  47.00   Dir. Conn.(%)=  30.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area      (ha)=      3.55          4.00
     Dep. Storage      (mm)=      1.60         16.40
     Average Slope      (%)=       .60          2.00
     Length             (m)=     40.00         20.00
     Mannings n           =       .013          .250

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

                              IMPERVIOUS    PERVIOUS (i)
     Max.eff.Inten.(mm/hr)=     26.28          1.29
                over (min)        5.00         30.00
     Storage Coeff.  (min)=       2.93 (ii)    29.45 (ii)
     Unit Hyd. Tpeak (min)=       5.00         30.00
     Unit Hyd. peak  (cms)=        .28           .04
                                                            *TOTALS*
     PEAK FLOW       (cms)=        .16           .01            .17 (iii)
     TIME TO PEAK    (hrs)=       8.00          8.83           8.00
     RUNOFF VOLUME    (mm)=      39.49          5.42          15.64
     TOTAL RAINFALL   (mm)=      41.09         41.09          41.09
     RUNOFF COEFFICIENT   =        .96           .13            .38

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  61.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-----------------------------------------------------------------------------
* Residential area  (building density 1 per acre)
--------------------
| CALIB              |
| NASHYD    (0110)  |   Area     (ha)=  75.20   Curve Number   (CN)= 68.0
|ID= 2 DT= 5.0 min  |   Ia       (mm)=  13.90   # of Linear Res.(N)= 2.50
--------------------    U.H. Tp(hrs)=     .30

     Unit Hyd Qpeak  (cms)=    8.181

     PEAK FLOW       (cms)=     .115 (i)
     TIME TO PEAK    (hrs)=    8.750
     RUNOFF VOLUME    (mm)=    5.028
     TOTAL RAINFALL   (mm)=   41.094
     RUNOFF COEFFICIENT   =     .122

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

-----------------------------------------------------------------------------
*

--------------------
| ADD HYD    (1010) |
|   1 +  2 =  3     |        AREA     QPEAK    TPEAK      R.V.
--------------------         (ha)     (cms)    (hrs)      (mm)
          ID1= 1 (0100):     7.55       .17     8.00     15.64
        + ID2= 2 (0110):    75.20       .12     8.75      5.03
          ==============================================
          ID = 3 (1010):    82.75       .19     8.00      6.00
```

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

-----------------------------------------------------------------------------
*
*Irrigated land
--------------------
| CALIB              |
| NASHYD    (0120)   |   Area     (ha)=  50.45   Curve Number   (CN)= 64.0
|ID= 4 DT= 5.0 min   |   Ia       (mm)=  15.30   # of Linear Res.(N)= 2.50
--------------------     U.H. Tp(hrs)=     .55

     Unit Hyd Qpeak  (cms)=   2.994

     PEAK FLOW       (cms)=    .047 (i)
     TIME TO PEAK    (hrs)=   9.833
     RUNOFF VOLUME    (mm)=   3.942
     TOTAL RAINFALL   (mm)=  41.094
     RUNOFF COEFFICIENT   =    .096

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

-----------------------------------------------------------------------------
* Reserved land
--------------------
| CALIB              |
| NASHYD    (0130)   |   Area     (ha)=  33.49   Curve Number   (CN)= 61.0
|ID= 5 DT= 5.0 min   |   Ia       (mm)=  16.40   # of Linear Res.(N)= 2.50
--------------------     U.H. Tp(hrs)=     .45

     Unit Hyd Qpeak  (cms)=   2.429

     PEAK FLOW       (cms)=    .024 (i)
     TIME TO PEAK    (hrs)=   9.833
     RUNOFF VOLUME    (mm)=   3.256
     TOTAL RAINFALL   (mm)=  41.094
     RUNOFF COEFFICIENT   =    .079

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

-----------------------------------------------------------------------------
*

--------------------
| ADD HYD   (1020)  |
|   3 +  4 =  6     |          AREA     QPEAK     TPEAK      R.V.
--------------------           (ha)     (cms)     (hrs)      (mm)
          ID1= 3 (1010):      82.75       .19      8.00      6.00
        + ID2= 4 (0120):      50.45       .05      9.83      3.94
          ==============================================
          ID = 6 (1020):     133.20       .19      8.00      5.22

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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

*

--------------------
| ADD HYD   (1030)  |
|   6 +  5 =  7     |          AREA     QPEAK     TPEAK      R.V.
--------------------           (ha)     (cms)     (hrs)      (mm)
          ID1= 6 (1020):     133.20       .19      8.00      5.22
        + ID2= 5 (0130):      33.49       .02      9.83      3.26
          ==============================================
          ID = 7 (1030):     166.69       .20      9.00      4.82

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-----------------------------------------------------------------------------
*
* Park Area including lakes
--------------------
| CALIB              |
| STANDHYD  (0140)   |   Area     (ha)=  12.03
|ID= 8 DT= 5.0 min   |   Total Imp(%)=   33.00   Dir. Conn.(%)=   33.00
--------------------
                                IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        3.97          8.06
     Dep. Storage     (mm)=         .10         15.30
```

```
     Average Slope      (%)=       .10        2.00
     Length             (m)=     40.00       20.00
     Mannings n            =      .013        .250

     Max.eff.Inten.(mm/hr)=      26.28         .41
              over (min)         5.00        50.00
     Storage Coeff.  (min)=      5.02 (ii)   46.81 (ii)
     Unit Hyd. Tpeak (min)=      5.00        50.00
     Unit Hyd. peak  (cms)=       .21          .02
                                                          *TOTALS*
     PEAK FLOW       (cms)=       .28          .01          .28 (iii)
     TIME TO PEAK    (hrs)=      8.00        10.25         8.00
     RUNOFF VOLUME    (mm)=     40.99         3.94        16.17
     TOTAL RAINFALL   (mm)=     41.09        41.09        41.09
     RUNOFF COEFFICIENT   =      1.00          .10          .39

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  64.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
*

--------------------
| ADD HYD   (1040) |
|  8 + 7 = 9       |           AREA     QPEAK     TPEAK      R.V.
--------------------           (ha)     (cms)     (hrs)      (mm)
          ID1= 8 (0140):      12.03       .28      8.00     16.17
        + ID2= 7 (1030):     166.69       .20      9.00      4.82
          ===============================================
          ID = 9 (1040):     178.72       .47      8.00      5.59

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
*
--------------------
| COMPUTE VOLUME   |
| ID= 9   (1040)   |               DISCHARGE      TIME
--------------------                 (cms)        (hrs)
            START CONTROLLING AT       .00          .08
            INFLOW HYD. PEAKS AT       .47         8.00
            STOP  CONTROLLING AT       .00          .00

            REQUIRED STORAGE VOLUME (ha.m.)=     .9986
            TOTAL HYDROGRAPH VOLUME (ha.m.)=     .9986
            % OF HYDROGRAPH TO STORE       =   99.9995

            NOTE:  Storage was computed to reduce the Inflow
                   peak to     .00  (cms).

-------------------------------------------------------------------------------
*
--------------------
| RESERVOIR (1000) |
| IN= 9---> OUT=10 |
| DT=  5.0 min     |      OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------       (cms)     (ha.m.)   |   (cms)     (ha.m.)
                            .000       .000    |    .250      2.870
                            .107       .230    |    .302      3.875
                            .185      1.060    |    .000       .000

                                  AREA     QPEAK     TPEAK      R.V.
                                  (ha)     (cms)     (hrs)      (mm)
     INFLOW : ID= 9 (1040)      178.72       .47      8.00      5.59
     OUTFLOW: ID=10 (1000)      178.72       .12     20.75      5.58

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)= 24.961
                  TIME SHIFT OF PEAK FLOW        (min)=765.000
                  MAXIMUM  STORAGE  USED       (ha.m.)=   .336

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

  FINISH
===============================================================================
```

