Robinson Consultants

Steven Creek Floodplain Mapping Update Rideau River to Malakoff Road Progress Report Hydraulics

Volume 1

Prepared for:

Rideau Valley Conservation Authority

Prepared by:

Robinson Consultants Inc.
Consulting Engineers

Project No. 92098
May 1995

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May 9, 1995

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Attention: **Mr. Patrick Larson,**
Water Resources Technician

Reference: **Update Flood Risk Mapping, Steven Creek**
Our File No. 92098

Dear Mr. Larson:

We are pleased to submit herewith five (5) copies of the final hydraulics report as well as a hardcopy of the HEC-2 model (Volume 2) and the survey notes (Volume 3) for the above noted study. The top copy of the report contains the HEC-2 files on diskette (Appendix K).

Should you have any questions, please do not hesitate to call.

Yours truly,

ROBINSON CONSULTANTS INC.

Frank Hendriksen, P.Eng.
Project Manager

FH/lmj

Enclosures

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1.0 INTRODUCTION

In the fall of 1992, the Rideau Valley Conservation Authority authorized Robinson Consultants Inc. (formerly A.J. Robinson & Associates Inc.) to undertake a floodplain mapping study of Steven Creek from the Rideau River to Malakoff Road. Floodplain mapping of Steven Creek was first completed in 1972. This mapping now requires updating for the following reasons:

1) The hydrologic and hydraulic analyses and the cartography used in the 1972 study do not meet present day standards for the delineation of flood risk areas.

2) Numerous changes have occurred in the watershed and floodplain since the preparation of the 1972 floodline mapping. Updated floodlines will be presented on up-to-date base mapping.

3) The 1972 study produced water surface profiles and floodlines for only the 1:100 year flood. Water surface profiles and floodlines for other events (1:2 year to 1:50 year return periods) are required.

4) The recent estimates of the Rideau River flood levels showed higher flood levels than the ones assumed for the 1972 study.

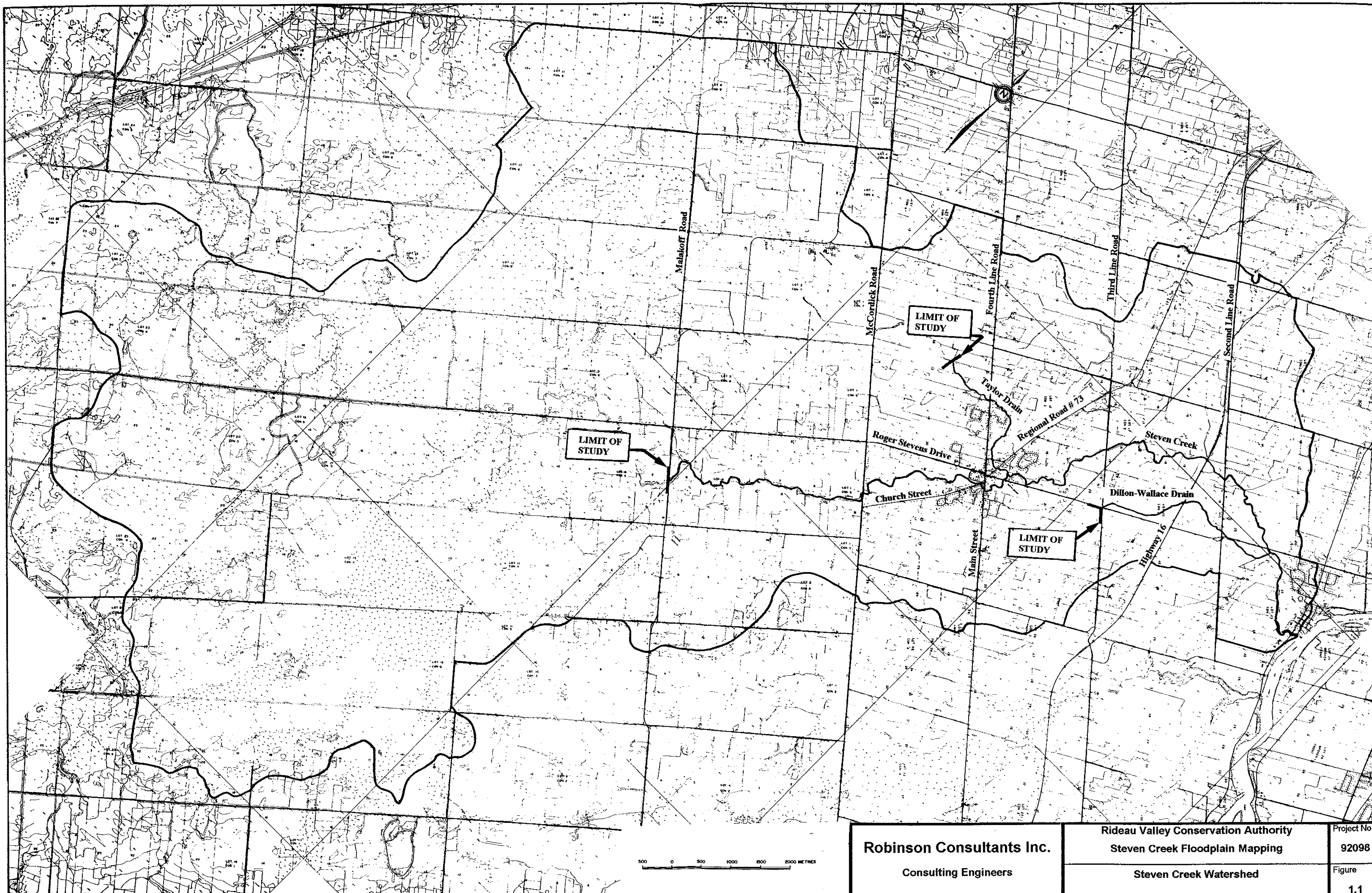
The content of the study is documented in a series of four reports. The Hydrology Report which determines flood flows; the Hydraulics Report which determines the water surface elevations through the study area; the Mapping Report which reports on mapping accuracy; and a General Report which deals with the final mapping of the achieved results through this study.

