RIDEAU VALLEY CONSERVATION AUTHORITY

Technical Memo

October 27, 2007

To: Bruce Reid, P.Eng.
Director, Watershed Sciences and Engineering Services

From: Ferdous Ahmed, Ph.D., P.Eng.
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Subject: **Kemptville Creek Floodplain Mapping – Estimation of Flows**

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Flood flows along the Kemptville Creek, to be used in the hydraulic model for floodplain delineation, have been estimated by conducting a frequency analysis on available historical data at Kemptville and then transposing the data to other locations by area pro-rating.

This has been done in two steps:

Single Station Frequency Analysis

First, the flood flows at the gauge location (Kemptville Creek at Kemptville, 02LA006) have been estimated by single station frequency analysis of 38 years the measured data (1970 to 2007). The maximum instantaneous flow for each year was taken from flow record published in the HYDAT CD. For most of the years, both the instantaneous and daily average flows were available. Where instantaneous value was not published, it was estimated by increasing the daily value by 2%. This factor was found empirically from correlating the instantaneous and daily average values when both were available.

The frequency analysis was conducted using the CFA_3 program of Environment Canada. Table 1 shows the input file. The following four distributions were fitted:

- General Extreme Value (GEV)
- Three Parameter Log-Normal (3PLN)
- Log-Pearson III (LP3)
- Wakeby

Out of the four distributions considered, the Three-Parameter Log-Normal (3PLN) distribution was found to match the data best (as judged by visual inspection of the computed flood frequency curves against plotting positions of observed annual maxima) and was also the most conservative (Figure 1). As such, this distribution was selected for the present purpose.

The flood flows computed here using frequency analysis were slightly lower than the values found by Dillon (1995)[1] using the same frequency distribution (3PLN) but with only 23 years of data (Figure 2). It should be mentioned that Dillon did not recommend using the flows estimated by single station frequency analysis because 35 years of data – usually deemed necessary to derive statistically valid estimates of 1:100 year flood – was not available at that time; instead, they recommended flows derived form a regional frequency analysis. Figure 2 indicates that the additional 15 years of data causes the estimated flows to decrease by about 2.2%.

Now, we have 38 years of data, and can confidently use the single station frequency analysis to estimate 1:100 year flood flows. We also expect this to be more accurate than what we can get from regional frequency analysis.

Transposing Flow to Un-Gauged Locations

The flows at the gauge station were then transposed to other locations where no data is available. This was done using the method of area pro-rating, which can be expressed as

$$Q_2 = Q_1\left(\frac{A_2}{A_1}\right)^m$$

where, Q_1 and Q_2 are the flows at the gauged (known) and un-gauged (unknown) locations with areas A_1 and A_2 respectively. The exponent m depends on the basin characteristics and a value of 0.76 is generally accepted for Southern Ontario. This value was also used by Dillon (1995)

The locations where flows were estimated are shown in Figure 3. These nodal points were selected based on a few criteria, such as:

- Natural boundary of watershed
- Boundary of mapping exercise
- Gauge location
- Relative uniformity of sub-watersheds
- Presence of major inflows

[1] Dillon (1995). *Kemptville Creek Watershed Plan – Hydrology/Hydraulics Study*, prepared for Rideau Valley Conservation Authority, May 1995.

- Presence of major confluences
- No major change of flow from node to node

Once the nodal points were selected, the drainage areas were delineated using the 10 x 10 m grid Digital Elevation Model, which we received from the Ministry of Natural Resources in 2006. Use of this high quality topographical information as well as a GIS-based automatic delineation process is expected to give accurate values of drainage area. Comparison with previous data reveals a variation less than 1%.

Coming back to Figure 3, nodal point K4 is the gauge location, where the flood flows have already been calculated by frequency analysis. Flows at other nodal points were calculated by area pro-rating. All flows are shown in Table 3. These flows will be used in the hydraulic model.

Figure 4 shows a graphical comparison of the flows estimated here to those calculated by Dillon (1995) using regional analysis and area pro-rating. A decrease of about 25% in the estimated flows is observed, i.e., the flood frequency analysis using 38 years of data gives flows 25% lower than those estimated by regional analysis. This may largely be attributed to the preponderance of low-lying wetlands within the Kemptville basin compared to other basins used in the regional analysis. However, considering all, it appears that the present analysis gives more realistic flows.

<u>Recommendations</u>

It is recommended that the estimated flows in Table 3 be used in flood mapping and associated hydraulic modeling. In particular, the waters surface profile and flood lines associated with the estimated 1:100 year flows should be used for the purpose of delineating flood hazard areas for use in municipal land use planning and development control and in the plotting of regulation limits maps for use in the Authority's development regulations under Section 28 of the Conservation Authorities Act.

