APPENDIX 15-O
NORTH TREATY AND SOUTH TEIGEN CREEK INSTREAM FLOW THRESHOLD ASSESSMENT

Memorandum

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TO:	Chris Burns	
FROM:	Ali Naghibi and David Luzi	
SUBJECT:	KSM Project: Instream Flow Threshold for Proposed Tailings Management Facility	

1. Introduction

The results from the completed flow threshold analysis for the proposed Tailings Management Facility (TMF) are presented in this report. The analysis involved the determination of the instream flow thresholds using a long-term dataset. This was conducted as a first approximation to determine potential fish habitat and related aquatic losses due to the diversion of surface waters from the stream channels, as well to the construction of the TMF. The proposed TMF is to be located within the upper South Teigen and North Treaty Creek drainage basins; therefore, the analysis was conducted for both drainage basins.

The instream flow thresholds can be identified using a long-term time series of synthetic flow discharges. In British Columbia, the provincial instream flow threshold guidelines recommend that a minimum of twenty years of continuous natural daily flow discharge records should be used for the analysis (Hatfield et al. 2003). However, a record of this length is generally not available for the majority of hydrometric monitoring stations in the province. Thus, synthetic periods of flow discharge records are usually constructed.

2. Methodology

The 2008 to 2010 daily discharge records from the South Teigen Creek (NTWM-H1) and North Treaty Creek (STWM-H1) hydrometric stations were used as the baseline period for the analysis. The records were extended by completing a correlation analysis with longer term discharge records from four regional Water Survey of Canada (WSC) hydrometric stations from Hydrologic Zones 1 and 5 in British Columbia (Obedkoff 2003). The extended long-term record provided the seasonal and monthly variation in surface water flows in TMF area that in turn were used to establish the instream flow thresholds for all calendar months. The 2011 daily discharge records were used to verify the results of the analysis.

The following seven step procedure was employed for the completion of flow threshold analysis.

1. South Teigen and North Treaty hydrometric stations NTWM-H1 and STWM-H1 were selected for analysis. Three years of continuous daily flow data starting from 2008 were used as a baseline for data extension. It should be noted that the drainage area at these stations are approximately 61 and 33 km^2, respectively; a simple area-discharge relationship can be employed to convert the data from these locations to any location downstream of the seepage dams.
2. The selection of reference WSC's long-term regional gauging stations was based on the following criteria:

- The station has continuous daily discharge records of at least 20 years, and has a concurrent period of record with NTWM-H1 and STWM-H1.
- The station is located in Hydrologic Zones 1 or 5 as defined by Obedkoff (2001, 2003).
- Its monthly discharge distribution is similar to those of NTWM-H1 and STWM-H1.

3. Developed correlations between South Teigen Creek and the four WSC stations using regression equations. To achieve this, a regression analysis of ranked and unranked daily flows over 2008 to 2010 was undertaken. The data was analysed on a monthly basis, and thus regression relationships were developed for each month. It was found that the ranked method offered improved results. This method is essentially a comparison of the flow frequency distributions, and as such overcomes the difference in the timing of rainstorm or snowmelt events between the watersheds (Terry *et al.* 2010). Whenever two patterns in the data were evident, piecewise regression analysis was used. In a few instances the regression relationships produced negative results. In these cases the negative values were replaced using a linear interpolation between temporally successive positive values on either side of the negative occurrence.
4. Similar to step 3, correlation analysis was performed for North Treaty Creek.
5. The short term (3 years) daily discharge records from Stations NTWM-H1 and STWM-H1 were extended to produce long-term daily flow records using the best monthly correlations. From this, the long-term synthetic flow discharge records that were produced for Stations NTWM-H1 and STWM-H1 contained 40 years of synthetic flow discharge record and 3 years of measured flow discharge record.
6. Observed and modelled daily discharge values were compared both for the period of 2008 to 2010 (i.e., calibration period) and for 2011 (i.e., validation period).
7. Based on the generated long-term synthetic flow discharges, the methods as outlined in the British Columbia Instream Flow Threshold Guideline were followed (Hatfield *et al.* 2003). The method produces monthly values that are employed as instream flow thresholds. The British Columbia Instream Flow Threshold Guideline proposes the following steps to determine these thresholds (Hatfield *et al.* 2003):
   - "determine fish-bearing status of streams in the impact area
   - obtain 20 or more years of continuous **natural** daily flow records (i.e., corrected for existing water uses),
   - calculate the 80th percentile flow over the period of record to set the maximum diversion rate,
   - calculate the median of mean daily flows during each calendar month,
   - order monthly values from step 4 in sequence from lowest to highest,
   - set the flow threshold in the lowest flow month to 90th percentile of mean daily flows in that month,
   - set the flow threshold in the highest flow month to 20th percentile of mean daily flows in that month,
   - set the flow threshold for all other months as a percentile of mean daily flows in that month, where the percentile is calculated according to the formula:

$$90 - \left[\left(\frac{median_i - median_{min}}{median_{max} - median_{min}}\right) \times (90 - 20)\right]$$

where

$median_i$ is the median of mean daily flows for month *i*,

$median_{min}$ is the month of lowest median flows,

$median_{max}$ is the month of highest median flows.

Using this formula the percentile for each month will vary between 20th and 90th."

3. Results and Observations

Based on the criteria outlined in the methods section, four WSC stations were selected. These are Kispiox River Near Hazelton (08EB004), Iskut River below Johnson River (08CG001), Nass River Above Shumal Creek (08DB001), and Surprise Creek Near The Mouth (08DA005). These stations have continuous long-term datasets from 1968 to 2010. As shown in Figures 3-1 to 3-8 (Appendix A), the comparison of unit runoff hydrographs features a relatively good correlation between the reference WSC stations and South Teigen (NTWM-H1) and North Treaty (STWM-H1) creeks. Differences are notable during the spring freshet and the summer periods when Surprise Creek has higher unit runoff values compared with NTWM-H1 and STWM-H1. During these periods, unit runoff values of Kispiox River are lower than those of NTWM-H1 and STWM-H1. Unit runoff values of Iskut River and Nass River show a mix of higher and lower values compared with NTWM-H1 and STWM-H1.

3.1 Regression Analysis

Monthly regression analysis using the ranked monthly daily flow data for South Teigen Creek and the reference WSC stations was carried out. Monthly regression equations were developed that were used to produce the best fit curves. In Appendix A, Figures 3-9 and 3-10 show two examples. For the month of October, two regression equations between NTWM-H1 and Surprise Creek best defined the relationship, as opposed to the month of April where one equation between NTWM-H1 and Iskut River was sufficient. The resulting monthly regression equations (Table 3.1-1) were applied to the reference WSC stations data to calculate the long-term synthetic flows for South Teigen Creek.

Table 3.1-1. Selected Regression Equations to Estimate Daily Synthetic Flows at NTWM-H1

Month	Equation	Month	Equation
Jan	$Q = 0.1269\ln(K) + 0.0570$	Jul	$Q = 0.0043(N) - 1.1203$
Feb	$Q = 0.3337\ln(S) + 0.3734$	Aug	$Q = 0.00024(I)1.3593$
Mar	$Q = 0.568\ln(S) + 0.2926$, if $S<2$	Sep	$Q = 0.0035(I) - 0.2247$, if $I<1000$
	$Q = 0.1104\ln(S) + 0.6139$, if $S\geq2$		$Q = 0.0076(I) - 4.2218$, if $I\geq1000$
Apr	$Q = 0.7001\ln(I) - 2.4443$	Oct	$Q=0.1638(S) - 0.0605$, if $S<22.5$
May	$Q = 0.0101(I) - 1.1349$, if $I<1000$		$Q = 0.4928(S) - 7.5747$, if $S\geq22.5$
	$Q = 0.0036(I) + 5.4138$, if $I\geq1000$	Nov	$Q = 0.162(S) + 0.2485$
Jun	$Q = 0.0048(N) - 1.5523$	Dec	$Q = 0.0965e0.0163(K)$

Q = *Daily flow at NTWM-H1 (m^3/s)*
K = *Daily flow in Kispiox River (m^3/s)*
S = *Daily flow in Surprise Creek (m^3/s)*
I = *Daily flow in Iskut River (m^3/s)*
N = *Daily flow in Nass River (m^3/s)*

Likewise, monthly regression analysis using the ranked monthly daily flow data for North Treaty Creek and the reference WSC stations was conducted. Monthly regression equations were developed that were used to produce the best fit curves (Table 3.1-2). Figures 3-11 and 3-12 show two examples of fitted curves. For the month of June, two regression equations between STWM-H1 and Nass River best defined the relationship, as opposed to the month of April where one equation between STWM-H1 and Iskut River was sufficient. The resulting monthly regression equations (Table 3.1-2) were applied to the reference WSC stations data to calculate the long-term synthetic flows for South Teigen Creek.

