



# Nottawasaga Valley Conservation Authority



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Canada

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Canada

Report

## Watershed Hydrology Study for Nottawasaga, Pretty and Batteaux Rivers Black Ash, Silver and Sturgeon Creeks

Volume I — Technical Report

Canada/Ontario Flood Damage Reduction Program

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**MaLaren Plansearch**

**Lavalin**

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- D.H. White, B.Sc., General Manager, Nottawasaga Valley Conservation Authority
- S. Moin, P. Eng., Environment Canada
- H. Sayeed, P. Eng., Ministry of Natural Resources, Central Region

The background data presented in this report was obtained from several sources including the Inland Water Directorate and the Atmospheric Environment Service of Environment Canada and the Ontario Ministry of the Environment.

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- Black Ash Creek near Collingwood
- Silver Creek near Collingwood
- Pretty River at Collingwood.

The discretized models for each of the above areas were separated from the main model. Downstream sub-catchment areas were included in each model to the point of a major confluence in order to assess the hydrologic impact of urbanization. Each sub-model was subsequently run for 22 years of historic events for both present and future conditions. Frequency analyses were then conducted at points of interest for both present and future conditions using the CFA88 program. At each point, the increase in flow from present to future conditions was determined for the various return periods (1 in 5 to 1 in 100 year). To obtain the future flows, the increase in flow was added to the corresponding return period flow established in Section 3.3.2.2 under existing conditions. An example of this procedure is provided in Appendix I.

A similar procedure was used for some of the other watercourses flowing into Georgian Bay and the local sub-catchments downstream of Minesing Swamp flowing directly into the Nottawasaga River.

#### 3.3.3.2 Documentation of Flows

Using the methodology outlined in the previous section, the future flows for the Timmins Storm and 1 in 5 to 1 in 100 year events were determined. These flows are tabulated in Appendix G. The increase in future flows is small for both the Timmins Storm and the 1 in 5 to 1 in 100 year events.

#### 3.3.4 Flow Estimation at Intermediate Locations

While the watercourses within the NVCA have been discretized into 191 sub-catchments for this study, it is recognized that the Conservation Authority

may have future requirements to obtain design flows at other flow points. As indicated previously, design flows developed for this study are presented in Appendix G. The location of the flow points are cross-referenced to Figure 3.11. From a review of Figure 3.11, it can be seen that design flows may be required for (i) smaller headwater drainage basins than were modelled using QUALHYMO and (ii) along major waterways. This section of the report deals with the development of two methodologies to obtain design flows for headwater drainage areas and along major watercourses.

#### 3.3.4.1 Headwater Drainage Areas

In consultation with the Project Committee, it was decided that the design flows for headwater drainage areas would be established by conducting linear regression analyses of peak flows versus drainage areas. The equation has the form of:

$$Q = CA^n$$

where:

Q is the peak discharge (m<sup>3</sup>/s)

A is the drainage area (km<sup>2</sup>)

and n and C are the slope of the line and intercept, respectively.

A computer program developed in-house was used to conduct linear regression analyses for the 1 in 5, 1 in 10, 1 in 20, 1 in 50, 1 in 100 year events and Timmins Storm. Regression analyses were conducted separately for the major watercourses to account for geographic and physiographic differences. Linear regression analyses were conducted for the following watercourses:

- Innisfil/Beeton/Bailey Creeks
- Upper Nottawasaga River (including Sheldon Creek)
- Boyne River
- Pine River
- Mad River
- Willow Creek
- Georgian Bay watercourses

The number of flows versus drainage area points used in the regression analyses ranged from seven to thirteen. The size of the drainage areas ranged from 1 km<sup>2</sup> to 134 km<sup>2</sup> and are documented in Table 3.17. Reference should be made to Appendix G for flow values. The result of the regression analyses for the above-noted watercourses are plotted in Figures 3.12(a) to 3.12(g) for the 1 in 20 and 1 in 100 year event and the Timmins Storm. From these figures, it can be seen that the slopes of the lines for each watercourse are similar for the 1 in 20, 1 in 100 year and Timmins Storm. This is also true for the 1 in 5, 1 in 10 and 1 in 50 year events.

A summary of the C and n parameters established from the linear regression analysis is presented in Table 3.18 for each watercourse. To compute the design flow at a point of interest for headwater drainage areas, the following procedure is recommended:

- i) measure the drainage area to the point of interest using suitable mapping
- ii) from Table 3.18, select the appropriate C and n values for the desired recurrence interval or Timmins Storm flows
- iii) substitute the values obtained in (i) and (ii) above in  $Q = CA^n$  to obtain design flow

TABLE 3.18  
SUMMARY OF LINEAR REGRESSION ANALYSIS PARAMETERS FOR HEADWATER DRAINAGE AREAS

| WATERCOURSES                  | 1 in 5 Year |       | 1 in 10 Year |       | 1 in 20 Year |       | 1 in 50 Year |       | 1 in 100 Year            |       | Timmins |       |
|-------------------------------|-------------|-------|--------------|-------|--------------|-------|--------------|-------|--------------------------|-------|---------|-------|
|                               | C           | n     | C            | n     | C            | n     | C            | n     | C                        | n     | C       | n     |
| Innisfil/Beeton/Bailey Creeks | 0.556       | 0.751 | 0.683        | 0.753 | 0.826        | 0.750 | 0.993        | 0.753 | <del>0.112</del><br>1.12 | 0.757 | 5.36    | 0.709 |
| Upper Nottawasaga River       | 0.639       | 0.652 | 0.820        | 0.643 | 0.957        | 0.647 | 1.19         | 0.644 | 1.35                     | 0.646 | 7.02    | 0.616 |
| Boyne River                   | 0.767       | 0.894 | 1.05         | 0.883 | 1.47         | 0.851 | 1.79         | 0.869 | 2.31                     | 0.842 | 7.11    | 0.638 |
| Pine River                    | 0.228       | 1.00  | 0.289        | 0.999 | 0.332        | 0.999 | 0.396        | 0.998 | 0.443                    | 0.999 | 0.928   | 1.00  |
| Mad River                     | 2.43        | 0.489 | 2.99         | 0.489 | 3.51         | 0.489 | 4.24         | 0.489 | 4.81                     | 0.489 | 20.86   | 0.423 |
| Willow Creek                  | 0.553       | 0.880 | 0.624        | 0.880 | 0.698        | 0.878 | 0.789        | 0.878 | 0.879                    | 0.872 | 3.21    | 0.959 |
| Georgian Bay Inflows          | 1.58        | 0.817 | 2.02         | 0.808 | 2.51         | 0.790 | 3.37         | 0.749 | 3.99                     | 0.729 | 9.33    | 0.754 |