The report in hand is the second report, Progress Report Hydraulics; it presents the various return period flood elevations through the study area.

1.1 Study Area

The Steven Creek watershed, shown on Figure 1.1, is located within Rideau Township and has a drainage area of approximately 15,705 ha (157.1 km^2). The northern part of the watershed is drained by a main tributary, Taylor Drain, and the southern part is drained by a second tributary, the Dillon-Wallace Drain. The channel has a low bedslope (the total relief is approximately 27.5 m over its 26 km length) and strong meanders. Taylor Drain and other tributaries are channelized over much of their lengths. The watershed is characterized by extensive wetlands in the upper basin. These wetlands cover approximately 50% of the watershed (78.0 km^2). Land use in the lower basin is mostly agricultural. Steven Creek transects the Village of North Gower, 8 km upstream from the Rideau River. The confluence with Taylor Drain is at the eastern limit of the village. The outlet of Dillon-Wallace Drain is just downstream of Roger Stevens Drive near the Village of Kars. At the mouth along the north bank of the creek, is the Village of Kars.

The wetlands in the upper basin are underlain by Farmington and Grenville sandy loams, as well as Huntley, Greely, and some Goulbourn organic soils (forest peat). Soils in the middle and lower basins are dominated by loams and clay loams of the Dalhousie, North Gower, and Osgoode varieties.



Robinson Consultants Inc.	Rideau Valley Conservation Authority	Project No.
	Steven Creek Floodplain Mapping	92098
Consulting Engineers	Steven Creek Watershed	Figure 1.1

Table 2.1
Description of Cross Sections

Name	Chainage	Description	Figure No.
Steven Creek			
Steven Creek @ Outlet	0 + 000	- Outlet of Steven Creek to the Rideau River	A-1
Rideau Valley Drive	0 + 030	- Downstream face	
Rideau Valley Drive	0 + 042	- Upstream face	A-1
Rideau Valley Drive	0 + 092	- 30 m upstream of bridge	
Steven Creek	0 + 967	- Main channel	
Steven Creek	1 + 067	- Main channel	
Roger Stevens Drive	1 + 817	- 30 m downstream of bridge and Dillon-Wallace Drain outlet	A-2
Roger Stevens Drive	1 + 847	- Downstream face	
Roger Stevens Drive	1 + 857	- Upstream face	A-2
Roger Stevens Drive	1 + 888	- 31 m upstream of bridge	
Second Line Road	3 + 638	- 30 m downstream of bridge	
Second Line Road	3 + 668	- Downstream face	
Second Line Road	3 + 674	- Upstream face	A-3
Second Line Road	3 + 704	- 30 m upstream of bridge	
Highway 16	4 + 129	- 30 m downstream of bridge	
Highway 16	4 + 159	- Downstream face	
Highway 16	4 + 174	- Upstream face	A-3
Highway 16	4 + 204	- 30 m upstream of bridge	
Third Line Road	6 + 304	- 30 m downstream of bridge	
Third Line Road	6 + 334	- Downstream face	
Third Line Road	6 + 340	- Upstream face	A-4
Third Line Road	6 + 370	- 30 m upstream of bridge	
Private Driveway	6 + 970	- 30 m downstream of bridge	
Private Driveway	7 + 000	- Downstream face	
Private Driveway	7 + 005	- Upstream face	A-4
Private Driveway	7 + 035	- 30 m upstream of bridge	
Steven Creek	7 + 785	- Main channel	

Table 2.1 (Cont'd)
Description of Cross Sections

Name	Chainage	Description	Figure No.
Steven Creek	8 + 035	- Main channel	
Steven Creek	8 + 285	- Main channel	
Steven Creek	8 + 535	- Main channel	A-5
Roger Stevens Drive (RR #6)	8 + 895	- 30 m downstream of bridge	
Roger Stevens Drive (RR #6)	8 + 925	- Downstream face	
Roger Stevens Drive (RR #6)	8 + 943	- Upstream face	A-5
Roger Stevens Drive (R.R. #6)	8 + 973	- 30 m upstream of bridge	
Main Street	9 + 253	- 28 m downstream of bridge	
Main Street	9 + 281	- Downstream face	A-6
Main Street	9 + 302	- Upstream face	
Main Street	9 + 330	- 30 m upstream	
Steven Creek	9 + 370	- Halfway between Main Street Bridge and Church Street Bridge	
Church Street	9 + 410	- Downstream face	
Church Street	9 + 421	- Upstream face of structure	A-6
Weir	9 + 452	- Cross section of weir	A-7
Weir	9 + 653	- 200 m upstream of weir	
McCordick Road	12 + 053	- 30 m downstream of bridge	
McCordick Road	12 + 083	- Downstream face	
McCordick Road	12 + 088	- Upstream face	A-7
McCordick Road	12 + 118	- 30 m Upstream of bridge	
Steven Creek	14 + 218	- Main channel	
Steven Creek	14 + 518	- Main channel	
Steven Creek	14 + 751	- Main channel	
Steven Creek	14 + 984	- Main channel	
Steven Creek	15 + 218	- Main channel	
Steven Creek	15 + 268	- Main channel	
Steven Creek	15 + 318	- Main channel	