Water surface profiles and flood lines computed from the flows estimated for other flood frequencies should be used in the ongoing work of assessing flood risk and flood damage potential in the Kemptville Creek watershed, and delivering flood forecasting and warning services.

Table 1 CFA_3 Input File

```
02LA006
  KEMPTVILLE CREEK NEAR KEMPTVILLE
   35      .025    0    0      .000
     35      NUMBER OF OBSERVATIONS
     409      AREA
02LA006           1970             4              72.20
02LA006           1971             4              78.20
02LA006           1972             4              81.60
02LA006           1973             3              54.53
02LA006           1974             4              59.20
02LA006           1975             4              47.60
02LA006           1976             3              74.20
02LA006           1977             3              80.10
02LA006           1978             4              66.50
02LA006           1979             3              50.30
02LA006           1980             3              56.67
02LA006           1981             2              58.61
02LA006           1982             4              73.70
02LA006           1983             3              32.40
02LA006           1984             4              55.80
02LA006           1985             3              33.20
02LA006           1986             3              43.20
02LA006           1987             3              49.60
02LA006           1988             3              40.50
02LA006           1989             3              35.68
02LA006           1990             3              43.00
02LA006           1991             4              42.20
02LA006           1992             4              34.04
02LA006           1993             4              68.70
02LA006           1994             4              55.90
02LA006           1995             3              24.46
02LA006           1996             2              34.66
02LA006           1997             4              59.20
02LA006           1998             3              59.70
02LA006           1999             4              58.00
02LA006           2000             4              39.90
02LA006           2001             4              52.40
02LA006           2002             4              26.40
02LA006           2003             3              39.80
02LA006           2004             3              30.10
02LA006           2005             3              65.28
02LA006           2006             3              28.51
02LA006           2007             3              30.00
```

Table 2 Flood Flows (cms) Estimated by Frequency Analysis using CFA_3 for Kemptville Creek at Kemptville (02LA006)

Return Period (Years)	GEV	3PLN	LP3	WAKEBY
1.003	11.5	14.6	12.0	22.7
1.05	24.6	26.2	24.3	25.5
1.25	36.2	36.8	37.0	34.4
2	49.7	49.5	51.3	50.2
5	65.2	64.3	65.4	65.9
10	73.9	73.0	72.0	73.6
20	81.3	80.7	77.0	80.0
50	89.7	90.1	81.9	87.6
100	95.1	96.8	84.7	92.8
200	100.0	103.0	86.9	97.6
500	106.0	111.0	89.3	103.0

Table 3 Estimated Flood Flows (in cms) at Nodal Points

Nodal Point >>	SK1	SK2	SK3	SK4	NK1	NK2	NK3	K1	K2
Drainage Area (km2) >>	113.46	139.50	173.87	201.31	49.70	108.99	129.65	330.96	377.94
Return Period (Year)	SK1	SK2	SK3	SK4	NK1	NK2	NK3	K1	K2
2	18.55	21.70	25.65	28.68	9.90	17.99	20.53	41.84	46.28
5	24.09	28.19	33.33	37.25	12.86	23.37	26.66	54.35	60.12
10	27.35	32.00	37.83	42.29	14.61	26.53	30.27	61.71	68.26
20	30.24	35.38	41.82	46.75	16.15	29.33	33.46	68.22	75.46
50	33.76	39.50	46.70	52.20	18.03	32.74	37.36	76.16	84.25
100	36.27	42.44	50.17	56.08	19.37	35.18	40.14	81.83	90.51
200	38.59	45.15	53.38	59.67	20.61	37.43	42.71	87.07	96.31
500	41.59	48.66	57.53	64.30	22.21	40.34	46.03	93.83	103.79

Nodal Point >>	K3	K4	K5 -	B1	B2	B3	B4	K5	K6
Drainage Area (km2) >>	401.34	412.87	416.94	6.93	14.65	21.57	26.79	443.72	454.42
Return Period (Year)	K3	K4	K4	BC1	BC2	BC3	BC3	K5	K6
2	48.45	49.50	49.87	2.22	3.91	5.25	6.19	52.29	53.24
5	62.93	64.30	64.78	2.88	5.08	6.82	8.04	67.92	69.16
10	71.45	73.00	73.55	3.27	5.77	7.75	9.13	77.11	78.52
20	78.98	80.70	81.30	3.61	6.38	8.56	10.09	85.24	86.80
50	88.18	90.10	90.77	4.03	7.12	9.56	11.27	95.17	96.91
100	94.74	96.80	97.52	4.33	7.65	10.27	12.11	102.25	104.12
200	100.81	103.00	103.77	4.61	8.14	10.93	12.88	108.80	110.79
500	108.64	111.00	111.83	4.97	8.78	11.78	13.88	117.25	119.39