Equation :  $Q = CA^n$   
 where  $Q$  = peak discharge ( $m^3/s$ )  
 $A$  = drainage area ( $Km^2$ )  
 $c, n$  as given above

- iv) repeat steps (ii) and (iii) for other recurrence interval flows or Timmins Storm flow

The above procedure is presented in flow chart format in Figure 3.12(h).

#### 3.3.4.2 Major Waterways

Flow points along the major watercourses have been established at fairly close intervals as indicated in Figure 3.11. The change in flows from one flow point to the next point downstream is usually not very great. Therefore, to obtain design flows for intermediate points along the major watercourses, it is recommended that the flows be pro-rated linearly based on the incremental drainage area for those occasions where peak flows increase in a downstream direction. Careful attention must be taken when evaluating the tributary drainage at intermediate locations. Topographic maps are to be used to determine the portion of the incremental drainage area between flow points used in this study (Figure 3.11) which is tributary to the waterway upstream of the location of interest. Linear interpolation of flows based on stream length between flow points is not recommended as a computational procedure since the incremental drainage area may not be proportional to stream length. In those locations where design flows calculated at flow points decrease in the downstream direction, flow estimation at intermediate locations should be based on a linear interpolation of stream length between the flow points. Flow routing effects are considered of primary importance in attenuating peak flows in a downstream direction and this is most readily reflected in the stream length.

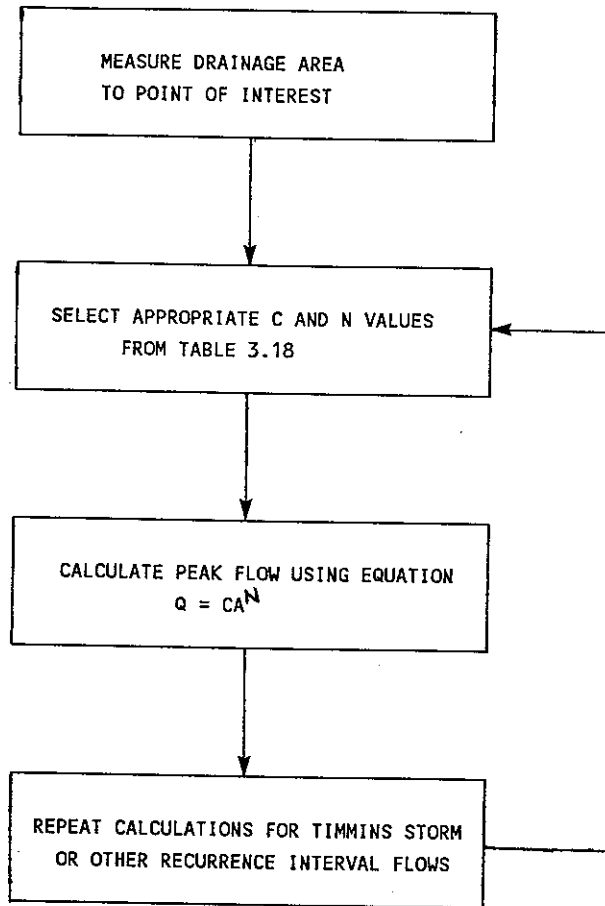
The above procedure is presented in flow chart format in Figure 3.12(i).

#### 3.3.5 Flow Hydrographs

In order to establish design flows along the lower Nottawasaga River downstream of Minesing Swamp, it is necessary to carry out dynamic flow modell-

FIGURE 3.12 (h)

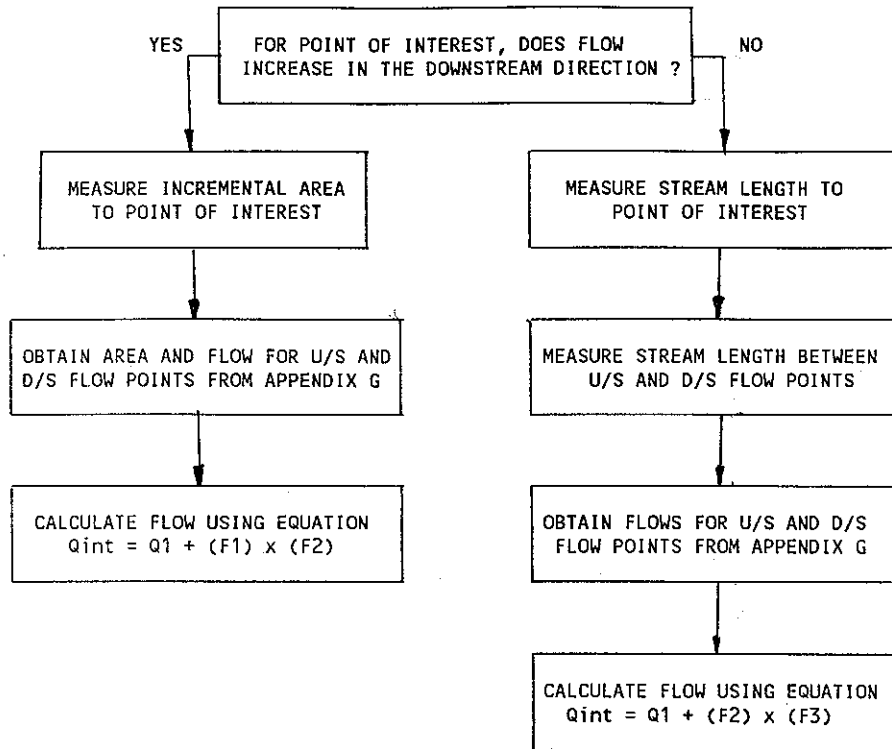
PROCEDURE TO CALCULATE FLOWS FOR HEADWATER DRAINAGE AREAS



WHERE :  $Q$  = PEAK DISCHARGE ( $M^3/S$ )  
 $A$  = DRAINAGE AREA ( $KM^2$ )  
 $N$  and  $C$  VALUES ARE AS PRESENTED IN TABLE 3.18

