5 Hydrology and Aquatic Resources

Table 5-1 provides a summary of the reviewer comments and the location of the response.

Table 5-1 Hydrology and Aquatic Resources Table of Conformance

Reviewer	EAR Section	Reviewer Comment	Response Report Section Where Addressed
5 Hydrology and Aquatic Resources			
Environment Canada	Section 7.4.2.1; Section 7.4.2.2	**Monthly and Annual Evaporation Rates** Evaporation data – it is important to substantiate all input and output in the hydrology modeling.	Section 2.3
Environment Canada	Section 7.4.2.1	**Flow Records** A more complete site flow record is needed, and continuous flow records should be produced.	Section 5.1; Appendix B4
YTG- Environment Yukon	Section 7.4.2.1; Table 7.4-2	**Hydrometric Data (Stream Flow)** Table 7.4.2 lists the regional hydrometric stations which are used in the hydrologic analyses. Tom Creek, an additional nearby hydrometric station, is not listed.	Section 5.1
YTG- Environment Yukon	Section 7.4.2.1	**Local Data** Detailed information on stream metering cross sections and techniques should be included, as well as instrument brand and model of the velocity meter and hydrometric station. Daily streamflow discharge averages should be provided in the appendix.	Section 5.1; Appendices B4 and B5
YTG- Environment Yukon	Section 7.4.2.1; Table 7.4-7	**Peak Flow Analyses** Peak flow estimates – no specific details of the calculations are provided.	Section 5.1.1
YTG- Environment Yukon	Section 7.4.2.2	**Stream Flows – Predicted Mean Monthly and Mean Annual Flows** Independent estimates of mean annual flow for the project drainages yielded values which were significantly lower, with values which were a factor of 5 to 7 lower for the smaller basins and a factor of 2 lower for the larger basis.	Section 5.1.2
YTG- Environment Yukon	Section 7.4.2.2; Table 7.4-7	**Peak Flows** Peak Flows – details of the calculations should be provided to allow assessment of the methodology. It would be worthwhile reassessing the methodology used to calculate these estimates.	Section 5.1.1
YTG- Environment Yukon	Section 7.4.2.2; Table 7.4-9	**Low Flows** Independent estimates of the minimum summer flows yielded values which were significantly lower, with values which were a factor of 6 to 11 lower for smaller basins, and a factor of 3 lower for larger basins.	Section 5.1.3
Environment Canada	Section 7.4.2.1; Table 7.4-4	**Streamflow Analysis** We note that some of the stations in this table are not in the GLL report – the basis for these values should be produced. The catchment area for W44 is incorrectly stated. Also, there is an error in the GLL report for average November flow at W12.	Section 5.1; Appendix B4

Reviewer	EAR Section	Reviewer Comment	Response Report Section Where Addressed
		Underlying work for these flow predictions should be presented in the document, and there should be a concerted effort to compare estimates against site data to enhance predictions. A more complete site flow record is needed, and continuous flow records should be produced so reviewers can better assess the work done to predict hydrologic conditions.	
Environment Canada	Section 7.4.2.1	**Frequency Analysis** Frequency analysis has been conducted on a mean annual flow basis for station W12 to indicate flows for different return periods. This should be presented on a monthly basis, and the implications discussed.	Section 5.1.2
Fisheries and Oceans Canada	Section 7.4 and 9.2	**Mitigation Measures** Ensure that mitigation measures included in our 23 December 2004 letter are included into your plans.	Section 5.2.2

5.1 Regional Hydrometric Information

This section should be reviewed in association with the EAR Section 7.4 and is not intended as a stand-alone section.

Peak flow, mean annual flow, mean monthly flow, and low flow for drainages of interest within the Wolverine project area have been re-evaluated. The response to comments has been incorporated into the method of analysis, the number of hydrometric stations used to perform the analysis has been expanded, and where possible predicted results have been verified against observed data. This analysis is only capable of capturing regional trends, and therefore some watershed-to-watershed variation must be expected. Nonetheless, the resultant predictions of peak, mean monthly, mean annual and low flow can be inferred from the observed data as described below.

In the EAR, five Water Survey of Canada (WSC) gauged hydrometric stations were used to estimate peak, mean monthly, mean annual, and low flows. These stations were King Creek, Big Creek, Liard River, Frances River and Rancheria River. As per comments from YTG Water Resources in 2005 and 2006, (R. Janowicz, 2005 pers. comm.), another regional WSC gauge station, at Tom Creek, was added to the analysis.

The analysis was expanded to include stations in the neighbouring Pelly Mountains, Cassiar Mountains and Yukon Plateau ecoregions, The WSC hydrometric network site map (Environment Canada, 2006b) was reviewed and additional WSC gauges were selected for the analysis, particularly concentrating on gauged watersheds under 1000 km², which were under represented in the original analysis. Seven candidate gauges were identified. Record durations and watershed areas for 13 gauges used in subsequent flow analyses are listed in Table 5-2 and shown on Figure 5-1.