Table 3.1-2. Selected Regression Equations to Estimate Daily Synthetic Flows at STWM-H1

Month	Equation	Month	Equation
Jan	Q = 0.1763(S) + 0.0531	Jul	Q = 0.0023(N) - 0.8719, if N<2240
Feb	Q = 0.315ln(S) + 0.3528		Q = 0.0094(N) - 16.357, if N≥2240
Mar	Q = 0.4288(S) - 0.1802, if S<2	Aug	$Q = 0.00036(I)^{1.19895}$
	Q = 0.1082ln(S) + 0.5835, if S≥2	Sep	Q = 0.0687(S) - 0.3566
Apr	Q = 0.8932ln(I) - 3.2455	Oct	Q = 0.1079(S) - 0.1592
May	Q = 0.0025(N) - 0.2468	Nov	Q = 0.079(S) + 0.1553
Jun	Q = 0.003(N) - 2.0507, if N<3600	Dec	Q = 0.2429e0.0278(K)
	Q = 0.0111(N) - 30.991, if N≥3600		

Q = *Daily flow at STWM-H1 (m^3/s)*
K = *Daily flow in Kispiox River (m^3/s)*
S = *Daily flow in Surprise Creek (m^3/s)*
I = *Daily flow in Iskut River (m^3/s)*
N = *Daily flow in Nass River (m^3/s)*

A comparison between the synthetic and observed hydrographs of South Teigen and North Treaty Creeks for 2008, 2009 and 2010 are presented in Appendix A, Figures 3-13 and 3-14. Visually the actual and synthetic daily discharges match well with respect to time and magnitude, although some of the peaks were overestimated by the synthetic results. Using regression to establish the fit between the synthetic and observed datasets at NTWM-H1 and STWM-H1, the r^2 values were estimated and summarized in Table 3.1-3. As an additional metric to evaluate the goodness of fit between observed and synthetic hydrologic data, the Nash-Sutcliffe model efficiency (NSE) value was applied (Nash and Sutcliffe, 1970). The resulting NSE values for NTWM-H1 and STWM-H1 data in 2008, 2009 and 2010 are provided in Table 3.1-3. The results from both metrics are comparable, and thus indicate that the synthetic flows are sufficiently calibrated and match reasonably well with the observed data for the three year period.

Table 3.1-3. Goodness of Fit Measures for Modelled Daily Discharges at NTWM-H1 and STWM-H1 during 2008, 2009, and 2010

	Goodness of Fit Measure	2008	2009	2010
South Teigen Creek (NTWM-H1)	R^2	0.90	0.94	0.77
	NSE	0.88	0.94	0.77
North Treaty Creek (STWM-H1)	R^2	0.73	0.74	0.82
	NSE	0.57	0.74	0.82

For validation purpose, the synthetic and observed hydrographs of South Teigen Creek for 2011 were compared (Figure 3-15). These hydrographs follow the same pattern with respect to time and magnitude but show some differences throughout the year. Quantitative comparison of the synthetic and observed hydrographs with the linear regression analysis and Nash-Sutcliffe model results in r^2 and NSE values of 0.77 and 0.62, respectively. The synthetic and observed hydrographs of North Treaty Creek for 2011 were also compared (Figure 3-16). Goodness of fit measures of r^2 and NSE are 0.76 and 0.65, respectively. It should be noted that the ranked regression analysis is not intended to precisely model the daily flows. Rather, its goal is to generate synthetic long-term daily flows that have the same mean and variability statistics to the actual historical flows (Terry *et al*. 2010). Therefore, the accuracy of generated synthetic flows is sufficient for the purpose of this report.

3.2 B.C. Instream Flow Thresholds Guidelines

The British Columbia Instream Flow Threshold Guidelines (Hatfield *et al*. 2003) were applied to the synthetic flow discharge data for Stations NTWM-H1 and STWM-H1 (Figures 3-17 and 3-18). The summary statistics are presented in Tables 3.2-1 and 3.2-2. Based on the synthetic flow data, the mean annual discharge at NTWM-H1 and STWM-H1 are 2.43 and 1.42 m^3/s, respectively. This equates to a mean annual unit runoffs of 39.8 and 43.0 $l/s/km^2$. A regional analysis, completed in 2012 (Rescan 2012), calculated mean annual unit runoff for the Stations NTWM-H1 and STWM-H1 to be 43.4 and 38.8 $l/s/km^2$, respectively. These values are considered to be of fairly good agreement with the synthetic values.

Table 3.2-1. Summary Statistics for Synthetic Flow Discharges for South Teigen Creek (Station NTWM-H1) by Month for the Period of Record (POR)

Monthly Flow Discharge Parameters					Monthly Flow Discharge Percentiles								
Month	Mean	Median	Min	Max	10th	20th	30th	40th	50th	60th	70th	80th	90th
Jan	0.31	0.31	0.29	0.36	0.25	0.27	0.28	0.29	0.31	0.32	0.33	0.35	0.39
Feb	0.38	0.40	0.33	0.45	0.19	0.26	0.29	0.33	0.40	0.42	0.46	0.51	0.59
Mar	0.35	0.32	0.23	0.51	0.09	0.18	0.21	0.26	0.32	0.38	0.44	0.56	0.67
Apr	0.90	0.90	0.52	1.45	0.61	0.64	0.79	0.87	0.90	0.96	1.03	1.08	1.22
May	3.90	3.65	1.29	7.97	2.16	2.46	2.96	3.47	3.65	4.28	4.48	5.24	5.83
Jun	8.43	8.16	5.05	13.47	6.45	6.95	7.40	7.86	8.16	8.34	9.21	9.99	10.96
Jul	5.91	5.84	3.91	8.89	3.98	4.79	5.03	5.42	5.84	6.00	6.49	7.07	7.89
Aug	2.69	2.69	1.41	4.93	2.02	2.23	2.40	2.58	2.69	2.77	2.90	3.13	3.39
Sep	2.35	2.18	0.94	7.48	1.46	1.70	1.88	1.99	2.18	2.31	2.59	2.90	3.27
Oct	2.73	2.10	0.78	16.09	1.04	1.25	1.44	1.63	2.10	2.36	2.99	3.48	5.63
Nov	1.02	0.89	0.65	2.44	0.63	0.72	0.81	0.84	0.89	1.02	1.12	1.21	1.66
Dec	0.12	0.11	0.11	0.17	0.11	0.11	0.11	0.11	0.11	0.11	0.12	0.12	0.15
POR	2.43	2.43	0.11	16.09	2.04	2.16	2.26	2.35	2.43	2.59	2.66	2.78	2.97

Flows are expressed as m^3/s.

As per the guideline for fish-bearing streams, the maximum diversion rate is set to the 80th percentile and is based on the entire period of record (POR). For Stations NTWM-H1 and STWM-H1, the 80th percentile was determined to be 2.78 and 1.53 m^3/s, as noted in Tables 3.2-1 and 3.2-2. These discharge values represent the estimated maximum flow discharges that can be diverted at any time from the two creeks.

The minimum required monthly instream flows were derived from the data provided in Tables 3.2-1 and 3.2-2. The results are calculated as described in section 2, and presented in Tables 3.2-3 and 3.2-4.

Suggested ratios of instream flow threshold to mean monthly flow are more than 100% for most of the months (Tables 3.2-4 and 3.2-5). That is, for drier than normal years, no reduction to the baseline flows are allowed. Nevertheless, proposed operational flows (Appendix 13-B) in Tables 3.2-5 and 3.2-6 show flow reduction in South Teigen Creek for all months of year during the first 45 years of the Project. In North Treaty Creek, flow reduction is seen between years 25 to 30 and years 45 to 56 of operation. Further investigation is required to determine whether the proposed operational flows will lead to HADD.

Table 3.2-2. Summary Statistics for Synthetic Flow Discharges for North Treaty Creek (Station STWM-H1) by Month for the Period of Record (POR)

Monthly Flow Discharge Parameters					Monthly Flow Discharge Percentiles								
Month	Mean	Median	Min	Max	10th	20th	30th	40th	50th	60th	70th	80th	90th
Jan	0.29	0.27	0.25	0.38	0.19	0.22	0.23	0.26	0.27	0.30	0.33	0.37	0.41
Feb	0.36	0.38	0.31	0.43	0.18	0.25	0.28	0.31	0.38	0.40	0.43	0.48	0.56
Mar	0.32	0.27	0.22	0.46	0.09	0.18	0.20	0.23	0.27	0.34	0.38	0.51	0.64
Apr	1.03	1.03	0.55	1.72	0.66	0.69	0.89	0.98	1.03	1.09	1.19	1.25	1.42
May	3.03	2.99	1.30	5.99	1.91	2.11	2.59	2.86	2.99	3.12	3.48	3.78	4.07
Jun	4.29	4.02	2.08	8.46	2.95	3.26	3.56	3.83	4.02	4.13	4.68	5.26	5.85
Jul	3.23	2.89	1.82	6.65	1.86	2.31	2.42	2.64	2.89	3.02	3.34	4.16	5.37
Aug	1.33	1.34	0.76	2.28	1.04	1.13	1.21	1.29	1.34	1.37	1.42	1.53	1.64
Sep	0.97	0.97	0.23	2.84	0.48	0.60	0.73	0.84	0.97	1.04	1.21	1.37	1.52
Oct	1.23	1.09	0.40	4.89	0.57	0.70	0.83	0.91	1.09	1.20	1.33	1.50	2.25
Nov	0.53	0.47	0.35	1.22	0.34	0.38	0.43	0.45	0.47	0.53	0.58	0.62	0.84
Dec	0.39	0.32	0.31	1.08	0.29	0.30	0.30	0.30	0.32	0.32	0.35	0.38	0.55
POR	1.42	1.40	0.22	8.46	1.21	1.28	1.34	1.37	1.40	1.43	1.46	1.53	1.61

Flows are expressed as m^3/s.