FIGURE 3.12 (i)

PROCEDURE TO CALCULATE INTERMEDIATE FLOWS FOR MAJOR WATERWAYS



WHERE :  $Q_{int}$  = DESIRED FLOW AT POINT OF INTEREST ( $M^3/S$ )

$Q_1$  = FLOW AT UPSTREAM FLOW POINT ( $M^3/S$ )

$F_1 = \left( \frac{A_{int} - A_1}{A_2 - A_1} \right)$  (AREA FACTOR)

$A_{int}$  = TOTAL DRAINAGE AREA AT POINT OF INTEREST ( $KM^2$ )  
(TOTAL AREA AT UPSTREAM FLOW POINT PLUS INCREMENTAL AREA)

$A_1, A_2$  = TOTAL DRAINAGE AREAS ( $KM^2$ ) AT UPSTREAM AND DOWNSTREAM FLOW POINTS, RESPECTIVELY

$F_2 = (Q_2 - Q_1)$  (FLOW FACTOR)

$Q_1, Q_2$  = FLOW ( $M^3/S$ ) AT UPSTREAM AND DOWNSTREAM FLOW POINTS RESPECTIVELY

$F_3 = \left( \frac{L_1}{L_2} \right)$  (LENGTH FACTOR)

$L_1$  = STREAM LENGTH FROM UPSTREAM FLOW POINT TO POINT OF INTEREST (KM)

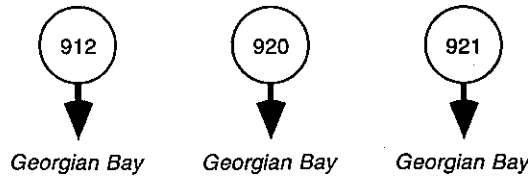
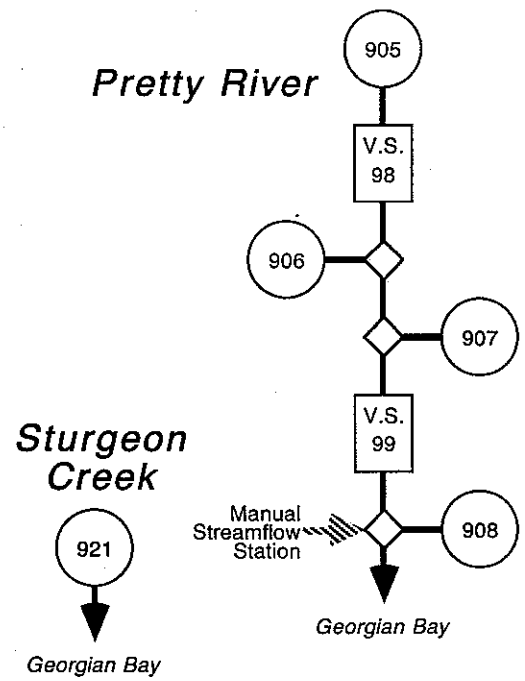
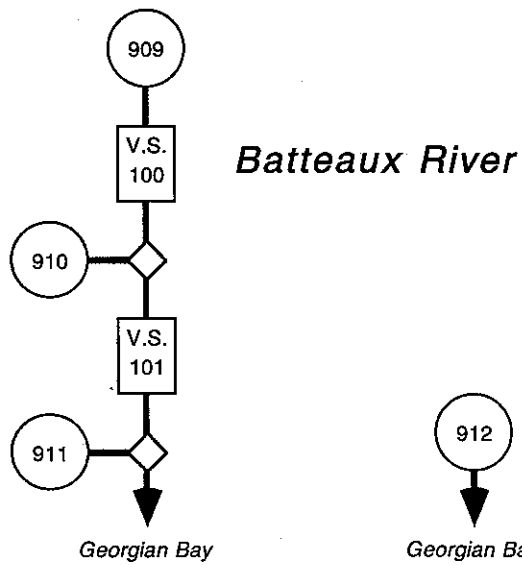
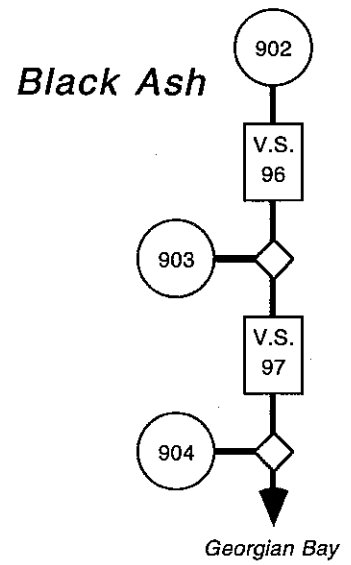
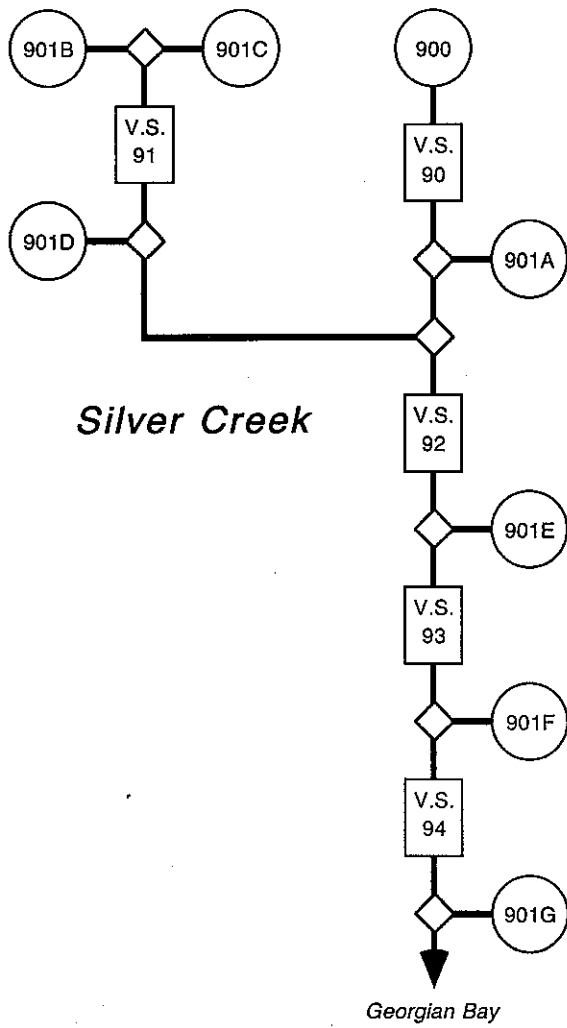
$L_2$  = STREAM LENGTH FROM UPSTREAM FLOW POINT TO DOWNSTREAM FLOW POINT (KM)