Table 5-2 WSC Gauges used for Revised Flow Analysis

Station ID	Name	Years of Record	Drainage Area (km²)
10AB003	King Creek @ Nahanni Range Road	1975-1994	13.7
10AA001	Liard River @ Upper Crossing	1960-2004	33400
10AB001	Frances River nr. Watson Lk.	1962-2004	12800
10AA004	Rancheria R. nr Mouth	1985-2004	5100
10AA005	Big Creek @ Alaska Highway	1989-2004	986
10AA002	Tom Creek @ R.C. Highway	1974-1993	435
09AD002	Sidney Creek @ Mouth	1982-1994	372
09AG003	South Big Salmon R. below Livingstone Cr.	1982-1996	515
10BE009	Teeter Creek @ mouth	1979-2004	211
10BE008	Geddes Creek @ mouth	1979-1996	77.8
09BA002	180 Mile Creek @ Canol Highway	1975-1993	81.9
09AE003	Partridge Creek near Mouth	1978-1994	61.2
09BB001	Boulder Creek @ Canol Highway	1978-1990	60.9

Figure 5-1 Regional Hydrologic Stations (Figures Section)

5.1.1 Peak Flow Analysis

For each hydrometric station, the observed annual series of instantaneous peak floods obtained from the WSC website, (WSC, 2006), were analyzed with the Consolidated Frequency Analysis (CFA) program of Environment Canada. CFA fits five parametric and one non-parametric distribution to the observed data to predict expected flood magnitudes for 2-year to 500-year return periods.

For 180 Mile Creek, Partridge Creek, and Boulder Creek, although the WSC lists these stations on its hydrometric network, the hydrometric data (HYDAT) website does not present hydrometric data. For these stations, the record of annual peak floods was obtained from the Yukon Hydrometric Manual (Environment Yukon, 2006a), after a discussion with Lynne Campo of WSC (Campo, L. 2005 pers. comm.). For four of the thirteen hydrometric stations (Partridge Creek, 180 Mile Creek, Boulder Creek and Big Creek) there were discrepancies between the drainage area listed by WSC and the drainage area given in the Yukon Hydrometric Manual. After consultation with the WSC (L. Campo, 2005) and Yukon Environment (R. Janowicz 2005), revised drainage areas were determined for these watersheds. Finally, for 180 Mile Creek, one anomalously large flood recorded in 1988 (related to ice jams) was excluded from the record of instantaneous peak flows.

For Partridge Creek, the instantaneous peak flow data is strongly bimodal, with floods larger than 15 m³/s and smaller than 9 m³/s, but no reported floods in the range of 9 to 15 m³/s. For mixed data like this, the distributions used by CFA provide a generally poor fit to the observed data. A program written by Dr. Younes Alila of UBC called MD.exe was used to fit a mixed distribution to the observed data for Partridge Creek. For all other stations, the six distributions used by CFA were plotted against the observed data and compared visually. Distributions that provided obviously poor fits for a station were excluded from the analysis, and the remaining results were averaged to estimate expected instantaneous peak flows for each station for return periods ranging from 2 to 500 years. The use of visual fits rather than statistical goodness-of-fit measures was chosen because CFA does not compute statistical measures of goodness of fit, and because once the obviously poor fits are eliminated, there is not a visually significant difference between the fits of the remaining distributions, meaning that a statistical analysis followed by the choice of one distribution would amount to choosing one distribution out of four or five that performed almost equally well. The results are presented in Table 5-3.

Table 5-3 Estimated 2-Year to 500-Year Instantaneous Peak Flow (m³/s) for WSC Gauges

		Mean Instantaneous Peak Flow by return period (m³/s)							
Stream Name	**Area (km²)**	**Q2**	**Q5**	**Q10**	**Q20**	**Q50**	**Q100**	**Q200**	**Q500**
Tom	435	19	27.5	32.6	37.5	43.6	48	52.5	58.6
King	13.7	1.34	1.71	1.94	2.14	2.39	2.56	2.72	2.93
Liard	33400	1727	2270	2615	2918	3267	3512	3740	4037
Rancheria	5100	259	380	472	561	680	777	880	1027
Frances	12800	669	834	935	1038	1158	1245	1335	1452
Big	607	33.4	51.9	66.8	85	108.1	128.4	152.1	189.3
Geddes	77.8	0.81	1.19	1.47	1.79	2.21	2.54	2.9	3.43
Teeter	211	3.21	5.08	6.29	7.41	8.79	9.79	10.77	12.06
Sidney	372	44.7	60.5	68.25	74.65	81.78	86.5	90.73	95.88

Table 5-3 Estimated 2-Year to 500-Year Instantaneous Peak Flow (m^3/s) for WSC Gauges (cont'd)

		Mean Instantaneous Peak Flow by return period (m^3/s)							
Stream Name	**Area (km^2)**	**Q2**	**Q5**	**Q10**	**Q20**	**Q50**	**Q100**	**Q200**	**Q500**
South Big Salmon	515	34.1	54.3	68.6	82.8	101.5	116.3	131.5	152.8
Partridge	59.7	8.5	14.1	18.1	19.3	23.7	25.9	28.2	31.1
Boulder	84.1	19.95	26.48	29.38	31.5	33.58	34.88	35.93	37.2
180 Mile	97.9	8.3	11.6	14.5	16.8	19.7	21.9	24.3	27.7

Of the 13 stations, 11 display generally similar regional trends, while two, Teeter Creek and Geddes Creek, exhibit significantly smaller floods. Examination of the annual hydrographs for Teeter Creek and Geddes Creek indicated that in these two drainages, the majority of peak flood events result from summer or fall rainfall, and that spring snowmelt floods are sometimes present and sometimes absent. For the remaining eleven watersheds, snowmelt and rain-on-snow events are the dominant peak flood generation mechanisms. Geddes Creek and Teeter Creek are therefore considered to be unrepresentative with respect to the Wolverine area, which consists of treeline and subalpine drainages in which snowmelt and rain-on-snow events are expected to be the dominant mechanism of peak flow generation. For the peak flow analysis, Geddes Creek and Teeter Creek were excluded.

