QUINTE CONSERVATION

Consecon Lake and Creek Flood Hazard and Erosion Mapping

Hydrology Report

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STATEMENT OF LIMITATIONS AND CONDITIONS

Limitations

This report has been prepared for the Quinte Conservation in accordance with the agreement between KGS Group and Quinte Conservation (the “Agreement”). This report represents KGS Group’s professional judgment and exercising due care consistent with the preparation of similar reports. The information, data, recommendations, and conclusions in this report are subject to the constraints and limitations in the Agreement and the qualifications in this report. This report must be read as a whole, and sections or parts should not be read out of context.

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1.0 INTRODUCTION

1.1 Objectives of the Study

KGS Group was retained by Quinte Conservation (QC) to update the regulatory floodplain mapping and prepare erosion hazard mapping for Consecon Lake and Creek (Figure 1-1). The study includes the collection of topographic data, site inspections, hydrologic assessments, hydraulic modeling and analyses, and mapping of the Regulatory Floodplain.

The study was conducted in accordance with the requirements outlined in the Ontario Ministry of Natural Resources and Forestry (MNRF), and the Flood Hazard Identification and Mapping Program (FHIMP) – Project Eligibility and Requirements. The technical guidelines used were the following:

- Natural Resources Canada Federal Flood Mapping Guidelines Series
- OMNR (2011) Technical Bulletins associated with the Lakes and Rivers Improvement Act (LRIA)
- OMNR Technical Guide – River & Stream Systems: Flooding Hazard Limit (2002)
- OMNR Technical Guide – River & Stream Systems: Erosion Hazard Limit (2002)
- USACE HEC-HMS and HEC-RAS User’s Manual and Technical Reference Manual

This report provides an overview of the hydrologic analysis of the study area, which includes statistical analysis and hydrologic modeling to assess the magnitude of recurrent flood events ranging from 2 to 500-year return periods (events with annual exceedance probability, AEP, ranging from 50% to 0.2%) and the flood that would result from the occurrence of the Timmins (Regional) Storm in the study area.

It should be noted that the approach adopted in the hydrologic analysis corresponds to the overall strategy proposed and adopted for the preparation of the floodplain maps. In this respect, to fit the characteristics of the study area, Consecon Lake was included in the model as a separate sub-catchment, to capture the rapid reaction to direct rainfall, and the flood routing that naturally occurs in the lakes was not included in the hydrologic model. Instead, it was envisioned that the hydrologic model would be used to obtain the natural runoff inflows and that the flood routing in the lake was to be implemented in the hydraulic model that is being prepared as part of the study.

Following guidance from Environment and Climate Change Canada (ECCC), in this study, recurrent events are referred to with both return periods and AEPs. This is to provide clarity to users of the report, and to the public, regarding the likelihood of a flood event happening in any given year. It highlights the fact that the event referred to as the 100-year flood has a 1% probability of occurring or being exceeded in any given year. The correspondence between return periods and AEPs is provided in Table 1-1. The two approaches are interchangeable in this report.

TABLE 1-1: RETURN PERIODS AND AEPS

Return Period	Annual Exceedance Probability (AEP)
2 years	50%
5 years	20%
10 years	10%
20 years	5%
25 years	4%
50 years	2%
100 years	1%
200 years	0.5%
500 years	0.2%

1.2 Criteria For Floodplain Mapping

1.2.1 REGULATORY FLOOD

Consecon Lake and Consecon Creek are located within Zone 3 in Ontario, as defined in the “Technical Guide – River and Stream Systems: Flood Hazard Limit” (MNRF 2002). Based on that guideline, the Regulatory Flood Event for this watershed is the greater of the 100-year Flood or the flood resulting from the Timmins Storm.

LATHEM (1985) identified the 100-year snowmelt event as the Regulatory Flood for the Consecon Lake and Creek watershed.

1.3 General Description of Watershed and Study Area

The Consecon Lake and Creek watershed is located within the jurisdiction of Quinte Conservation with a drainage area of approximately 186 km^2. The Consecon Creek watercourse spans 37 km and begins just north of Picton. It flows towards the west through several large swamp bodies, Consecon Lake, and the hamlet of Consecon, before draining into Wellers Bay. The creek also features several structures along its path including Melville Road Bridge, Whitney Dam, Loyalist Parkway Road Bridge (Highway 33), Consecon Main Street Bridge, Consecon Mill Dam, and Regional Rd 29 Bridge.

The main storage feature along the creek is Consecon Lake. The clear east side of the lake and the marshy west end of the lake are separated by the Millennium Trail causeway. This causeway was originally a railway trestle bridge which was converted into a hiking trail in 1995. The water levels of Consecon Lake are influenced by the Millennium Trail causeway and the Whitney Memorial Dam, which was constructed in 1969 for the purpose of managing water levels for recreation (LATHEM, 1985). A short distance below the Whitney Dam, and upstream of Regional Rd 29, there is a small reservoir, created by the Consecon Mill Dam.

Several swamp bodies are present on the east and upstream end of Consecon Creek. The swamps feature depressions of porous organic soils, which provide additional water storage within the watershed and are known to attenuate flows during flood events. These swamps were studied in detail in LATHEM (1985). The effect of the swamps on the hydrologic response of the watershed is considered in this project, in a similar way to that used in LATHEM (1985).

The floodplain mapping area subject of this study is the reach of Consecon Creek from Melville Road to Wellers Bay.

2.0 DATA COLLECTION AND BACKGROUND REVIEW

2.1 Previous Studies

KGS performed a background review of the data provided by Quinte Conservation which included:

- Previous Studies:
    - Consecon Creek Water Management Study (LATHEM, 1985)
    - Consecon Creek Flood Risk Map (LATHEM, 1982)
    - Whitney Dam DSR Report (WILLS, 2021)
- 2019-2022 Inspection Reports and Photos for Consecon Mill Dam and Whitney Memorial Dam
- Consecon Lake Bathymetry Contour Map (Dated October 5, 1971)
- Ortho-imagery (Dated 2018)
- Elevation: LiDAR Data, EPSG:2959 – NAD83(CSRS) / UTM Zone 18N (Dated 2022)

Previous floodplain mapping for Consecon Lake and Creek was prepared as part of the Consecon Creek Water Management Study completed by LATHEM in 1985.

FIGURE 1-1: STUDY AREA: CONSECON LAKE AND CONSECON CREEK

3.0 HYDROLOGIC ANALYSIS

3.1 Climate and Hydrometric Data

3.1.1 PRECIPITATION DATA

Three resources were investigated and used to identify locations with precipitation data available for this study. These databases and tools were obtained from Environment and Climate Change Canada (ECCC):

- ECCC Climate Data for a Resilient Canada was a database accessed at https://climatedata.ca. It provides short duration (5 minutes to 24 hour) rainfall intensity duration frequency (IDF) curves with 2-, 5-, 10-, 25-, 50- and 100-year return periods.
- ECCC Engineering Climate Datasets Archive was a database that was accessed. It provides IDF curves for recurrent storms with longer durations than the first source listed above (e.g., 1 day and longer).
- ECCC Climate Data Extraction Tool was a resource that was used. Historical hourly and daily precipitation from meteorological stations is available for retrieval from this source.

Table 3-1 lists the meteorological stations located in the vicinity of the watershed and the type of data that was available from each (either IDF curves or data records). Figure 3-1 shows the location of the stations and the study watershed.

TABLE 3-1: CLIMATE STATIONS IN THE VICINITY OF THE STUDY AREA

Station Name	Climate ID	Latitude Longitude	Data Duration (Length, years)	Data Availability
Picton, ON	6156533	44°01'00.000" N 77°08'00.000" W	1966 – 1994 (28)	IDFs
			1915 - 1995	Historical Daily
Belleville, ON	6150689	44°09'02.052" N 77°23'41.046" W	1960 – 2016 (56)	IDFs
			1866 - 2023	Historical Daily
Belleville Quinte	6150690	44°09'33.705" N 77°26'23.430" W	2021 - 2023	Historical Hourly and Daily
Trenton A, ON	6158875	44°07'08.000" N 77°31'41.000" W	1965 - 2017 (52)	IDFs
			1953 - 2023	Historical Daily
Smithfield CDA, ON	6157831	44°05'00.000" N 77°40'00.000" W	1969 – 1992 (23)	IDFs
			1949 - 1990	Historical Daily

IDF curves are required to generate input design storms for hydrologic model. The Picton, Belleville and Trenton A stations were considered since they have IDF values available. They were also closer to the study area and had more recent data. Trenton A was adopted as it had the most conservative values for rainfall out of the three stations.

Hourly precipitation data is required for calibrating the hydrologic model. Belleville Quinte was selected for calibration as it was the only station with available hourly data.

FIGURE 3-1: ENVIRONMENT CANADA METEOROLOGICAL STATIONS WITHIN THE VICINITY OF THE STUDY WATERSHED

3.1.1.1 Development of Design Storms: 2 to 500 Year Summer Storms

The IDF curves available from the databases are only for return periods of 2 to 100 years. To obtain the IDF for return periods of 200-years and 500-years, extrapolation was carried out by fitting the existing data to a matching equation. A logarithmic regression equation was used as it fitted well to the existing 2-to-100-year data. This equation was in the form of $y = Aln(x) + B$ where x is the return period and y is the rainfall depth. Table 3-2 shows the equation parameters, A and B used for extrapolation. Trenton A station was selected for this study.

To select the duration for the storms' simulation, the historical hourly rainfall data from Station Belleville Quinte was graphed against the high flow records at WSC Station 02HE002, Allisonville. This comparison suggested that the storm duration for the watershed varies between 20 to 24 hours. A storm duration of 24-hr was adopted for this study. The 24-hr duration IDF values for Trenton A station are shown in Table 3-3.

TABLE 3-2: LOGARITHMIC EQUATION PARAMETERS

Duration	Logarithmic Equation Parameters	
	A	B
5 min	2.9877	5.11
10 min	3.2141	8.0628
15 min	3.7184	9.7229
30 min	4.6846	12.691
1 hr	7.4492	15.095
2 hr	9.3503	18.851
6 hr	11.522	28.302
12 hr	13.351	35.688
24 hr	14.609	41.562

TABLE 3-3: RAINFALL AMOUNTS (MM) FOR DIFFERENT RETURN PERIODS: IDF ANALYSIS BY ECCC FOR TRENTON A STATION

TRENTON A	Return Period (Years)	AEP	Duration								
			5 min	10 min	15 min	30 min	1 hr	2 hr	6 hr	12 hr	24 hr
Reported in ECCC	2	50.0%	6.9	10.0	12.0	15.5	19.6	24.5	35.3	43.8	50.4
	5	20.0%	10.1	13.4	15.9	20.5	27.5	34.4	47.5	57.9	65.9
	10	10.0%	12.2	15.7	18.5	23.8	32.7	41.0	55.5	67.2	76.1
	25	4.0%	14.8	18.5	21.8	27.9	39.3	49.2	65.7	79.1	89.0
	50	2.0%	16.8	20.6	24.2	31.0	44.2	55.4	73.3	87.8	98.6
	100	1.0%	18.7	22.7	26.7	34.0	49.0	61.4	80.8	96.5	108.1
Extrapolated	200	0.5%	20.9	25.1	29.4	37.5	54.6	68.4	89.3	106.4	119.0
	500	0.2%	23.7	28.0	32.8	41.8	61.4	77.0	99.9	118.7	132.4

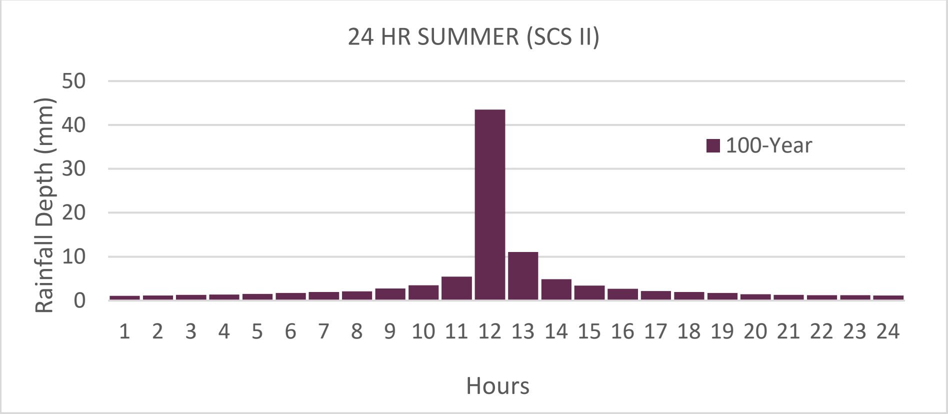
Temporal distribution of the design storms was obtained using the synthetic SCS (U.S. Soil Conservation Service) Type II distribution. The SCS storm distribution was originally developed for large watersheds greater than 25 km^2 and it is considered applicable to all inland regions of the United States and Canada. This distribution is recommended in MNRF (2002) for 24-hour storms. Its application provides high intensity synthetic events, since 64% of the precipitation is assumed to occur within 4 hours. An areal reduction factor (ARF) of 94% was applied to the IDF values for a 24-hour distribution. This areal reduction factor was estimated using Figure A.3 of the MNRF (2002) guidelines and corresponds to the size of the watershed (191 km^2) and the adopted 24-hr storm duration. Table 3-4 shows the storm temporal distributions after adjustment with the aerial reduction factor, for return periods ranging from 2 to 500-year.

