DISCUSSION PAPER

Arrowsmith Water Service
Englishman River Water Intake Study
Phase 1 – Conceptual Planning

Discussion Paper 4-1 – Raw Water Quality

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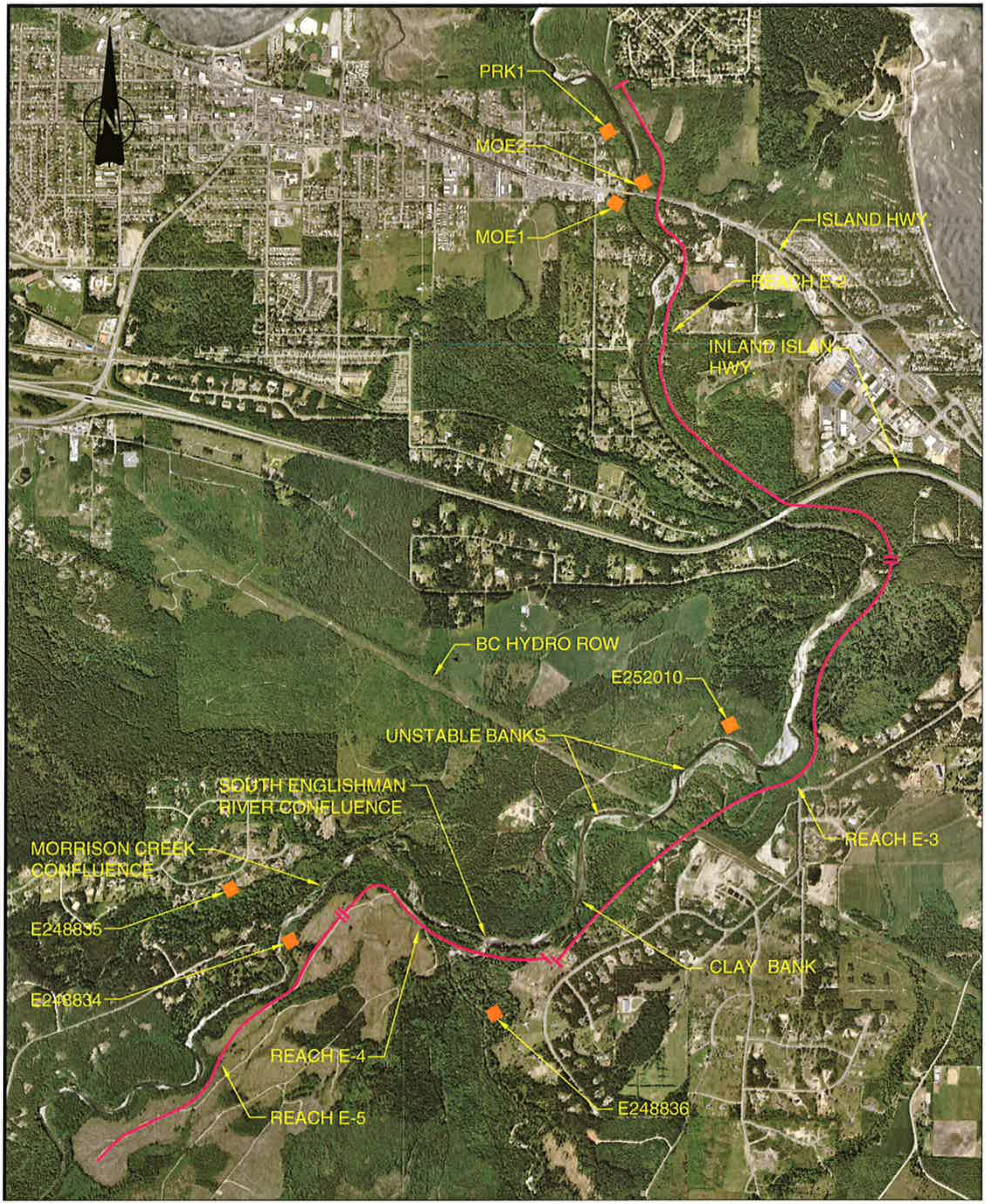
1 The Englishman River