In order to estimate expected peak flows for the drainages within the Wolverine project area, instantaneous peak flow was plotted against drainage area for each return period. Additionally, for the 10-year peak flood (Q10), estimates of the expected Omineca-Peace regional peak flood magnitude derived by Obedkoff (2000) were calculated for watersheds of 10, 100, 1000, and 10000 km^2 drainage area and added to the plot for comparative purposes. For the Q2, Q50, and Q100, estimates of the regional mean annual flood, Q50 and Q100 derived by Beaumont (1991) were also calculated for the same reference drainage areas and plotted on the graphs for comparative purposes. The relationship derived from the 11 regional stations plots slightly below the Obedkoff and Beaumont predictions, but shows a similar trend.

In the original six station analysis, not enough stations were below 100 km^2 to detect a difference in the performance of small and large watersheds. Beaumont (1991), Obedkoff (2000) and Beckers, Alila and Mtiraoui (2002) all found differences in the peak flow response of small and large watersheds, with a decrease in the slope of the power-law relationship for larger watersheds compared to smaller watersheds. With the increase from six to eleven stations, such a decrease becomes evident, although the magnitude of the effect is not great. Figure 5-2 shows the relationship for area and discharge for Q2, Q10, Q50 and Q100. The complete suite of peak instantaneous discharges from Q2 to Q500 with the summary data is available in Appendix B1.

Using the power-law relationships calculated from the plots of regional hydrometric station drainage area verses discharge, the magnitude of the expected peak floods for each return period has been calculated for the water gauging sites within the Wolverine area. These values are presented in Figure 5-2.

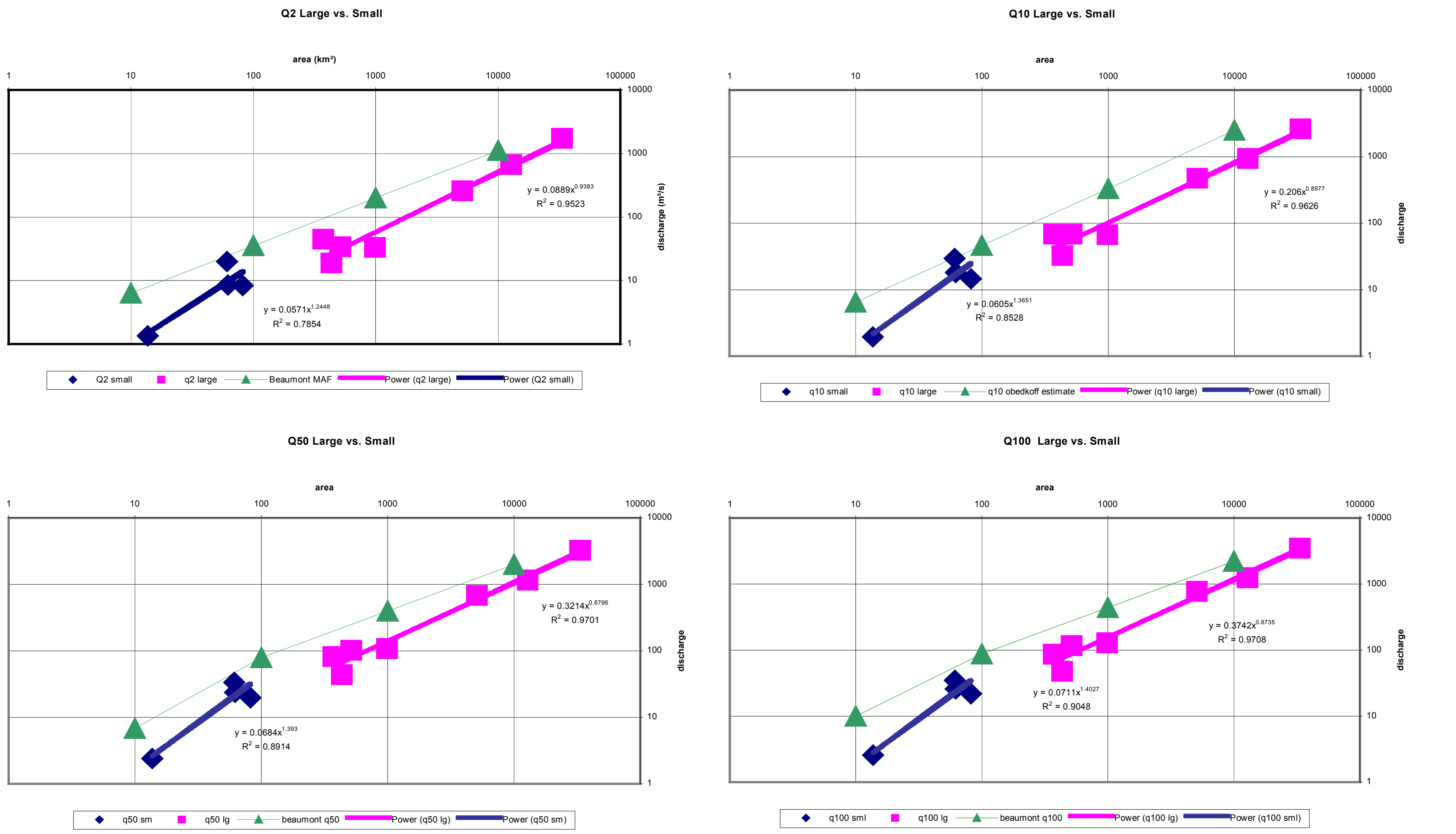

Figure 5-2 Peak Instantaneous Discharge (m^3/s) by Drainage Area for Q2, Q10, Q50 and Q100 Periods

Table 5-4 Expected Instantaneous Peak Flow (m^3/s) by Return Period for Specified Watersheds within the Wolverine Project Area