TABLE 3-4: 2-500 YEAR (50%-0.2% AEP) SUMMER STORM DISTRIBUTIONS (24-HR SCS) FOR CONSECON WATERSHED

Hour	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	200-Year	500-Year
AEP	50.0%	20.0%	10.0%	4.0%	2.0%	1.0%	0.5%	0.2%
1	0.50	0.65	0.75	0.88	0.97	1.07	1.17	1.31
2	0.54	0.71	0.82	0.96	1.07	1.17	1.29	1.43
3	0.59	0.77	0.89	1.05	1.16	1.27	1.40	1.56
4	0.64	0.84	0.97	1.13	1.25	1.37	1.51	1.68
5	0.71	0.93	1.07	1.25	1.39	1.52	1.68	1.87
6	0.81	1.05	1.22	1.42	1.58	1.73	1.90	2.11
7	0.90	1.18	1.36	1.59	1.76	1.93	2.12	2.36
8	0.99	1.30	1.50	1.76	1.95	2.13	2.35	2.61
9	1.28	1.67	1.93	2.26	2.50	2.74	3.02	3.36
10	1.61	2.11	2.43	2.84	3.15	3.45	3.80	4.23
11	2.56	3.35	3.86	4.52	5.00	5.49	6.04	6.72
12	20.28	26.51	30.62	35.81	39.67	43.49	47.86	53.25
13	5.16	6.75	7.80	9.12	10.10	11.08	12.19	13.56
14	2.27	2.97	3.43	4.02	4.45	4.88	5.37	5.97
15	1.59	2.08	2.40	2.80	3.10	3.40	3.75	4.17
16	1.26	1.64	1.90	2.22	2.46	2.69	2.96	3.30
17	1.03	1.35	1.56	1.82	2.02	2.21	2.43	2.71
18	0.91	1.19	1.38	1.61	1.78	1.96	2.15	2.39
19	0.79	1.04	1.20	1.40	1.55	1.70	1.87	2.08
20	0.68	0.88	1.02	1.19	1.32	1.45	1.59	1.77
21	0.60	0.79	0.91	1.07	1.18	1.30	1.43	1.59
22	0.58	0.76	0.88	1.02	1.14	1.24	1.37	1.52
23	0.56	0.73	0.84	0.98	1.09	1.19	1.31	1.46
24	0.53	0.70	0.80	0.94	1.04	1.14	1.26	1.40
Total (mm)	47.38	61.95	71.53	83.66	92.68	101.61	111.83	124.41
Total Depth of Rainfall (mm) Reported in LATHEM (1985)	46.00	59.60	68.60	80.00	88.50	96.90	_	_

The total amount of rainfall reported in LATHEM (1985) is also provided in Table 3-3. LATHEM (1985) obtained the rain plus snowmelt IDFs from Bloomfield, ON station. The IDFs at this station are no longer accessible through ECCC. The hyetograph for the 100-Year 24-hour summer storm is shown in Figure 3-2.

FIGURE 3-2: 100-YEAR (1% AEP) SUMMER STORM HYETOGRAPH: SCS II DISTRIBUTION



3.1.1.2 Development of Design Storms: 2-500 Year Spring Events

The model precipitation inputs for the spring season were selected considering combination of snowmelt (driven by temperature) and rainfall. To select the duration of these events, historical daily rainfall, temperature, and snow on the ground at Station Belleville Quinte were compared with the observed daily flow at WSC Station 02HE002, Allisonville. This comparison suggested that, on average, there was a three-day duration for the snowmelt and that peak runoff occurred during that time frame. Therefore, a 72-hr snowmelt event was adopted for simulation of the spring recurrent events.

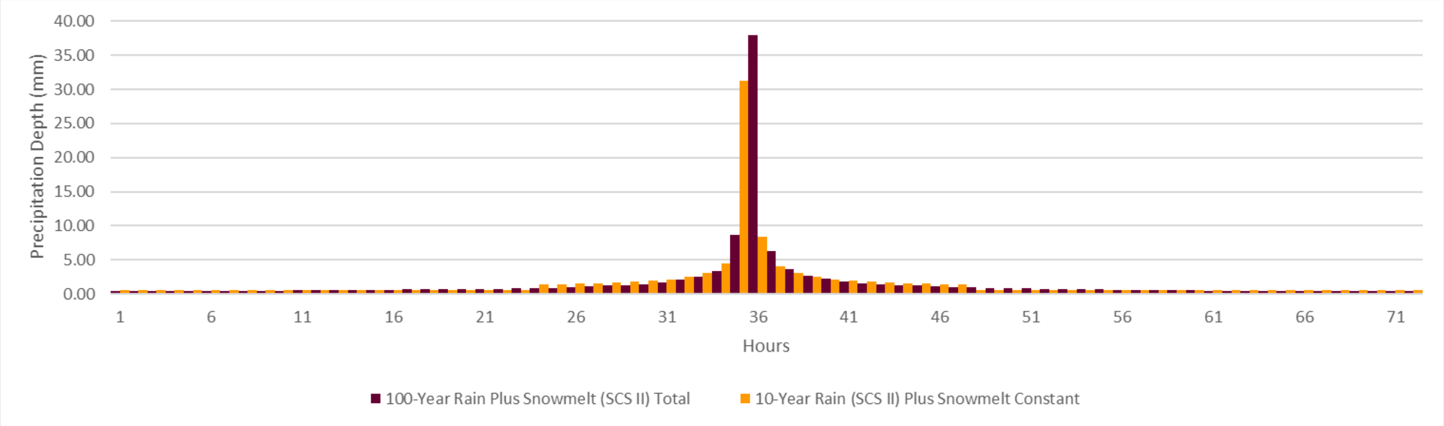
Snowmelt was not explicitly simulated due to limited availability of adequate data. Instead, combined rain plus snowmelt (i.e., spring) IDF distributions were obtained from the Trenton A ECCC meteorological station and used to generate the 72-hour snowmelt/rainfall hyetographs.

The graphs of the 72-hr storms for 0.2% to 50% AEPs are included in Appendix A. The 72-hour SCS Type II distribution was developed using the same pattern provided for the 24-hour distribution. Basically, the same portion of the total precipitation that is assigned to a 1-hour interval (for a 24-hour storm) was assigned to a three-hour interval for the 72-hour storm. The corresponding table used to convert the 24-hr SCS Type II distribution to 72-hr is also included in Appendix A.

To input the rain/snowmelt combinations representing the recurrent spring events into the hydrologic model, hyetographs were needed. Since there are no standard temporal distributions for rain/snowmelt combinations, various approaches were tested. They basically consisted of either distributing the entire water content of each event using the synthetic SCS Type II distribution (similar to the previous Section) or dividing the water content in two, with one part (i.e., rain) distributed over 24-hours using SCS Type II, and the rest (i.e., snowmelt) distributed evenly throughout the entire event (72 hours). Two hyetographs for the 100-year (1% AEP) rain plus snowmelt recurrent event are shown on Figure 3-3: one with the entire water content distributed using SCS Type II, and the other in which the rain amount would be similar to the 10-year-24-hour summer event and the rest of the water content is constant snowmelt.

The first option would put more of the water content into rainfall, with a small contribution from snowmelt, while the second option would increase the snowmelt and reduce the rainfall component.

FIGURE 3-3: 100-YEAR (1% AEP) WINTER RAIN+SNOW HYETOGRAPH: SCS II DISTRIBUTION



A sensitivity analysis showed that the difference in flows at Allisonville obtained with these two hyetographs was within 6%, so that the choice of the temporal distribution was not found to be determinant on the results. The most conservative temporal distribution (using SCS Type II for the entire water content) was adopted. Table 3-5 shows the adopted hyetographs for the 2-year to the 500-year spring events.

An areal reduction factor (ARF) of 96%, obtained from the MNRF (2002) guideline (Figure D-6), was applied to the IDF values of the 72-hour distribution.

TABLE 3-5: 2-500 YEAR (50%-0.2% AEP) WINTER RAIN+SNOW DISTRIBUTIONS (72-HR SCS) FOR CONSECON WATERSHED

Hour	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	200-Year	500-Year
AEP	**50.0%**	**20.0%**	**10.0%**	**4.0%**	**2.0%**	**1.0%**	**0.5%**	**0.2%**
1	0.19	0.24	0.28	0.33	0.36	0.40	0.44	0.49
…	…	…	…	…	…	…	…	…
12	0.25	0.33	0.38	0.44	0.49	0.54	0.59	0.66
…	…	…	…	…	…	…	…	…
24	0.40	0.52	0.60	0.70	0.77	0.84	0.93	1.03
…	…	…	…	…	…	…	…	…
36	17.85	23.23	26.79	31.29	34.63	37.94	41.73	46.39
…	…	…	…	…	…	…	…	…
48	0.44	0.58	0.67	0.78	0.86	0.94	1.04	1.15
…	…	…	…	…	…	…	…	…
60	0.25	0.32	0.37	0.43	0.48	0.52	0.58	0.64
…	…	…	…	…	…	…	…	…
72	0.20	0.26	0.30	0.36	0.39	0.43	0.47	0.53
Total (mm)	**55.00**	**71.58**	**82.56**	**96.43**	**106.72**	**116.94**	**128.60**	**142.97**
Total Depth of Rainfall (mm) Reported in LATHEM (1985)	**52.87**	**72.14**	**84.89**	**101.01**	**112.96**	**124.83**	**–**	**–**

3.1.1.3 Timmins Storm

The Regional Storm for the Consecon Lake and Creek watershed is the Timmins Storm. The hyetograph for this storm event was calculated using the methodology provided in MNRF's technical guide (MNRF, 2002). The MNRF technical guide provides point rainfall values to be applied to watersheds with areas less than 25 km^2. For larger basins, the rainfall amount should be modified using an areal reduction factor corresponding to the drainage area of the basin. As MNRF (2002) explains, the areal reduction factor should be based on an equivalent circular area. MNRF (2002) also advises that for an elongated watershed, the isohyetal technique to be applied to determine the rainfall amount.

Using MNRF (2002) guideline and considering an equivalent circular area for the Consecon watershed, an areal reduction factor (ARF) of 74% was obtained. However, with the total area of the watershed (not using the equivalent circular area), a larger areal reduction factor of 84% was obtained from the MNRF (2002) guideline (Table D-5). In this study, the isohyetal technique was not used and the areal reduction factor of 84% was selected to modify the Timmins rainfall amount. The resultant hyetograph is shown in Table 3-6. It should be noted that LATHEM (1985) also used an ARF of 84%, based on the size of the watershed, and obtained a total depth of 162.2 mm for the Timmins Storm.

As Timmins Storm is a summer event (MNRF, 2002), it was simulated with the HEC-HMS model prepared for summer condition.

TABLE 3-6: TIMMINS STORM ADJUSTED RAINFALL DEPTHS

Time (Hours)	Rainfall Depth (mm)
1	13.0
2	16.2
3	9.7
4	1.6
5	4.9
6	16.2
7	37.3
8	16.2
9	19.5
10	9.7
11	11.3
12	6.5
Total (mm)	**162.12**

3.2 Flow Data

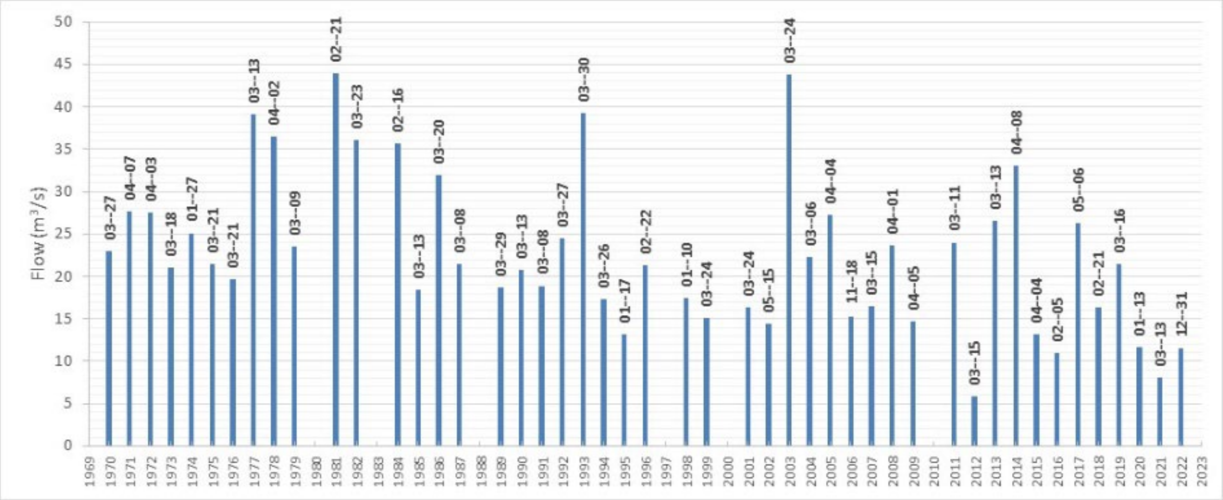
A hydrometric Water Survey Canada (WSC) station is located in Allisonville along the Consecon Creek with historical water level and flow data available for the period 1970-2023. Table 3-7 shows the name, location, and data availability at this station.