APPENDIX B

QUALHYMO MODEL I/O Files

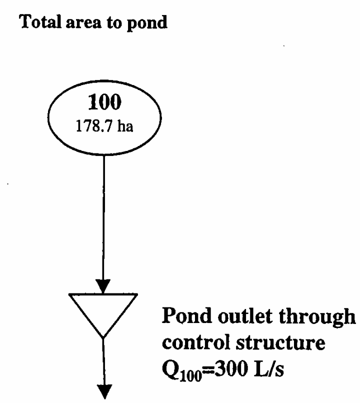


FIGURE 1-B

Twin Valley Resort

Water Budget using Qualhymo Model

```
1234567890 *./-
21
START                  1 27
STORE                  2  4
GENERATE               3 52
PRINT SPAN             4 10
PLOT SPAN              5 10
ADD SERIES             6  4
POND                   7310
REACH                  8310
CALIBRATE              9310
POLLUTANT SERIES      10  9
SPLIT SERIES          11310
DUMP PRINT            12  1
EXCEEDANCE CURVES     13310
DUMP PLOT             14  9
SHEAR1                15310
MAXFLW                16  8
SERIES STATS          17  7
PRINT FLOWS           18  8
ROUTE RESERVOIR       19 64
SCAN SERIES           20 16
FINISH                21  0
*
*******************   Q U A L H Y M O   **********************
*
*                              VERSION 2.12
*                    Twin Valley Reservoir
*                   Runoff Volume Calculations
*                   Maximum discharge 50 L/s
*              ====  input file: "Twval-Q.dat"  ====
*              ====  rain file: "raindata.pre" ====
*              ====  output file: "Twval-Qout  ====
*
*              prepared by EL, October , 2004
***********************************************************************
*
START                   START DATE OF SIMULATION         60 05 01
                        END DATE OF SIMULATION           95 06 30
                        RAINFALL WILL BE READ ON DEVICE  IRAIN  9
                        PRECIP IS IN AES HOURLY FORMAT   IPFORM 1
                        FLOW FILE WILL BE READ ON DEVICE IFLOW 10
                        SET EVAPORATION FLAG ON          ICASE  0.94
                        EVAP CORRECTION COEFF            CPAN 1
                            JAN  1.9  FEB  8.0  MAR  38.8
                            APR 95.2  MAY 149.4  JUN 168.4
                            JUL 195.9 AUG 163.2  SEP 102.6
                            OCT  45.0 NOV  8.4  DEC  1.4
                        SET POLLUTANT FLAG OFF           IFDECA 0
                        SET SEDIMENTATION FLAG OFF       IFSEDT 0
*
GENERATE                ID=1 ISER=100 DT=1.0  DA=178 HA
                                     AB=0      PRIMP=0.04
                          ====IMPERVIOUS AREA=====
                        NASH UNIT HYD AA=1          N=3.5        TP=0.80 HRS
                                     ABSIMP=1.7 MM   RIMP=0.90 CTIMP=1.0
                          ====PERVIOUS AREA=====
                        NASH UNIT HYD AA=1          N=2.5        TP=1.22 HRS
                                     SMIN=60MM  SMAX=380 MM  SK=0.035
                                    APIK=0.9     APII=60 MM   IA=13.3 MM
                                    CETPER=1.0
                         ====BASE FLOW  DATA====
                        NUMBER OF GROUNDWATER RESERVOIRS NSVOL=0
                        MINIMUM BASE FLOW                BASMIN=0.0
                        BASE FLOW DEPLETION FACTOR       BFACR=2.0
                        STARTING SOIL MOISTURE           SVOL=2.0 MM
                        SOIL MOISTURE AT WILTING PT      SWILT=0.01 MM
                        SOIL MOISTURE AT FIELD CAPACITY  SFIELD=0.1 MM
                        BASE RECESSION CONSTANT          SLOSKA=0.00001
                        BASE FLOW REDUCTION FACTOR       SLOSKB=0.15
                        EVAP CORR COEFF                  CET=1.0
*
```

```
ROUTE RESERVOIR     IDIN=1 IDOUT=2 SERIES=1000 IDVOL=3
                    OUTFLAG=0 NINTER=1 SSTORAGE=0
                    NPAIRS=6
                     VOLUME (CUM)       OUTFLOW (CUMS)
                         0.00                0.000
                      2263.00                0.107
                     10600.00                0.185
                     28700.00                0.250
                     34000.00                0.288
                     36600.00                0.302
*
* ANNUAL MAXIMUM VOLUMES FROM LAKE STORAGE SERIES
MAXFLW              IDVOL=3 IOPT=-1
                    IFY=60 IFM=05 IFD=02
                    IFY=95 IFM=06 IFD=30
FINISH
```

```
********  Q   U   A   L   H   Y   M   O   ********
 ****                                         ****
 ****              Supported by               ****
 ****   Water Resources Software Group        ****
 ****   Centre for Water Resources Studies    ****
 ****    Technical University of Nova Scotia      ****
 ****          P. O. Box 1000                 ****
 ****          Halifax, Nova Scotia           ****
 ****          Canada  B3J 2X4                ****
 ****                                         ****
 ****          (902)420-7857  (phone)         ****
 ****          (902)420-7551  (fax)           ****
 ****                                         ****
 ***************************************************


           Q U A L H Y M O    M O D E L    O U T P U T

    Program Execution Started on  10-31-2004 at time 19:53:43


           ZALFA = 1234567890 *./-


               COMMAND TABLE

         START                 1 27
         STORE                 2  4
         GENERATE              3 52
         PRINT SPAN            4 10
         PLOT SPAN             5 10
         ADD SERIES            6  4
         POND                  7310
         REACH                 8310
         CALIBRATE             9310
         POLLUTANT SERIES     10  9
         SPLIT SERIES         11310
         DUMP PRINT           12  1
         EXCEEDANCE CURVES    13310
         DUMP PLOT            14  9
         SHEAR1               15310
         MAXFLW               16  8
         SERIES STATS         17  7
         PRINT FLOWS          18  8
         ROUTE RESERVOIR      19 64
         SCAN SERIES          20 16
         FINISH               21  0
    *
```

```
*******************    Q U A L H Y M O    **********************
*                                                              *
*                        VERSION 2.12                          *
*                                                              *
*                    Twin Valley Reservoir                     *
*                   Runoff Volume Calculations                 *
*                   Maximum discharge 50 L/s                   *
*             ====  input file: "Twval-Q.dat"  ====            *
*             ====  rain file: "raindata.pre" ====             *
*             ====  output file: "Twval-Qout  ====             *
*                                                              *
*             prepared by EL, October , 2004                   *
****************************************************************
*