The Englishman River passes through the eastern edge of the City of Parksville and serves as a potable water supply to the area, a source of recreational activities, a spawning ground for a variety of salmon, and a home for various bird species at the estuary. **Figure 1-1** shows the portion of the river that is of interest for this study. A study by LGL Limited, entitled *"A Strategy for Protection and Restoration of the Englishman River Mainstem, October 2005"*, partitioned the Englishman River into ten reaches, four of which are of interest. These four reaches are described below and shown in **Figure 1-1**.

E-2: The E-2 reach extends from the Island Highway (19A) crossing to the Inland Island Highway (19) crossing. Aerial photos taken from 1949 to 2002 show that the reach suffers from continuous channel instability, likely due to sediment delivery from upper basins and logging of the banks over 50 years ago (LGL, 2005).

E-3: E-3 extends from the Inland Highway (19) crossing to the South Englishman River confluence. A BC Hydro right-of-way (ROW) crosses through this reach. E-3 is considered the primary salmon spawning and rearing area of the river. This reach also suffers from the greatest degree of channel instability of the ten examined by LGL. A clay bank within the reach, located 150 m downstream of the South Englishman River, was long suspected of being the major source of sediment contributions. However, the studied rate of channel migration in this area indicated that the clay bank is not a significant sediment source (LGL, 2005). Instead, two banks, shown in **Figure 1-1**, were determined to be major sediment contributors due to their vulnerability during high flood discharges.

E-4: E-4 extends from the South Englishman River confluence to the Morrison Creek confluence. Some bank instability was observed, and three basins in the reach are believed to be sources of coarse sediment contributions.



PROJECT No.	20092356
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SCALE:	1 : 20000
DWG. No.	FIGURE 1-1

Associated Engineering

ARROWSMITH WATER SERVICE

ENGLISHMAN RIVER WATER INTAKE STUDY

MONITORING STATION LOCATIONS

P:\20092356\01_Concept_Planning\Engineering\03.00_Conceptual_Feasibility_Design\Task 4-1 Raw Water Quality Evaluation\FIG 1-1.dwg
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E-5: E-5 extends from Morrison Creek upstream for approximately 3.5 km. The area banks along this reach are reported to be relatively stable.

2 Monitoring Sites

Three water quality monitoring stations that are still active were identified along the Englishman River. Key station details are provided in **Table 2-1** and their approximate locations are shown in **Figure 1-1**. These stations and sources of information are described in the subsections below.

Table 2-1
Station Details

Station ID	Ownership	Alternative ID	Location		Date of Data	Sample Type
MOE 1	Ministry of Environment/ Water Survey Canada	**Federal:** 08HB002	49°19’00” N	124°17’51” W	2008-2009	15-minute intervals. Turbidity.
MOE 2	Ministry of Environment/ Environment Canada	**Federal:** BC08HB0019 **Provincial:** 0121580	49°18’57.6” N	124°17’07” W	2005-2009	Two-week intervals. Physical/ chemical, bacteriological.
PRK1	City of Parksville	-	49°19’09” N	124°17’09” W	2007-2008	5-minute intervals. Turbidity.

2.1 PRK1

At the intake of the Arrowsmith Water Service (AWS) disinfection facility, the City of Parksville has collected grab water samples and has an online turbidimeter. The turbidimeter sampling tube is located in the infiltration gallery, beneath the Englishman River gravel bed at an approximate depth of 2.2 m. As the turbidimeter is located in the filtration gallery the measured turbidity may be lower than the levels measured directly from the river. The turbidimeter is also impacted during the periodic back-flushing of the filtration gallery, where air bubbles and escaping trapped sediment can cause false readings. The dates that back-flushing occurred were removed from the turbidity data set used in this paper.