Watershed	Drainage Area (km^2)	Q2	Q5	Q10	Q20	Q50	Q100	Q200	Q500
W1 Nougha Creek at Lake	209	13.36	20.36	24.93	29.54	34.17	39.79	44.48	51.08
W8 Campbell Creek	7.2	0.67	0.82	0.90	0.97	1.07	1.13	1.19	1.26
W9 Wolverine Creek	1.7	0.111	0.122	0.125	0.135	0.143	0.150	0.154	0.160
W11 Money above Go	194	12.46	19.03	23.31	27.65	32.02	37.28	41.70	47.90
W12 Go above Pup	36.5	5.03	6.96	8.21	9.01	10.26	11.05	11.82	12.81
W13 Pup above Go	7	0.64	0.79	0.86	0.94	1.03	1.09	1.14	1.21
W14 Money below Go	238	15.10	22.91	28.01	33.15	38.28	44.57	49.79	57.12
W15 Hawkowl above Go	9.8	0.98	1.23	1.36	1.49	1.64	1.75	1.84	1.96
W16 Go above Hawkowl	10.2	1.03	1.29	1.44	1.57	1.74	1.85	1.95	2.07
W18 Upper Go	3.5	0.27	0.32	0.33	0.36	0.39	0.41	0.43	0.45
W19 Upper Hawkowl	6.5	0.59	0.71	0.78	0.85	0.93	0.98	1.03	1.09
W21 Nougha @ Highway	287	17.99	27.16	33.14	39.16	45.08	52.49	58.58	67.10
W22 Money above Highway	425	26.01	38.80	47.14	55.51	63.52	73.96	82.36	94.07
W23 Money above Dollar	163	10.58	16.25	19.94	23.68	27.50	32.02	35.85	41.24
W31 Go at Airstrip	4.7	0.39	0.47	0.50	0.54	0.59	0.62	0.65	0.68
W40 Money below Highway	426	26.07	38.88	47.24	55.62	63.66	74.11	82.52	94.26
W44 below tailings dam	1.05	0.061	0.064	0.065	0.070	0.073	0.076	0.078	0.080
W80 compliance point	30.75	4.06	5.55	6.50	7.13	8.08	8.69	9.28	10.03

Although few measurements of peak floods have been made within the study area, two measurements made in May 2005 may approximate the Q2 discharge. During field measurements made at Stations W15 and W16, flood stage was just overtopping the bank. The return period of bankfull discharge is often estimated at 1.5 to 2 years. The magnitudes of the observed bankfull discharges for these two stations (0.772 m^3/s at Station W15 and 0.975 m^3/s at Station W16 – from EAR Table 7.4-6) are quite close to the predicted Q2's for these two stations. This indicates that the estimates of peak flow may be valid.

Where possible, predicted values were verified against field measurements. A Swoffer 2100 Current Velocity Meter was used for field measurements. Automated hydrometric stations vary slightly, W12 is a ChartPac with a PS 9800 transducer, W21 is a ChartPac (CP-X), and W22 is an RT2X pressure transducer and datalogger. Detailed information on stream metering data and techniques are available in Appendix B5, which provides the field notes compiled for sample calculations. The complete set of field notes is available upon request.

5.1.2 Mean Monthly and Mean Annual Flow

Ten of the 13 stations used in the peak flow analysis were used for the analysis of mean monthly and mean annual flow. Partridge, Boulder, and 180 Mile Creeks were not used in the analysis of mean monthly and mean annual because their daily and monthly flow records had significant gaps making the estimation of mean flows difficult. Mean monthly and annual flows over the period of gauged record are computed by the WSC and obtained from the WSC website (WSC, 2006.) The mean monthly flows by month, mean annual flow, and mean annual yield (flow per unit area) are presented in Table 5-5. Mean monthly flows for Wolverine and Go Creek stations, plus two stations at Money Creek are shown in Figure 5-3. All supporting data and a complete year of mean monthly and mean annual flows are documented in Appendix B2.

Figure 5-3 Mean Monthly Flows (m^3/s) for Stations near the Wolverine Project (Figures Section)

In general, the watersheds show similar mean annual yields, with the exception of Geddes Creek, which has significantly lower yield than do the other watersheds. Teeter Creek is the second lowest, but is not much lower than South Big Salmon or Tom Creek. When the mean monthly flows are plotted against drainage area (Figure 5-4), there is a generally strong power-law relationship between monthly flow and drainage area. As was noted for peak flows, Geddes Creek and Teeter Creek do not experience significant snowmelt floods most winters. This results in much lower monthly flows for the snowmelt-fed months (May, June and July) and explains much of the difference in mean annual flow. During the winter months, Teeter Creek and Geddes Creek do not display differing flow regimes from the other watersheds.

Table 5-5 Observed Mean Monthly and Mean Annual Flow (m/s^3) and Mean Annual Yield by Watershed