Table 3.2-3. Monthly Flow Discharge Thresholds for NTWM-H1 as Determined using the Guidelines in Hatfield *et al*. (2003)

Month	Mean Baseline Flow (m^3/s)*	Instream Flow Threshold (m^3/s)	Ratio of Instream Flow Threshold to Mean Monthly Baseline Flow
Jan	0.30	0.39	127.0%
Feb	0.27	0.54	196.4%
March	0.29	0.65	225.2%
April	0.63	1.14	180.5%
May	4.03	4.28	106.2%
June	7.76	6.95	89.6%
July	5.11	5.43	106.2%
Aug	3.00	2.86	95.2%
Sept	3.98	2.67	67.1%
Oct	2.61	3.17	121.7%
Nov	1.15	1.50	130.5%
Dec	0.56	0.16	27.6%

** Based on hydrometric monitoring during 2008 to 2011.*
Flows expressed as m^3/s.

Table 3.2-4. Monthly Flow Discharge Thresholds for STWM-H1 as Determined using the Guidelines in Hatfield *et al*. (2003)

Month	Mean Baseline Flow (m^3/s)*	Instream Flow Threshold (m^3/s)	Ratio of Instream Flow Threshold to Mean Monthly Baseline Flow
Jan	0.24	0.41	172.1%
Feb	0.27	0.51	193.8%
March	0.28	0.64	228.0%
April	0.72	1.23	169.7%
May	3.22	2.84	88.3%
June	4.08	3.26	80.0%
July	2.75	2.65	96.1%
Aug	1.45	1.42	98.0%
Sept	1.55	1.28	82.3%
Oct	1.06	1.37	129.8%
Nov	0.50	0.82	165.2%
Dec	0.35	0.52	150.7%

** Based on hydrometric monitoring during 2008 to 2011.*
Flows expressed as m^3/s.

Table 3.2-5. Comparison of Instream Flow Thresholds, Based on Hatfield et al. 2003, and Proposed Operational Flows for South Teigen Creek (NTWM-H1)

Month	Flow Threshold (m^3/s)	Baseline Flow (m^3/s)	Operational Flow (m3/s)					
			Years 0-24	Years 25-30	Years 30-45	Years 45-50	Years 51-56	Years 57+
Jan	0.39	0.30	0.25	0.25	0.25	0.32	0.32	0.31
Feb	0.54	0.27	0.21	0.21	0.21	0.27	0.27	0.26
Mar	0.65	0.29	0.24	0.24	0.24	0.30	0.30	0.29
Apr	1.14	0.63	0.51	0.51	0.51	0.63	0.63	0.60
May	4.28	4.03	3.29	3.29	3.29	3.96	3.96	3.62
Jun	6.95	7.76	6.21	6.21	6.21	7.62	7.62	7.12
Jul	5.43	5.11	4.24	4.24	4.24	5.24	5.24	5.16
Aug	2.86	3.00	2.49	2.49	2.49	3.02	3.02	2.97
Sep	2.67	3.98	3.23	3.23	3.23	3.90	3.90	3.75
Oct	3.17	2.61	2.16	2.16	2.16	2.71	2.71	2.68
Nov	1.50	1.15	0.94	0.94	0.94	1.22	1.22	1.24
Dec	0.16	0.56	0.47	0.47	0.47	0.59	0.59	0.59
MAD		2.47	2.02	2.02	2.02	2.48	2.48	2.38

Table 3.2-6. Comparison of Instream Flow Thresholds, Based on Hatfield et al. 2003, and Proposed Operational Flows for North Treaty Creek (STWM-H1)

Month	Flow Threshold (m^3/s)	Baseline Flow (m^3/s)	Operational Flow (m3/s)					
			Years 0-24	Years 25-30	Years 30-45	Years 45-50	Years 51-56	Years 57+
Jan	0.41	0.24	0.23	0.19	0.28	0.19	0.17	0.24
Feb	0.51	0.27	0.25	0.20	0.29	0.20	0.18	0.25
Mar	0.64	0.28	0.27	0.22	0.32	0.22	0.20	0.28
Apr	1.23	0.72	0.69	0.56	0.79	0.56	0.50	0.71
May	2.84	3.22	3.10	2.46	3.41	2.46	2.26	3.27
Jun	3.26	4.08	3.88	3.09	4.41	3.09	2.85	4.12
Jul	2.65	2.75	2.65	2.16	3.12	2.16	1.93	2.62
Aug	1.42	1.45	1.39	1.13	1.60	1.13	1.02	1.34
Sep	1.28	1.55	1.48	1.21	1.67	1.21	1.08	1.48
Oct	1.37	1.06	1.02	0.83	1.23	0.83	0.74	1.05
Nov	0.82	0.50	0.47	0.39	0.60	0.39	0.35	0.49
Dec	0.52	0.35	0.34	0.27	0.42	0.27	0.24	0.35
MAD		1.37	1.31	1.06	1.51	1.06	0.96	1.35

4. Conclusions and Recommendations

The report has presented the results from the completed flow threshold analysis for the proposed Tailings Management Facility (TMF). The analysis was conducted at the location of South Teigen and North Treaty creeks' hydrometric stations (i.e., NTWM-H1 and STWM-H1), and involved the determination of the minimum instream flow discharge thresholds using a long-term dataset. This was required in order to minimize potential fish habitat and related aquatic losses due to the diversion of surface waters from the stream channels, as well to the construction of the TMF.

The flow threshold analysis was completed by first conducting a monthly regression analysis using the ranked monthly daily flow discharge data for these two creeks and four reference WSC stations. Then the British Columbia Instream Flow Guidelines for Fish and Fish Habitat (Hatfield *et al*. 2003) was applied to the generated synthetic flow discharge data for NTWM-H1 and STWM-H1 to estimate the instream flow thresholds in different calendar months.

Since these thresholds are not met by the Project, further assessment must be conducted by applying the Instream Flow Assessment Methods (Lewis at al. 2004) to determine whether exceeding the minimum flow threshold will lead to a HADD. Such an assessment is provided in the accompanying memo report (Instream Flow Assessment- Impacts of the Project on physical fish habitat) where impacts of the Project on physical habitat are estimated.

The analysis for determining the instream flow discharge thresholds is limiting at this time because it has been based on the only three years data from NTWM-H1 and STWM-H1 and the reference WSC stations. However, more realistic results can be expected once additional flow records are obtained. As the project moves into the design phase, it is anticipated that any additional flow information collected at the South Teigen and North Treaty hydrometric stations will improve the modelling results that have been presented in this analysis.

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- Appendix A -

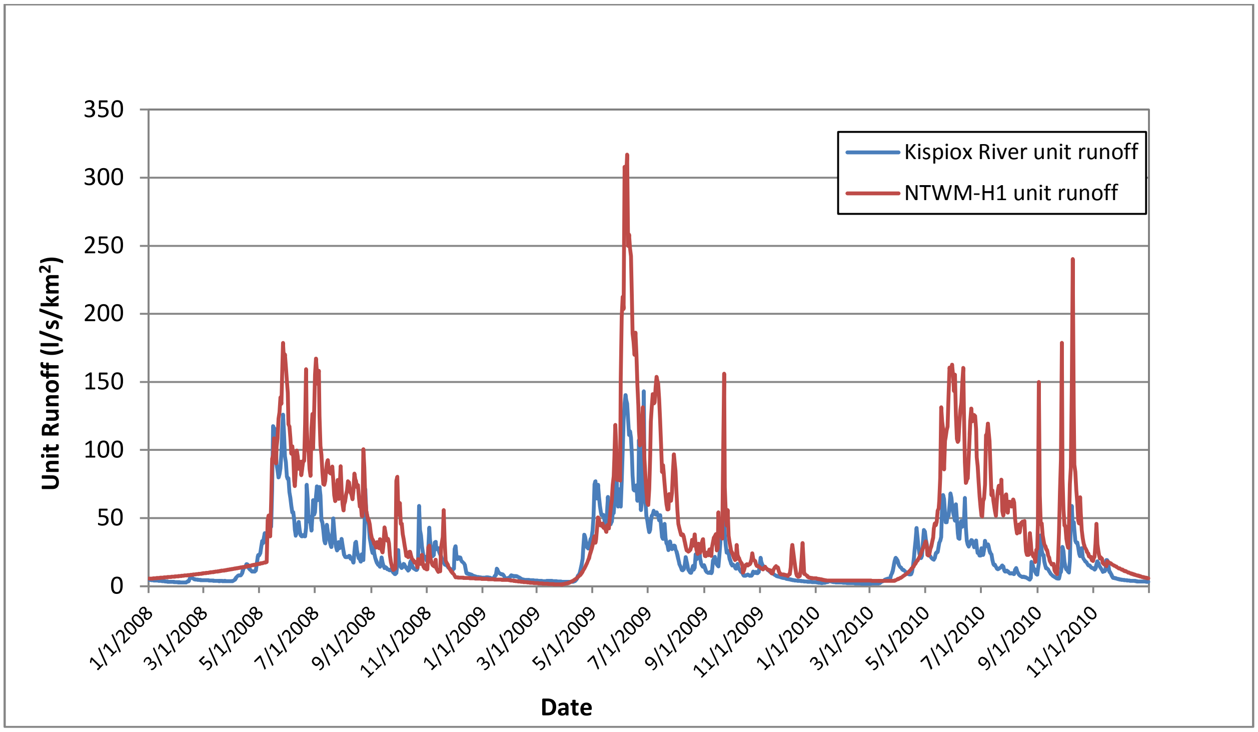

Figure 3-1. Comparison of Daily Unit Runoff between South Teigen Creek and Kispiox River