2.2 MOE1

The BC Ministry of Environment (MOE) has a turbidimeter mounted to a hydrometric river monitoring station belonging to Water Survey Canada. Turbidity data was available from this station for December 21, 2007 through to June 30, 2009.

During the summer of 2008 the MOE1 turbidimeter read negative values and three readings exceeding 1000 NTU (1223, 1192, and 1192 NTU). The MOE has indicated that the turbidimeter is calibrated for a range of 0 to 1000 NTU and values beyond this range should be treated as outliers. Data above 1000 NTU were removed from the MOE1 data set.

2.3 MOE2

As part of a Water Quality Monitoring Program a Federal-Provincial monitoring station is located near the AWS disinfection facility intake. This monitoring station was used in the Environmental Protection Division (EPD) draft report entitled “Water Quality Assessment and Objectives for the Englishman River Community Watershed”, which assessed water quality along the Englishman River from 2003 to 2005. The raw data from 2003 to 2005 was not available, but the results of the analyses documented in the EPD report were included in this paper for comparison (MOE, 2009).

Since 2005 a variety of physical, chemical and microbiological parameters are measured approximately every two weeks. Data was available for January 4, 2005 to June 23, 2009.

2.4 E28834, E25210

In addition to MOE2, the EPD contained data from monitoring stations along the Englishman River at E248834 and E252010. Data was also collected at monitoring stations on Morrison Creek (E248835) and the South Englishman River (E248836). The locations of these stations are shown in **Figure 1-1**, but only the data from stations directly on the Englishman River were included in this document. The EPD report provides a summary of physical and chemical water quality properties from the monitoring stations from 2003 to 2005, though no raw data is available. The EPD report suggests that turbidity levels are lower at E28834.

2.5 Other References

Physical and chemical water quality parameters were measured from annual samples taken at the existing Arrowsmith intake. The results of the analyses from 2005 to 2008 have been published by the AWS and the City of Parksville.
Physical, chemical, and microbiological data was available in the 1993 KRC Consultants report entitled “*Regional Water Supply System Englishman River – Draft Predesign Report (Update)*” and from the 2004 Gartner Lee report entitled “Arrowsmith Water Service –

Englishman River Water Quality Study." The data from the KRC report is from 1991 to 1992 near the Morrison Creek and South Englishman River confluences (Reaches E-3, E-4, and E-5). The data from the Gartner Lee report is from 2002 to 2003 from sample points upstream of the Morrison Creek confluence (Reach E-5), upstream of the South Englishman River confluence (Reach E-4), near the BC Hydro ROW (Reach E-3), and near the Highway 19 crossing (Reach E-2). While the data sets are older, the results were used to compare to more recently collected samples and to compare water quality at different locations.

3 Water Quality Summary

3.1 Turbidity

3.1.1 Continuous Turbidity Measurement Results

Daily minimum, average, and maximum turbidity levels as measured at PRK1 and MOE1 are shown in **Figures 3-1** and **3-2**, respectively. A numerical summary of turbidity data from PRK1, MOE1, and MOE2 is provided in **Table 3-1**.