Table 2.1 (Cont'd)
Description of Cross Sections

Name	Chainage	Description	Figure No.
Steven Creek	15 + 403	- Main channel	
Steven Creek	15 + 488	- Main channel	
Steven Creek	15 + 573	- Main channel	
Steven Creek	15 + 658	- Main channel	
Steven Creek	15 + 743	- Main channel	
Steven Creek	15 + 828	- Main channel	
Malakoff Road	15 + 918	- 30 m downstream of bridge	
Malakoff Road	15 + 948	- Downstream face	A-8
Malakoff Road	15 + 958	- Upstream limit of study area	
<u>Taylor Drain</u>			
Taylor Drain @ Outlet	0 + 000	- Outlet of Taylor Drain to Steven Creek	
Craig Street	0 + 155	- 30 m downstream of bridge	
Craig Street	0 + 185	- Downstream face	
Craig Street	0 + 194	- Upstream face	A-8
Craig Street	0 + 304	- Midway between Craig Street and Old Highway 16	
Highway 73	0 + 404	- 30 m downstream of bridge	
Highway 73	0 + 434	- Downstream face	
Highway 73	0 + 451	- Upstream face	A-9
Highway 73	0 + 501	- 30 m upstream of bridge	
Taylor Drain	0 + 918	- Main channel	
Taylor Drain	1 + 334	- Main channel	
Taylor Drain	1 + 543	- Main channel	
Fourth Line Road	1 + 751	- 30 m downstream of bridge	
Fourth Line Road	1 + 781	- Downstream face	
Fourth Line Road	1 + 792	- Upstream face	A-9
Fourth Line Road	1 + 822	- 30 m upstream of bridge	
Taylor Drain	2 + 322	- Main channel	
Fourth Line Road	2 + 822	- Upstream limit of study	

Table 2.1 (Cont'd)
Description of Cross Sections

Name	Chainage	Description	Figure No.
Dillon-Wallace Drain			
Dillon-Wallace Drain @ Outlet	0 + 000	- Outlet of Dillon-Wallace Drain to Steven Creek	
Roger Stevens Drive	0 + 651	- 30 m downstream	
Roger Stevens Drive	0 + 711	- Upstream face	A-10
Roger Stevens Drive	0 + 801	- Midway between Roger Stevens Drive and Second Line Road	
Second Line Road	0 + 831	- Downstream face	
Second Line Road	0 + 901	- Upstream face	A-11
Highway 16	1 + 851	- 30 m downstream	
Highway 16	1 + 881	- Downstream face	
Highway 16	1 + 960	- Upstream face	A-10
Dillon-Wallace Drain	2 + 225	- Main channel	
Dillon-Wallace Drain	2 + 490	- Main channel	
Dillon-Wallace Drain	2 + 755	- Main channel	
Dillon-Wallace Drain	3 + 020	- Main channel	
Third Line Road	3 + 285	- 30 m downstream	
Third Line Road	3 + 305	- Downstream face	
Third Line Road	3 + 395	- Upstream limit of study area	A-11
Third Line Road	3 + 425	- 30 m upstream	

Table 2.2
Starting Water Surface Elevations

Return Period	Elevation (m)
100	87.745
50	87.445
20	87.24
10	86.94
5	86.73
2	86.32

TABLE 2.3
Summary of Flows

Location	Chainage	Flow (m3/s)					
		100 YR	50 YR	20 YR	10 YR	5 YR	2 YR
Steven Creek @ Outlet	0 + 000	65.90	59.20	50.00	42.50	34.50	22.10
Roger Stevens Drive	1 + 817	63.30	56.50	47.40	40.30	32.90	21.40
Second Line Road	3 + 638	62.10	55.50	46.60	39.60	32.40	21.20
Third Line Road	6 + 304	54.90	49.60	42.40	36.60	30.30	20.00
Roger Stevens Drive	8 + 895	33.90	30.40	25.60	21.90	17.90	11.90
Main Street	9 + 253	33.10	29.70	25.10	21.50	17.60	11.70
Church Street	9 + 370	30.40	27.60	23.70	20.50	17.10	11.40
McCordick Road	12 + 053	30.80	28.00	24.10	21.00	17.50	11.70
Steven Creek @ 14 km	14 + 218	26.10	24.70	22.60	20.70	18.30	13.40
Malakoff Road	14 + 518	21.90	19.80	16.90	14.60	12.10	8.01
Taylor Drain @ Outlet	0 + 000	24.00	21.50	18.20	15.50	12.70	8.25
Taylor Drain @ 4th Line Road	1 + 751	23.60	21.10	17.80	15.20	12.40	8.06
Dillon-Wallace @ Outlet	0 + 000	7.64	6.99	6.08	5.34	4.52	3.16
Dillon-Wallace @ 2nd Line Road	0 + 711	4.15	3.89	3.50	3.16	2.75	2.01
Dillon-Wallace @ Highway 16	1 + 851	3.32	3.12	2.80	2.53	2.20	1.61
Dillon-Wallace @ 3rd Line Road	3 + 285	2.49	2.33	2.10	1.90	1.65	1.20

2.4 Model Parameters

The HEC-2 model requires a number of hydraulic characteristics to generate the water surface elevations. The needed characteristics were determined as follows:

- The new mapping;

  - All cross sections which where completed using field survey information (STA(x))
  - Length of the segments between each cross section (XLOBL, XLOBR, XLCH)
  - Over road flow weir length (RDLEN)

- The HEC-2 manual (User's Manual, 1990)

  - Pier shape coefficient (XK)
  - Total loss coefficient used in orifice flow (XKOR)
  - Coefficient of discharge used in weir flow (COFQ)
  - Manning's coefficient for the culvert barrel (CUNV)
  - Entrance loss coefficient for culverts (ENTLC)
  - Federal Highway Administration Chart number for culverts (CHRT)
  - Federal Highway Administration scale number for culvert (SCL)
  - Manning's "n" for channel flow (XNCH)
  - Manning's "n" for overbank flow (XNL, XNR)
  - Channel contraction coefficient (CCHV)
  - Channel Expansion coefficient (CEHV)