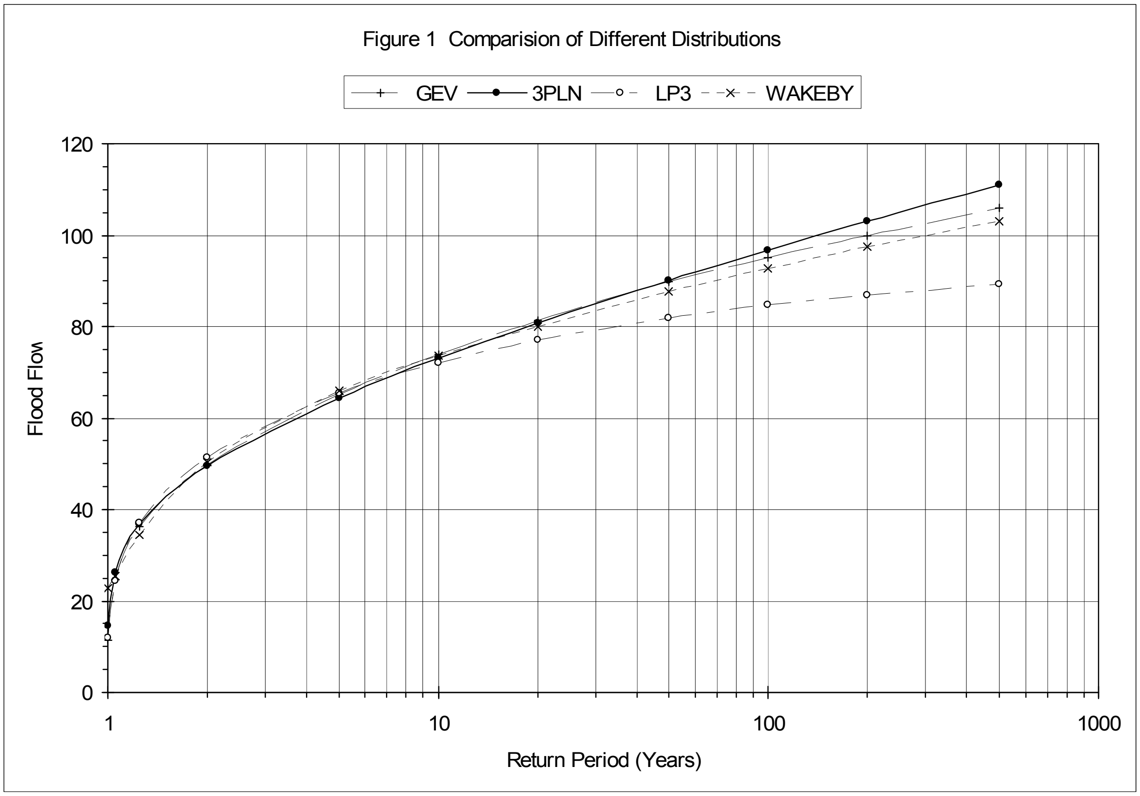
Figure 1 Comparision of Different Distributions
GEV
3PLN
LP3
WAKEBY
Flood Flow
120
100
80
60
40
20
0
1
10
100
1000
Return Period (Years)