START             START DATE OF SIMULATION          60 05 01
                  END DATE OF SIMULATION            95 06 30
                  RAINFALL WILL BE READ ON DEVICE  IRAIN  9
                  PRECIP IS IN AES HOURLY FORMAT   IPFORM 1
                  FLOW FILE WILL BE READ ON DEVICE IFLOW 10
                  SET EVAPORATION FLAG ON          ICASE  1
                  EVAP CORRECTION COEFF            CPAN 0.94
                      JAN  1.9  FEB  8.0  MAR  38.8
                      APR 95.2  MAY 149.4  JUN 168.4
                      JUL 195.9 AUG 163.2  SEP 102.6
                      OCT  45.0 NOV  8.4  DEC  1.4
                  SET POLLUTANT FLAG OFF           IFDECA 0
                  SET SEDIMENTATION FLAG OFF       IFSEDT 0
FLOW RECORDS SOUGHT ON DEVICE          10
 *
GENERATE          ID=1 ISER=100 DT=1.0  DA=178 HA
                               AB=0       FRIMP=0.04
                    ====IMPERVIOUS AREA=====
                  NASH UNIT HYD AA=1          N=3.5         TP=0.80 HRS
                               ABSIMP=1.7 MM   RIMP=0.90 CTIMP=1.0
                    ====PERVIOUS AREA=====
                  NASH UNIT HYD AA=1          N=2.5         TP=1.22 HRS
                               SMIN=60MM  SMAX=380 MM  SK=0.035
                              APIK=0.9     APII=60 MM   IA=13.3 MM
                              CETPER=1.0
                   ====BASE FLOW  DATA====
                  NUMBER OF GROUNDWATER RESERVOIRS NSVOL=0
                  MINIMUM BASE FLOW                BASMIN=0.0
                  BASE FLOW DEPLETION FACTOR       BFACR=2.0
                  STARTING SOIL MOISTURE           SVOL=2.0 MM
                  SOIL MOISTURE AT WILTING PT      SWILT=0.01 MM
                  SOIL MOISTURE AT FIELD CAPACITY  SFIELD=0.1 MM
                  BASE RECESSION CONSTANT          SLOSKA=0.00001
                  BASE FLOW REDUCTION FACTOR       SLOSKB=0.15
                  EVAP CORR COEFF                  CET=1.0

====== IMPERVIOUS AREA UNIT HYDROGRAPH DATA ======

 - SHAPE CONSTANT, N =  3.500          - UNIT PEAK,QP =    .0099 CMS
 - THE UH YIELDS   1.0081 MM VOL SO MULT BY     .9919 WILL ENSURE A 1 MM UH.

======= PERVIOUS AREA UNIT HYDROGRAPH DATA =======

 - SHAPE CONSTANT, N =  2.500          - UNIT PEAK,QP =    .1800 CMS

 - THE UH YIELDS    .9577 MM VOL SO MULT BY   1.0442 WILL ENSURE A 1 MM UH.

        API REDUCTION FACTOR IS    .996E+00 PER TIME STEP OR   .900E+00 PER DAY

 RECESSION CONSTANT BASE FLOW INVOKED

 RAINFALL AND DIRECT  RUNOFF TOTALS OVER THE SIMULATION TIME SPAN ==========
   RAINFALL  PERVIOUS  IMPERVIOUS   TOTAL
             RUNOFF     RUNOFF     RUNOFF
     (MM)     (MM)       (MM)       (MM)
  9528.6300   134.8749  5789.8000   361.0724
    *
   ROUTE RESERVOIR     IDIN=1 IDOUT=2 SERIES=1000 IDVOL=3
                       OUTFLAG=0 NINTER=1 SSTORAGE=0
                       NPAIRS=6
                        VOLUME (CUM)       OUTFLOW (CUMS)
                            0.00                0.000
                         2263.00                0.107
                        10600.00                0.185
                        28700.00                0.250
                        34000.00                0.288
```

```
                    36600.00                0.302

        Printing Lake Storage is requested

 SIMPLE RESERVOIR ROUTE:
      Inflow series ID      =  1 with DT =    1.00 hours
      Lake Volume series ID =  3
      Outflow series ID     =  2
      Outflow series ISER   = 1000


        Max hourly inflow rate   =      1.0785m3/s
        Max hourly outflow rate  =       .2419m3/s
        Max hourly storage       =    26452.0m3
        Starting storage     =          .0m3
        Total inflow volume  =    640767.7m3
        Total outflow volume =    640734.3m3
        Final storage        =          .0m3
   Note that above maxima are maximum averages for each interval of DT =  1.00 hrs.

     Peak outflow computed in intermediate steps =       .2419 m3/s
     Peak storage computed in intermediate steps =    26452.0 m3
        Hours of extrapolated outflows =        .00
     *
     * ANNUAL MAXIMUM VOLUMES FROM LAKE STORAGE SERIES
     MAXFLW              IDVOL=3 IOPT=-1
                         IFY=60 IFM=05 IFD=02
                         IFY=95 IFM=06 IFD=30

 START DATE: 60 5 2
 STOP DATA: 95 630


 ANNUAL MAXIMUM FLOOD SERIES


 Peak Volume:       715.08960 M**3  Date (YrMoDy):  60  7 20
 Peak Volume:       642.94570 M**3  Date (YrMoDy):  61  7 21
 Peak Volume:      1215.46800 M**3  Date (YrMoDy):  62  8  5
 Peak Volume:      6678.22900 M**3  Date (YrMoDy):  63  6 22
 Peak Volume:      3318.06600 M**3  Date (YrMoDy):  64  7  5
 Peak Volume:      6018.45400 M**3  Date (YrMoDy):  65  7 21
 Peak Volume:      5196.96800 M**3  Date (YrMoDy):  66  7  2
 Peak Volume:       770.71480 M**3  Date (YrMoDy):  67  6 17
 Peak Volume:      3346.70700 M**3  Date (YrMoDy):  68  7 20
 Peak Volume:      1765.27500 M**3  Date (YrMoDy):  69  6 25
 Peak Volume:       588.78080 M**3  Date (YrMoDy):  70  7 27
 Peak Volume:       796.04960 M**3  Date (YrMoDy):  71  6  5
 Peak Volume:      7138.24500 M**3  Date (YrMoDy):  72  6 24
 Peak Volume:       978.85080 M**3  Date (YrMoDy):  73  6 14
 Peak Volume:      1700.43000 M**3  Date (YrMoDy):  74  4 27
 Peak Volume:       557.78360 M**3  Date (YrMoDy):  75  7 21
 Peak Volume:      1478.08500 M**3  Date (YrMoDy):  76  8  9
 Peak Volume:      1547.09400 M**3  Date (YrMoDy):  77  8 19
 Peak Volume:     12234.03000 M**3  Date (YrMoDy):  78  8 17
 Peak Volume:       881.05930 M**3  Date (YrMoDy):  79  6 20

 Peak Volume:      3892.98600 M**3  Date (YrMoDy):  80  5 24
 Peak Volume:      1504.60100 M**3  Date (YrMoDy):  81  9 19
 Peak Volume:      1025.49700 M**3  Date (YrMoDy):  82  5 27
 Peak Volume:      1260.47800 M**3  Date (YrMoDy):  83  7  3
 Peak Volume:      2899.20600 M**3  Date (YrMoDy):  84  9  7
 Peak Volume:     26452.00000 M**3  Date (YrMoDy):  85  9 12
 Peak Volume:      4993.07800 M**3  Date (YrMoDy):  86  6 29
 Peak Volume:      1920.77100 M**3  Date (YrMoDy):  87  7  4
 Peak Volume:     10657.45000 M**3  Date (YrMoDy):  88  8  1
 Peak Volume:       842.52330 M**3  Date (YrMoDy):  89  7 10
 Peak Volume:      1517.77100 M**3  Date (YrMoDy):  90  5 25
 Peak Volume:      2254.84600 M**3  Date (YrMoDy):  91  6 21
 Peak Volume:      6569.63500 M**3  Date (YrMoDy):  92  6 14
 Peak Volume:      3249.51700 M**3  Date (YrMoDy):  93  6 29
 Peak Volume:      1513.97500 M**3  Date (YrMoDy):  94  6  6
     FINISH


      Execution was terminated on10-31-2004 at time 19:54:55
          Q U A L H Y M O     M O D E L     S T O P
```