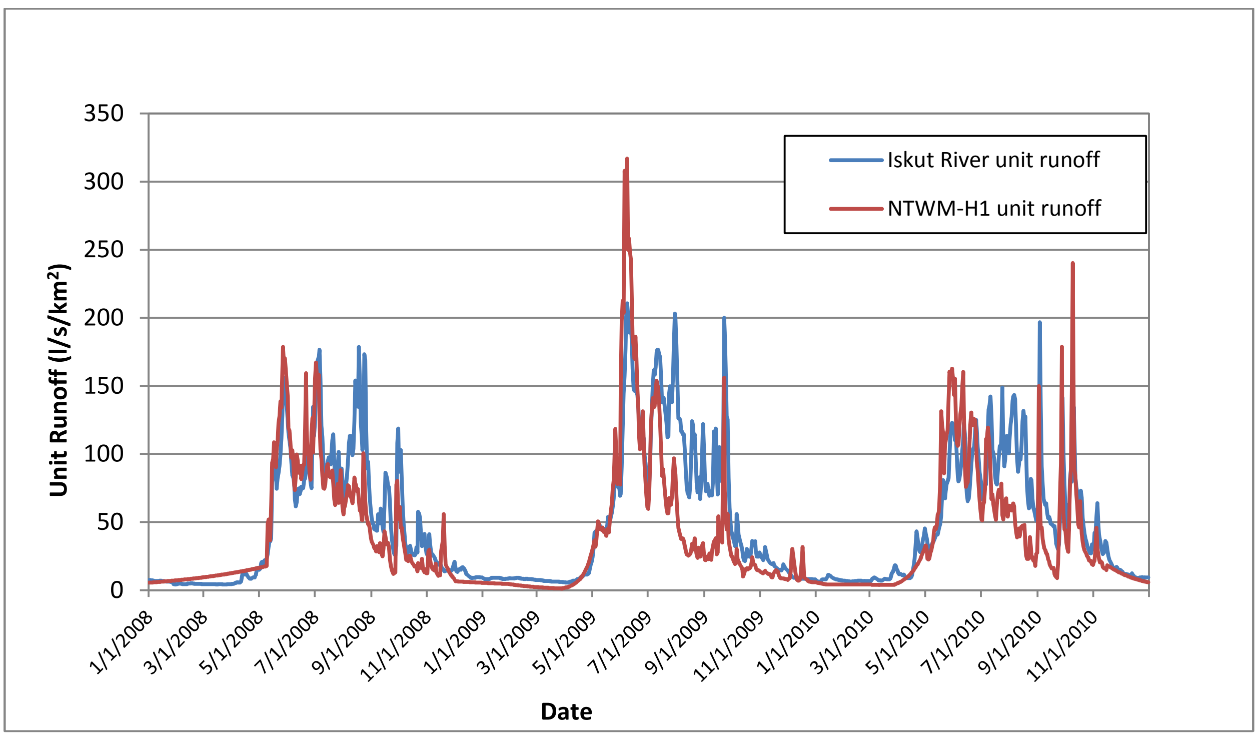

Figure 3-2. Comparison of Daily Unit Runoff between South Teigen Creek and Iskut River

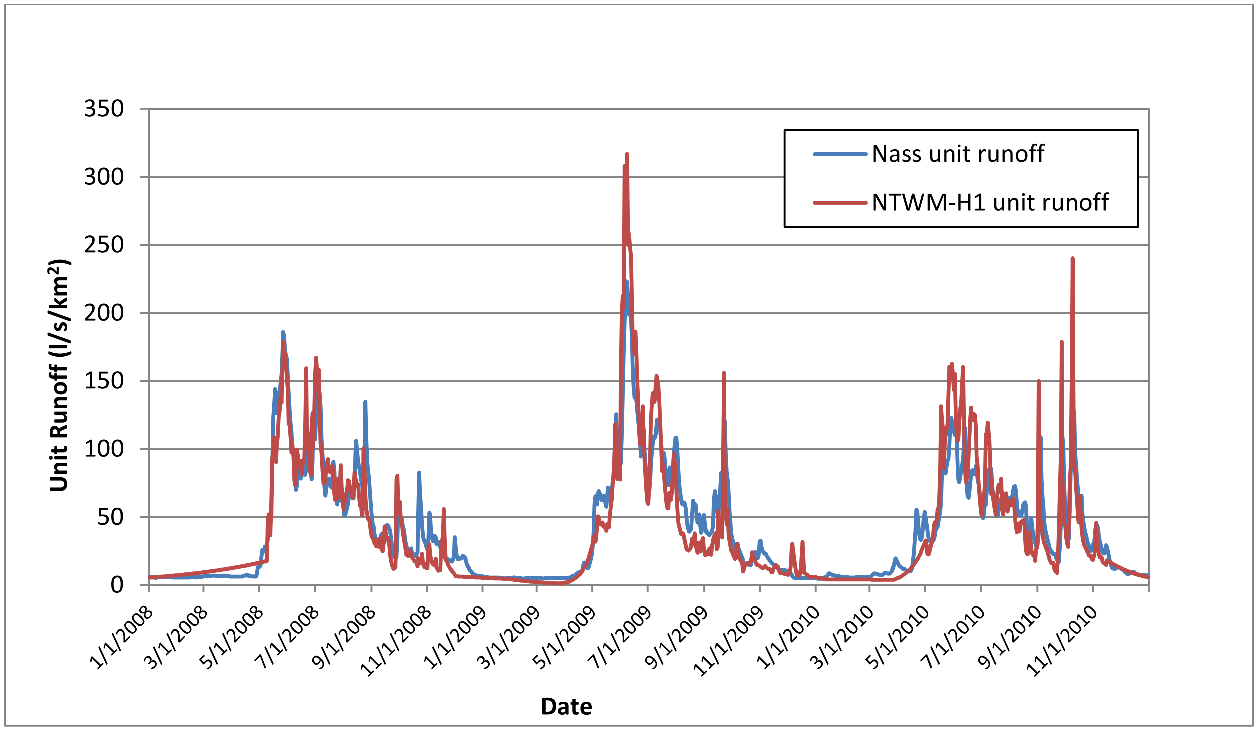

Figure 3-3. Comparison of Daily Unit Runoff between South Teigen Creek and Nass River

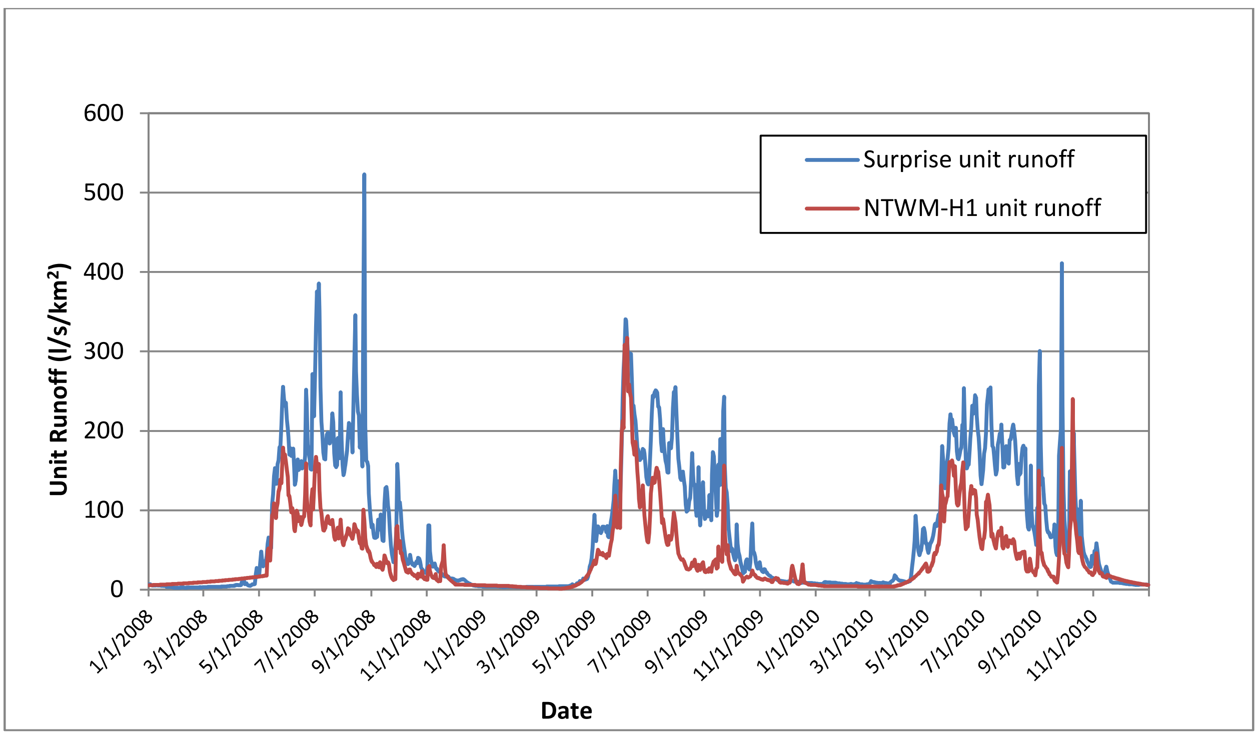

Figure 3-4. Comparison of Daily Unit Runoff between South Teigen Creek and Surprise Creek