- Obtained from field survey of the structures;

  - Artificial levees for effective flow applications at bridges (ELLEA, ELREA)
  - Bottom width of bridge opening (BWC)
  - Total width of obstructions in channel (BWP)
  - Net area of Bridge opening below the low chord (BAREA)
  - Vertical side slopes (SS)
  - Number of culverts in a series (CUNO)
  - Elevation of bridge low chord (ELLC)
  - Elevation of the horizontal top of roadway (ELTRD)
  - Diameter or rise of culvert (RISE)
  - Width of box culvert opening (SPAN)
  - Length of the culvert barrel (CULVLN)
  - Channel side elevation (STCHL, STCHR)
  - Low chord and corresponding top of road (RDST, RDEL)

- From the Hydrology report;

  - Flow values (Q(x))

The hydraulic characteristics used in the hydraulic model are summarized in Table 2.4 for general cross sections, Table 2.5 for bridges and Table 2.6 for culverts. In HEC-2, weirs are modelled using the Special Bridge Card (SB) and an infinitely small bridge opening. Using this method, HEC-2 simulates weir flow over the structure.

Table 2.4
Hydraulic Parameters Used in General Cross Sections

Cross Section ID	XLOBL	XLCH	XLOBR	XNCH	XNL	XNR	CCHV	CEHV
Steven Creek								
0.000	0	0	0	.025	.075	.075	.3	.5
0.030	30	30	30	.025	.075	.075	.3	.5
0.092	50	50	50	.025	.075	.075	.3	.5
0.967	900	875	850	.025	.075	.075	.3	.5
1.067	100	100	100	.025	.075	.075	.3	.5
1.817	750	750	750	.025	.075	.075	.3	.5
1.847	30	30	30	.025	.075	.075	.3	.5
1.888	30	30	30	.025	.075	.075	.3	.5
3.638	1850	1750	1850	.025	.075	.075	.3	.5
3.668	30	30	30	.025	.075	.075	.3	.5
3.704	30	30	30	.025	.075	.075	.3	.5
4.129	450	425	410	.025	.075	.075	.3	.5
4.159	30	30	30	.025	.075	.075	.3	.5
4.204	30	30	30	.025	.075	.075	.3	.5
6.304	2150	2100	2150	.025	.075	.075	.3	.5
6.334	30	30	30	.025	.075	.075	.3	.5
6.370	30	30	30	.025	.075	.075	.3	.5
6.970	625	600	625	.025	.075	.075	.3	.5
7.000	30	30	30	.025	.075	.075	.3	.5
7.035	30	30	30	.025	.075	.075	.3	.5
7.785	250	250	250	.025	.075	.075	.3	.5
8.035	250	250	250	.025	.075	.075	.3	.5
8.285	250	250	250	.025	.075	.075	.3	.5
8.535	250	250	250	.025	.075	.075	.3	.5
8.895	360	360	360	.025	.075	.075	.3	.5
8.925	30	30	30	.025	.075	.075	.3	.5
8.973	30	30	30	.025	.075	.075	.3	.5
9.253	280	280	280	.025	.075	.075	.3	.5

Table 2.4 (Cont'd)
Hydraulic Parameters Used In General Cross Sections

Cross Section ID	XLOBL	XLCH	XLOBR	XNCH	XNL	XNR	CCHV	CEHV
9.281	30	28	26	.025	.075	.075	.3	.5
9.330	26	28	30	.025	.075	.075	.3	.5
9.370	45	40	35	.025	.075	.075	.3	.5
9.410	40	40	40	.025	.075	.075	.3	.5
9.452	30	30	35	.025	.075	.075	.3	.5
9.653	215	200	200	.025	.075	.075	.3	.5
12.053	2400	2400	2400	.035	.075	.075	.3	.5
12.083	30	30	30	.035	.075	.075	.3	.5
12.118	30	30	30	.035	.075	.075	.3	.5
14.218	2100	2100	2100	.035	.075	.075	.3	.5
14.518	300	300	300	.035	.075	.075	.3	.5
14.751	233	233	233	.035	.075	.075	.3	.5
14.984	233	233	233	.035	.075	.075	.3	.5
15.218	233	233	233	.035	.075	.075	.3	.5
15.268	50	50	50	.035	.075	.075	.3	.5
15.318	50	50	50	.035	.075	.075	.3	.5
15.403	85	85	85	.035	.075	.075	.3	.5
15.488	85	85	85	.035	.075	.075	.3	.5
15.573	85	85	85	.035	.075	.075	.3	.5
15.658	85	85	85	.035	.075	.075	.3	.5
15.743	85	85	85	.035	.075	.075	.3	.5
15.828	85	85	85	.035	.075	.075	.3	.5
15.918	85	85	85	.035	.075	.075	.3	.5
15.948	30	30	30	.035	.075	.075	.3	.5
Taylor Drain								
-8.535	0	0	0	.035	.075	.075	.3	.5
0.155	155	155	155	.035	.075	.075	.3	.5
0.185	30	30	30	.035	.075	.075	.3	.5
0.304	110	110	110	.035	.075	.075	.3	.5