Figure 3-1
Daily Turbidity as per PRK1

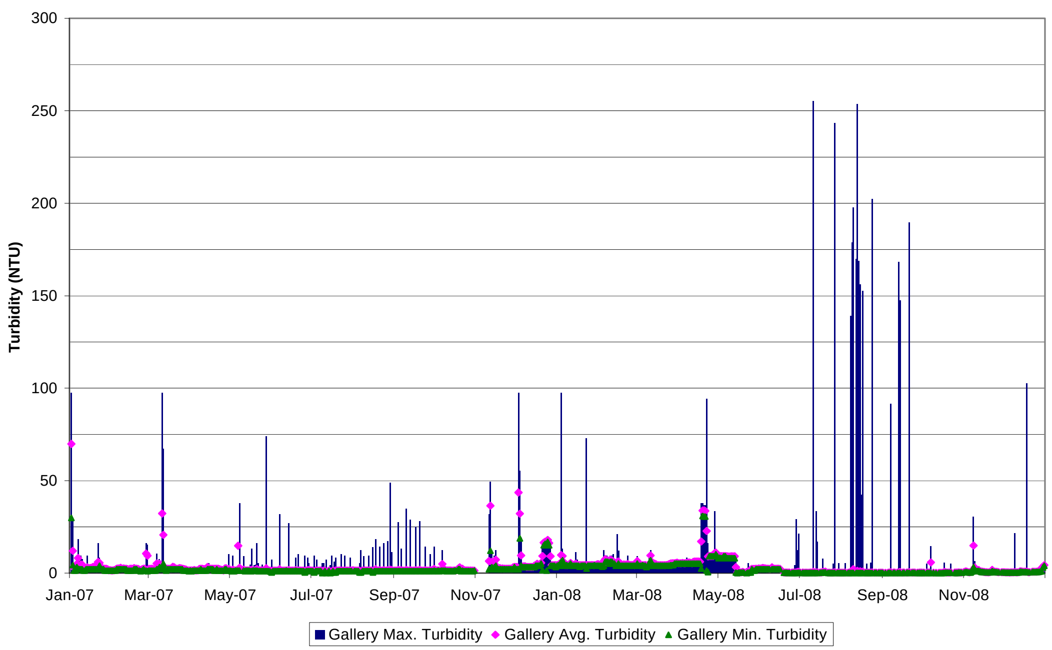


Figure 3-2
Daily Turbidity as per MOE1

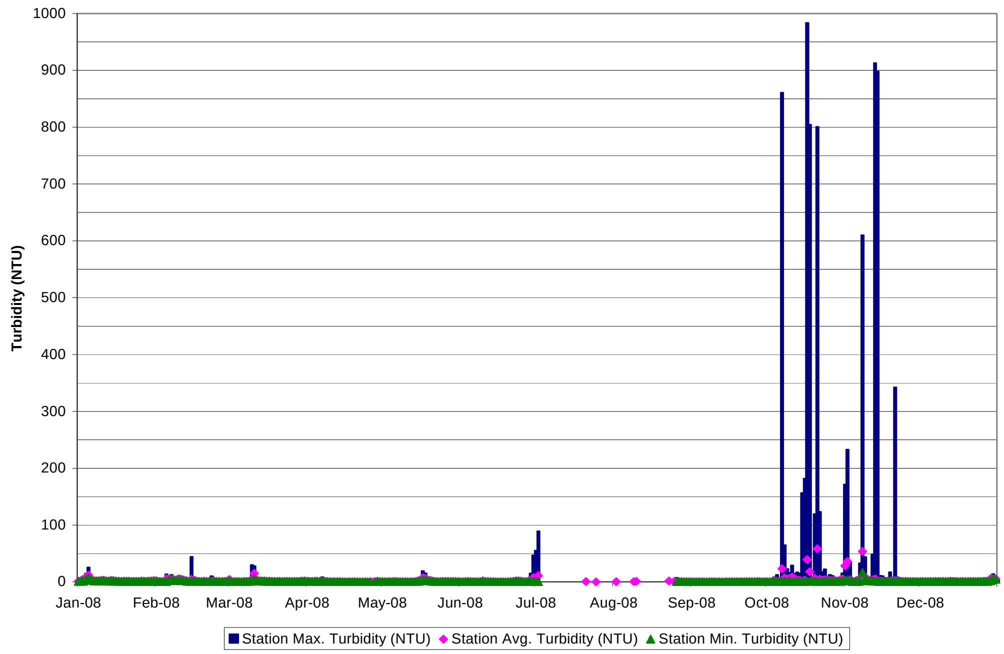


Table 3-1
Turbidity Data Summary

Date of Measurements Frequency of Occurrence	MOE1 2008-2009	MOE2 2003-2005 (Source: EPD report)	MOE2 2006-2007 (Source: MOE)	PRK1 2008 (Source: City of Parksville)
< 1 NTU	55%	73.1%	61%	52%
1-5 NTU	37%	16.1%	32%	27%
5-10 NTU	5%	3.5%	3%	18%
10-50 NTU	3%	4.4%	2%	3%
>50 NTU	0.3%	3.0%	2%	0.02%
Maximum	984 NTU	1470 NTU	92 NTU	255 NTU
Average	2.6 NTU	-	2.8 NTU	3.0 NTU
Median	0.9 NTU	-	0.8 NTU	0.8 NTU