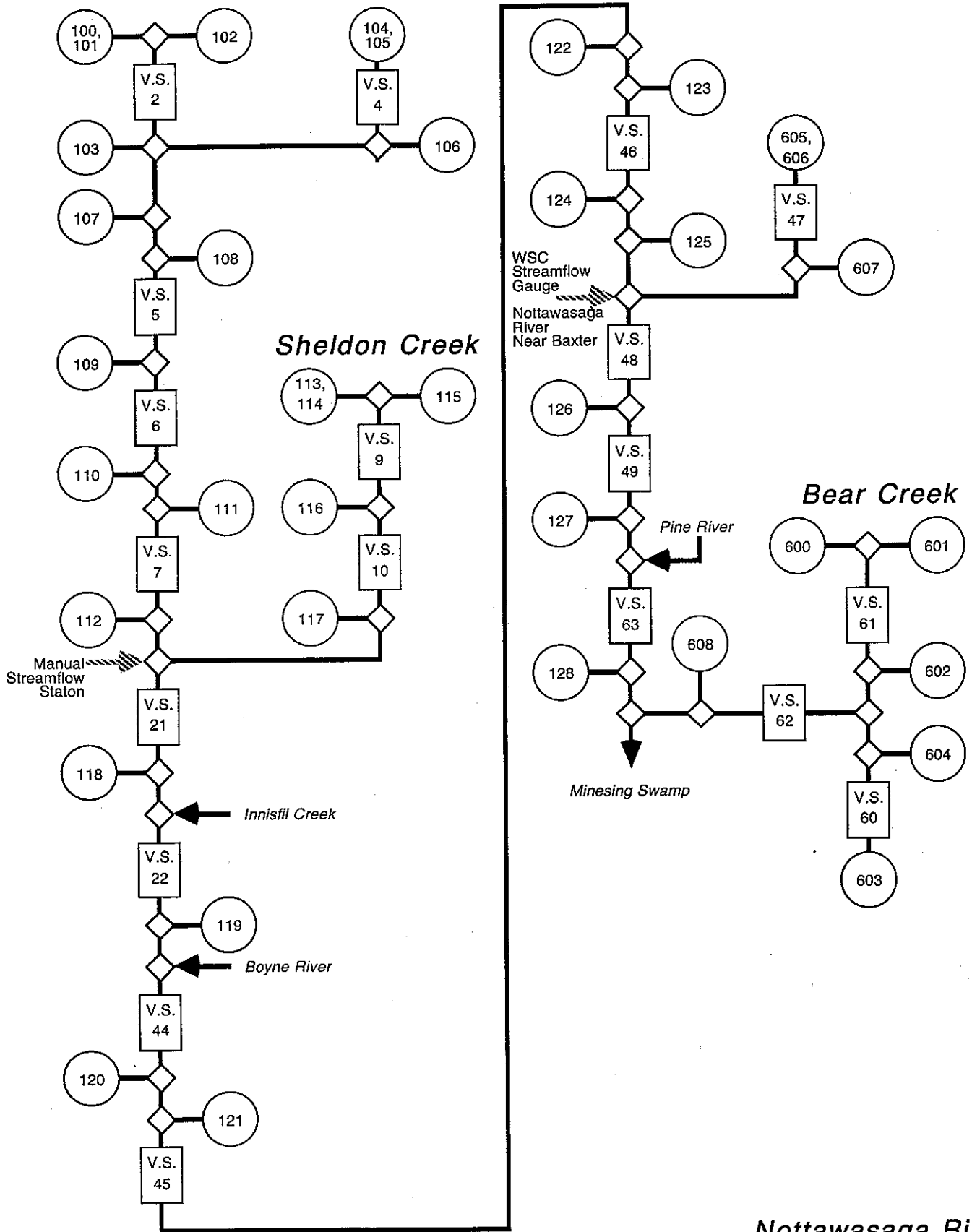
APPENDIX K  
HYDROLOGIC MODEL SCHEMATICS

APPENDIX K

Note: Refer to the following List of Identification Numbers for cross-referencing between computer models and basin schematics.