Drainage	Tom	Liard	King	Frances	Rancheria	Big	Geddes	Sidney	Teeter	South Big Salmon
Area (km²)	**435**	**33400**	**13.7**	**12800**	**5100**	**986**	**77.8**	**372**	**211**	**515**
Jan	0.565	97.3	0.027	33.9	15.1	2.76	0.116	1.07	0.703	0.691
Feb	0.466	79.3	0.024	26.7	12.6	2.38	0.114	0.875	0.639	0.472
Mar	0.439	70	0.02	23.1	11	2.24	0.118	0.772	0.597	0.393
April	0.801	84.8	0.021	25.9	12.8	3.01	0.22	1.05	0.762	0.549
May	8.86	548	0.246	182	74.2	13.5	0.349	9.48	1.72	4.87
June	8.91	1280	0.467	545	164	20.6	0.234	16.9	1.87	13.3
July	5.91	784	0.274	367	103	11.6	0.258	7.49	1.75	9.33
Aug	2.66	450	0.132	219	55.7	7.09	0.197	3.72	1.46	5.96
Sept	2.51	402	0.105	180	53	7.52	0.214	3.74	1.31	5.64
Oct	2.42	331	0.093	143	45	6.29	0.197	3.42	1.28	3.7
Nov	1.3	174	0.055	77.9	27	4.14	0.153	1.87	0.989	1.78
Dec	0.795	128	0.034	48.7	20	3.35	0.132	1.43	0.853	1.06
Mean Annual	3.00	370	0.126	157	49.7	7.03	0.191	4.30	1.16	4.02
Mean Annual Yield (m³/s/km²)	0.0069	0.011078	0.009197	0.012266	0.0097451	0.0071	0.002455	0.011559	0.005498	0.007805825

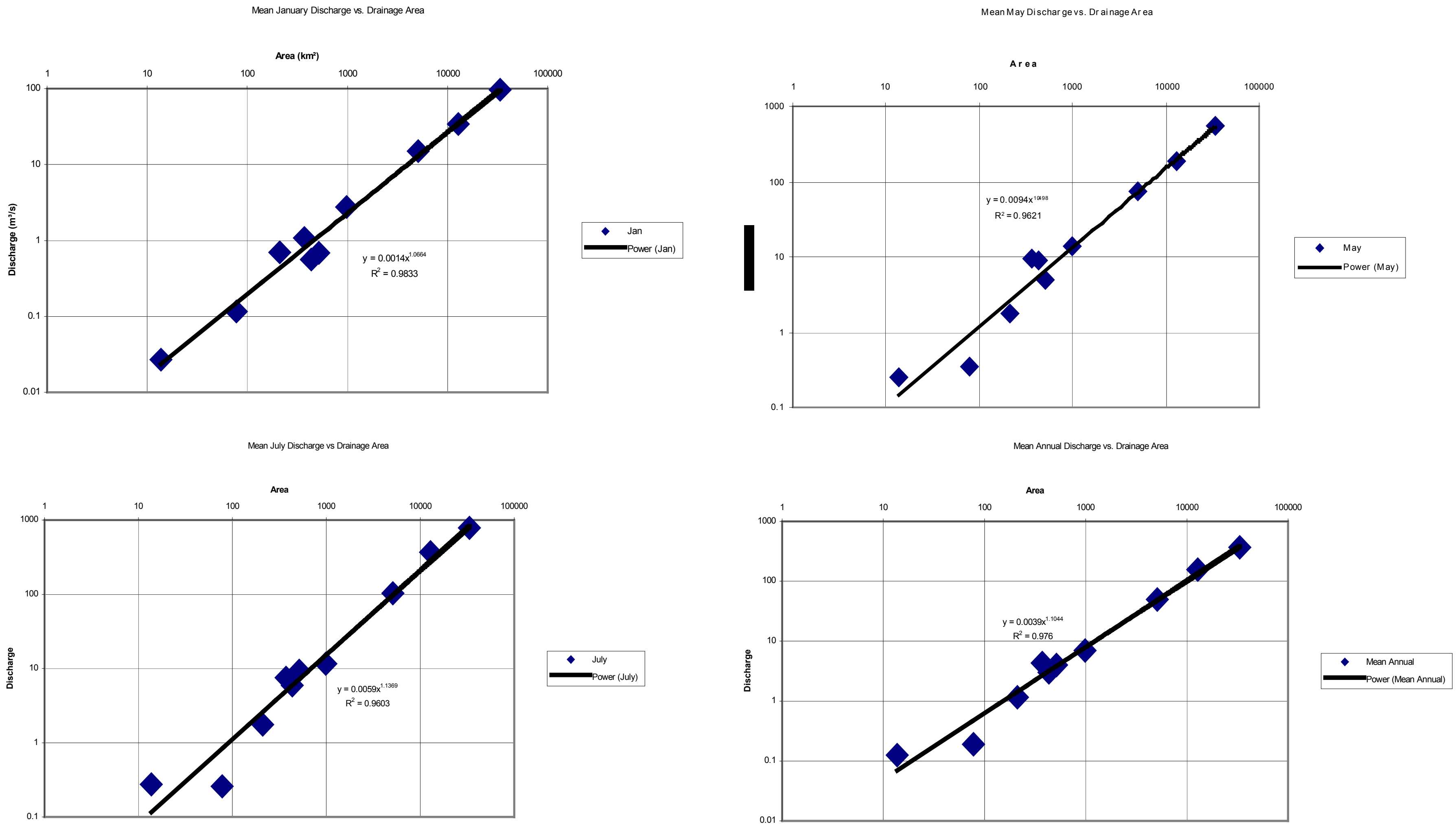

Figure 5-4 Plots of Mean Monthly Discharge (m^3/s) vs. Drainage Area (km^2) for Selected Months

The power-law equations determined from the plots of monthly and annual flow against drainage area were used to estimate mean monthly and mean annual flow for the drainages within the project area. The results are presented in Table 5-5 and compared to the observed flows (EAR Table 7.4-6) these predicted flows are within the range of observed flows. Although it would be wrong to expect the observed flows to match the predicted mean flows, the observed flows do cluster around the predicted monthly means – some above and some below. No systematic deviations between observed and predicted monthly flow were noted (for instance, all observations higher or lower than predicted).

Mean monthly or annual flow during wet and dry years can be predicted using the values in Table 5-6, which apply to the annual year, and frequency analysis of annual runoff presented as EAR Table 7.4-5.