TABLE 3-7: WSC STATION IN THE CONSECON WATERSHED

Gauge #	Name	Contributing Drainage Area (km^2)	Data Availability	Record Years	Data Source
02HE002	CONSECON CREEK AT ALLISONVILLE	119	Continuous flow (daily)	1970 – 2023	WSC
			Continuous flow (hourly)	2021 – 2023	
			Continuous water levels (daily)	2002 – 2023	

Figure 3-4 presents the Annual Maximum Instantaneous Discharge provided by Water Survey Canada (WSC) for Station 02HE002, CONSECON CREEK AT ALLISONVILLE. The majority of the peak values were recorded in spring, which suggests that the largest floods occurring in the watershed could be winter/spring events produced by rain plus snowmelt.

FIGURE 3-4: ANNUAL MAXIMUM INSTANTANEOUS DISCHARGE AT WSC STATION 02HE002 AT ALLISONVILLE (1970-2022)



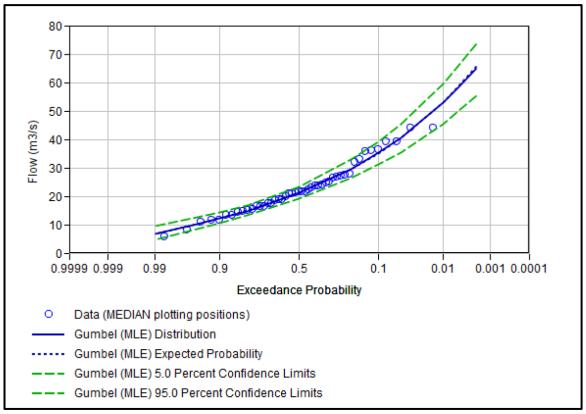
3.2.1 FLOOD FREQUENCY ANALYSIS: RECURRENT EVENTS

Flood Frequency Analysis (FFA) was conducted with the annual maximum instantaneous flows from WSC Station 02HE002 using the statistical software package, HEC-SSP developed by the U.S. Army Corps of Engineers, Hydrologic Engineering Center (HEC). Multiple frequency distributions including Gamma, Generalized Extreme Value, Gumbel, Log-Pearson III, Log10-Normal, and Pearson III were considered. The best fit of the data was obtained by inspection of the plots and analysis of the Kolmogorov-Smirnov Test. The Gumbel distribution was selected as the best fit. Table 3-8 shows the various probability distributions that were considered along with their test statistic values and distribution parameters. Figure 3-5, obtained from HEC-SSP, depicts the adopted frequency distribution, 95% confidence limits and the flow data from WSC Station 02HE002.

TABLE 3-8: PROBABILITY DISTRIBUTION PARAMETERS

Distribution	Goodness of Fit	Distribution Parameters		
	Kolmogorov-Smirnov (Test Statistic)	Loctn	Scale	Shape
Gumbel (MLE)	0.062	18.356	7.505	-
Generalized Extreme Value (MLE)	0.066	18.673	7.664	0.079
Gamma (MLE)	0.068	-	3.701	6.102
		Mean	StDv	Skew
Pearson III (MLE)	0.069	22.585	9.07	0.755
		MeanLog	StDvLog	Skew
Log10-Normal (MLE)	0.072	1.317	0.186	-
Log-Pearson III (MLE)	0.075	1.317	0.185	-0.537

FIGURE 3-5: GUMBEL PROBABILITY DISTRIBUTION FITTED TO ANNUAL PEAK FLOWS (WSC STATION 02HE002)



A total of 47 annual peak flow values recorded at Station 02HE002 were available for flood frequency analysis. The results of the FFA are summarized in Table 3-9. Additionally, Table 3-9 includes the results of LATHEM's flood frequency analysis conducted in 1985. LATHEM (1985) performed the FFA using a limited dataset of peak flows available at the time, comprising 12 annual peak flow values from 1970 to 1982. It is noted that their results are up to 30% higher than those calculated by KGS. KGS utilized a longer and more recent dataset for FFA, with data available at WSC Station 02HE002.

TABLE 3-9: FFA RESULTS FOR WSC STATION 02HE002 AT ALLISONVILLE

Return Period (year)	AEP	FFA Peak Flows at WSC Station 02HE002	
		KGS (2023)	LATHEM (1985)
2	50%	21.1	25.1
5	20%	29.5	37.1
10	10%	35.2	45.0
20	5%	40.6	55.1
50	2%	47.8	62.6
100	1%	53.2	69.9
Distribution Method		Gumbel (MLE)	Log Pearson III
Data Period		1970-2022	1970-1982

3.3 Previous Hydrologic Modeling

The previous hydrologic modeling for the study area was conducted by LATHEM in 1985 using the US Soil Conservation Service model, TR-20.

LATHEM (1985) completed a thorough study of the hydrologic characteristics of the treed swamp bodies in the Consecon watershed. Their findings suggested that the deep and porous layer of organic soil present within the swamp bodies had high water storage and flood attenuation potential. This effect could greatly reduce peak flows during flood events, particularly the flood from the Timmins Storm, which would occur in the summer when the swamps and the soil can absorb more of the direct inflow than in spring/frozen conditions. LATHEM simulated the delaying effect of routing the flows through the swamps in their TR-20 hydrologic model by greatly increasing the time of concentration for the self-contained swamp subbasins.

The TR-20 hydrologic model was used for the simulation of the Timmins Storm and the recurrent summer and spring storms. The watershed was split into 16 subbasins which included Consecon Lake and two swamp bodies as self-contained subbasins. The Curve Number (CN) was used as a measure of imperviousness for each subbasin and was calculated using land use and soil type data (ranging between 70 and 90). LATHEM (1985) indicates that a CN value of 90 was selected for simulation of the winter/spring events. For the summer events, on the other hand, dry antecedent moisture conditions (AMC I) were used for validating the model, but it is not clear from the report if the CN values used for the simulation of the Timmins Storm corresponded to AMC II (average conditions) or AMC I (dry conditions).

LATHEM (1985) used a 24-hr duration for the summer storms and a 72-hr duration for the spring storms/snowmelt. A summary of the design peak flows reported in LATHEM is provided in Table 3-10. Volumes for the floods were not reported in LATHEM (1985).

TABLE 3-10: SUMMARY OF DESIGN FLOWS (M^3/S) IN THE CONSECON WATERSHED REPORTED IN LATHEM (1985)

Outlet of Subbasin	Timmins Storm Flows	100-Year Snowmelt 3-day (Spring) Event	100-Year Rainfall 24-hr (Summer) Storm
Big Swamp	33.4	47.2	11.0
Little Swamp	33.9	49.0	11.6
Allisonville	79.9	69.9	34.9
Melville	136.9	83.2	55.5
Whitney Dam	110.6	104.2	19.9
Mouth of the Basin	110.5	104.1	19.8

Even though Table 3-10 shows higher values for the Timmins Storm than for the 100-year spring flood (snowmelt event) at various locations, the LATHEM (1985) report states that, after completion of the study, they were instructed to use the 100-year spring flood for the definition of the floodplain.

Despite reporting that the peak runoff from the Timmins Storm was greater than the 100-year snowmelt event at the majority of subbasins, 100-year snowmelt event was determined as the Regulatory Flood Event. The LATHEM (1985) report noted that after completion of the study, they were instructed to utilize the 100-year flows as Regional Flows and therefore, these flows were used in the preparation of floodplain maps.

Results presented in Table 3-10 along with a review of the report prepared by LATHEM (1985) indicates that:

- The 100-year spring peak flow was greater than the 100-year summer peak flow at all locations within the watershed.
- The 100-year spring peak flow was greater than that obtained from the Timmins Storm upstream of Allisonville.
- The peak flow resulting from the Timmins Storm was greater than the 100-year spring peak flow in Allisonville and locations downstream of Allisonville.
- The floodplain map was prepared with the water levels obtained for the 100-year spring peak flows at all locations and the water levels obtained for the Timmins Storm were not used for the preparation of the floodplain maps.
- The water levels obtained with the Timmins Storm were greater than those with the 100-year spring peak flows north of the Consecon Mill Dam.

3.4 Development of New Hydrologic Model

KGS Group prepared a new hydrologic model for the study watershed using HEC-HMS, a program developed by the US Army Corps of Engineers. HEC-HMS features a graphical user interface, integrated hydrologic analysis components, data management, and reporting and graphics facilities. It provides various methods for computing runoff transform, losses, baseflow, routing, and reservoirs. The software is free and publicly available, facilitating easy access to models and results. KGS has successfully applied HEC-HMS for other projects, and it is widely used in Ontario.

The data required for developing the hydrologic model using HEC-HMS include soil characteristics, land-use, and sub-catchment areas, which were obtained and calculated from Land Information Ontario, Ontario Watershed Information Tool (OWIT), the Ontario Agricultural Atlas, and data provided by QC. The sub-catchment delineation for the Consecon watershed model was obtained using OWIT, and the HEC-HMS GIS built-in tool for subbasin delineation based on the elevation (LiDAR data) of the watershed. The watershed was divided into 13 sub-catchments. Consecon Lake was modeled as two separate subbasins with an impervious value of 100%. The schematic of the model built for the Consecon watershed is shown in Figure 3-6. The location of WSC Station 02HE002 at Allisonville is below Junction 3 (J03) of the HEC-HMS model. Computed flows at J03 were plotted against the observed flow data at 02HE002 for calibration and validation of the model.

The watershed parameters including the CN and impervious % were calculated based on land use and soil type GIS data for the sub-catchments and the lag time parameters were adjusted during calibration of the model. After calibration, design storms were entered into the HEC-HMS model and simulation runs were completed. Results are summarized in Section 3.5 of the report.

FIGURE 3-6: MODEL REPRESENTATION OF THE CONSECON LAKE AND CREEK WATERSHED (KGS, 2023)

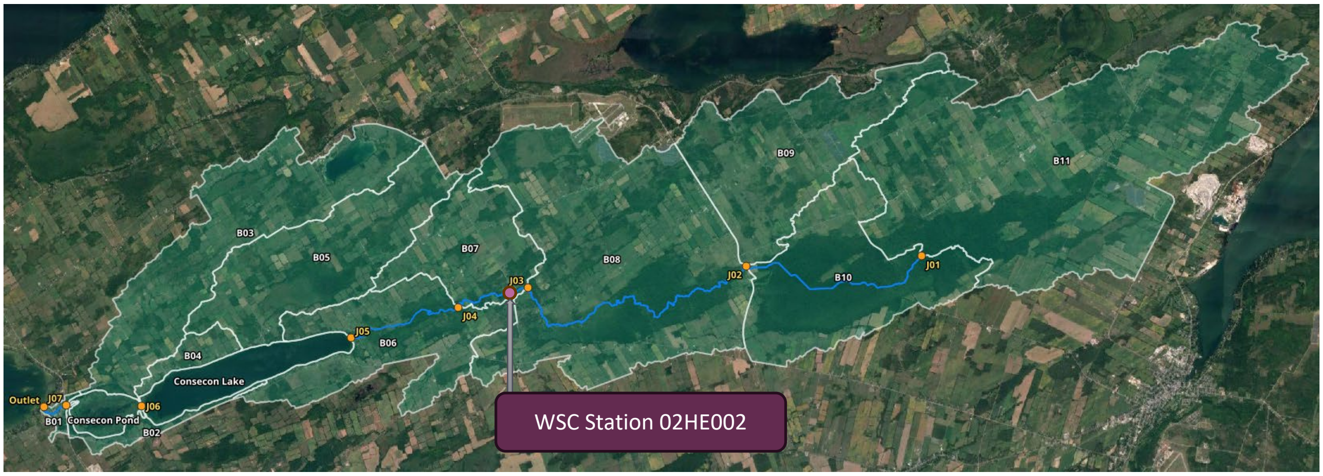
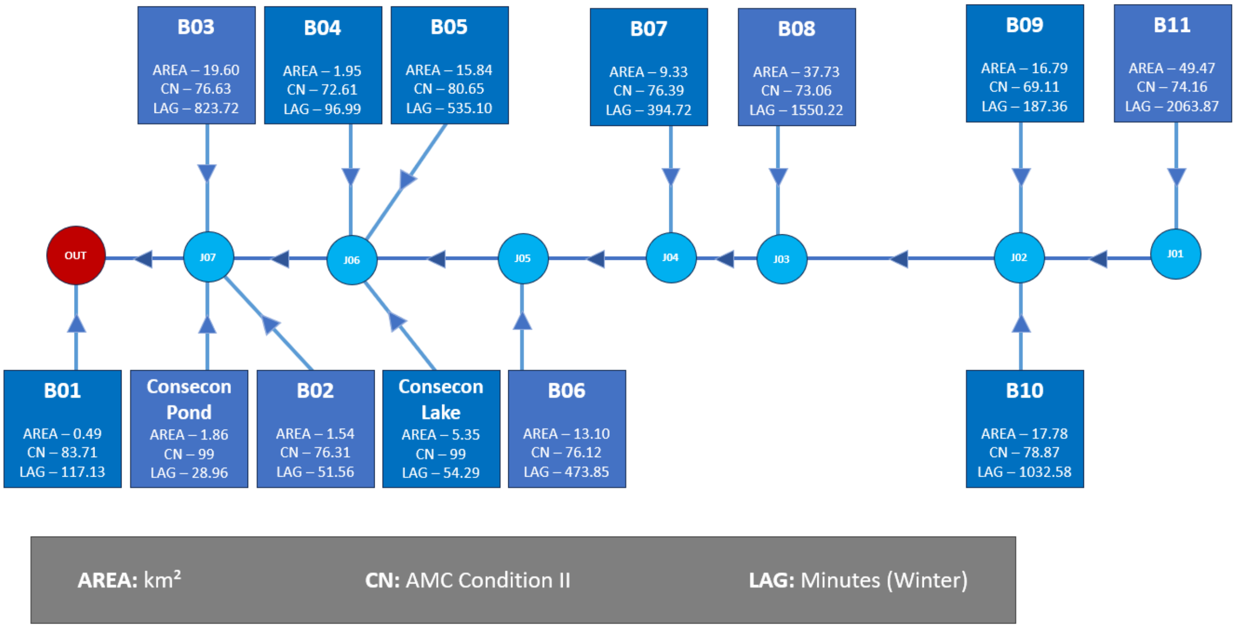