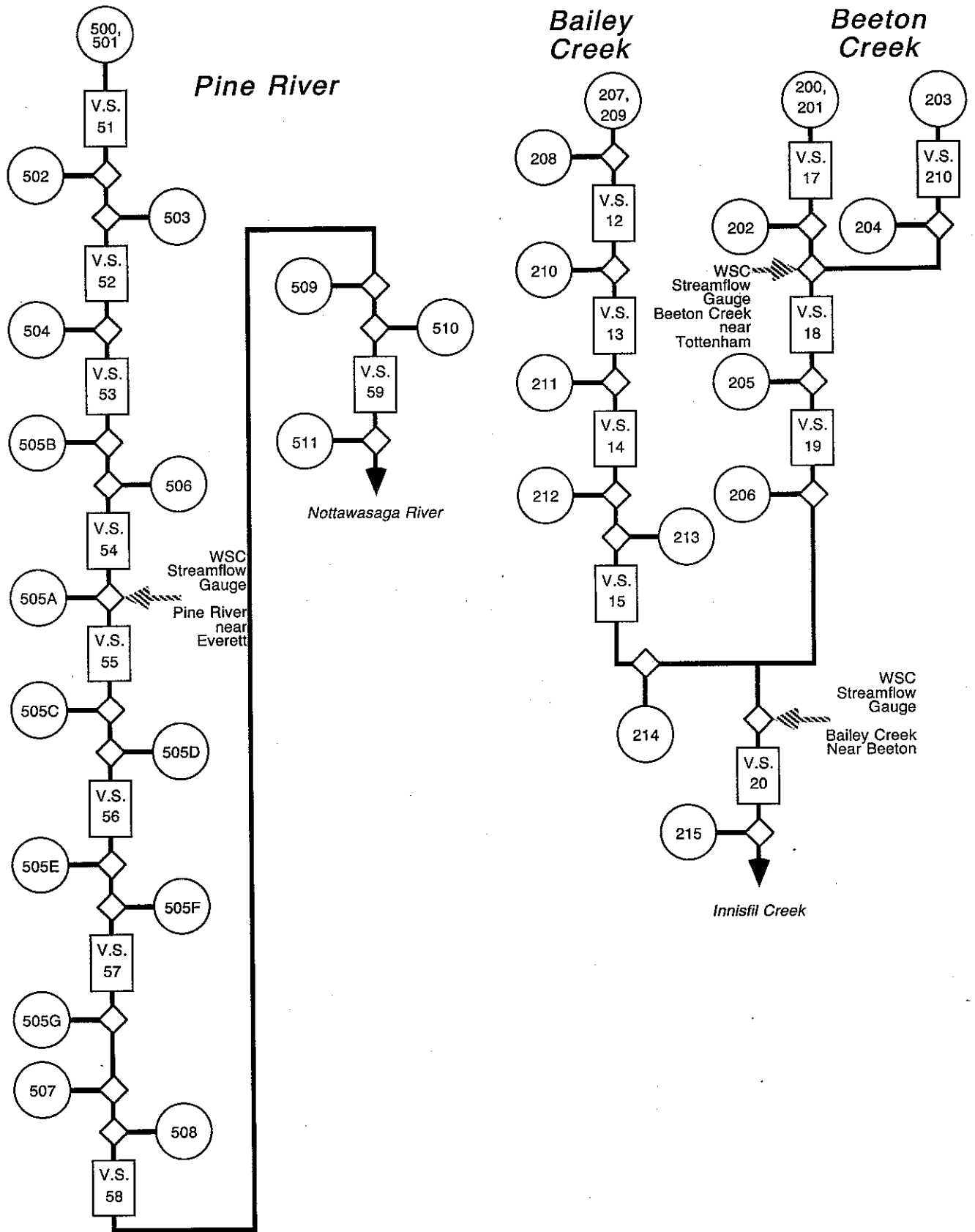
| <u>QUALHYMO Model</u> Identification Number | <u>Basin Schematic</u> Identification Number |
|---|--|
| 4101  | 410A   |
| 4102  | 410B   |
| 5051  | 505A   |
| 5052  | 505B   |
| 5053  | 505C   |
| 5054  | 505D   |
| 5055  | 505E   |
| 5056  | 505F   |
| 5057  | 505G   |
| 8111  | 811A   |
| 8112  | 811B   |
| 9011  | 901A   |
| 9012  | 901B   |
| 9013  | 901C   |
| 9014  | 901D   |
| 9015  | 901E   |
| 9016  | 901F   |
| 9017  | 901G   |
| 9018  | 901H   |
| 9019  | 901I   |