5.1.3 Low Flow

For the analysis of low flow, only seven hydrometric stations were used of the thirteen hydrometric stations identified. Geddes and Teeter Creeks sometimes experience higher flows in winter than in summer, a pattern which is not observed in the other creeks or within the Wolverine project area, and were excluded from the analysis. Liard River was not used in the low flow analysis because the preceding peak flow and mean monthly flow analyses had shown that Liard River performed similarly to Frances River and Rancheria River, and including Liard River in the analyses did not significantly increase the predictive power of the models at the scale of drainages within the project area. Again, Boulder, 180 Mile and Partridge Creeks had significant gaps in the daily flow records which meant that they were unsuitable for calculating low flows.

For each of the seven stations, daily flow records for each year from the WSC (WSC, 2006) were analyzed and the lowest seven-day period in each of the summer (ice absent) and winter (ice present) seasons was identified. The daily flow over the seven-day periods was averaged to evaluate seven-day low flow for each season. Then, the records of yearly seven-day low flows were analyzed using the Low Flow Frequency Analysis (LFA) program of Environment Canada. LFA fits the Gumbel Extreme Value III distribution to the observed data. Fits were generally good.

From the LFA analysis, 7-day low flows were predicted for each station for periods ranging from the 7Q2 (7-day 2-year low flow) to the 7Q500 (7-day 500-year low flow). These values were then plotted against drainage area to determine power low relationships between drainage area and summer and winter seven-day low flows.

King Creek, the smallest WSC gauged station, experienced two zero flows in its period of record. In the LFA analysis, the return period for zero flow in King Creek was determined to be nineteen years. When plotting low flow vs. drainage area on log-log plots, zero values are difficult to display. A surrogate value of 0.001 m^3/s (1 L/s) was therefore chosen as representing the lower limit of measurement, and used to represent zero flow for the analysis. Figure 5-5 shows plots of summer and winter low flow against drainage area for selected return periods.

Table 5-6 Expected Mean Monthly and Mean Annual Flow (m^3/s) by Drainage for Wolverine Project Area

Watershed	Drainage Area (km^2)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean annual
W1 Nougha Creek at Lake	209	0.417	0.380	0.343	0.470	2.563	3.719	2.562	1.530	1.418	1.255	0.787	0.549	1.424
W8 Campbell Creek	7.2	0.011	0.011	0.010	0.015	0.075	0.074	0.056	0.034	0.032	0.030	0.020	0.014	0.035
W9 Wolverine Creek	1.7	0.0025	0.0024	0.0023	0.0034	0.0164	0.0139	0.0108	0.0066	0.0062	0.0060	0.0043	0.0030	0.0070
W11 Money above Go	194	0.385	0.351	0.317	0.436	2.371	3.410	2.354	1.406	1.303	1.156	0.726	0.506	1.311
W12 Go above Pup	36.5	0.065	0.061	0.055	0.079	0.410	0.490	0.352	0.212	0.198	0.180	0.119	0.083	0.207
W13 Pup above Go	7	0.011	0.011	0.010	0.015	0.072	0.072	0.054	0.033	0.031	0.029	0.020	0.014	0.033
W14 Money below Go	238	0.479	0.435	0.392	0.537	2.938	4.324	2.970	1.772	1.642	1.450	0.906	0.631	1.643
W15 Hawkowl above Go	9.8	0.016	0.015	0.014	0.021	0.103	0.106	0.079	0.048	0.045	0.042	0.029	0.020	0.049
W16 Go above Hawkowl	10.2	0.017	0.016	0.015	0.021	0.108	0.111	0.083	0.050	0.047	0.044	0.030	0.021	0.051
W18 Upper Go	3.5	0.005	0.005	0.005	0.007	0.035	0.032	0.025	0.015	0.014	0.013	0.009	0.007	0.016
W19 Upper Hawkowl	6.5	0.010	0.010	0.009	0.014	0.067	0.066	0.050	0.030	0.028	0.026	0.018	0.013	0.031
W21 Nougha @ Highway	287	0.585	0.530	0.477	0.650	3.576	5.375	3.675	2.191	2.028	1.786	1.109	0.773	2.021
W22 Money above Highway	425	0.889	0.799	0.718	0.972	5.400	8.481	5.742	3.418	3.160	2.764	1.698	1.182	3.118
W23 Money above Dollar	163	0.320	0.293	0.264	0.365	1.975	2.786	1.931	1.154	1.071	0.952	0.601	0.419	1.082
W31 Go at Airstrip	4.7	0.007	0.007	0.007	0.010	0.048	0.045	0.034	0.021	0.020	0.018	0.013	0.009	0.022
W40 Money below Highway	426	0.892	0.801	0.720	0.974	5.414	8.504	5.757	3.427	3.169	2.771	1.702	1.185	3.126
W44 tailings dam	1.05	0.0015	0.0015	0.0014	0.0021	0.0099	0.0079	0.0062	0.0038	0.0036	0.0035	0.0025	0.0018	0.0041
W80 compliance point	30.75	0.054	0.051	0.046	0.066	0.343	0.401	0.290	0.174	0.163	0.149	0.098	0.069	0.171