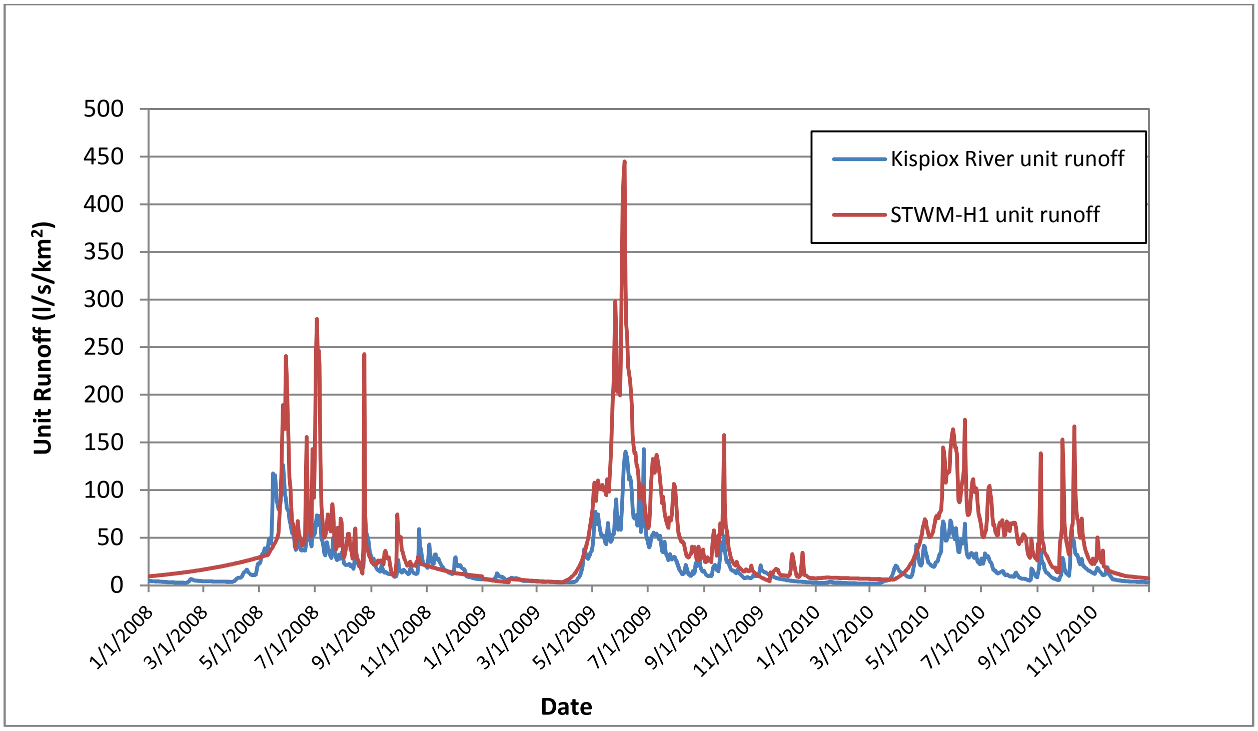

Figure 3-5. Comparison of Daily Unit Runoff between North Treaty Creek and Kispiox River

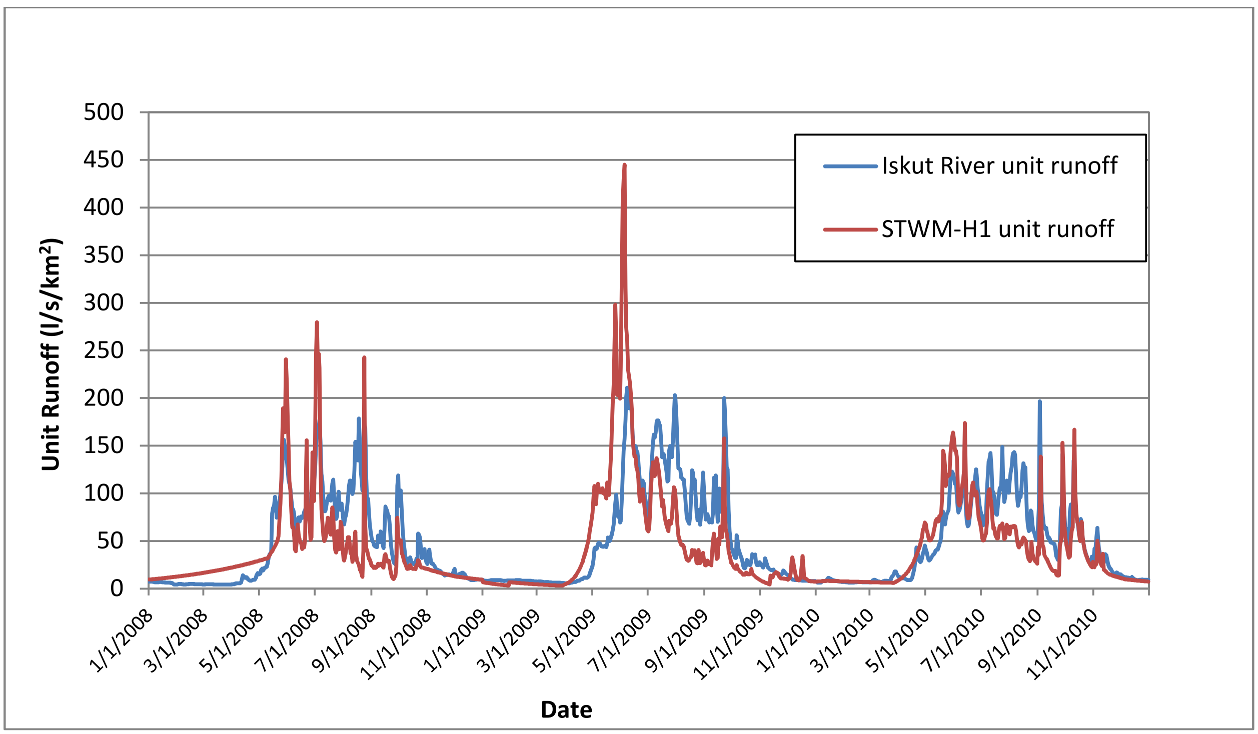

Figure 3-6. Comparison of Daily Unit Runoff between North Treaty Creek and Iskut River

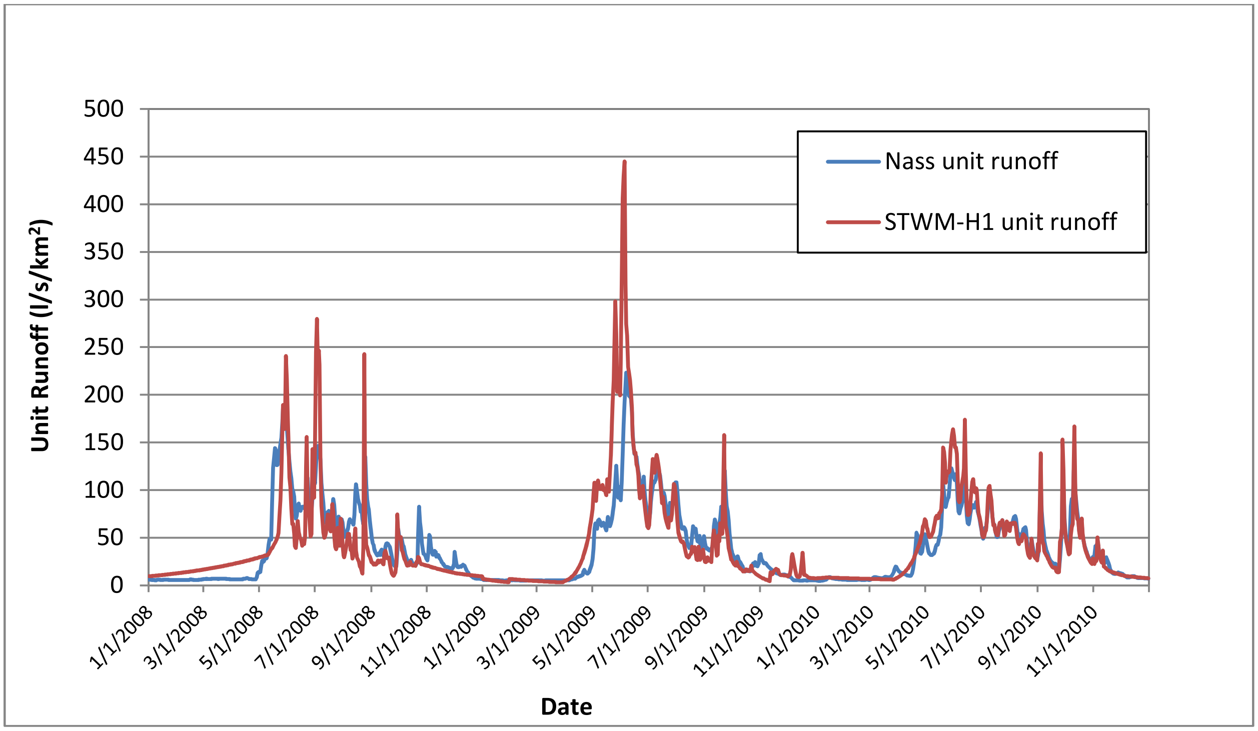

Figure 3-7. Comparison of Daily Unit Runoff between North Treaty Creek and Nass River