Table 2.4 (Cont'd)
Hydraulic Parameters Used in General Cross Sections

Cross Section ID	XLOBL	XLCH	XLOBR	XNCH	XNL	XNR	CCHV	CEHV
0.404	100	100	100	.035	.075	.075	.3	.5
0.434	30	30	30	.035	.075	.075	.3	.5
0.501	50	50	50	.035	.075	.075	.3	.5
0.918	417	417	417	.035	.075	.075	.3	.5
1.334	417	417	417	.035	.075	.075	.3	.5
1.543	209	209	209	.035	.075	.075	.3	.5
1.751	1200	1250	1250	.035	.075	.075	.3	.5
1.781	30	30	30	.035	.075	.075	.3	.5
1.822	30	30	30	.035	.075	.075	.3	.5
2.322	500	500	500	1035	.075	.075	.3	.5
2.822	500	500	500	.035	.075	.075	.3	.5
Dillon-Wallace Drain								
-1.067	0	0	0	.035	.075	.075	.3	.5
0.651	650	650	650	.035	.075	.075	.3	.5
0.831	30	30	30	.035	.075	.075	.3	.5
0.901	30	30	30	.035	.075	.075	.3	.5
1.851	950	950	950	.035	.075	.075	.3	.5
1.881	30	30	30	.035	.075	.075	.3	.5
1.960	30	30	30	.035	.075	.075	.3	.5
2.225	265	265	265	.035	.075	.075	.3	.5
2.490	265	265	265	.035	.075	.075	.3	.5
2.755	265	265	265	.035	.075	.075	.3	.5
3.020	265	265	265	.035	.075	.075	.3	.5
3.285	265	265	265	.035	.075	.075	.3	.5
3.305	30	30	30	.035	.075	.075	.3	.5
3.395	30	30	30	.035	.075	.075	.3	.5
3.425	30	30	30	.035	.075	.075	.3	.5

Table 2.5
Hydraulic Parameters Used in Bridge Modelling

Bridge I.D.	XK	XKOR	COFQ	ELLEA ELREA	BWC (m)	BWP	BAREA m^2	SS	ELLC	ELTRD	XLCH
Steven Creek											
Rideau Valley Drive	1.25	1.56	1.55	87.116	11.4		73.9	3.18	87.116	87.85	11.4
Roger Stevens Drive	1.25	1.56	1.55	87.87	9.5	1.5	90.0	3.5	87.87	88.6	10.4
Second Line Road	1.25	1.56	1.55	87.13	4.0		38.9	3.0	87.13	87.45	6.7
Highway 16	1.25	1.56	1.55	90.30	14.7		95.7		89.08	90.3	14.7
Third Line Road	1.25	1.56	1.55	88.252	0.1		25.0	3.0	88.252	89.4	6.3
Private Driveway	1.25	1.56	1.55	87.96	9.7		27.8		87.96	88.5	4.1
Roger Stevens Drive	1.25	1.56	1.55	88.94	15.0		63.0	3.0	88.94	90.7	17.6
Main Street	1.25	1.56	1.55	89.410	21.7		71.4		89.410	90.479	20.7
Church Street	1.25	1.56	1.55	90.32	15.2		58.0		90.09	90.81	11.0
McCordick Road	1.25	1.56	1.55	89.50	10.8		24.7		89.5	89.95	4.9
Malakoff Road	1.25	1.56	1.55	93.67	8.5		15.35		93.67	94.67	10.3
Taylor Drain											
Craig Street	1.25	1.56	1.55	89.13	6.1		12.3		88.67	89.13	9.1
Highway 73	1.25	1.56	1.55	89.57	18.3	1.5	54.4		89.57	90.19	17.3
Fourth Line Road	1.25	1.56	1.55	91.582	9.2		27.2		91.582	92.6	11

Table 2.6
Hydraulic Parameters Used in Culvert Modelling

Culvert I.D.	CUNV	ENTLC	CHRT	SCL	CUNO	RISE	SPAN	CULVLN	RDLEN
Dillon-Wallace Drain									
Second Line Road	.03	1.7	1	3	1	2		50	50
Highway 16	.03	1.7	1	3	1	2		40	50
Roger Stevens Drive	.03	.78	1	3	1	2.2		48.5	50
Third Line Road	.04	1.7	1	3	1	1.2	3	60	50

2.5 Model Adjustment

Since snowmelt related events have historically caused peak flows, the adjustment procedure was based on measured spring flows and elevations. Flows and elevations from the gauges at Fourth Line Road (Taylor Drain), Second Line Road (Steven Creek) and Church Street in North Gower (Steven Creek) were used for model adjustment. Adjustment events and results are summarised in Table 2.7.

Measured events were used to perform the required model adjustment. The starting water elevations used were the 2 and 5 year return period water levels on the Rideau River. These were selected because they were closest to the measured data. The measured flows and water surface elevations were recorded between April 8 and 17, 1993. A major limitation of the calibration/validation effort is the limited number of observed data available.

To proceed with the adjustment of the model, the values of the parameters needed were as realistically as possible established. The parameter with the greatest weight was found to be Manning's coefficient (XNCH, XNL and XNR).

The results obtained showed a close fit with the measured water surface elevations. At the Second Line Road gauge, the modelled elevations resulted in water depths that were 5.4% less for the event with the highest flow and 14.4% greater for the other measured event. The comparison with the gauge located at Church Street in North Gower showed the model output to be 4.1% and 21.3% greater than the measured elevations. The difference between the modelled and measured water elevations at those locations could be the result of variations in the starting water levels at the Rideau River. The water elevations of the Rideau River at Kars are not known for the days on which the water surface elevation data was collected, hence it is impossible to establish an exact correlation. The comparison at Fourth Line Road showed a difference of 0.9% and 2.9% in water depth. Because the Rideau River no longer affects the water level at this point on the Taylor Drain, the difference between the measured and modelled water depths is smaller for the smaller flow. A summary of the HEC-2 output is included in Appendix G.

Based on the validation results, the model produces somewhat conservative water surface elevation estimates.