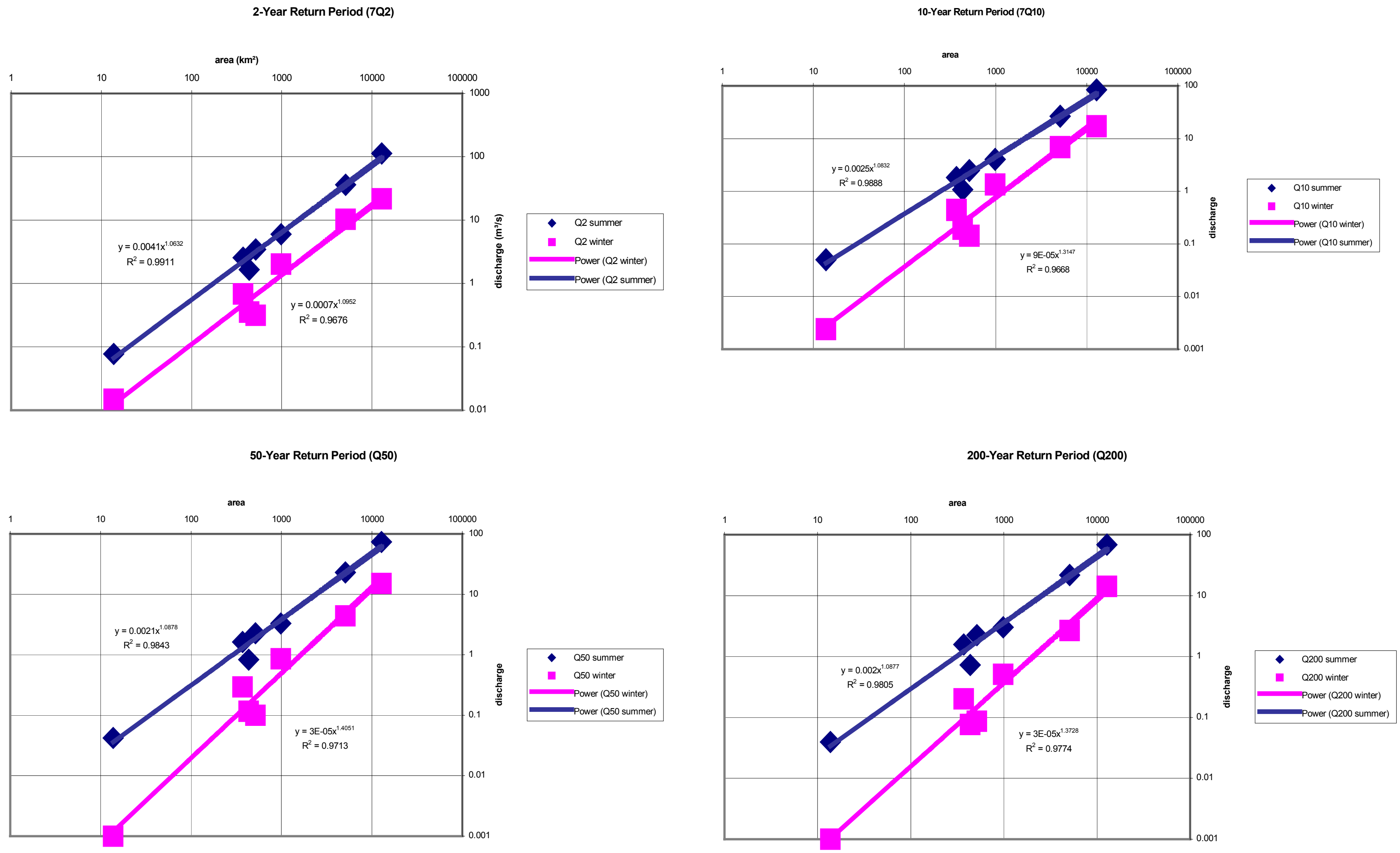

Figure 5-5 Summer and Winter 7-Day Low Flow (m^3/s) for Selected Return Periods

Table 5-7 and winter low flows calculated to be less than 0.001 m^3/s (1 L/s) have been set to zero to represent the stream in question freezing solid.

Table 5-7 Expected 7-day Summer Low Flows (m^3/s) For Wolverine Project Area

Watershed	Drainage Area (km²)	7Q2	7Q5	7Q10	7Q20	7Q50	7Q100	7Q200	7Q500
W1 Nougha Creek at Lake	209	1.2011	0.9184	0.8149	0.7623	0.7016	0.6678	0.6678	0.6324
W8 Campbell Creek	7.2	0.0334	0.0243	0.0212	0.0196	0.0180	0.0171	0.0171	0.0162
W9 Wolverine Creek	1.7	0.0072	0.0051	0.0044	0.0041	0.0037	0.0036	0.0036	0.0034
W11 Money above Go	194	1.1096	0.8476	0.7518	0.7030	0.6470	0.6158	0.6158	0.5832
W12 Go above Pup	36.5	0.1879	0.1400	0.1231	0.1145	0.1051	0.1001	0.1001	0.0949
W13 Pup above Go	7	0.0325	0.0236	0.0206	0.0190	0.0174	0.0166	0.0166	0.0158
W14 Money below Go	238	1.3790	1.0565	0.9381	0.8778	0.8081	0.7692	0.7692	0.7283
W15 Hawkowl above Go	9.8	0.0464	0.0339	0.0296	0.0274	0.0251	0.0239	0.0239	0.0227
W16 Go above Hawkowl	10.2	0.0484	0.0354	0.0309	0.0287	0.0263	0.0250	0.0250	0.0237
W18 Upper Go	3.5	0.0155	0.0112	0.0097	0.0090	0.0082	0.0078	0.0078	0.0074
W19 Upper Hawkowl	6.5	0.0300	0.0218	0.0190	0.0176	0.0161	0.0153	0.0153	0.0145
W21 Nougha @ Highway	287	1.6827	1.2927	1.1490	1.0758	0.9906	0.9429	0.9429	0.8927
W22 Money above Highway	425	2.5544	1.9737	1.7580	1.6480	1.5184	1.4452	1.4452	1.3680
W23 Money above Dollar	163	0.9221	0.7026	0.6226	0.5819	0.5353	0.5096	0.5096	0.4826
W31 Go at Airstrip	4.7	0.0212	0.0154	0.0134	0.0124	0.0113	0.0108	0.0108	0.0102
W40 Money below Highway	426	2.5608	1.9787	1.7624	1.6522	1.5223	1.4489	1.4489	1.3715
W44 below tailings dam	1.05	0.0043	0.0031	0.0026	0.0024	0.0022	0.0021	0.0021	0.0020
W80 compliance point	30.75	0.1566	0.1164	0.1022	0.0951	0.0872	0.0831	0.0831	0.0787