APPENDIX C

ADDITIONAL INFORMATION

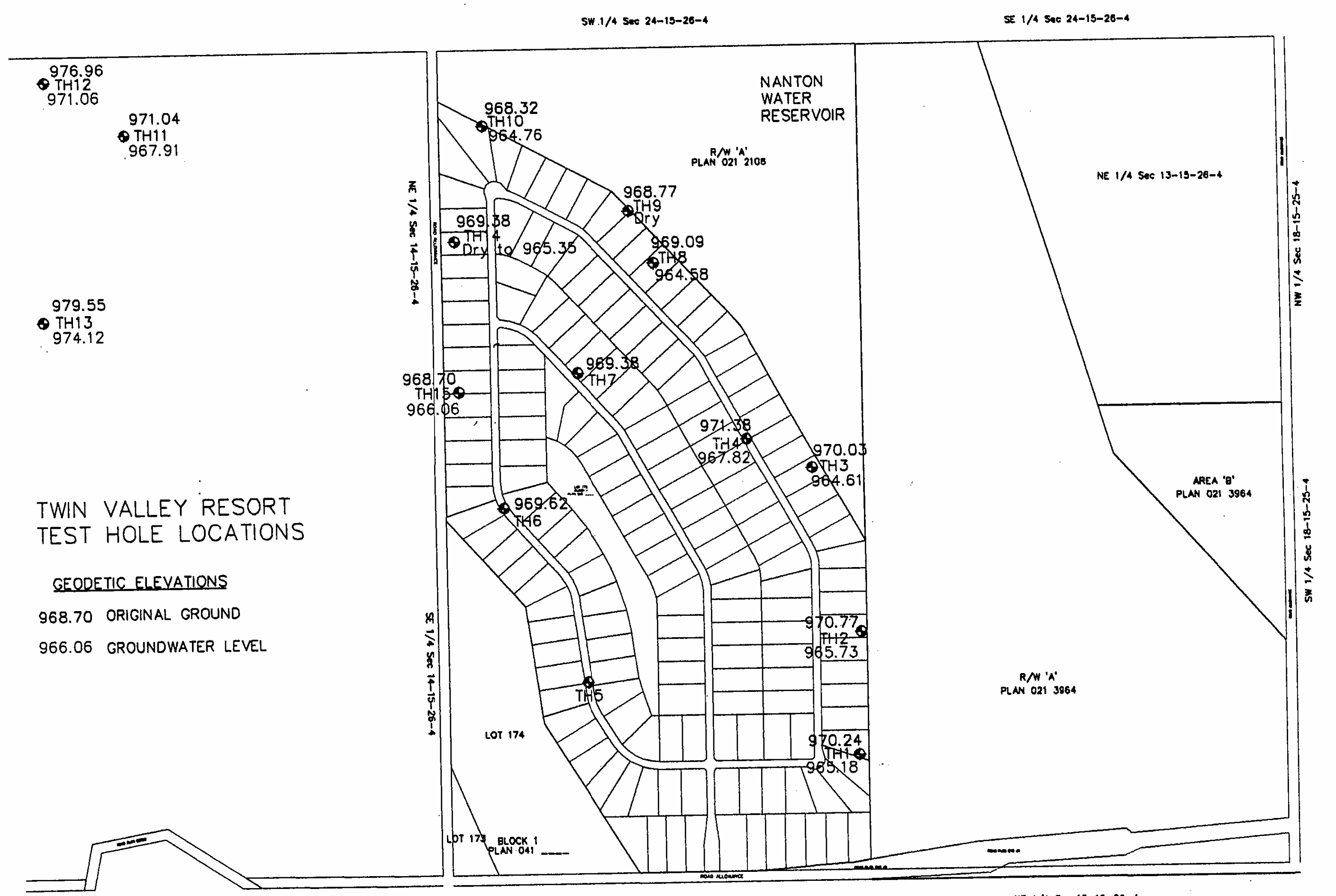

SW 1/4 Sec 24-15-26-4
SE 1/4 Sec 24-15-26-4
NANTON
WATER
RESERVOIR
R/W 'A'
PLAN 021 2108
NE 1/4 Sec 13-15-26-4
NW 1/4 Sec 18-15-25-4
SW 1/4 Sec 18-15-25-4
AREA 'B'
PLAN 021 3964
R/W 'A'
PLAN 021 3964
NE 1/4 Sec 14-15-26-4
SE 1/4 Sec 14-15-26-4
976.96
TH12
971.06
971.04
TH11
967.91
979.55
TH13
974.12
968.32
TH10
964.76
968.77
TH9
Dry
969.38
TH14
Dry to 965.35
969.09
TH8
964.58
969.38
TH7
968.70
TH15
966.06
971.38
TH4
967.82
970.03
TH3
964.61
969.62
TH6
970.77
TH2
965.73
TH5
970.24
TH1
965.18
LOT 174
LOT 173
BLOCK 1
PLAN 041
NW 1/4 Sec 12-15-26-4
NE 1/4 Sec 12-15-26-4
TWIN VALLEY RESORT
TEST HOLE LOCATIONS
GEODETIC ELEVATIONS
968.70 ORIGINAL GROUND
966.06 GROUNDWATER LEVEL