FIGURE 3-7: SCHEMATIC OF THE MODEL PREPARED FOR THE CONSECON LAKE AND CREEK WATERSHED (KGS, 2023)



3.4.1 DATA FOR HEC-HMS MODEL PREPARATION

The HEC-HMS model computes runoff volumes for each sub-catchment using the US Soil Conservation Service (SCS) Curve Number (CN) method. In this method, the hydrologic soil characteristics, and Antecedent Moisture Condition (AMC) are represented by the selection of a CN value. The CN for each sub-catchment was obtained, as part of this study, based on ground cover (land use and hydrologic soil types). The watershed map with land use and hydrologic soil types are shown in Figure 3-8 and Figure 3-9. For modeling purposes, CN I (corresponding to dry soil AMC) was used for summer events, CN II (corresponding to normal soil AMC) for events occurring in late fall or late spring, and CN III (corresponding to saturated soil AMC) for winter and spring events. Initial Abstraction (Ia) values were calculated based on the CN values using the following relationships (HEC-HMS Technical Reference Manual, 2000):

$$I_a = 0.2 \times S \qquad (1)$$

in which S represents the maximum retention:

$$S = \frac{25400 - 254 \times CN}{CN} \qquad (2)$$

The following formulas developed by the US SCS were used to convert the CN II values to CN III values for saturated condition and to CN I values for dry conditions:

$$CN\ (III) = \frac{23 \times CN(II)}{10 + 0.13 \times CN(II)} \qquad (3)$$

$$CN\ (I) = \frac{4.2 \times CN(II)}{10 - 0.058 \times CN(II)} \qquad (4)$$

FIGURE 3-8:LAND USE MAP OF THE WATERSHED

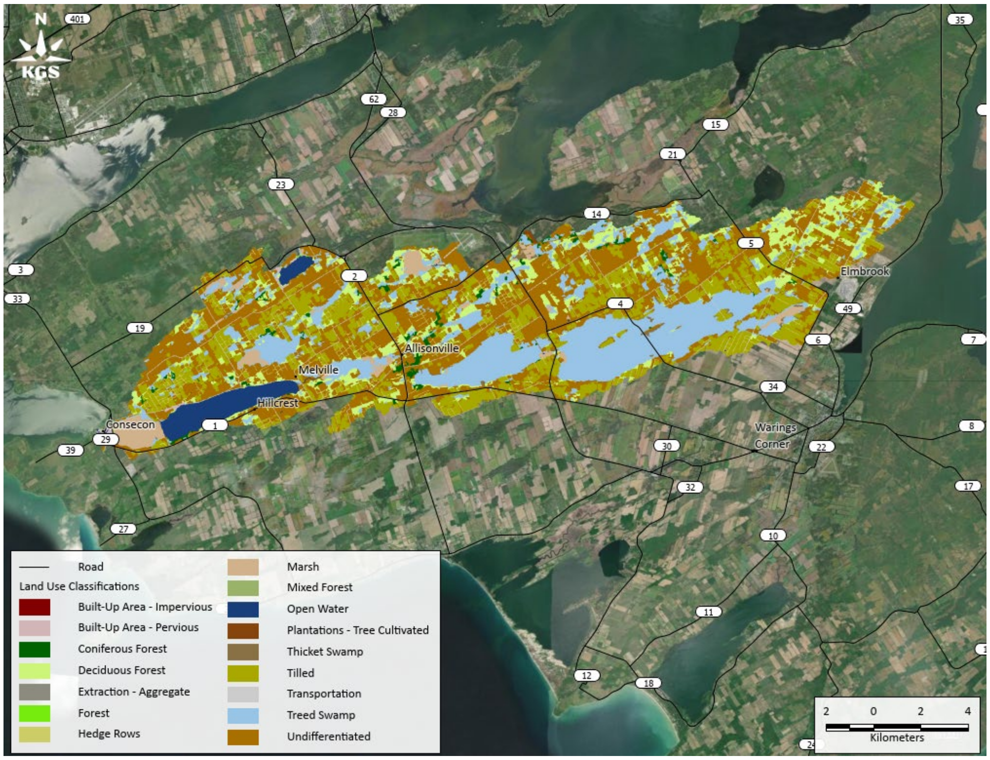
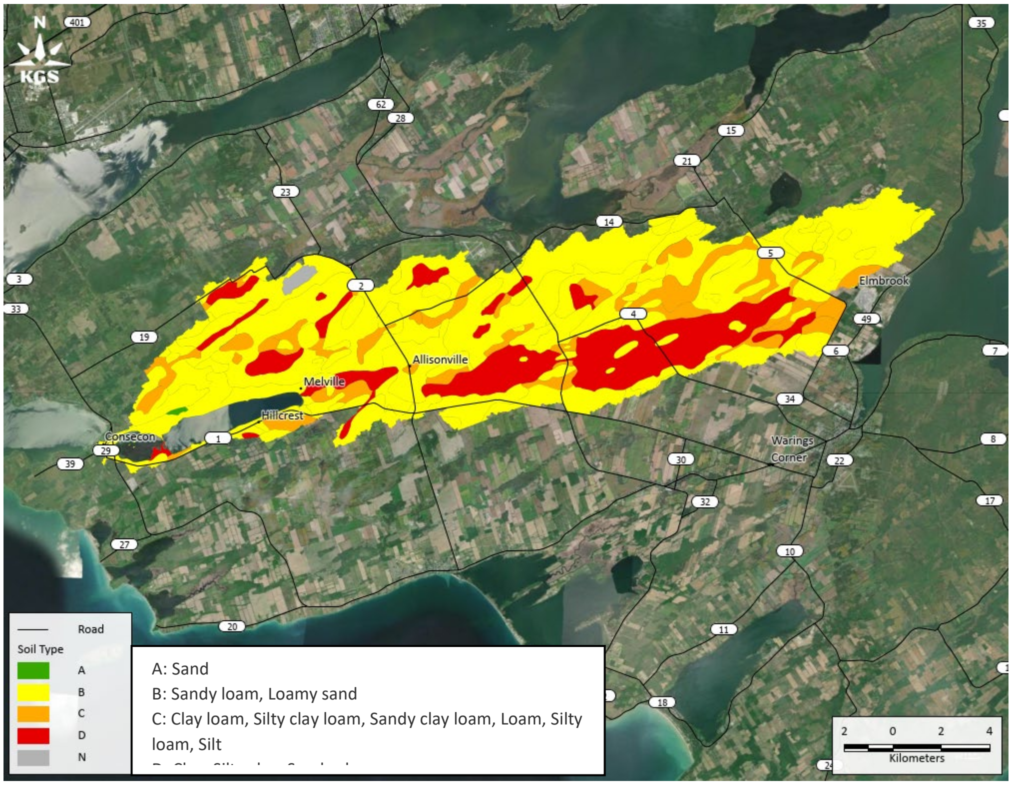


FIGURE 3-9: HYDROLOGIC SOIL TYPES IN THE WATERSHED



The percentage of impervious area for each sub-catchment was estimated based on the land use type, using the typical values provided in technical guidelines and standards such as Soil Conservation Service (1975), and the proportion of each land use within the sub-catchment. Table 3-11 and Table 3-12 show the hydrologic parameters adopted in the model for each sub-catchment. These are the final calibrated parameter values. Additional tables listing the subbasin area, land use, and soil type characteristics used to generate the % impervious, CN and lag times are provided in Appendix B. These tables show the percentage of land use for each subbasin as well as the CN values assigned to each land use category.

For the summer/fall model, the percent impervious was calculated accounting for impervious built-up areas and areas of clear open water. For the winter model, changes to the parameters were made to account for variations in seasonal moisture conditions and their effect on the runoff generation and flow routing. The treed swamp land types with typical CN values of 98, were additionally assumed to be fully impervious in winter and were calculated separately as well, resulting in higher impervious values for the winter model. The watershed lag time was also adjusted for winter conditions.

The HEC-HMS model applies the SCS Unit Hydrograph method to estimate the direct runoff resulting from excess precipitation (after the losses have been subtracted) through a process called the Transform Method. The input parameters for this method are lag time and Peak Rate Factor (PRF). Initial estimates of lag time were obtained using the SCS Watershed Lag formula, as a function of the geometry (e.g., slope obtained from the elevation data) and characteristics of the sub-catchments and were further refined as part of the model calibration. Subbasins containing treed swamps were assigned longer lag times to simulate the delaying effect of swamp routing. A similar approach was used in LATHEM (1985).

TABLE 3-11: HYDROLOGIC MODEL PARAMETERS: CN AND INITIAL ABSTRACTION (IA)

Subbasins	IA for CN I (mm)	CN I	IA for CN II (mm)	CN II	IA for CN III (mm)	CN III
B01	23.54	68.33	9.89	83.71	4.81	91.35
B02	37.54	57.50	15.77	76.31	7.28	87.47
B03	36.89	57.93	15.49	76.63	7.78	86.73
B04	45.62	52.69	19.16	72.61	8.37	85.85
B05	29.02	63.64	12.19	80.65	7.01	87.87
B06	37.95	57.24	15.94	76.12	8.07	86.29
B07	37.39	57.60	15.70	76.39	7.67	86.88
B08	30.98	62.12	18.74	73.06	8.15	86.18
B09	42.06	54.71	22.71	69.11	9.87	83.73
B10	13.28	79.28	13.61	78.87	5.92	89.57
B11	30.97	62.12	17.70	74.16	7.70	86.84
Consecon Lake	0.51	99	0.51	99	0.51	99
Consecon Pond	0.51	99	0.51	99	0.51	99

TABLE 3-12: HYDROLOGIC MODEL PARAMETERS: SUBBASINS IMPERVIOUS AND WATERSHED LAG

		Summer/Fall Model		Winter/Spring Model	
Subbasins	Area (km^2)	Impervious (%)	Adjusted Watershed Lag (min)	Impervious (%)	Adjusted Watershed Lag (min)
B01	0.49	5.42	105.43	14.80	117.13
B02	1.54	1.96	52.01	6.59	51.56
B03	19.60	4.55	825.70	15.12	823.72
B04	1.95	1.11	104.98	1.53	96.99
B05	15.84	0.02	497.66	21.49	535.10
B06	13.10	0.49	475.61	12.07	473.85
B07	9.33	0.12	400.57	9.19	394.72
B08	37.73	0.09	564.94	26.35	1550.22
B09	16.79	0.12	735.48	17.72	187.36
B10	17.78	0.01	295.66	58.74	1032.58
B11	49.47	0.05	770.51	22.92	2063.87
Consecon Lake	5.35	100	54.29	100	54.29
Consecon Pond	1.86	100	28.96	100	28.96

The percentage of runoff occurring before the peak is reflected in the PRF (flat watersheds typically have a lower PRF, in the range of 100, and steeper watersheds have a higher PRF, in the range of 600). A standard PRF of 484 was adopted in this study for all sub-catchments in the winter model, while the summer model used a PRF of 100 for all sub-catchments to represent seasonal changes in watershed characteristics. Baseflow was estimated using the Recession method of the HEC-HMS model, with parameters including initial discharge, the recession constant and the ratio to peak that were adjusted during calibration.

For reach routing, the hydrologic lag method was employed, with lag values adjusted through calibration as shown in Table 3-13. The lag routing method of HEC-HMS translates the reach inflow hydrograph by a specified duration without accounting for flow attenuation.

TABLE 3-13: REACH PARAMETERS IN THE HYDROLOGIC MODEL

	Lag Time (min)	
Reach	**Summer Model**	**Winter Model**
R01	22.99	145.95
R02	30.60	194.29
R03	3.41	7.59
R04	7.98	17.72

Two hydrologic models were created using HEC-HMS: one for simulating summer/fall events, and another for winter/spring events. The models were prepared using hourly flow and precipitation data. Hourly flow data was acquired from the WSC hydrometric station, 02HE002 in Allisonville, while hourly precipitation data was sourced from the ECCC Belleville Quinte Climate Station (Climate ID 6150690). These models were configured to run with an hourly time step.