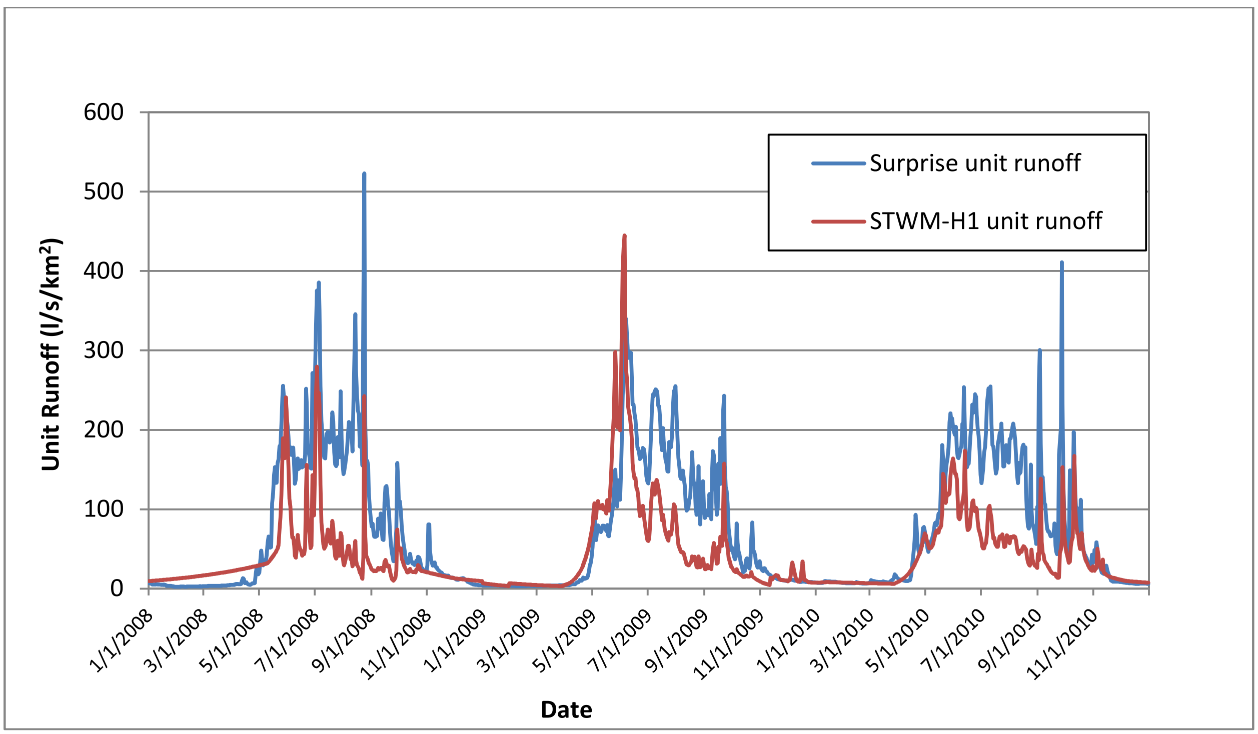

Figure 3-8. Comparison of Daily Unit Runoff between North Treaty Creek and Surprise Creek