Turbidity is below 1 NTU the majority of the time, and turbidity below 5 NTU 80%to 90% of the time. The 2003-2005 MOE2 data shows more extremes in turbidity conditions. The 2006-2009 MOE2 measured a lower maximum turbidity, but since requirements were only taken every two weeks, major turbidity events were likely missed. The EPD report states that the Morrison Creek is a major contributor to the River's turbidity, and that upstream of the Creek grab turbidity samples were always below 5 NTU at station E28834 (MOE, 2009). It is not noted whether any of these grab samples were taken during significant turbidity events.

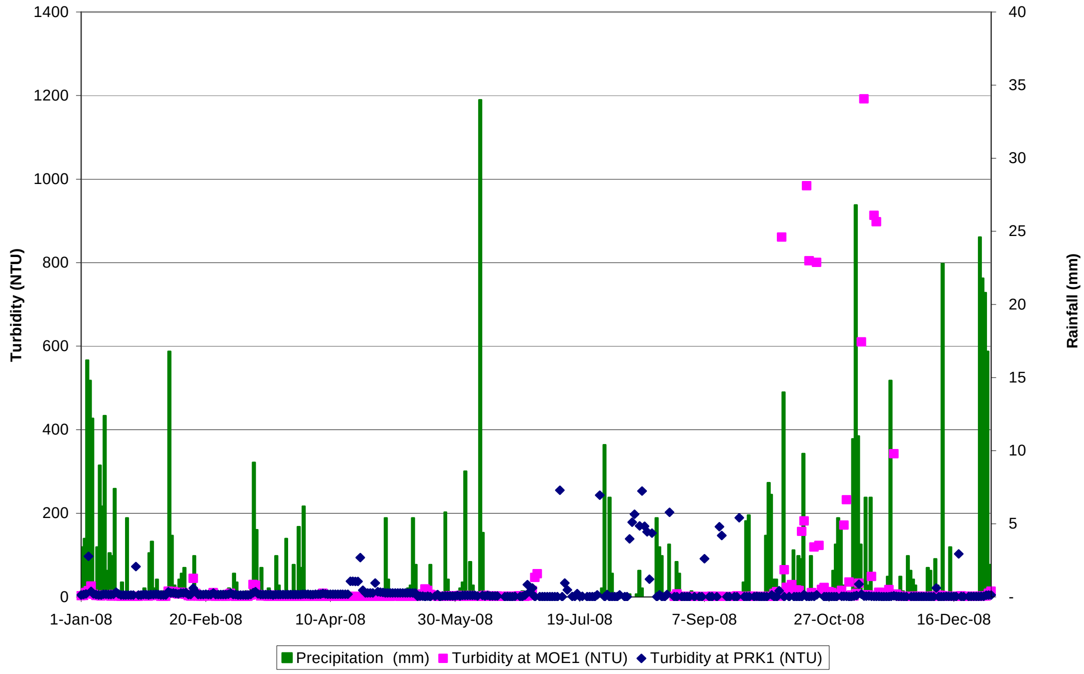
Significant discrepancies exist between the MOE1 and PRK1 data in terms of turbidity spike magnitude and date of occurrence. The PRK1 data shows turbidity spikes spread out throughout the year, with the most significant spikes occurring between August and October of 2008. In contrast, the MOE1 data shows that the most significant spikes occurred in 2008 between October and December. According to the EPD report, frequent spikes at MOE2 were observed in May to April, and in October to November (MOE, 2009).