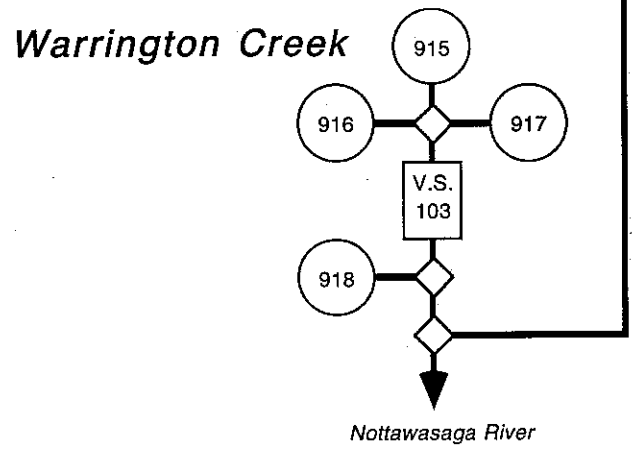
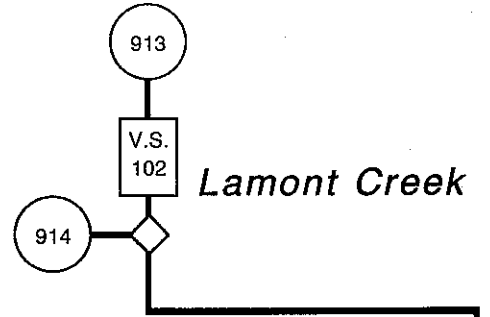
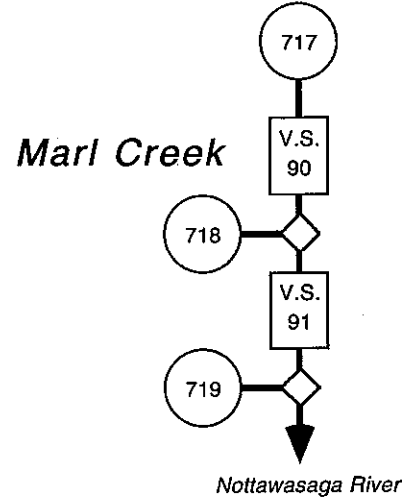
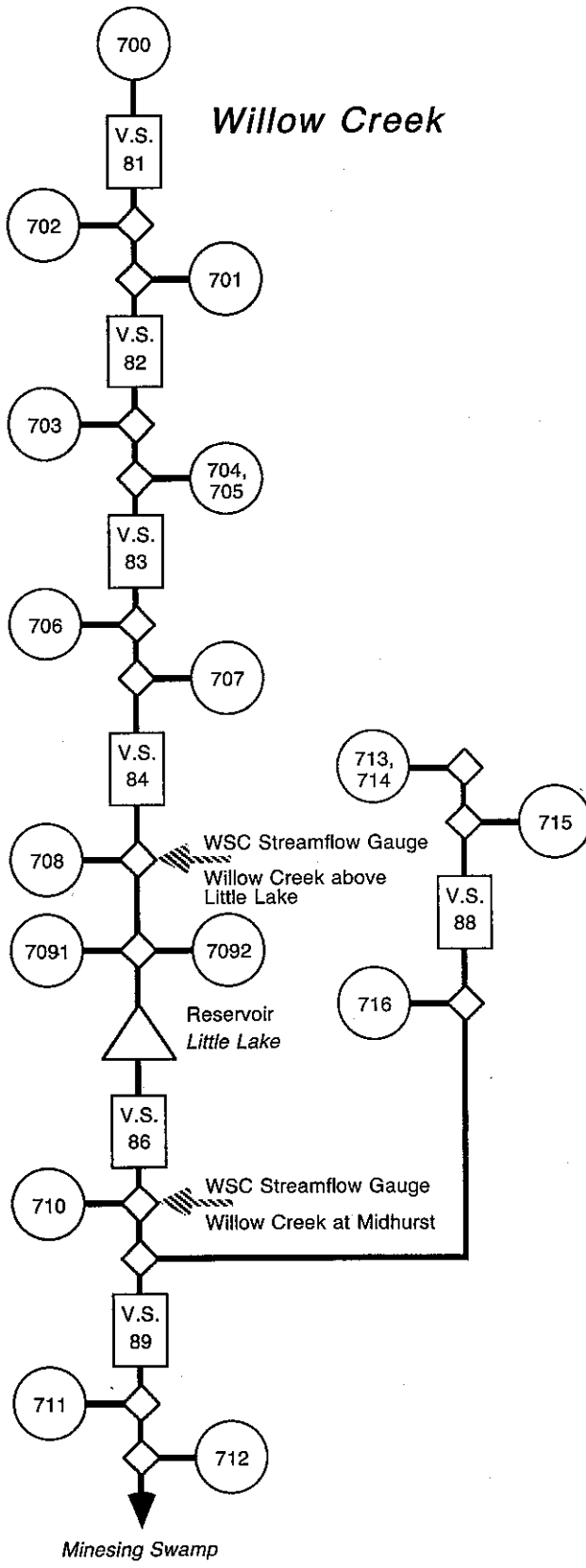