EXHIBIT 1

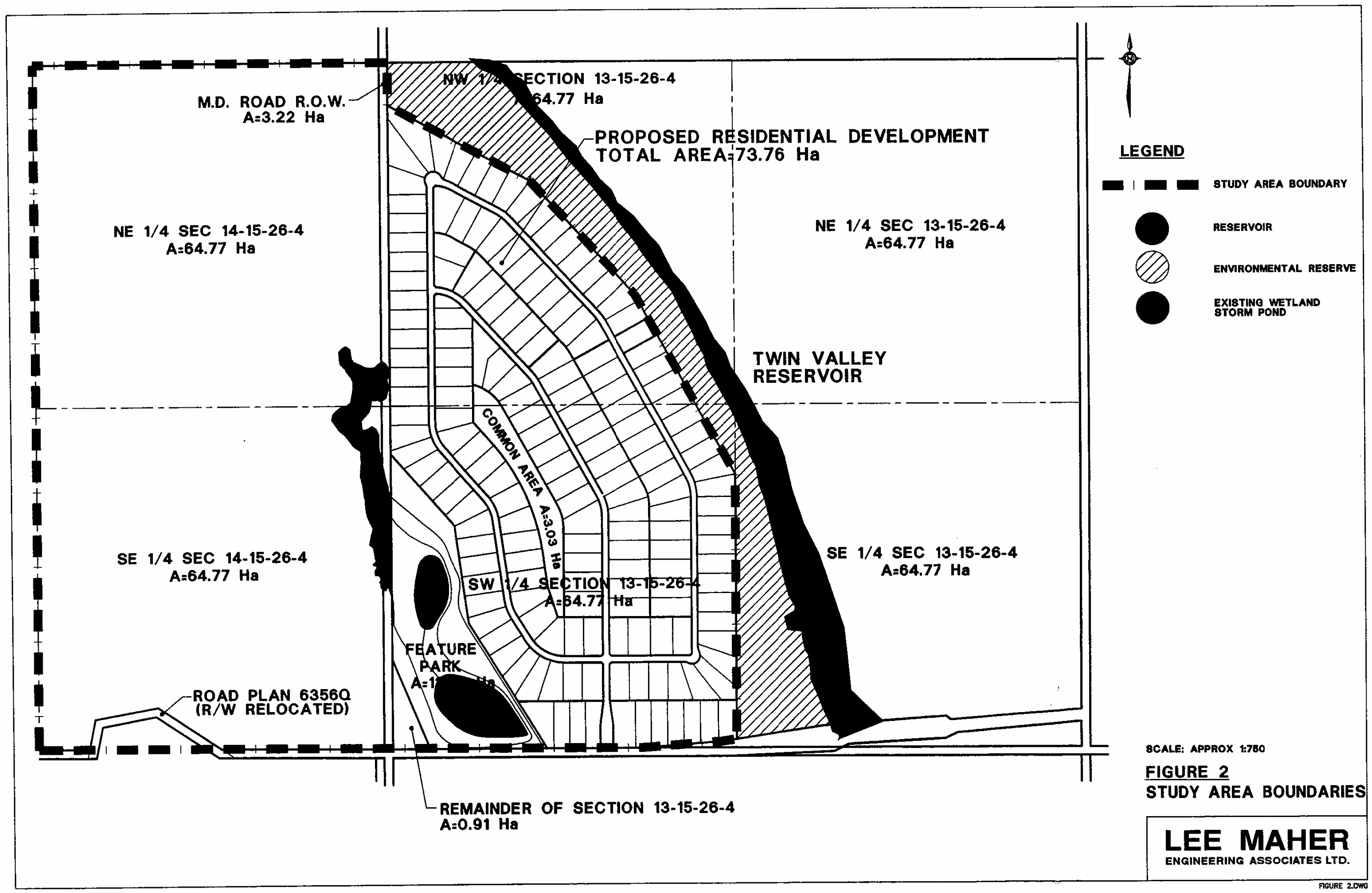


FIGURE 2
STUDY AREA BOUNDARIES

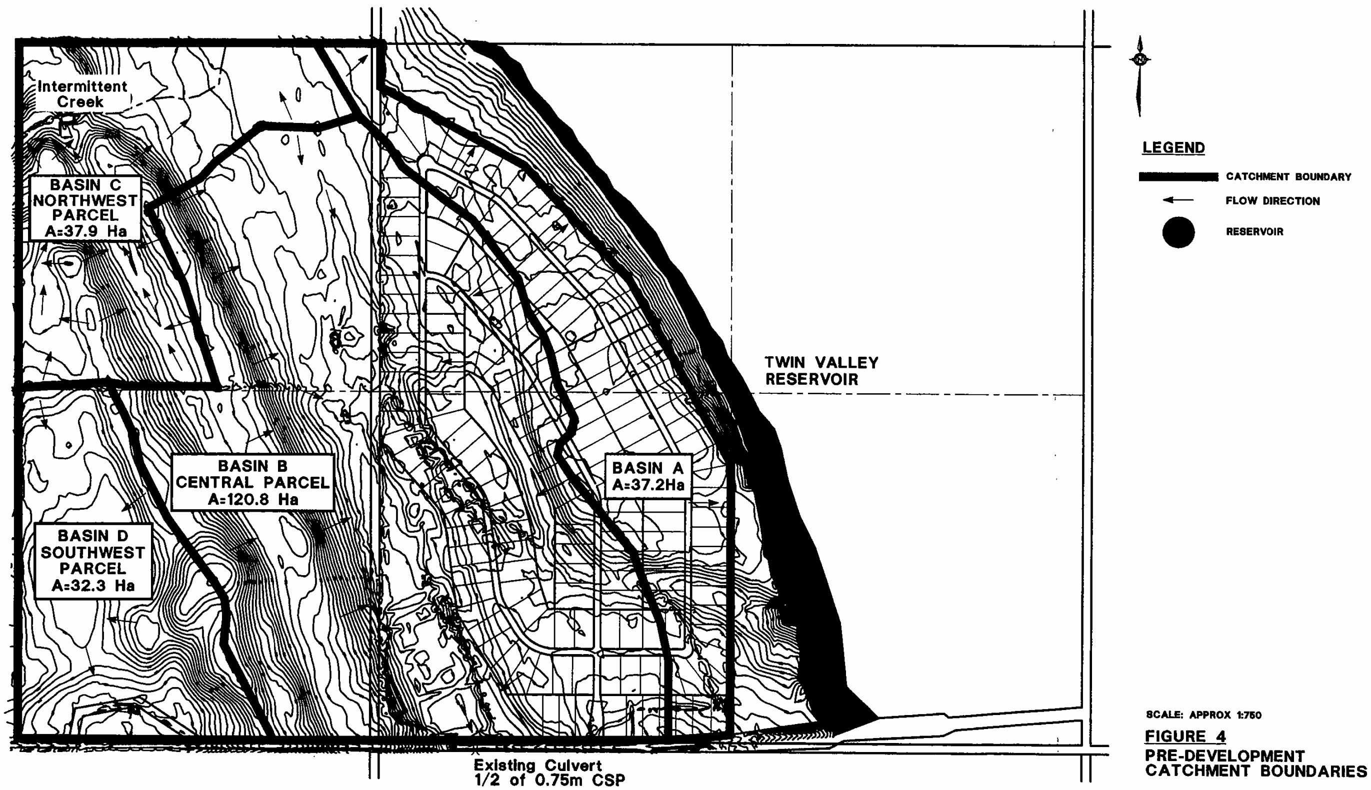


FIGURE 4
PRE-DEVELOPMENT CATCHMENT BOUNDARIES

LEE MAHER
ENGINEERING ASSOCIATES LTD.