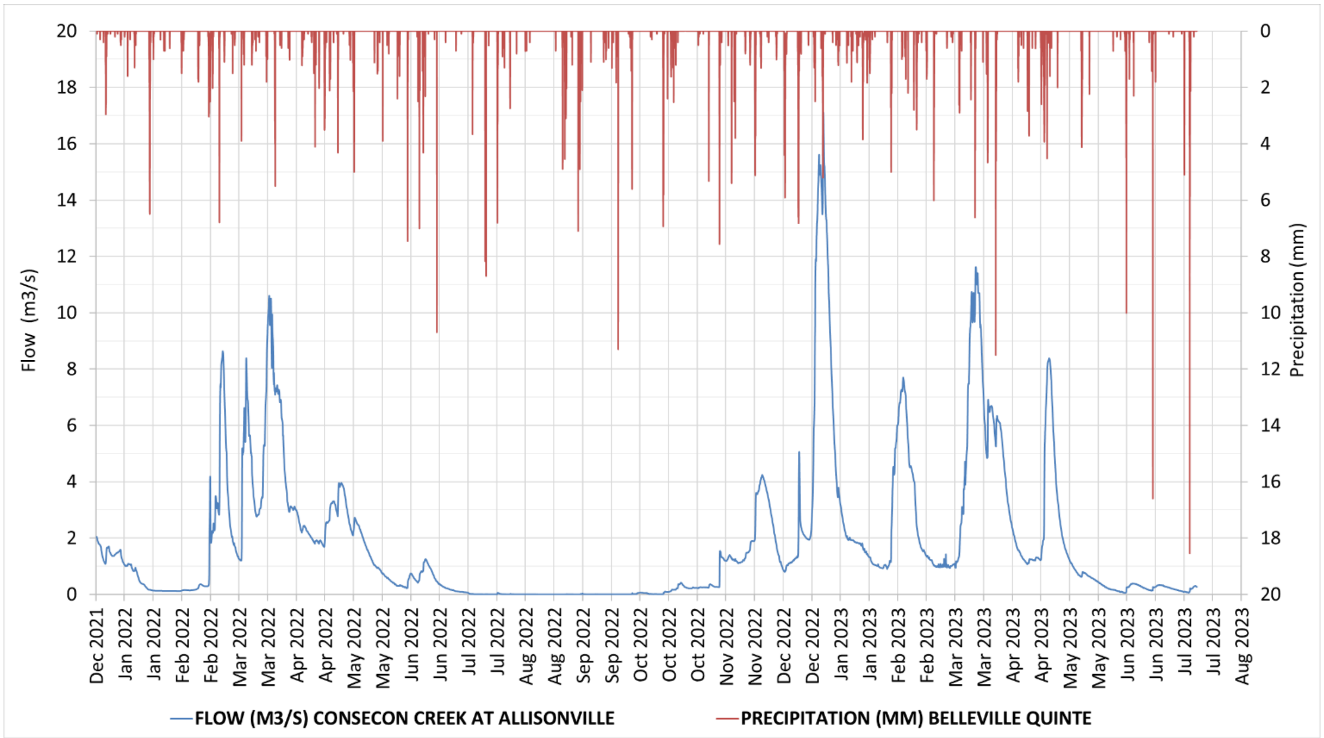
Figure 3-10 shows plotted hourly data available at WSC Station 02HE002 and at ECCC Belleville Climate Quinte Station. Inspection of this plot shows that there were few peak flows observed during the summer and fall (above zero temperature) months.

Daily precipitation at the ECCC Belleville Climate Station (Climate ID 6150689) and flow values at WSC Station 02HE002 for a longer period (2000-2023) were inspected and no significant summer/fall events were observed, with the exception of the summer of 2004. During this summer period, two significant storm events were recorded:

- The 2-day storm of late July with 124.6 mm of recorded rainfall (84.6 mm on July 30th and 40 mm on July 31st) and a measured daily peak flow of 2.7 m^3/s at WSC Station 02HE002.
- The 2-day storm of mid September with a total recorded precipitation of 117.5 mm (81.4 mm on September 9th and 35.5 mm on September 10th) and a measured daily peak flow of 13.7 m^3/s at WSC Station 02HE002.

This inspection confirmed that due to the swamp land types upstream of WSC Station 02HE002, the recorded summer flows at this station are very low, even for large summer storms, and that the summer/fall (above zero temperature) flows are significantly lower than the spring flood events. It should be noted that due to the absence of hourly precipitation and flow data, the events of the summer of 2004 were not simulated with the hydrologic model.

FIGURE 3-10: BELLEVILLE-QUINTE HOURLY PRECIPITATION DATA VS. WSC 02HE002 HOURLY FLOW DATA AT ALLISONVILLE



3.4.2 HEC-HMS MODEL CALIBRATION

Model calibration is necessary to ensure that observed flow conditions can be accurately simulated. The process of calibration involves adjusting hydrologic parameters to generate simulation outputs that are a close match to historical flow records. Both rainfall and streamflow data are required to perform model calibration and the precision of the calibration results are limited by the availability of adequate data.

The HEC-HMS model was manually calibrated by adjusting the model parameters for watershed lag time and reach lag until a result was reached that was close to the observed data. The parameters shown in Tables 3-11 and 3-12 represent the final calibrated parameter values for watershed and reach lag.

The model's calibration and validation performance were assessed by the comparison of the computed and observed flow hydrographs and evaluation of the Nash-Sutcliffe Efficiency Coefficient (NSE). A NSE of >0.75 is considered a good fit in the context of modelling flow in hydrologic models (Moriasi et al, 2015).

Among the limited available hourly data, one summer event recorded in the month of June of 2022 (total precipitation of 15.8 mm), and one winter event occurred in February of 2022 (total precipitation of 18.4 mm) were selected for calibration. AMC I was used in the summer/fall model for simulation of the event of June, and AMC III was used in the winter/spring model for simulation of the event of February.

It should be noted that the calibration was conducted by comparison of the model results with flows at WSC Station 02HE002 in Allisonville. A large portion of the watershed contributing to the flows at this location is covered with swampy terrain which significantly impacts the summer flows measured at WSC Station 02HE002.

To acknowledge that the terrain downstream of that station is different than upstream, in the summer model, AMC I was only applied to the subbasins upstream of Allisonville, and for subbasins downstream of Allisonville, normal antecedent moisture condition (AMC II) was applied.

The results of model simulations for the selected calibration events are presented in Figure 3-11 and Figure 3-12. Simulation performance (NSE value) of the model is reported in Table 3-14.

FIGURE 3-11: HYDROLOGIC MODEL CALIBRATION: SUMMER EVENT, JUNE 2022

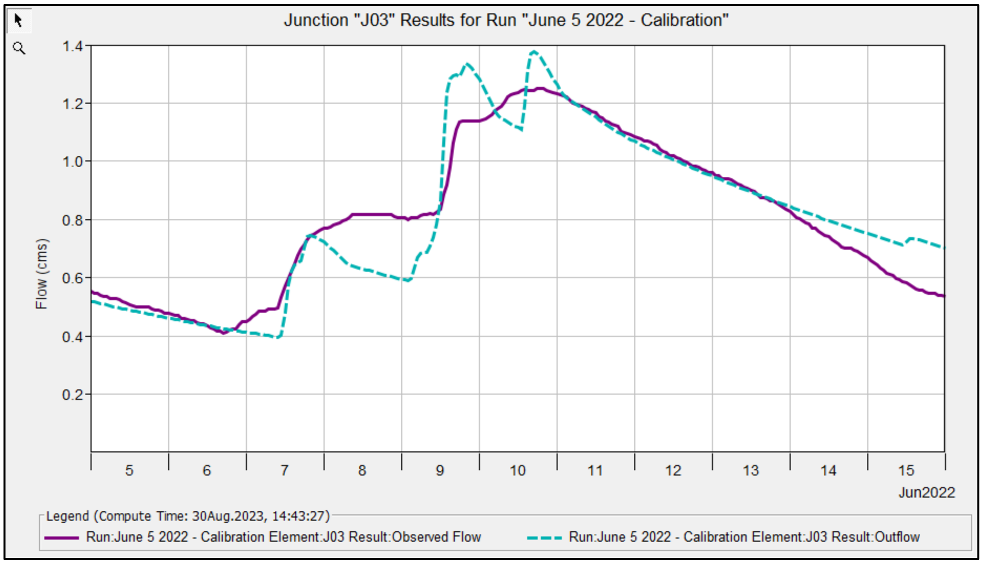


FIGURE 3-12: HYDROLOGIC MODEL CALIBRATION: WINTER EVENT, FEBRUARY 2022

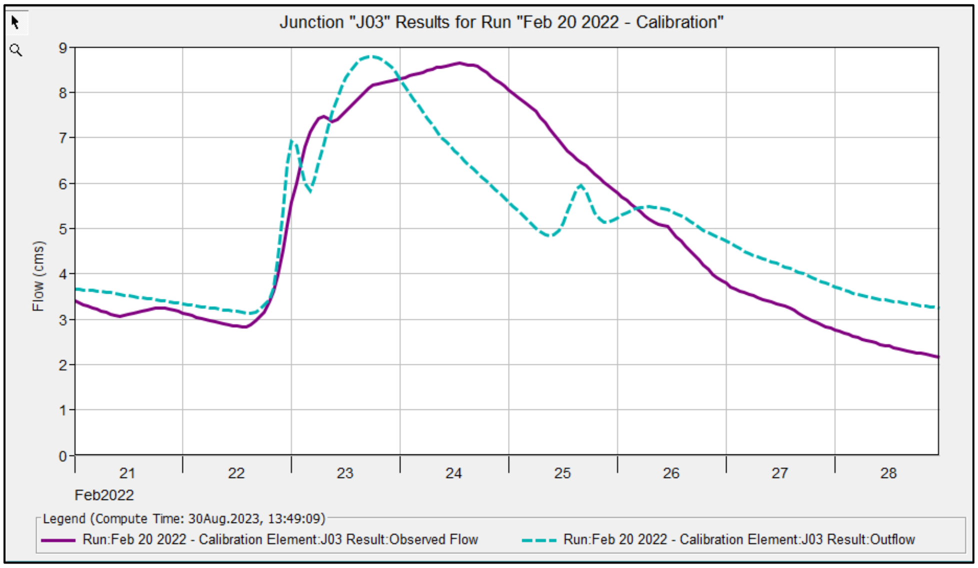


TABLE 3-14: SIMULATION PERFORMANCE OF HYDROLOGIC MODEL FOR CALIBRATION EVENTS

Value for Nash-Sutcliffe (NSE) Criterion	
Summer Event	Winter Event
June 5 2022	**Feb 20 2022**
0.862	**0.757**

3.4.3 HEC-HMS MODEL VALIDATION

Additional events were selected for validation of the summer/fall and winter/spring models. The event selected for validation of the summer/fall model occurred in early November of 2022 (total precipitation of 24.4 mm). For this validation the antecedent moisture condition of the areas upstream of Allisonville were modified to AMC II. All other hydrologic parameters used for validation remained the same as the parameters used for calibration.

The event selected for validation of the winter/spring model occurred in late April of 2023 (total precipitation of 46.3 mm). The antecedent moisture condition used for this event was also AMC II, as this event occurred in late spring. All other hydrologic parameters used for this validation remained the same as the parameters used for calibration.

The results of model simulations for the selected validation events are presented in Figure 3-13 and Figure 3-14. Simulation performance (NSE value) of the model is reported in Table 3-15.

FIGURE 3-13: HYDROLOGIC MODEL VALIDATION: SUMMER/FALL EVENT, NOVEMBER 2022

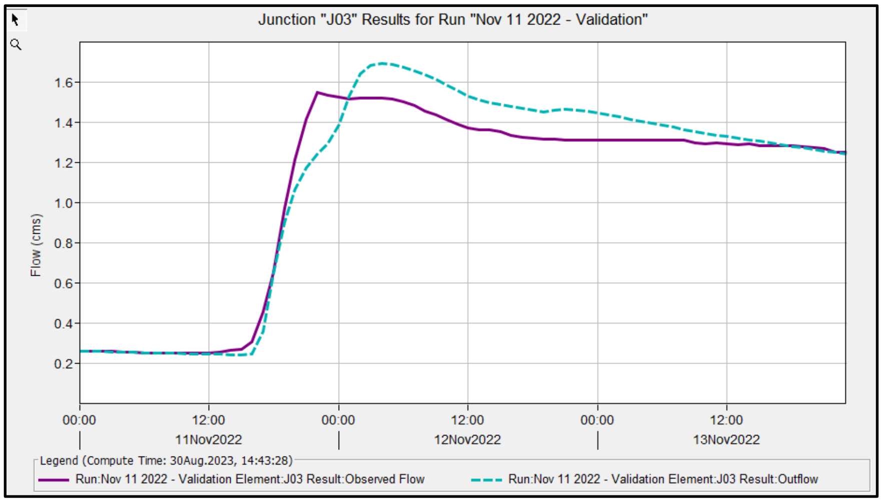


FIGURE 3-14: HYDROLOGIC MODEL VALIDATION: WINTER/SPRING EVENT, MAY 2023

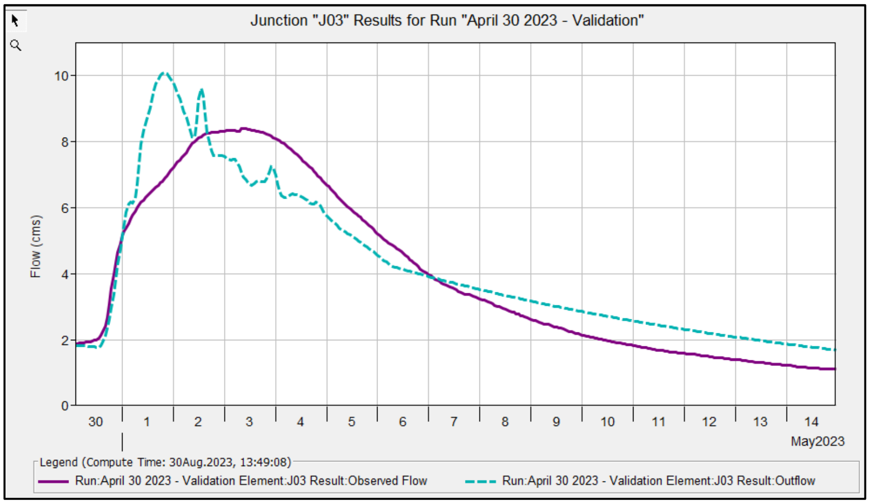


TABLE 3-15: SIMULATION PERFORMANCE OF HYDROLOGIC MODEL FOR VALIDATION EVENTS

Value for Nash-Sutcliffe (NSE) Criterion	
Summer/Fall Event **Nov 11 2022**	Winter/Spring Event **April 30 2023**
0.945	**0.855**

Overall, the HEC-HMS model for the Consecon Watershed produced good results for calibration and validation with NSE's being within an acceptable range for hydrologic modeling.