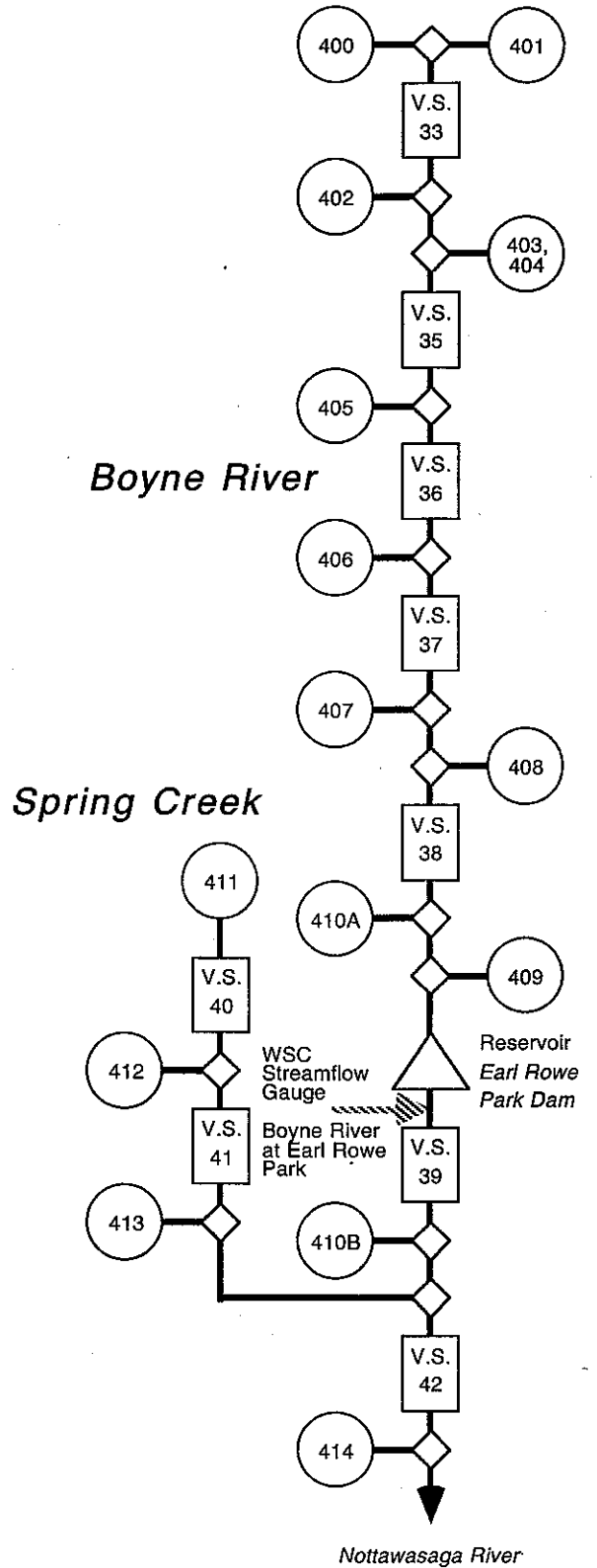
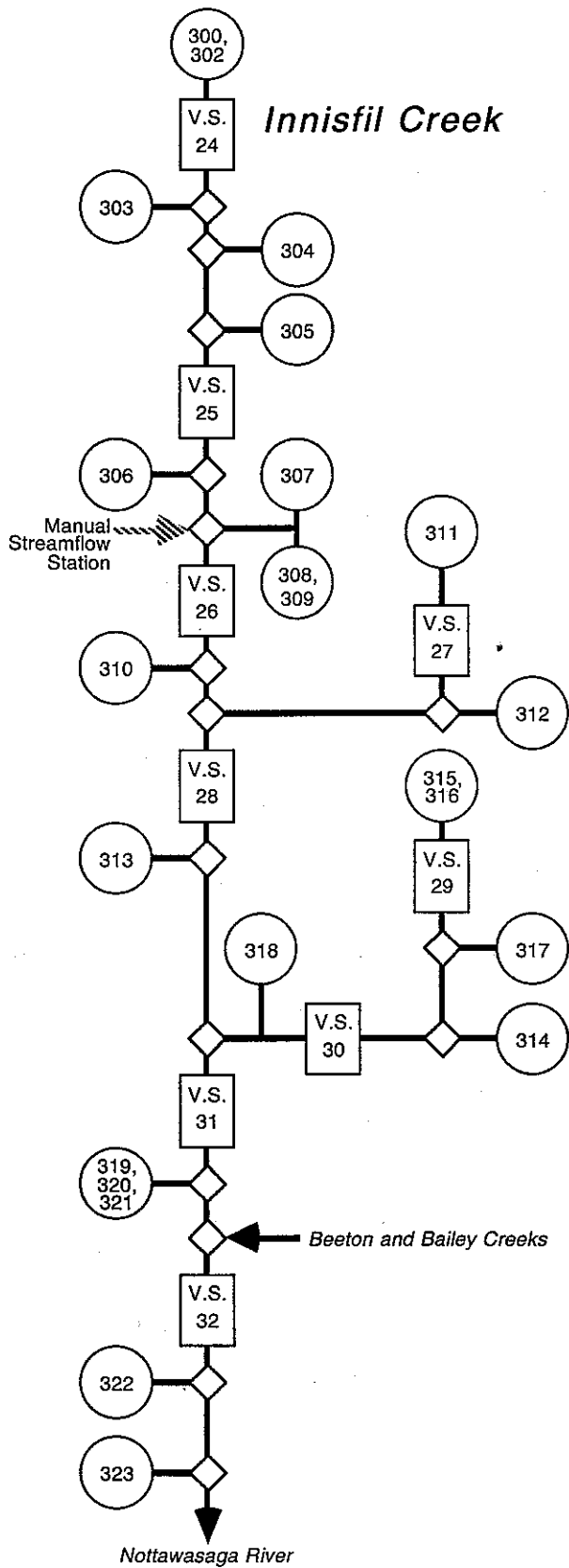
*Nottawasaga River*

# QUALHYMO Hydrologic Model Schematic

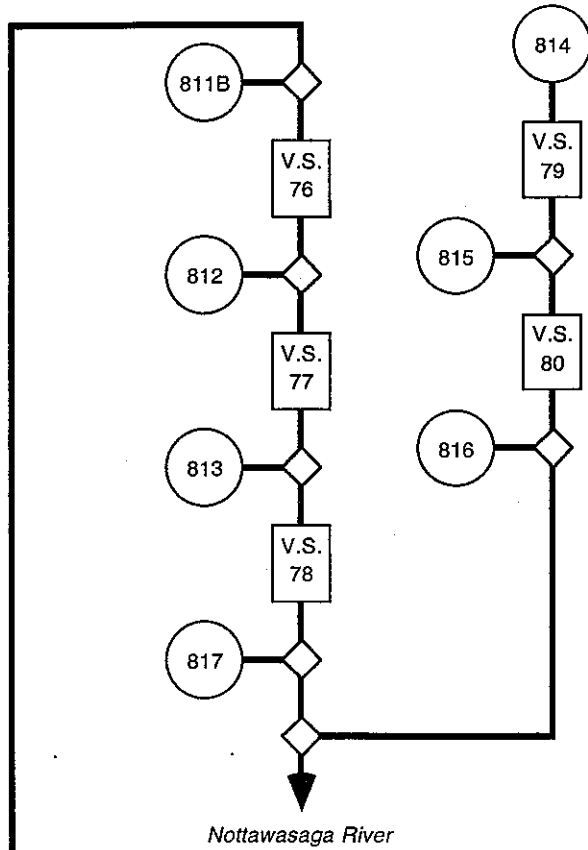
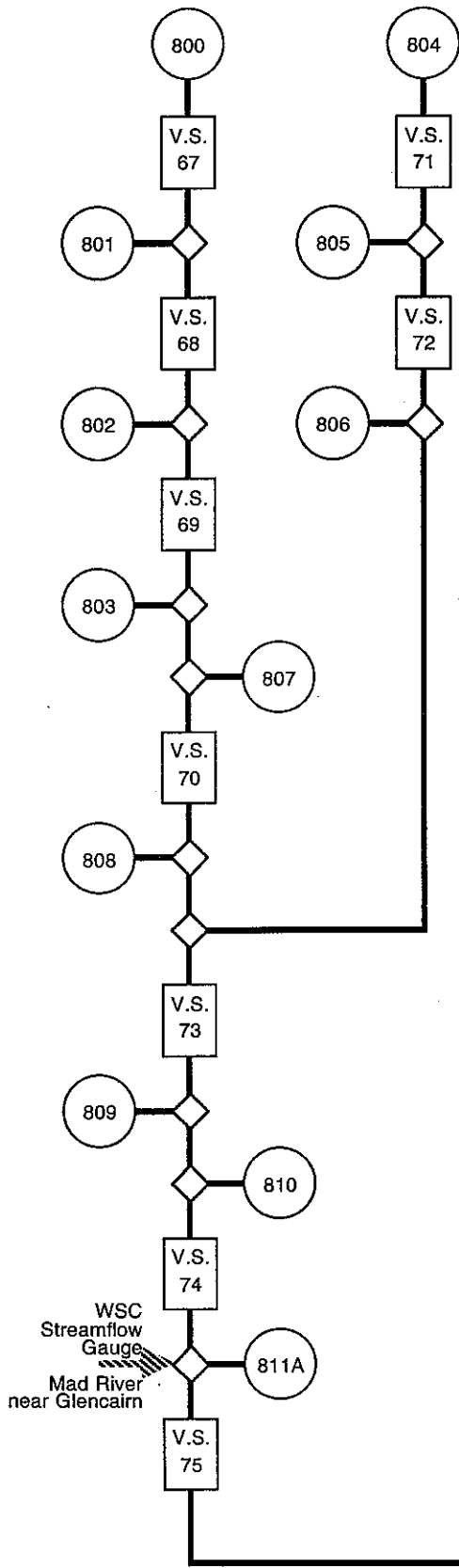