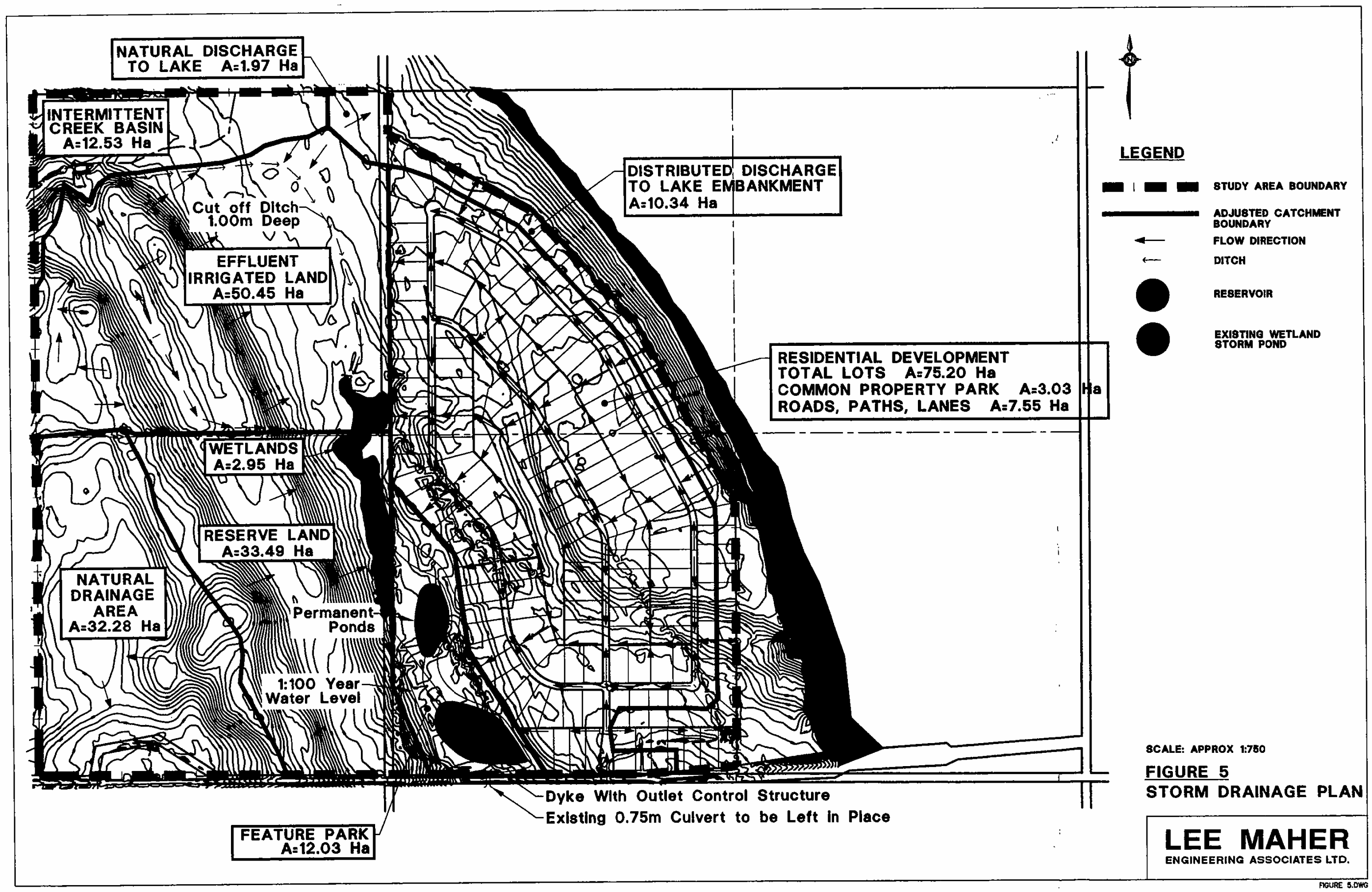


FIGURE 5
STORM DRAINAGE PLAN

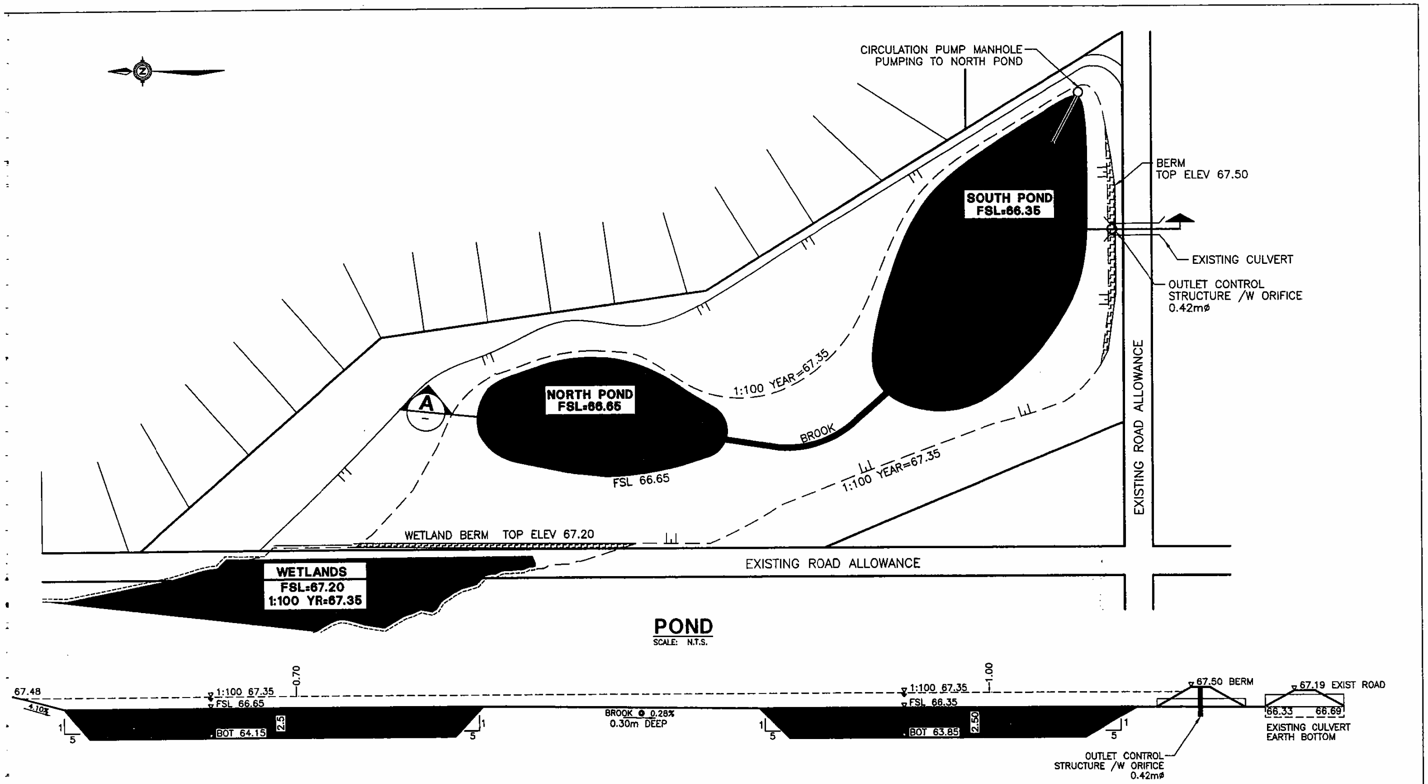