3.5 Summary of Hydrologic Analysis

3.5.1 PEAK FLOWS FOR RECURRENT EVENTS

The HEC-HMS model developed for summer conditions (with AMC I upstream of Allisonville, and AMC II downstream of Allisonville) was used to simulate the summer design storms, and the model prepared for spring condition (with AMC III) was used for simulation of the spring design storms, with recurrent intervals ranging from 2-year to 500-year. Table 3-16 presents the peak flows at WSC Station 02HE002 at Allisonville computed by the HEC-HMS as well as the results of the flood frequency analysis.

TABLE 3-16: HYDROLOGIC MODEL RESULTS: SUMMER AND WINTER PEAK FLOW VALUES VS FLOOD FREQUENCY ANALYSIS

Return Period (year)	AEP	KGS 2023 – Flow (m^3/s) at WSC Station 02HE002, Allisonville Flood Frequency Analysis (Instantaneous Flow Values at WSC 02HE002)	HEC-HMS Winter/Spring Model	HEC-HMS Summer/Fall Model
2	50%	21.1	20.5	2.0
5	20%	29.5	29.2	4.3
10	10%	35.2	35.2	6.3
20	5%	40.6	40.3	8.2
50	2%	47.8	48.7	11.6
100	1%	53.2	54.4	14.1
200	0.5%	58.6	61.1	17.1
500	0.2%	65.9	69.3	21.2

As Table 3-16 shows, the winter/spring simulations from the HEC-HMS model produced results consistent with those obtained from the flood frequency analysis which was conducted based on the annual spring events. This suggests that the model properly represents the spring flood conditions. The summer/fall simulations yielded significantly lower peak flows than the spring flows, which is consistent with the recorded flow data at WSC Station 02HE002 (discussed in Section 3.4).

To provide more context to the values obtained for summer flows, a comparison was conducted with the findings of LATHEM (1985). A summary of the design flows obtained by LATHEM (1985) is provided in Section 3.3, which shows a peak flow of 34.9 m^3/s for the 100-year summer flow at Allisonville (summer peak flows for other return periods are not reported in LATHEM, 1985). This peak flow is larger than that obtained by the KGS summer model which is 14.1 m^3/s. As outlined in Section 3.3, LATHEM (1985) employed dry antecedent moisture conditions (AMC I) for validating their summer model. However, their report does not distinctly specify whether the CN values utilized for simulating the summer storms and the Timmins Storm were based on AMC II (average conditions) or AMC I (dry conditions). Considering the discussion that follows, it is a reasonable conclusion that LATHEM (1985) incorporated AMC II conditions into their summer model.

Consequently, the resulting 100-year peak flow value of 34.9 m^3/s at Allisonville appears to be an overestimation when compared to what might be anticipated from a 100-year summer storm:

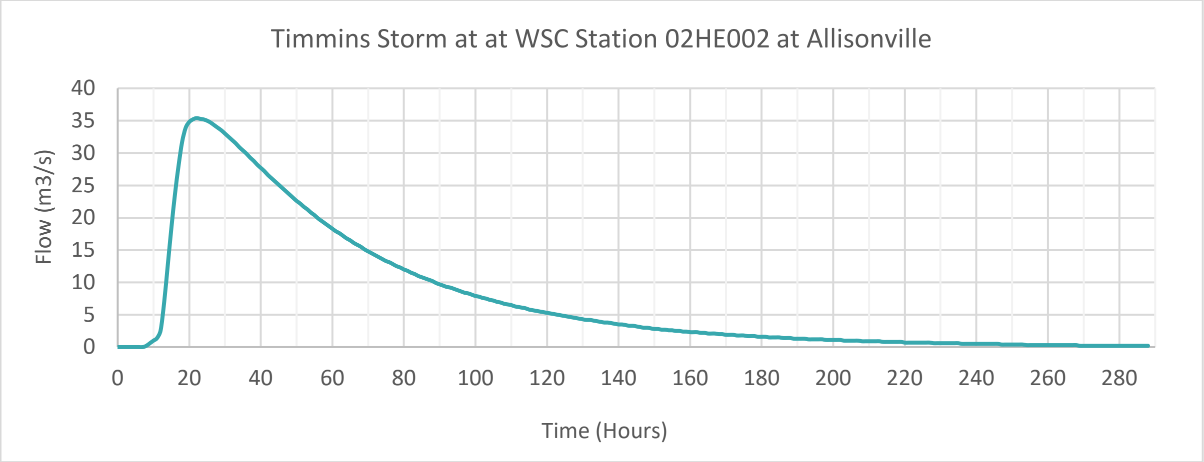
- The records of flows during the summer (2000-2023) at WSC Station 02HE002 are notably insignificant, with the exception of the flows recorded after two significant storms of summer 2004.
- A peak flow of 2.7 m^3/s was recorded after the storm of July with 124.6 mm of rainfall (84.6 mm on July 30th and 40 mm on July 31st). The total depth of rainfall for this event is comparable with the 24-hr 500-year summer design storm (see Table 3-4), and the resulting peak flow is in the range of 2-5 year return period summer floods (Table 3-16; results of HEC-HMS summer model).
- A peak flow of 13.7 m^3/s was recorded after the storm of September with a total rainfall of 117.5 mm (81.4 mm on September 9th and 35.5 mm on September 10th). The total depth of rainfall for this event is in the range between 24-hr 200 and 500 year summer storms (see Table 3-4), and the resulting peak flow is comparable with that of a 100-year summer flood (Table 3-16; results of HEC-HMS summer model).

In both of these summer events, even though there was substantial rainfall, the resulting peak flow at Allisonville remained relatively low or modest (significantly lower than the 100-year peak flow estimated by LATHEM, 1985). This observation underscores the dampening influence of the swamp land use upstream of Allisonville, and it suggests that the AMC I condition is a more accurate representation of the summer conditions for simulating the summer flows upstream of Allisonville.

3.5.2 SIMULATION OF THE TIMMINS STORM

The Timmins Storm was a localized flash flood event that occurred over Timmins, Ontario on August 31, 1961. As described in the previous sections, observed summer events at WSC Station 02HE002 are minimal primarily attributed to the swamp land use upstream of Allisonville and their damping effect. Consequently, it is reasonable to adopt Antecedent Moisture Condition (AMC) I as an appropriate representation of the summer conditions. Therefore, the HEC-HMS hydrologic model prepared for simulation of the summer flows, with AMC I, was used to obtain the flood generated by the Timmins Storm at Allisonville. The resultant hydrograph for the Timmins storm produced by the HEC-HMS summer model is illustrated in Figure 3-15. This hydrograph has a peak flow of 35.4 m^3/s and generates a flood volume of 7,793 x 10^3 m^3.

FIGURE 3-15: HYDROLOGIC MODEL SIMULATION OF THE TIMMINS STORM AT ALLISONVILLE: SUMMER MODEL WITH AMC I



The summer model employed for simulating the Timmins Storm utilized AMC I for subbasins upstream of Allisonville and AMC II for areas downstream of Allisonville. As detailed in Section 3.4, a review of late fall events recorded at WSC Station 02HE002 indicated that AMC II could represent the land use conditions for simulating the late fall events. To investigate how AMC II might impact the flood resulting from the Timmins Storm at Allisonville, summer model testing was conducted using AMC II for the entire watershed. The results indicated a peak flow of 55.7 m^3/s and a flood volume of 12,889 x 10^3 m^3 for the Timmins Storm at Allisonville (WSC Station 02HE002) which are larger than those obtained for the 100-year spring flood at the same location.

Review of historical information reported for the Timmins Storm, including the time of the storm which was during the summer, and temperature, which was recorded over 25 °C, suggests that AMC II is not representative of the condition at the upstream region of the study area during the Timmins Storm. Therefore, the choice of AMC I for simulating the Timmins Storm appears justifiable, as it aligns more closely with the observed conditions during that event, and with the summer model results under AMC I.

3.6 Selection of Regulatory Flood Event

Based on MNRF (2002), the greater of the 100-year or the flood caused by the Timmins Storm will be considered the Regulatory Flood Event for the Consecon Creek Watershed. Table 3-15 compares the peak flows and flood volumes from the 3-day 100-year spring event and the Timmins Storm obtained by KGS (2023), at Allisonville and at the watershed outlet. The results indicate that the 100-year spring event produced larger floods than the Timmins Storm, and therefore it was identified as the Regulatory Event for the Consecon Creek Watershed. As mentioned in Section 1.1, the HEC-HMS model does not account for the effect of routing from Consecon Lake, as flood routing within the lake will be implemented as part of the hydraulic model. Table 3-17 shows the results obtained in this study and those reported in LATHEM (1985).

TABLE 3-17: SIMULATION RESULTS FOR THE TIMMINS STORM AND THE 100-YEAR (1% AEP) FLOOD

	at Allisonville		at the Watershed Outlet	
	100 Year (1% AEP) Spring Storm	Timmins Storm	100 Year (1% AEP) Spring Storm	Timmins Storm
Peak Flow (m^3/s)	54.4	35.4	117	85.7
Volume (x10^3)	10,820	7,793	17,169	15,080

TABLE 3-18: COMPARISON OF THE RESULTS OBTAINED BY KGS (2023) AND LATHEM (1985)

	Upstream of Allisonville			**Watershed Outlet**		
	Peak Flow (m^3/s)		**Regulatory Flood**	Peak Flow (m^3/s)		**Regulatory Flood**
	100-year (1% AEP) spring	Timmins summer		100-year (1% AEP) spring	Timmins summer	
LATHEM (1985)	69.9	79.7	**Adopted 100-year Spring**	104.1	110.5*	**Adopted 100-year Spring**
KGS (2023)	54.4	35.4	**Adopted 100-year Spring**	117**	85.7**	**Adopted 100-year Spring**

* LATHEM (1985) also reports the value of 93.6 m^3/s at this location which is lower than the 100-year spring flood

** Not routed through Consecon Lake

Comparison of the results provided in Table 3-18 indicates that:

- The 100-year (1% AEP) spring flows determined by KGS (2023) at both Allisonville, and the watershed outlet exceed the flows generated by the Timmins Storm.
- The 100-year spring flows as determined by LATHEM (1985) at Allisonville, and the watershed outlet are less than the flows generated by the Timmins Storm.
- Both KGS (2023) and LATHEM (1985) adopted the 100-year (1% AEP) spring flow for the Regulatory Event in the Consecon Creek Watershed.
- At Allisonville, the flood produced by the Timmins Storm, as simulated by KGS (2023), is smaller than that reported in LATHEM (1985). This difference is attributed to the choice of antecedent moisture conditions in the respective hydrologic models. KGS utilized AMC I in the developed summer model for simulating both summer storms and the Timmins Storm. However, as previously discussed, it appears that LATHEM (1985) employed AMC II in their summer model for simulating summer storms and the Timmins Storm.

3.7 Consideration of Climate Change Impacts

As indicated in Section 3.6, the results obtained for the 100-year (1% AEP) spring flood event govern the selection of the Regulatory Flood and will be used for the development of the floodplain maps.

While there is no scientific consensus on a methodology to consider the potential effect of climate change, the FHIMP guidelines indicate that a good approximation is to use the 200-year (0.5% AEP) event. As proposed for this project and agreed in the scope definition, that event (0.5% AEP) and the 500-year (0.2% AEP) will be used for a sensitivity analysis to consider the potential effect of climate change on the floodplain definition for the study area.

3.8 Summary and Conclusion

In this study, hydrologic modeling and analysis was performed using the program HEC-HMS to assess the magnitude of recurrent summer and spring flood events ranging from 2 to 500-year return periods (events with 50% to 0.2% AEP), and the flood that would result from the occurrence of the Timmins (Regional) Storm in the Consecon Lake and Creek watershed. In this watershed, the majority of the historical peak values were recorded in spring, suggesting that the largest floods could be produced by rain plus snowmelt events. The hydrologic model was calibrated using available limited hourly precipitation and flow data, with only a few low peaks observed during the summer/fall season and two major spring seasons. Snowmelt was not explicitly simulated due to limited availability of adequate data. Consecon Lake was included in the model as a separate sub-catchment, and the flood routing that naturally occurs in the lake was not included in the hydrologic model. The model parameters were adjusted to generate simulation outputs that are a close match to historical flow records, at Allisonville. Based on the results, the model properly represented the spring flood conditions. The results also indicated that the 100-year (1% AEP) spring event produced larger floods than the Timmins Storm, and therefore, the 100-year (1% AEP) spring flood was adopted as the Regulatory flood, to be used for definition of the floodplain for the Consecon Creek Watershed.