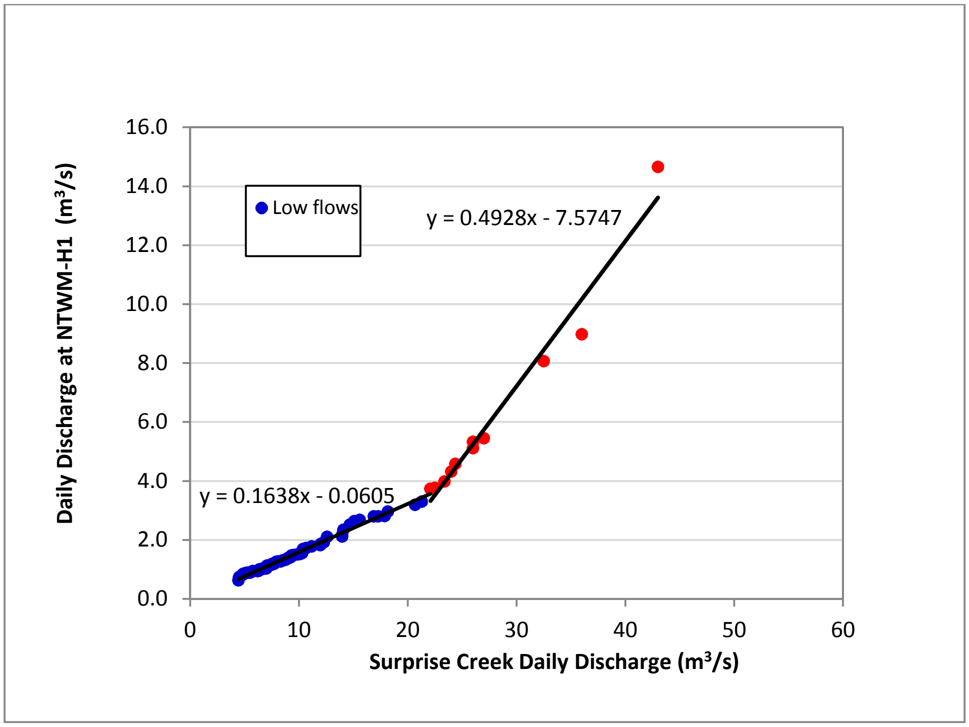

Figure 3-9. Regional Ranked Regression Analysis for NTWM-H1 - October

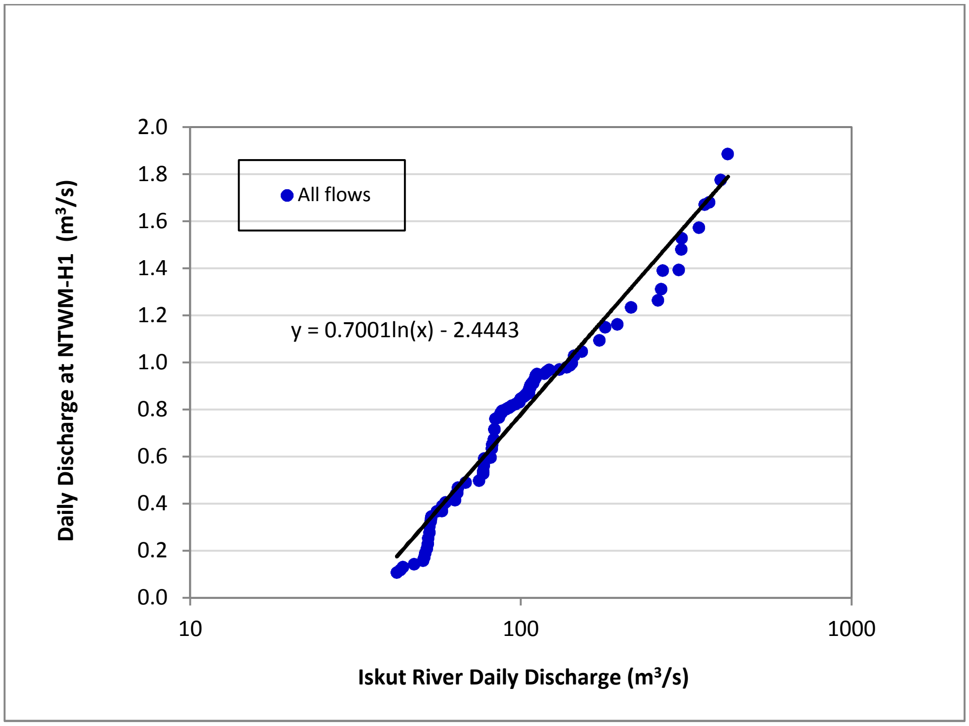

Figure 3-10. Regional Ranked Regression Analysis for NTWM-H1 - April

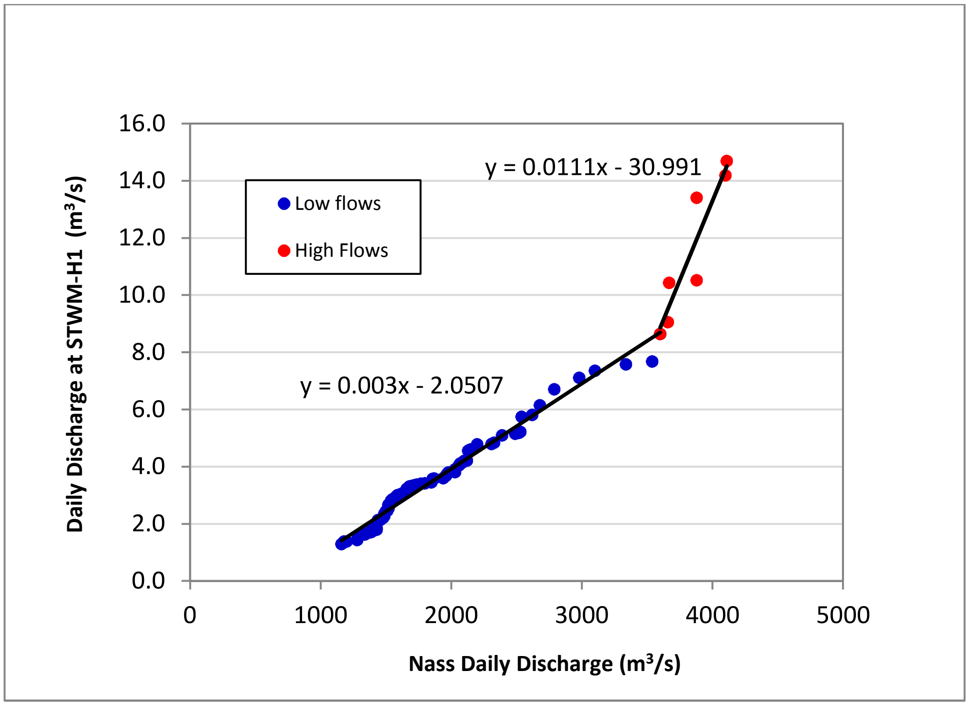

Figure 3-11. Regional Ranked Regression Analysis for STWM-H1 - June

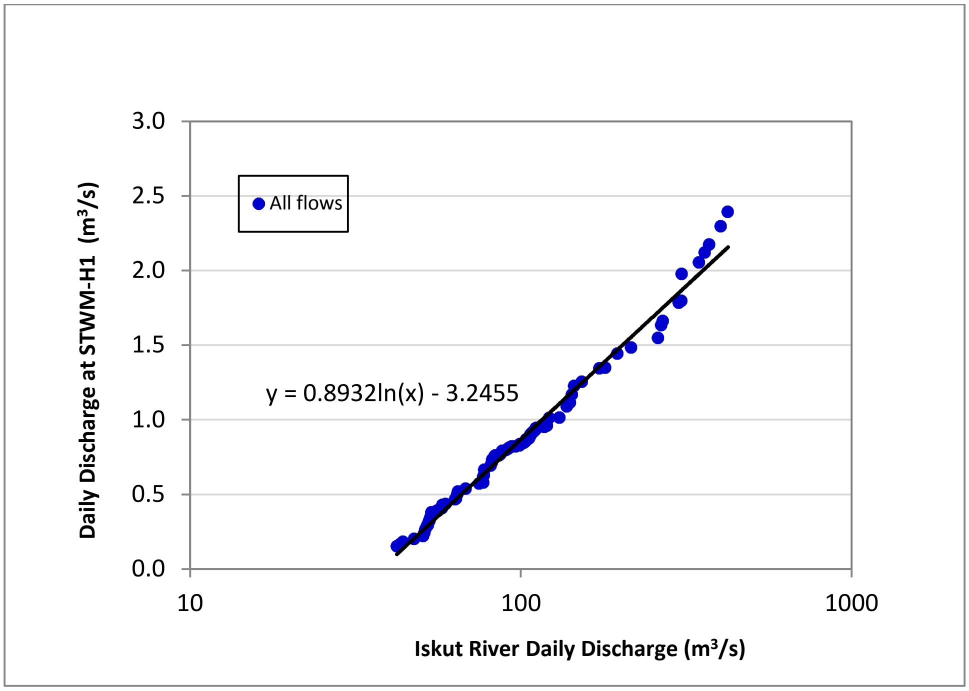

Figure 3-12. Regional Ranked Regression Analysis for STWM-H1 - April

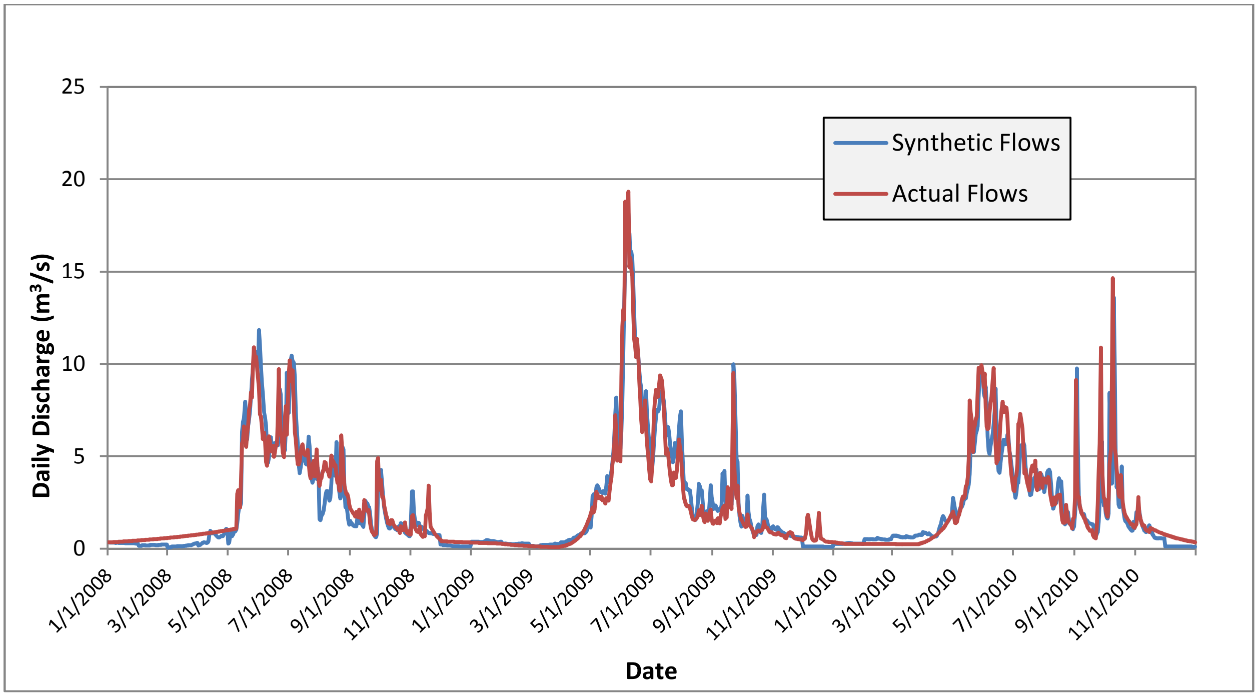

Figure 3-13. Comparison of Synthetic and Observed Hydrographs at NTWM-H1 during 2008 - 2010

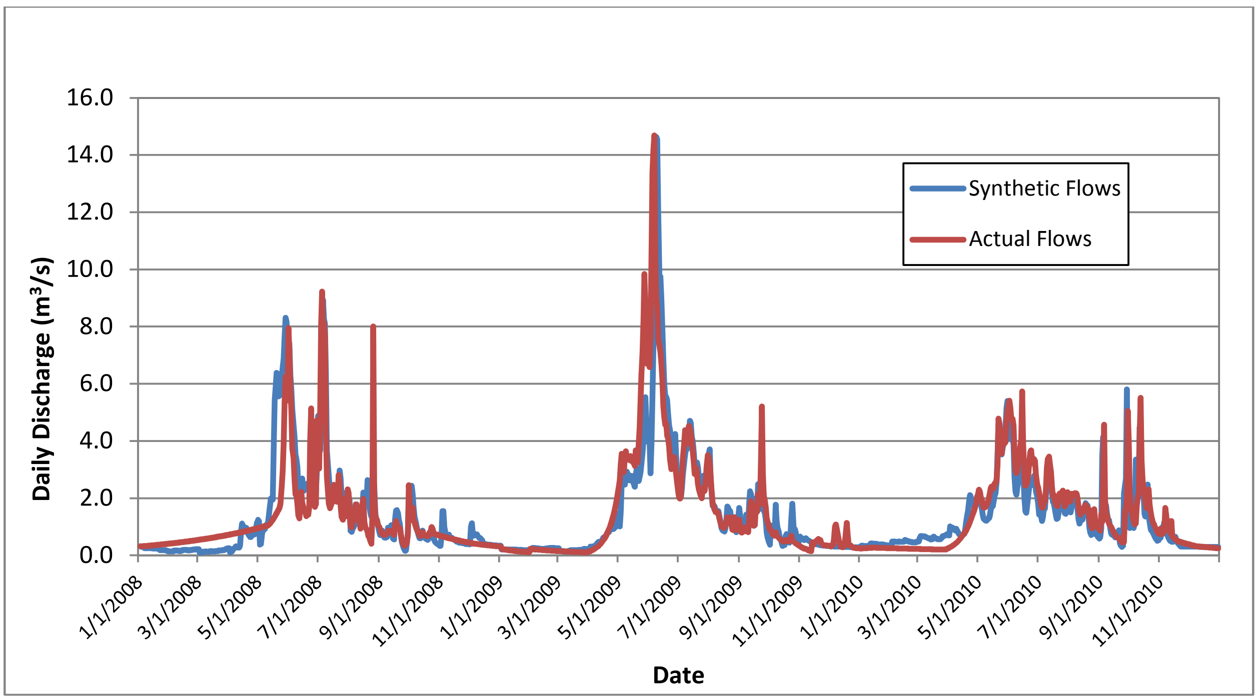

Figure 3-14. Comparison of Synthetic and Observed Hydrographs at STWM-H1 during 2008 - 2010