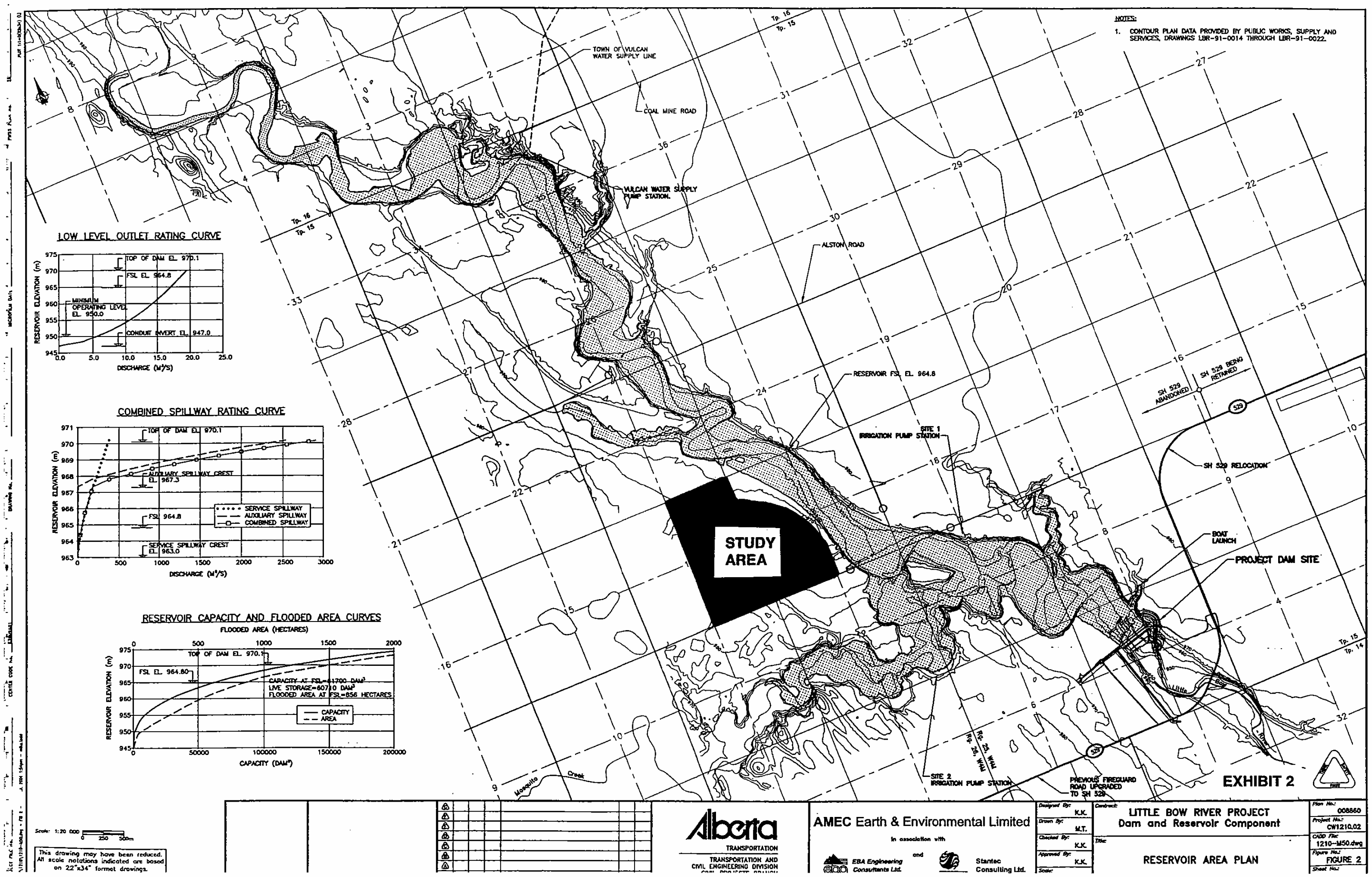


FIGURE 6
STORM POND
CONCEPTUAL DESIGN

LEE MAHER
ENGINEERING ASSOCIATES LTD.