The results obtained from the 100-year (1% AEP) spring flood event will be used in developing the floodplain with the hydraulic model developed with the program HEC-RAS. As agreed in the scope of work, the 200-year (0.5% AEP) and the 500-year (0.2% AEP) spring floods will be used for a sensitivity analysis to address climate change consideration.

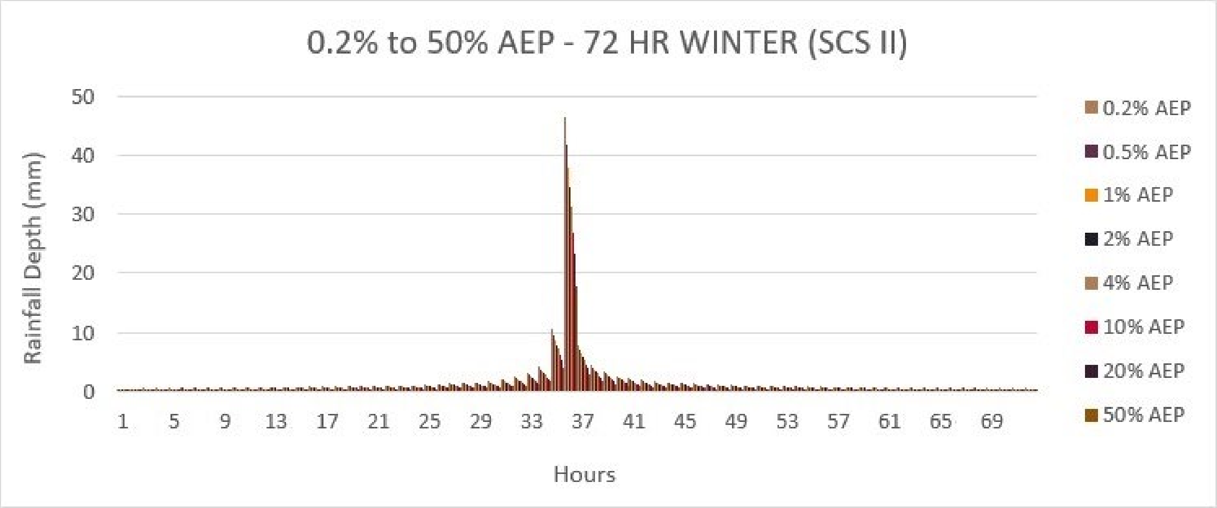
4.0 REFERENCES

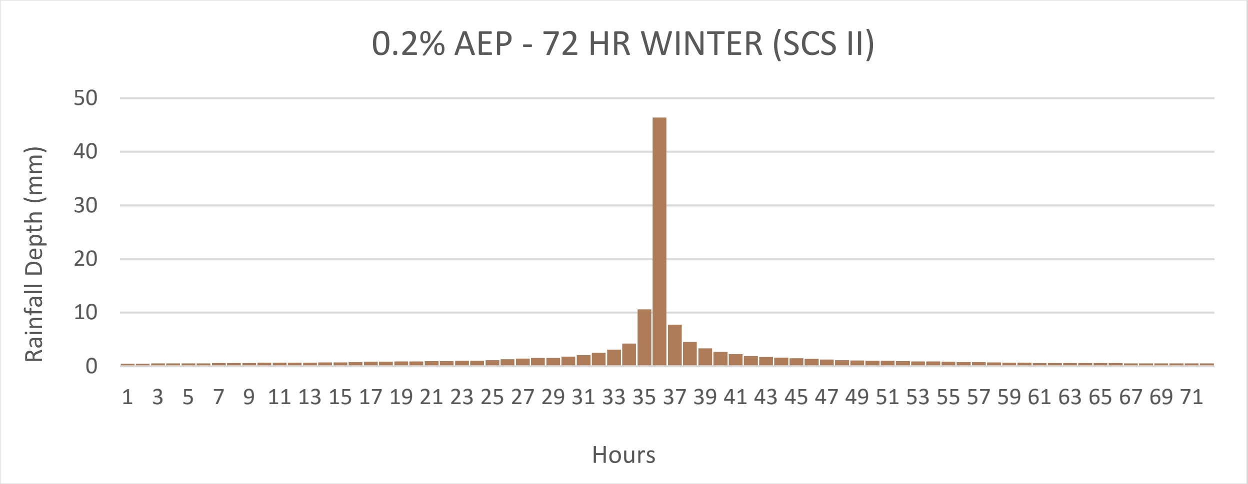
1) Chow, V. T., Maidment, D. R., & Mays, L. W. (1988). *Applied Hydrology*. McGraw-Hill.
2) LATHEM (1985). *Consecon Creek: A Quantitative Water Management Study*. Richmond Hill, Ontario: The LATHEM Group Inc.
3) Ontario Ministry of Natural Resources, (OMNR 2002), River & Stream Systems: Flooding Hazard Limit Technical Guide.
4) Ontario Ministry of Natural Resources, (OMNR 2011), Lakes and Rivers Improvement Act Administrative Guide and Associated Technical Bulletins.
5) U.S Geological Survey (USGS 2019) Guidelines for Determining Flood Flow Frequency Bulletin 17C.

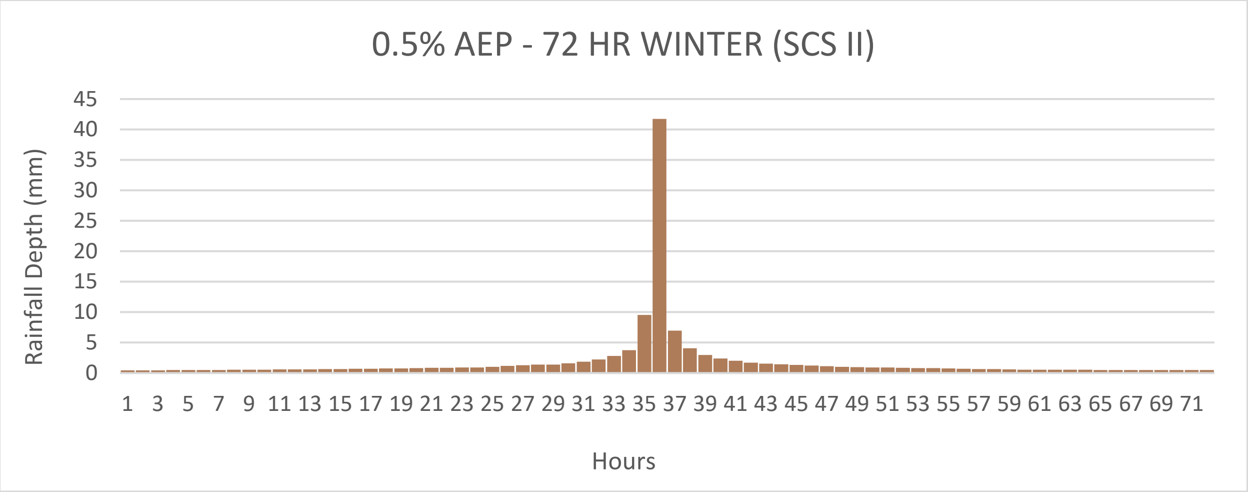
APPENDIX A

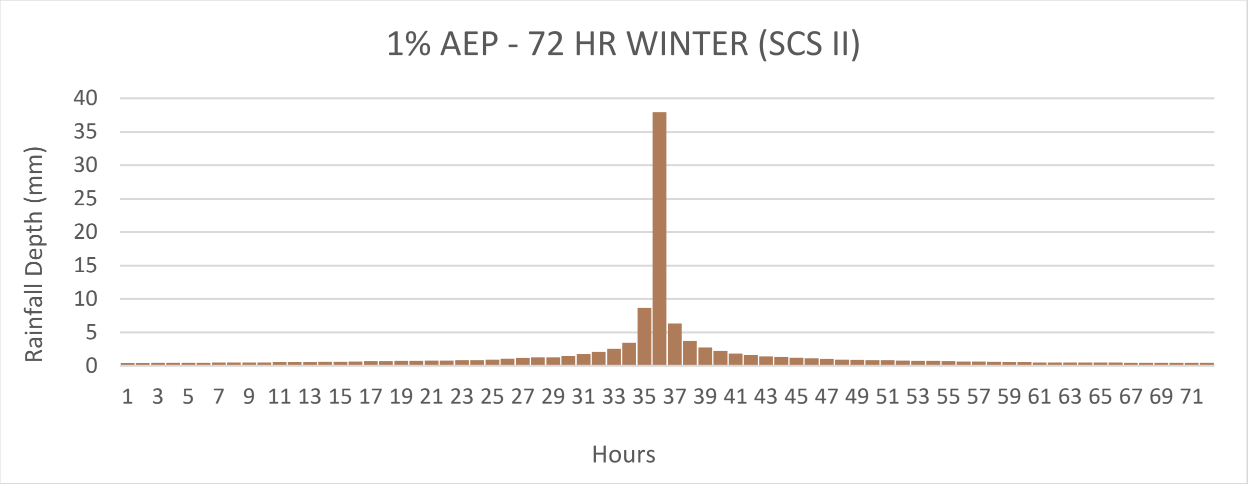
SCS Type II Hyetographs

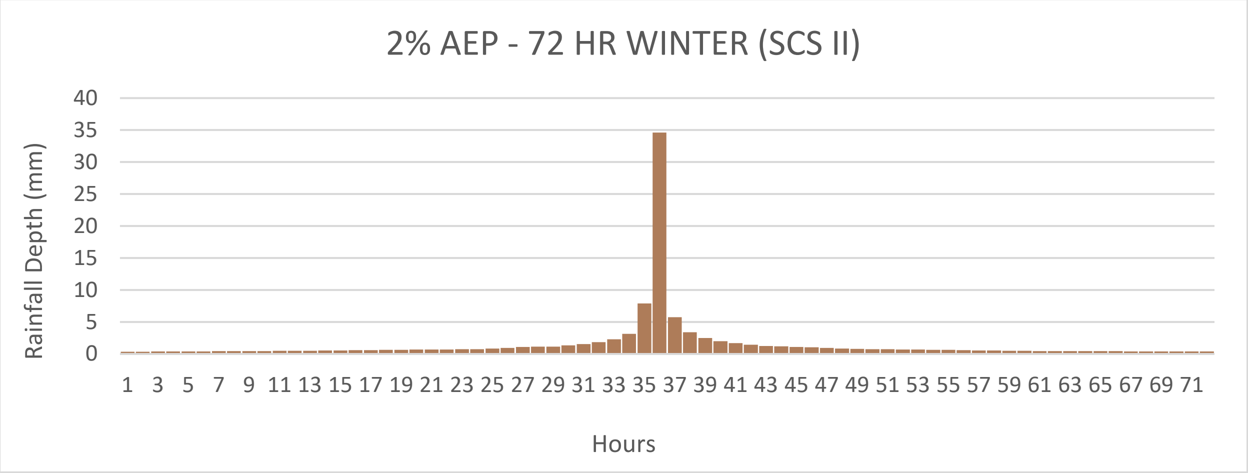
72-HR SCS II STORMS FOR 0.2% TO 50% AEPS