Table 2.7
Model Adjustment

Name	Chainage	Flow (m^3/s)	Measured		Modelled		% Diff. Depth
			Elevation (m)	Depth (m)	Elevation (m)	Depth (m)	
Steven Creek at 2nd Line Road	3 + 674	33.47 14.99	86.67 86.06	2.75 2.14	86.53 86.42	2.61 2.50	- 5.4 +14.4
Steven Creek at Church Street	9 + 422	14.51 7.54	88.53 87.97	1.89 1.33	88.61 88.33	1.97 1.69	+ 4.1 +21.3
Taylor Drain at Fourth Line Road	1 + 792	7.93 3.08	89.73 89.28	1.11 0.66	89.74 89.33	1.12 0.68	+0.9 +2.9

3.0 MODELLING RESULTS

3.1 Water Levels

To determine the water surface elevations, a HEC-2 model was developed from the sources discussed in Section 2.0 and adjusted using measured water surface elevations. A summary of the results is tabulated in Appendix D and shown graphically in Appendix E for each cross section. The overall profiles are shown in Appendix F.

Peak water surface elevations were generated at key locations along Steven Creek, Taylor Drain and Dillon-Wallace Drain. These locations are shown on Drawing No. 92098-02 and are generally located upstream of bridges and culverts. An analysis to evaluate the influence of the Rideau River on upstream water levels was carried out and is discussed further in Section 3.3.

It was found that the downstream section of Steven Creek was strongly affected by the Rideau River. The 100 year water surface elevation was established in two segments. In the first segment, the Rideau River governs while in the second segment, Steven Creek flows govern. Two separate HEC-2 Models were combined as shown in Table 3.1. The highest water surface elevation from these two combinations was then selected. These elevations are reported in the final water surface elevation table in Appendix D.

Table 3.1
Rideau River and Steven Creek Combinations

Combination 1		Combination 2	
Rideau River	**Steven Creek**	**Rideau River**	**Steven Creek**
100	2	2	100
50	2	2	50
20	2	2	20
10	2	2	10
5	2	2	5
2	2	2	2

3.2 Comparison With Previous Studies

The 100 year water surface elevations obtained using HEC-2 were compared with the results obtained in the 1972 study. The current study produced water surface elevations which are higher than those reported in 1972 for the areas where the influence of the Rideau River dominates. Upstream of Second Line Road, the revised water levels are lower than those established during the 1972 study. A summary of the results is presented in Table 3.2. As noted in the Hydrology Report (1994), the hydrological modelling and the statistical analysis produced smaller peak flows than those used for the 1972 study. This resulted in lower water surface elevations in the portion of Steven creek not affected by the Rideau River.

Table 3.2
Comparison of 100 Year Water Levels

Location	Chainage	Depth (m)		% Difference
		1972 Study	1993 Study	
Steven Creek @ Outlet	0 + 000	3.63	4.27	+15.0
Kars	0 + 092	3.05	3.66	+16.7
Roger Stevens Drive (R.R. #6)	1 + 857	3.64	3.76	+ 3.2
Second Line Road	3 + 674	4.57	3.85	-18.7
Third Line Road	6 + 340	3.17	2.49	-27.3
Private Driveway	7 + 005	3.89	3.16	-23.1
Roger Stevens Drive (R.R. #6)	8 + 973	3.67	2.65	-38.1
Main Street	9 + 281	3.93	2.95	-33.2
Church Street	9 + 422	3.69	2.90	-27.2
Taylor Drain @ Outlet	0 + 000	3.19	2.46	-29.7

3.3 Effect of Rideau River Levels

As part of this study, the influence of the Rideau River at the mouth of Steven Creek was assessed. It was found that the effect of the Rideau River water level influenced Steven Creek and Dillon-Wallace Drain several kilometres upstream.

An analysis of the effect of Rideau River levels on the Steven Creek 100 year return period flow was carried out. Simulations based on 2, 5, 10, 20, 50 and 100 year water levels of the Rideau River were executed. Results indicate that the water level of the Rideau River impacts on water levels in Steven Creek up to 9.3 km upstream (North Gower) and the Dillon-Wallace Drain for 3 km upstream (Third Line Road), as shown on the profiles presented in Appendix H. Taylor Drain is slightly affected by water levels in the Rideau River for about 0.15 km. The remainder of Steven Creek is not affected. A summary of the results, both in tabular and graphical format, is presented in Appendix H. Also included is a summary HEC-2 output.

Based on these results, it was concluded that the flood elevations of Steven Creek, Taylor Drain and Dillon-Wallace Drain must be established considering the backwater effect generated by the Rideau River. The influence of the Rideau River is accounted for by the starting water elevations used in the HEC-2 model. In reality, it is unlikely that the peak flows on Steven Creek coincide with the peak water levels on the Rideau River. It was therefore necessary to study further the relationship between the time to peak of the Rideau River and this tributary. Unfortunately, there is no continuous historical data for Steven Creek. An analysis of measured data (9 years total) from the Rideau River, the Jock River and the Kemptville Creek was carried out. The limited amount of data made it impossible to infirm or confirm any trend. However, there seemed to be a trend showing that the bigger the event, the closer they seemed together in time. Due to the lack of data to study this trend, it was decided in concert with the Rideau Valley Conservation Authority that, in keeping with the document "Floodplain Management in Ontario - Technical Guidelines", a 100 year Rideau River/2 year Steven Creek would be used where the Rideau River dominates and a 2 year Rideau River/100 year Steven Creek would be used where Steven Creek dominates. The same procedure was also applied to the other return periods. Therefore, it was decided that a combination of Rideau River and Steven Creek events would be the best way to accurately estimate floodplains. Table 3.1 summarizes the combinations used. A further consideration is that Rideau River and Steven Creek flood levels must match at the confluence to avoid discrepancies in regulatory flood levels.