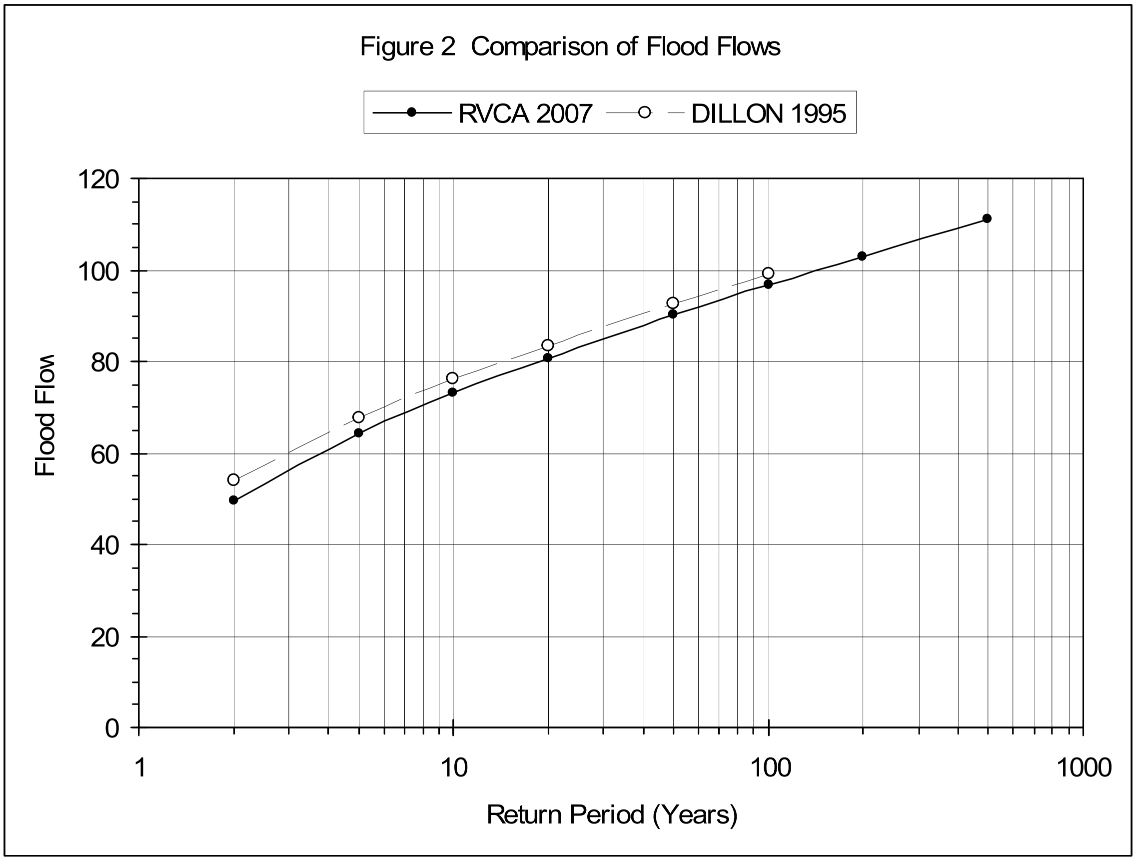

Figure 3 **Nodal Points** – *in a separate PDF file (Kemptville_catchments_11x17.pdf)*

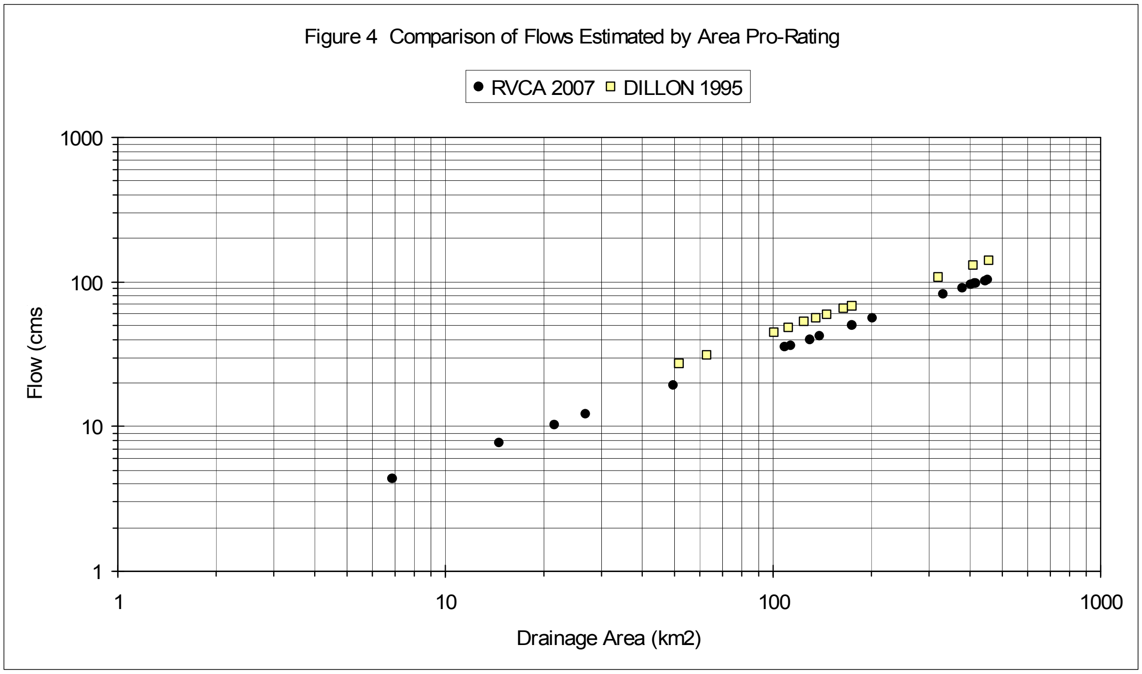
Figure 4 Comparison of Flows Estimated by Area Pro-Rating
RVCA 2007
DILLON 1995
1000
100
10
1
Flow (cms
1
10
100
1000
Drainage Area (km2)