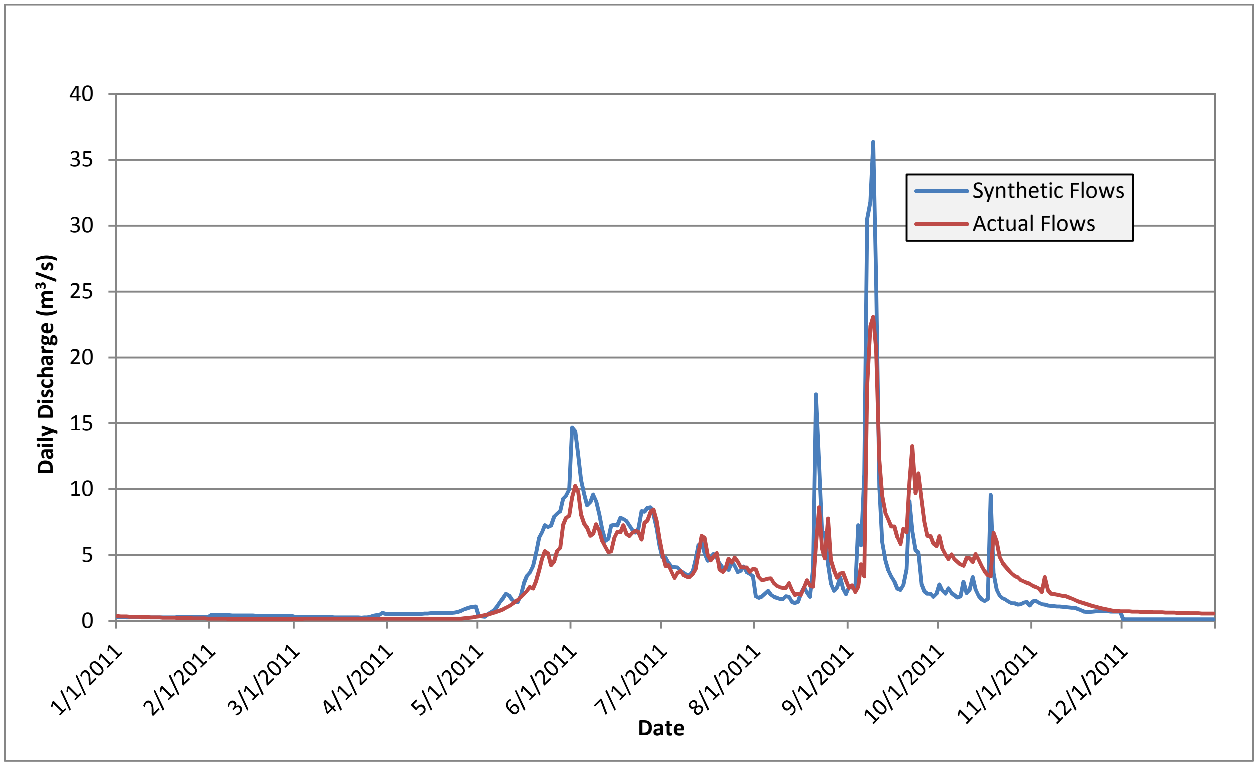

Figure 3-15. Comparison of Synthetic and Observed Hydrographs at NTWM-H1 during 2011

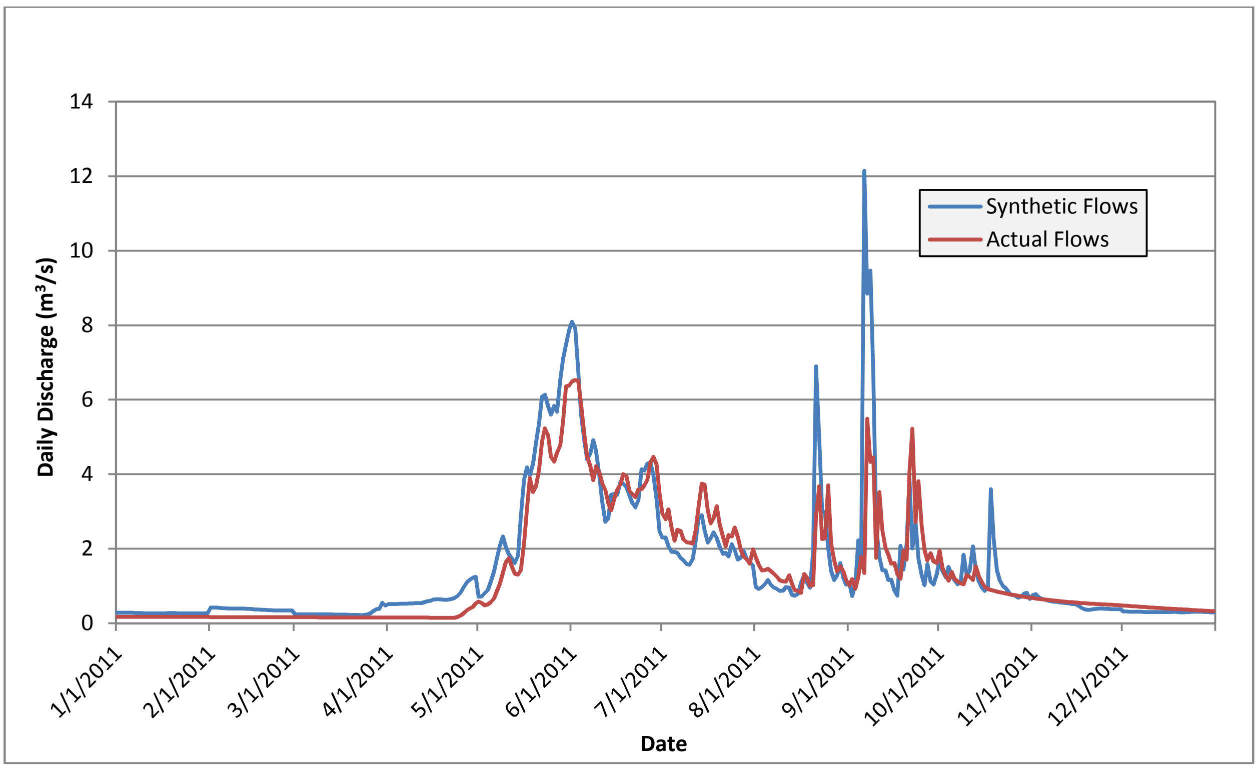

Figure 3-16. Comparison of Synthetic and Observed Hydrographs at STWM-H1 during 2011

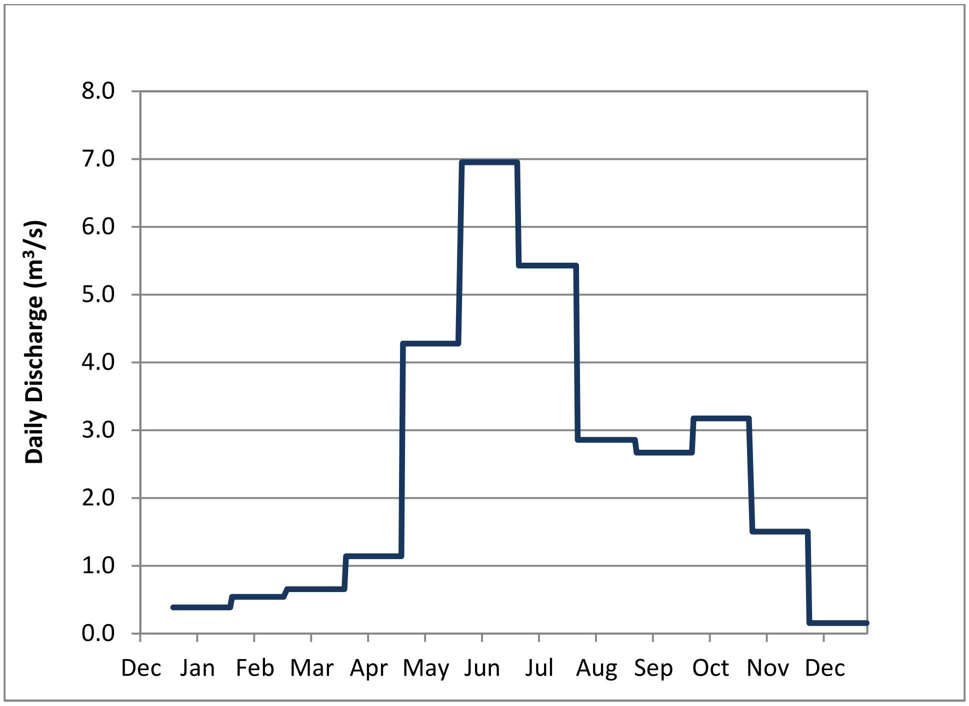

Figure 3-17. Instream flow threshold for South Teigen Creek (NTWM-H1) as Determined from the Proposed Guidelines for Fish-ebearing Streams (Hatfield *et al*. 2003)

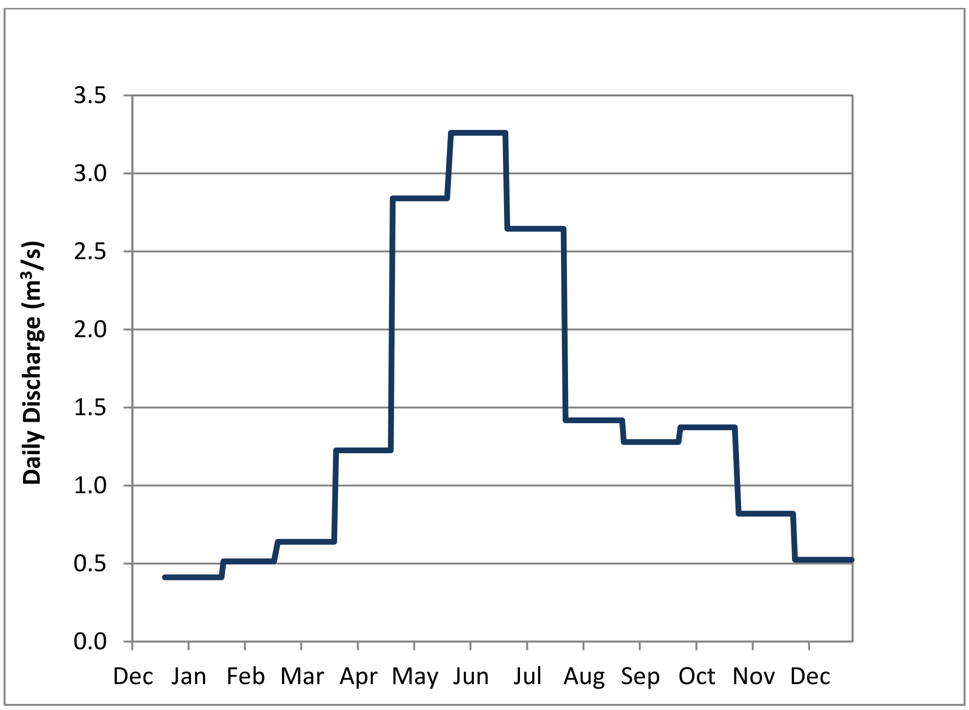

Figure 3-18. Instream flow threshold for North Treaty Creek (STWM-H1) as Determined from the Proposed Guidelines for Fish-ebearing Streams (Hatfield *et al*. 2003)