3.4 Effects of Variations in Discharge

The effect of flow variations on the water level was also investigated. An analysis of the change in water surface elevations brought about by slight changes in flow was executed using 2%, 5% and 10% variations in flow. Table 3.3 summarizes the flows used for this study. The tabulated results, profiles and a summary output are presented in Appendix I.

The first segment of Steven Creek, up to Second Line Road, is only slightly sensitive to flow variations. A change of 10% in flow variation will generate a maximum change in water level of 3 cm; a change of 5%, 1 cm and a change of 2% will not generate any change in water surface elevation. The influence of the Rideau River is most pronounced in this segment and small changes in flow have only a marginal impact on flood stages. The reaches upstream of Second Line Road are somewhat more affected by changes in flow. The changes in flow generated fluctuations in water surface elevation which average

Table 3.3
Sensitivity Analysis - Flows

Location	Chainage	Flow (m^3/s)						
		-10%	-5%	-2%	100 YR	+2%	+5%	+10%
Steven Creek @ Outlet	0 + 000	59.31	62.61	64.58	65.90	67.22	69.20	72.49
Roger Stevens Drive (R.R. #6)	1 + 817	56.97	60.40	62.03	63.30	64.57	66.47	69.63
Second Line Road	3 + 638	55.89	59.10	60.86	62.10	63.34	65.21	68.31
Third Line Road	6 + 304	49.41	52.16	53.80	54.90	56.00	57.65	60.39
Roger Stevens Drive (R.R. #6)	8 + 895	30.51	32.21	33.22	33.90	34.50	35.60	37.29
Main Street	9 + 253	29.79	31.45	32.44	33.10	33.76	34.76	36.41
Church Street	9 + 370	27.36	28.88	29.74	30.40	31.01	31.92	33.44
McCordick Road	12 + 053	27.72	29.26	30.18	30.80	31.42	32.34	33.88
Steven Creek @ 14 km	14 + 218	23.49	24.80	25.58	26.10	26.62	27.41	28.71
Malakoff Road	14 + 518	19.71	20.81	21.46	21.90	22.33	23.00	24.09
Taylor Drain @ Outlet	0 + 000	21.60	22.80	23.52	24.00	24.48	25.20	26.40
Taylor Drain @ 4th Line Road	1 + 597	21.24	22.42	23.13	23.60	24.07	24.70	25.96
Dillon-Wallace @ Outlet	0 + 000	6.88	7.26	7.49	7.64	7.79	8.02	8.40
Dillon-Wallace @ 2nd Line Road	0 + 711	3.74	3.94	4.07	4.15	4.23	4.36	4.57
Dillon-Wallace @ Highway 16	1 + 851	2.99	3.15	3.25	3.32	3.39	3.49	3.65
Dillon-Wallace @ 3rd Line Road	4 + 060	2.24	2.37	2.44	2.49	2.54	2.61	2.74

flow. The changes in flow generated fluctuations in water surface elevation which average 3 cm, 6 cm and 11 cm for a 2%, 5% and 10% change in flow respectively. The changes in surface water elevation induced by the changes in flows increase as the backwater effect of the Rideau River decreases. Therefore, the upper segment of this watercourse were more affected by the changes in flow. Table 3.4 summarizes the results.

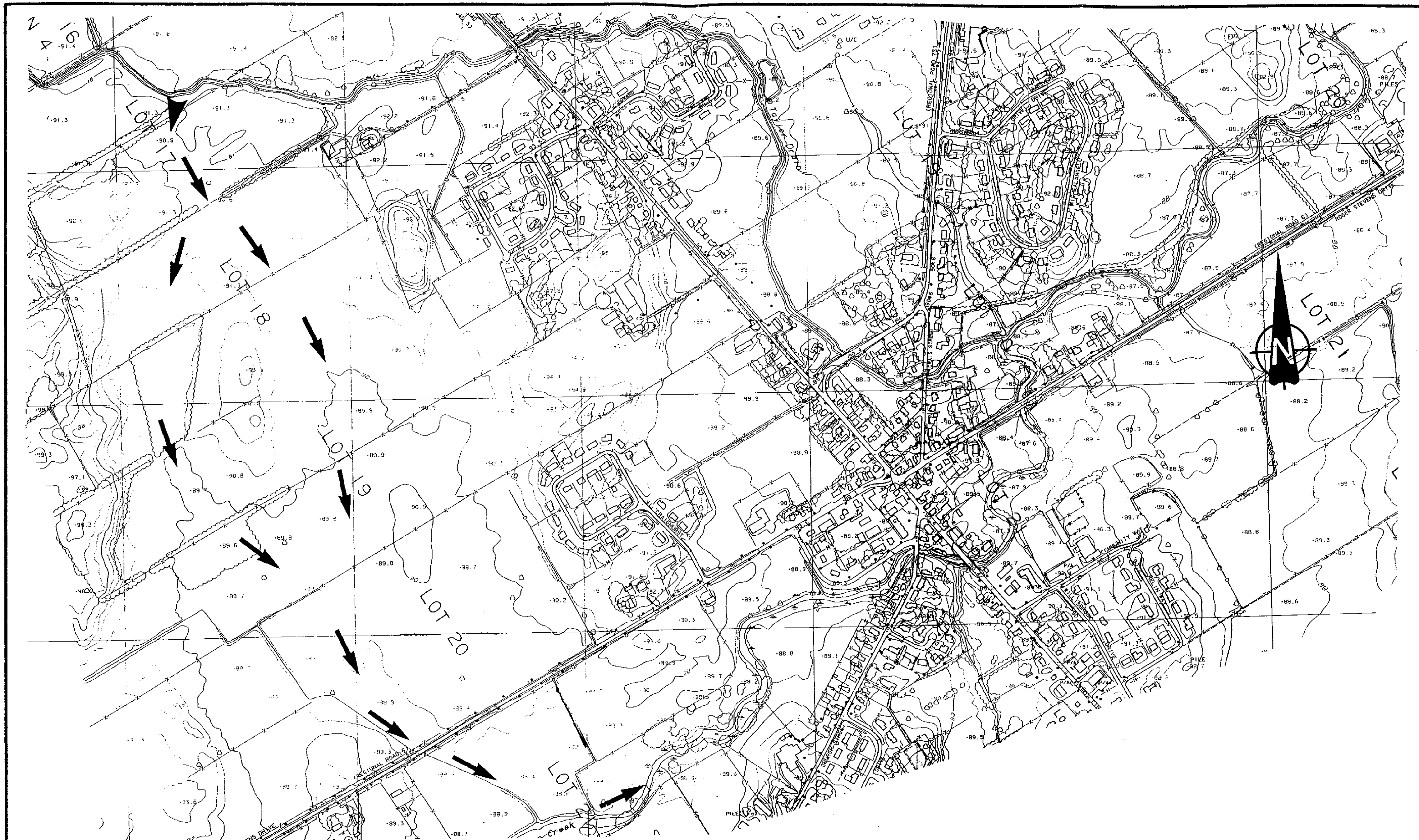
Segments of Steven Creek where the influence of the Rideau River is important are not affected by changes in flow, however other segments are. Thus confirming the importance of accurate flow determination. It would therefore be recommended that flow monitoring be continued for several years.