**QUALHYMO**  
Hydrologic Model Schematic



**QUALHYMO**  
**Hydrologic Model Schematic**

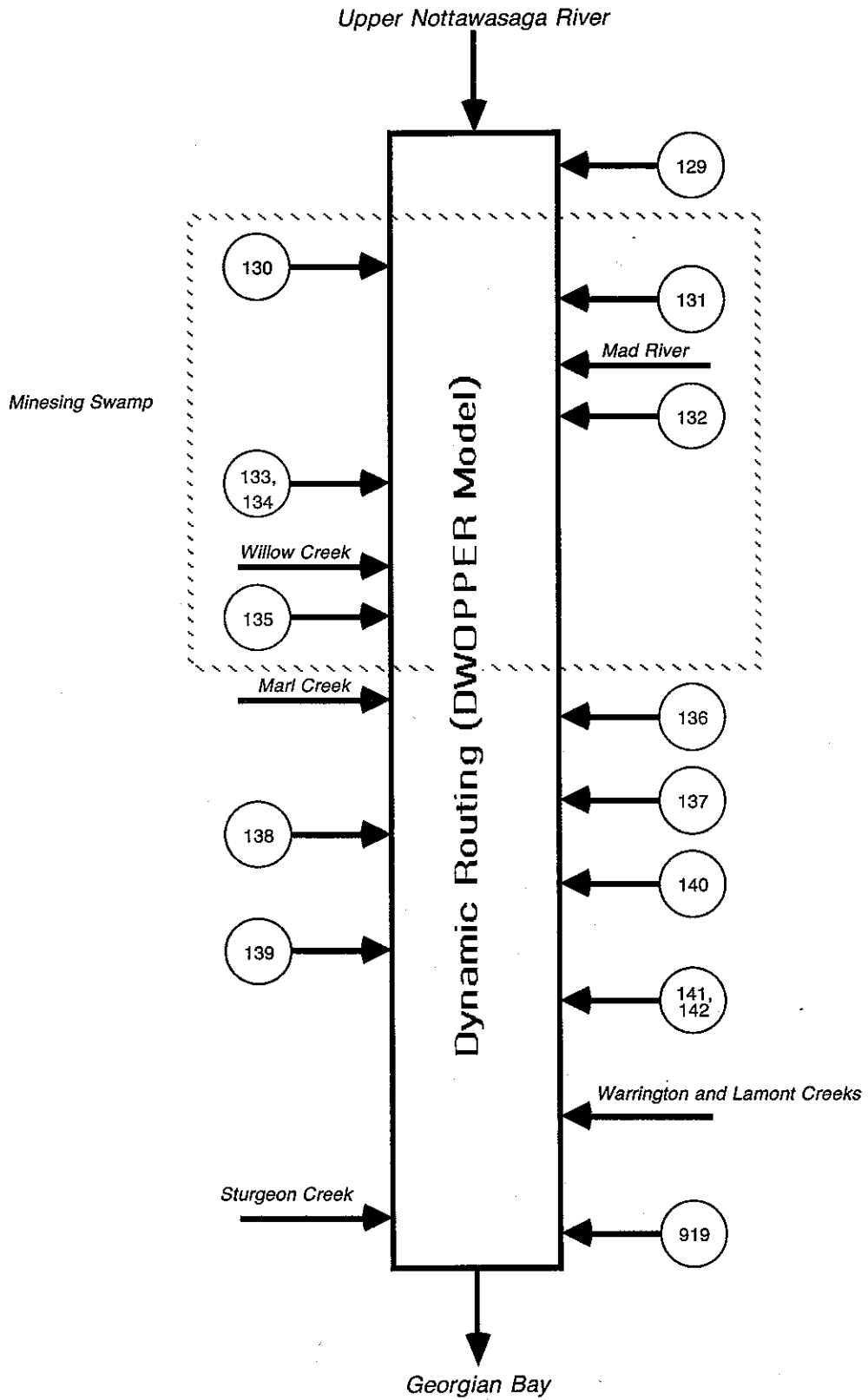


WSC  
 Streamflow  
 Gauge  
 Mad River  
 near Glencairn

Nottawasaga River

*Mad River*

# QUALHYMO Hydrologic Model Schematic



Lower Nottawasaga River

**QUALHYMO  
Hydrologic Model Schematic**