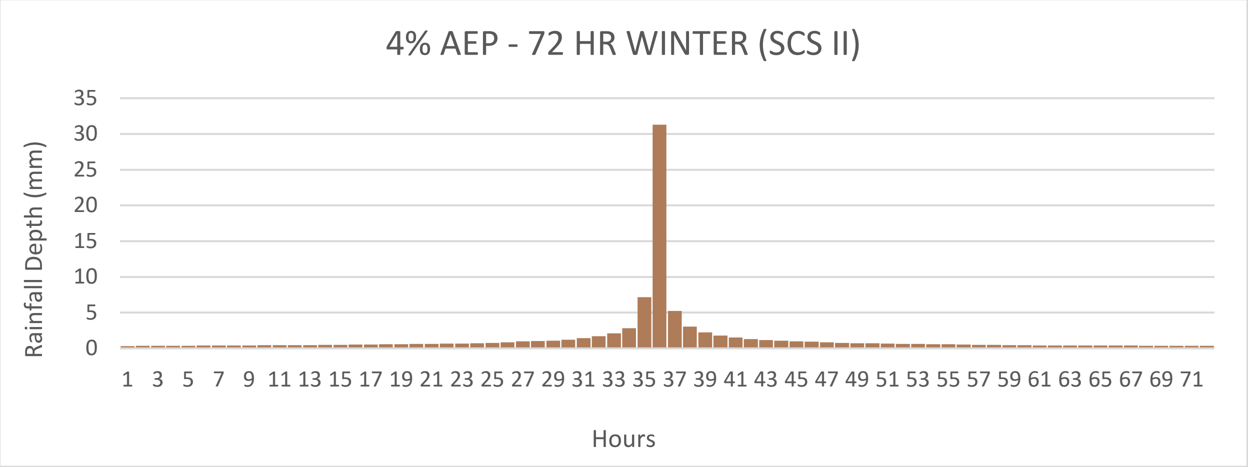


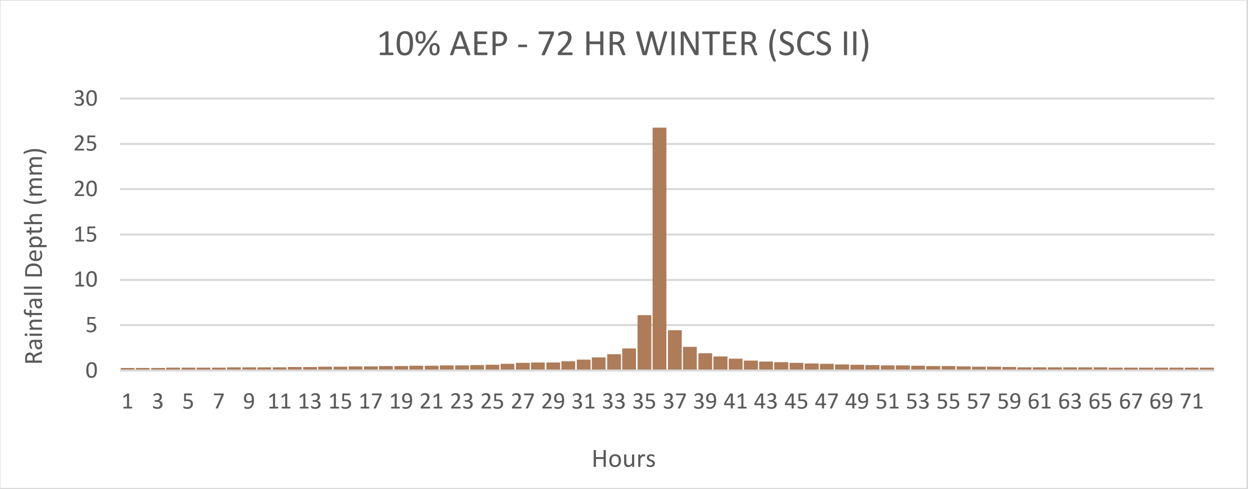


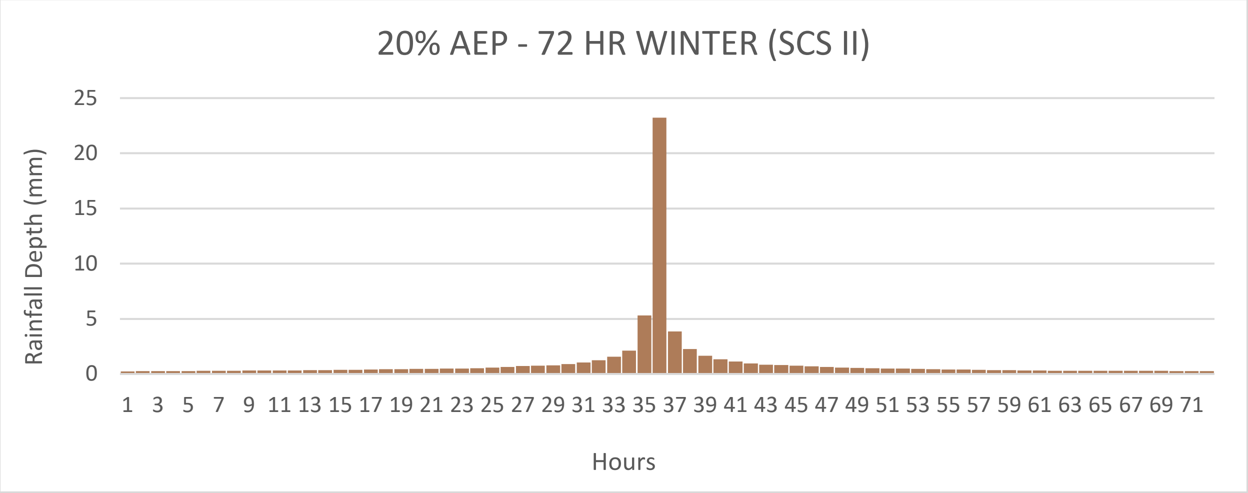



1% AEP - 72 HR WINTER (SCS II)
Rainfall Depth (mm)
40
35
30
25
20
15
10
5
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71
Hours


2% AEP - 72 HR WINTER (SCS II)
Rainfall Depth (mm)
40
35
30
25
20
15
10
5
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71
Hours


4% AEP - 72 HR WINTER (SCS II)
Rainfall Depth (mm)
35
30
25
20
15
10
5
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71
Hours


10% AEP - 72 HR WINTER (SCS II)
Rainfall Depth (mm)
30
25
20
15
10
5
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71
Hours


20% AEP - 72 HR WINTER (SCS II)
Rainfall Depth (mm)
25
20
15
10
5
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71
Hours

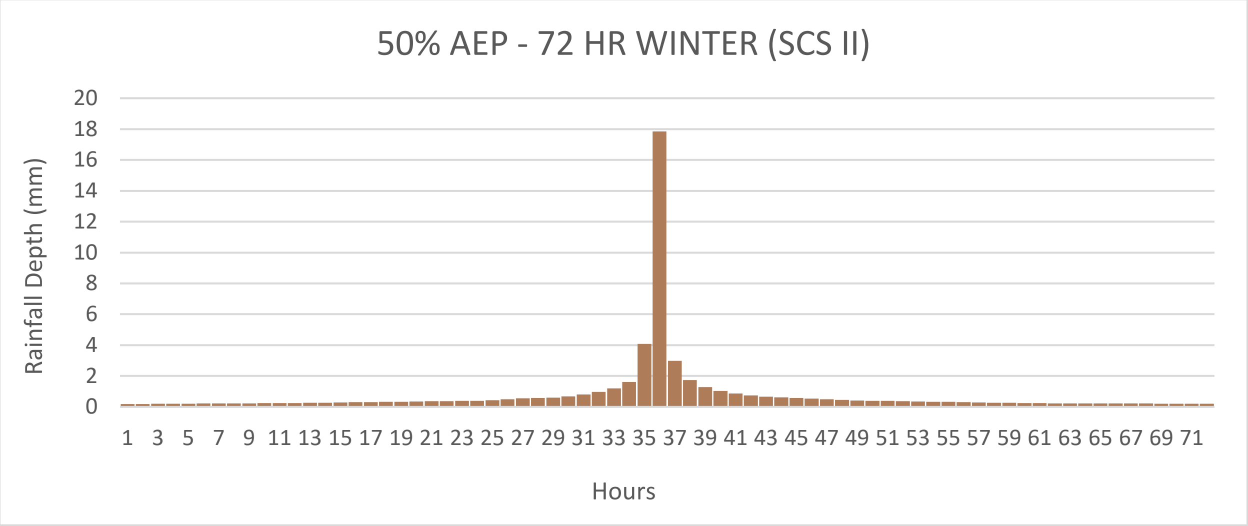

50% AEP - 72 HR WINTER (SCS II)
Rainfall Depth (mm)
20
18
16
14
12
10
8
6
4
2
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71
Hours

TABLE USED TO CONVERT 24-HR SCS TYPE II DISTRIBUTION TO 72-HR BY TIME STEP INTERPOLATION

The 72-hour SCS Type II distribution was developed using the same pattern provided for the 24-hour distribution. Basically, the same portion of the total precipitation that is assigned to a 1-hour interval (for a 24-hour storm) was assigned to a three-hour interval for the 72-hour storm.

Time (h) (72-HR)	Time (h) (24-HR)	Cumulative % of Total Precipitation	% of Total Precipitation for Each Interval
1	0.3	0.3	0.34
2	0.7	0.7	0.35
3	1.0	1.1	0.36
4	1.3	1.4	0.37
5	1.7	1.8	0.38
6	2.0	2.2	0.39
7	2.3	2.6	0.41
8	2.7	3.0	0.42
9	3.0	3.5	0.43
10	3.3	3.9	0.44
11	3.7	4.3	0.45
12	4.0	4.8	0.46
13	4.3	5.3	0.48
14	4.7	5.8	0.50
15	5.0	6.3	0.52
16	5.3	6.8	0.54
17	5.7	7.4	0.57
18	6.0	8.0	0.59
19	6.3	8.6	0.61
20	6.7	9.2	0.63
21	7.0	9.9	0.66
22	7.3	10.6	0.68
23	7.7	11.3	0.70
24	8.0	12.0	0.72
25	8.3	12.8	0.79
26	8.7	13.7	0.90
27	9.0	14.7	1.01
28	9.3	15.8	1.07
29	9.7	16.9	1.09
30	10.0	18.1	1.24
31	10.3	19.6	1.47
32	10.7	21.3	1.76
33	11.0	23.5	2.17
34	11.3	26.4	2.94
35	11.7	33.9	7.41
36	12.0	66.3	32.45
37	12.3	71.7	5.41
38	12.7	74.9	3.16
39	13.0	77.2	2.33
40	13.3	79.1	1.87
41	13.7	80.7	1.58
42	14.0	82.0	1.35
43	14.3	83.2	1.19
44	14.7	84.3	1.12
45	15.0	85.4	1.04
46	15.3	86.3	0.96
47	15.7	87.2	0.88
48	16.0	88.0	0.81
49	16.3	88.8	0.75
50	16.7	89.5	0.72
51	17.0	90.2	0.70
52	17.3	90.8	0.67
53	17.7	91.5	0.64
54	18.0	92.1	0.61
55	18.3	92.7	0.59
56	18.7	93.2	0.56
57	19.0	93.8	0.53
58	19.3	94.3	0.50
59	19.7	94.8	0.47
60	20.0	95.2	0.45
61	20.3	95.6	0.43
62	20.7	96.1	0.43
63	21.0	96.5	0.42
64	21.3	96.9	0.41
65	21.7	97.3	0.41
66	22.0	97.7	0.40
67	22.3	98.1	0.40
68	22.7	98.5	0.39
69	23.0	98.9	0.39
70	23.3	99.3	0.38
71	23.7	99.6	0.38
72	24.0	100.0	0.37

APPENDIX B

Hydrologic Model Inputs

PERCENT OF LAND USE PER SUBBASIN

Land Use Distribution (%)	Subbasin ID												
Land Use Classification	**B01**	**B02**	**B03**	**B04**	**B05**	**B06**	**B07**	**B08**	**B09**	**B10**	**B11**	**Consecon Lake + Pond**	**Watershed Total**
Built-Up Area - Impervious	0	0	0	0	0	0	0	0	0	0	0	0	0
Built-Up Area - Pervious	33	0	1	4	0	0	0	0	0	0	0	0	0
Coniferous Forest	0	6	1	0	1	1	1	2	2	0	0	0	1
Deciduous Forest	10	12	8	6	8	13	10	9	15	2	14	0	10
Extraction - Aggregate	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest	2	1	0	1	0	0	1	0	0	0	0	0	0
Hedge Rows	0	0	3	2	3	3	2	2	0	0	1	0	2
Marsh	4	10	3	0	4	2	2	3	2	0	1	26	3
Mixed Forest	0	0	0	0	0	0	0	0	0	0	0	0	0
Open Water	5	2	5	1	0	0	0	0	0	0	0	74	3
Plantations - Tree Cultivated	0	0	0	0	0	0	0	0	1	0	0	0	0
Thicket Swamp	0	0	0	0	0	0	0	0	1	1	0	0	0
Tilled	0	16	19	21	30	16	29	20	10	21	26	0	21
Transportation	16	8	2	4	2	3	3	2	1	1	2	0	2
Treed Swamp	9	5	11	0	21	12	9	25	16	58	21	0	21
Undifferentiated	20	40	47	61	31	49	44	37	50	16	34	0	36
Area (km2)	**0.49**	**1.54**	**19.60**	**1.95**	**15.84**	**13.10**	**9.33**	**37.73**	**16.79**	**17.78**	**49.47**	**7.21**	**190.83**

PERCENT OF SOIL TYPE PER SUBBASIN

Soil Type Distribution (%)	Subbasin ID												
Soil Type Classification	**B01**	**B02**	**B03**	**B04**	**B05**	**B06**	**B07**	**B08**	**B09**	**B10**	**B11**	**Consecon Lake + Pond**	**Watershed Total**
A	0	0	0	6	0	0	0	0	0	0	0	0	0
B	100	75	76	94	71	68	86	69	89	38	64	93	69
C	0	10	9	0	15	16	11	10	5	8	23	0	13
D	0	15	10	0	14	15	3	21	6	54	14	7	17
N	0	0	4	0	0	0	0	0	0	0	0	0	0
Area (km2)	**0.49**	**1.54**	**19.60**	**1.95**	**15.84**	**13.10**	**9.33**	**37.73**	**16.79**	**17.78**	**49.47**	**7.21**	**190.83**

CN VALUES BASED ON LAND USE AND SOIL TYPE

GIS Land Use Code	CN Table Code	Hydrologic Condition	A	B	C	D	Source
Built-Up Area - Pervious	Urban Districts: Commercial and Business	-	89	92	94	95	TR55
Coniferous Forest	Woods	Good	30	55	70	77	TR55
Deciduous Forest	Woods	Good	30	55	70	77	TR55
Extraction - Aggregate	Streets and Roads: Gravel	-	76	85	89	91	TR55
Forest	Open Forest	-	36	60	79	79	Quijano et al., 2014
Hedge Rows	Woods	Good	30	55	70	77	TR55
Marsh	Marshland / Swamp	-	72	81	88	91	Quijano et al., 2014
Mixed Forest	Woods	Good	30	55	70	77	TR55
Plantations - Tree Cultivated	Woods	Good	30	55	70	77	TR55
Thicket Swamp	Marshland / Swamp	-	72	81	88	91	Quijano et al., 2014
Tilled	Fallow - Bare Soil	-	77	86	91	94	TR55
Transportation	Streets and Roads: Paved, curbs and sewers	-	98	98	98	98	TR55
Treed Swamp	Mangrove Forest	-	98	98	98	98	Quijano et al., 2014
Undifferentiated	Pasture, grassland, or range	Fair	49	69	79	84	TR55

KGS
GROUP

Experience in Action