3.5 Spill Zones

The entire study area was checked for possible spill zones. One spill area was identified. Further investigation confirmed that this area was of sufficient size to warrant flow volume estimation. The head of spill zone #1 is located near chainage 2 + 822 on Taylor Drain and flows southward to Steven Creek between chainage 9 + 653 and 12 + 053, shown on Figure 3.1. For the 100 year return period water surface elevation, the maximum spill flow was estimated to be approximately 1.8 m^3/s. Calculations of spill flow volume are presented in Appendix J. Due to the limited flows involved, no modifications were made to the flows summarized in Table 2.3.

Table 3.4
Mean Variations in Water Level

Description	Chainage	Variation in Discharge					
		-10%	-5%	-2%	+2%	+5%	+10%
		Mean Variation in Water Level (m)					
Steven Creek							
Segment #1	0 + 000 to 3 + 704	-.02	-.01	0	0	+.01	+.02
Segment #2	3 + 704 to 12 + 088	-.10	-.06	-.03	+.03	+.06	+.12
Remainder	12 + 088 to 15 + 950	-.05	-.03	-.03	+.03	+.06	+.10
Taylor Drain							
Segment #1	0 + 000 to 0 + 347	-.05	-.04	-.01	+.01	+.03	+.05
Segment #2	0 + 347 to 2 + 668	-.08	-.04	-.02	+.01	+.03	+.06
Dillon-Wallace Drain							
Segment #1	0 + 000 to 1 + 881	-.01	-.01	0	0	+.01	+.01
Segment #2	1 + 881 to 4.210	-.04	-.03	-.01	+.01	+.02	+.04



Robinson Consultants Inc. CONSULTING ENGINEERS P.O.Box 13130 Kanata,Ontario K2K 1X3 Telephone (613) 592-6060	Rideau Valley Conservation Authority STEVEN CREEK FLOODPLAIN MAPPING SPILL ZONE # 1	LEGEND SPILL ZONE SPILL ORIGIN	PROJECT No. 92098 SCALE N.T.S. Figure 3.1

4.0 CONCLUSIONS AND RECOMMENDATIONS

The 100 year water level for the study area were generated using the HEC-2 model and found to be higher (.64 m) than the water levels establish during the 1972 study for those reaches where the influence of the Rideau River dominates. The 100 year water depth for the remainder of the study area was found to be as much as 1 m lower that the water levels reported in the 1972 study. It was found that Rideau River flood levels have a significant effect on Steven Creek water levels downstream of North Gower. The water surface elevations obtained through this study provide an adequate representation of expected flood levels within the Steven Creek basin. Model accuracy could be enhanced through continued monitoring as recommended in the Hydrology Report.

The sensitivity analysis showed that the Rideau River levels have a significant impact on water levels up to North Gower (9.3 km upstream). The Dillon-Wallace Drain is also affected up to Third Line Road (3 km upstream of the confluence with Steven Creek). Taylor Drain is very slightly influenced by the Rideau River. In reaches influenced by the Rideau River, small changes in flow were not found to have much impact on flood levels. Elsewhere in the study area, changes in flows resulted in changes in the water surface elevation from 0 to ±10 cm for changes in flows ranging from ±2% to ±10%.

Based on these conclusions, it is recommended that the water levels reported in Appendix D be adopted for floodplain delineation. It is also recommended that the flow monitoring at Church Street in North Gower and Fourth Line Road be continued if more accurate discharge and water level estimates are desired.

5.0 REFERENCES

1972	J.L. Richards & Associates Limited, "Flood Plain Mapping of Steven Creek Between Kars and North Gower", Rideau Valley Conservation Authority.
1990	HEC-2 User's Manual. Published by the Hydrologic Engineering Center, U.S. Army Corps of Engineers.
1994	Robinson Consultants Inc., "Steven Creek Floodplain Mapping Update, Rideau River to Malakoff Road, Progress Report Hydrology", Rideau Valley Conservation Authority.
to be submitted	Robinson Consultants Inc., "Rideau River Floodplain Mapping Update, Kars to Burritts Rapids, Hydraulic Report", Rideau Valley Conservation Authority.