Table 5-8 gives the expected 7-day summer (ice absent) and winter (ice present) low flows, respectively, for the drainages within the study area.

Table 5-8 Expected 7-day Winter Low Flows (m^3/s) for the Wolverine Project Area

Watershed	Drainage Area (km²)	7Q2	7Q5	7Q10	7Q20	7Q50	7Q100	7Q200	7Q500
W1 Nougha Creek at Lake	209	0.2433	0.1212	0.1011	0.0598	0.0546	0.0504	0.0459	0.0389
W8 Campbell Creek	7.2	0.0061	0.0021	0.0012	0.0000	0.0000	0.0000	0.0000	0.0000
W9 Wolverine Creek	1.7	0.0013	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
W11 Money above Go	194	0.2242	0.1109	0.0916	0.0538	0.0492	0.0455	0.0415	0.0352
W12 Go above Pup	36.5	0.0360	0.0150	0.0102	0.0050	0.0047	0.0045	0.0042	0.0037
W13 Pup above Go	7	0.0059	0.0021	0.0012	0.0000	0.0000	0.0000	0.0000	0.0000
W14 Money below Go	238	0.2805	0.1417	0.1199	0.0720	0.0655	0.0604	0.0549	0.0463
W15 Hawkowl above Go	9.8	0.0085	0.0031	0.0018	0.0000	0.0000	0.0000	0.0000	0.0000
W16 Go above Hawkowl	10.2	0.0089	0.0032	0.0019	0.0000	0.0000	0.0000	0.0000	0.0000
W18 Upper Go	3.5	0.0028	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
W19 Upper Hawkowl	6.5	0.0054	0.0019	0.0011	0.0000	0.0000	0.0000	0.0000	0.0000
W21 Nougha @ Highway	287	0.3443	0.1773	0.1533	0.0939	0.0852	0.0784	0.0710	0.0595
W22 Money above Highway	425	0.5293	0.2840	0.2569	0.1641	0.1480	0.1352	0.1217	0.1008

Table 5-8 Expected 7-day Winter Low Flows (m^3/s) for the Wolverine Project Area (cont'd)

Watershed	Drainage Area (km^2)	7Q2	7Q5	7Q10	7Q20	7Q50	7Q100	7Q200	7Q500
W23 Money above Dollar	163	0.1853	0.0900	0.0729	0.0420	0.0385	0.0357	0.0327	0.0279
W31 Go at Airstrip	4.7	0.0038	0.0013	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
W40 Money below Highway	426	0.5307	0.2848	0.2577	0.1647	0.1485	0.1357	0.1221	0.1012
W44 below tailings dam	1.05	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
W80 compliance point	30.75	0.0298	0.0122	0.0081	0.0039	0.0037	0.0035	0.0033	0.0030

Notes: Winter low flows calculated to be less than 0.001 m^3/s (1 L/s) have been set to zero to represent the stream in question freezing solid.

Again, there are a few measurements made for the drainages within the project area under true low flow conditions that can be used to assess the accuracy of the predicted values. EAR Table 7.4-6 lists the measured flows. If the predicted values are accurate, then based on the mean annual hydrograph, the observed September flows should be slightly higher than the summer 7Q2, the observed November flows should be intermediate between the estimated summer 7Q2 and winter 7Q2, and the observed March flows should be slightly higher than the estimated winter 7Q2. A comparison of Table 5-7 with EAR Table 7.4-6 reveals that these assumptions are correct. The entire suite of flows from 7Q2 to 7Q500 and supporting data is described in Appendix B3.

5.2 Fisheries

5.2.1 Fisheries Study Area

The LSA includes all streams and associated waterbodies that may be influenced by mine construction and operation, and by use of the access road. This includes streams in the Money and Wolverine creek watersheds, and several headwater streams that will be crossed by the access road between the industrial complex and the Robert Campbell Highway.

The RSA includes water bodies and watersheds beyond the LSA that reflect the general region to be considered for cumulative effects and that provide suitable reference areas for sampling:

- Money Creek, upstream and downstream of the Go Creek confluence; and
- Wolverine Lake, Little Wolverine Lake and Nougha Creek, and larger streams near the access road that receive drainage from tributaries crossed by the road.

5.2.2 Stream Crossing Mitigation Measures

Adverse environmental effects will be minimized by incorporating best management practices into construction and maintenance activities as described in WLAP (2004). All mitigation measures detailed in the Fisheries and Oceans Canada letter dated December 23, 2004 will be adhered to during culvert installations along the permanent road route to ensure that any potentially adverse effects on fish and fish habitat will be mitigated. In addition to those mitigation measures outlined in EAR Section 9.2 Environmental Protection Plan (EPP), the following item will be incorporated:

- all waste materials removed from the worksite will be stabilized to prevent entry to waterbodies. This may include covering stockpiles with biodegradable mats or tarps or replanting stockpiles with grasses and/or shrubs.