NOTES:
1. CONTOUR PLAN DATA PROVIDED BY PUBLIC WORKS, SUPPLY AND SERVICES, DRAWINGS LBR-91-0014 THROUGH LBR-91-0022.
TOWN OF VULCAN WATER SUPPLY LINE
COAL MINE ROAD
VULCAN WATER SUPPLY PUMP STATION
ALSTON ROAD
RESERVOIR FSL EL. 964.8
SITE 1 IRRIGATION PUMP STATION
SH 529 ABANDONED
SH 529 BEING RETAINED
SH 529 RELOCATION
BOAT LAUNCH
PROJECT DAM SITE
SITE 2 IRRIGATION PUMP STATION
PREVIOUS FIREGUARD ROAD UPGRADED TO SH 529
STUDY AREA
Mosquito Creek
LOW LEVEL OUTLET RATING CURVE
TOP OF DAM EL. 970.1
FSL EL. 964.8
MINIMUM OPERATING LEVEL EL. 950.0
CONDUIT INVERT EL. 947.0
RESERVOIR ELEVATION (m)
DISCHARGE (M³/S)
COMBINED SPILLWAY RATING CURVE
TOP OF DAM EL. 970.1
AUXILIARY SPILLWAY CREST EL. 967.3
FSL 964.8
SERVICE SPILLWAY CREST EL. 963.0
SERVICE SPILLWAY
AUXILIARY SPILLWAY
COMBINED SPILLWAY
RESERVOIR CAPACITY AND FLOODED AREA CURVES
FLOODED AREA (HECTARES)
TOP OF DAM EL. 970.1
FSL EL. 964.80
CAPACITY AT FSL=61700 DAM³
LIVE STORAGE=60710 DAM³
FLOODED AREA AT FSL=856 HECTARES
CAPACITY
AREA
CAPACITY (DAM³)
EXHIBIT 2
Scale: 1:20 000
This drawing may have been reduced. All scale notations indicated are based on 22"x34" format drawings.
Alberta TRANSPORTATION
TRANSPORTATION AND CIVIL ENGINEERING DIVISION
AMEC Earth & Environmental Limited
In association with
EBA Engineering Consultants Ltd.
and
Stantec Consulting Ltd.
Designed By: K.K.
Drawn By: M.T.
Checked By: K.K.
Approved By: K.K.
Contract: LITTLE BOW RIVER PROJECT Dam and Reservoir Component
Title: RESERVOIR AREA PLAN
Plan No: 008860
Project No: CW1210.02
CADD File: 1210-M50.dwg
Figure No: FIGURE 2

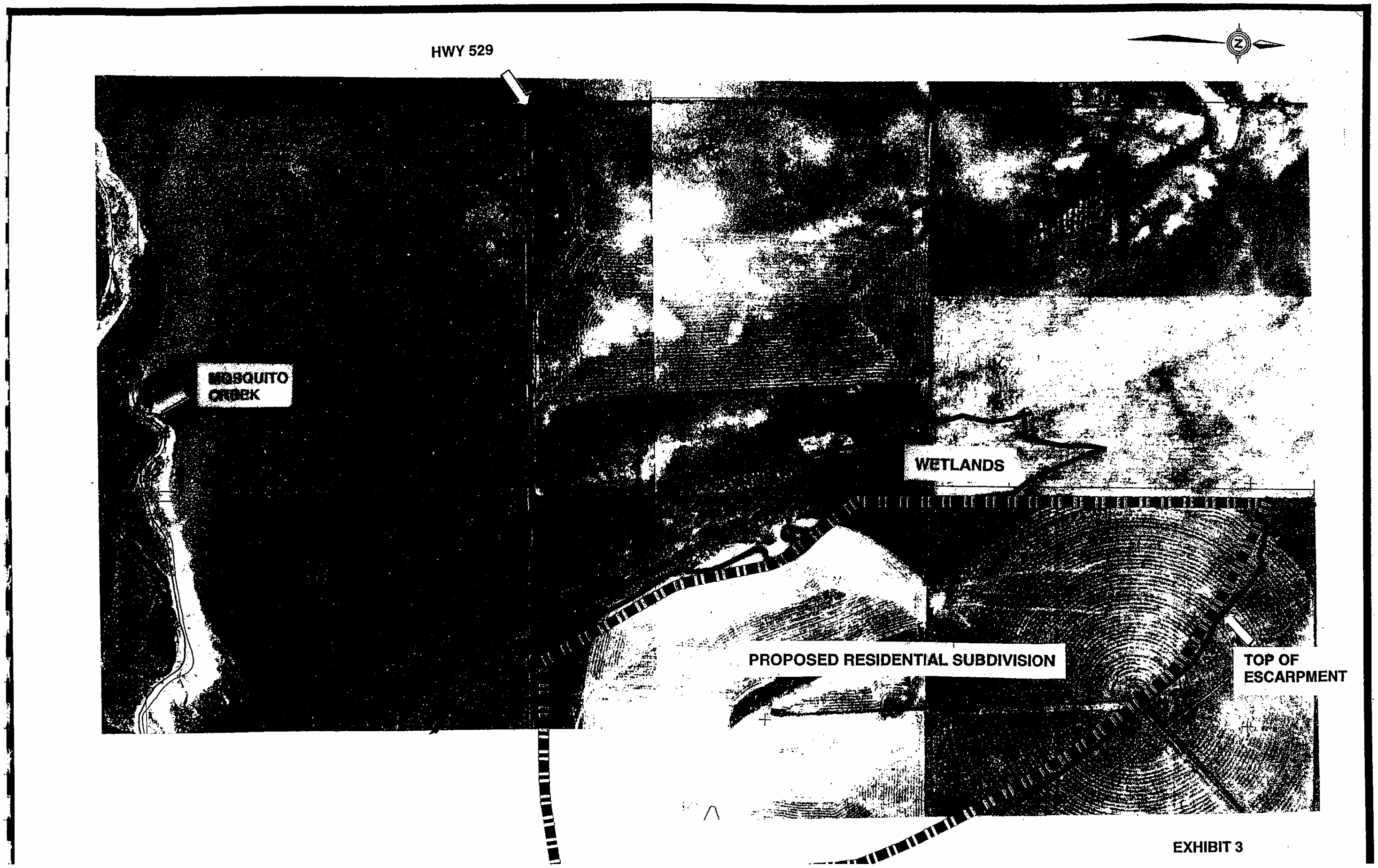

HWY 529
MOSQUITO
CREEK
WETLANDS
PROPOSED RESIDENTIAL SUBDIVISION
TOP OF
ESCARPMENT

EXHIBIT 3