Both the recent data from MOE1 and from PRK1 show that the turbidity spikes occurred and receded quickly. The MOE1 data showed that the majority of the turbidity spikes were less than 30 minutes in duration. Some turbidity spikes were missed at PRK1 when measurements were recorded at 15 minute intervals instead of every 5 minutes. In contrast, the EPD report observed turbidity levels at MOE 2 spiking and remaining about 5 NTU for 10 hours or more on numerous occasions.

3.1.2 Turbidity versus Precipitation

The City of Parksville operates a rainfall gauge at the Engineering and Public Works Yard. The City indicated that historically rainfall is greatest from October to February. Daily maximum turbidity readings as measured at MOE1 and PRK1 were contrasted to 2008 precipitation data, and presented in **Figure 3-3**.

Figure 3-3
Daily Average Turbidity Versus Precipitation



Spikes measured at PRK1 show no relation to rainfall, while the MOE1 data only shows turbidity spikes coinciding with heavy rainfalls at the start of winter.

3.1.3 Turbidity versus River Flow

MOE1 and PRK1 2008 data was compared to mean daily flow rates as measured at MOE1, shown in Figure 3-4. Turbidity spikes in MOE1 data are generally accompanied by a sudden increase in flow. The spikes are less pronounced during the winter but are greater in the fall.

The 2008 PRK1 data does not correspond well with river flows. A large number of spikes were observed in the summer, where flows are at their lowest. Figure 3-5 shows PRK1 2007 turbidity data plotted against flow. For 2007, the turbidity spikes coincide with increases in flow. Unlike MOE1, the magnitude of the spikes was independent of season. However, as with the 2008 data, frequent turbidity spikes were observed in the summer that did not correlate with flow.

Figure 3-4
Turbidity Versus River Flow, 2008

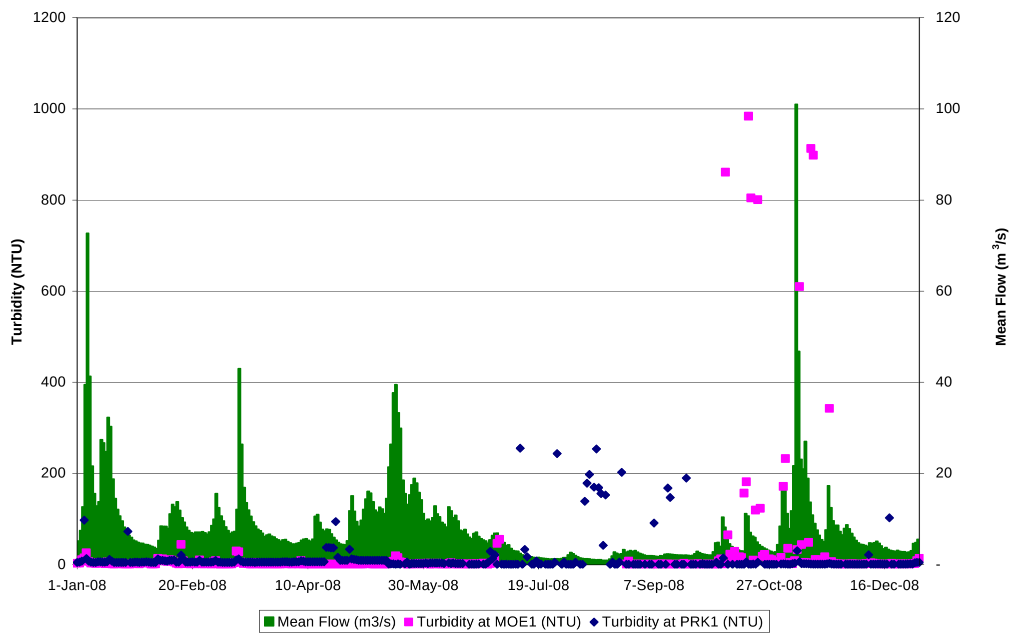
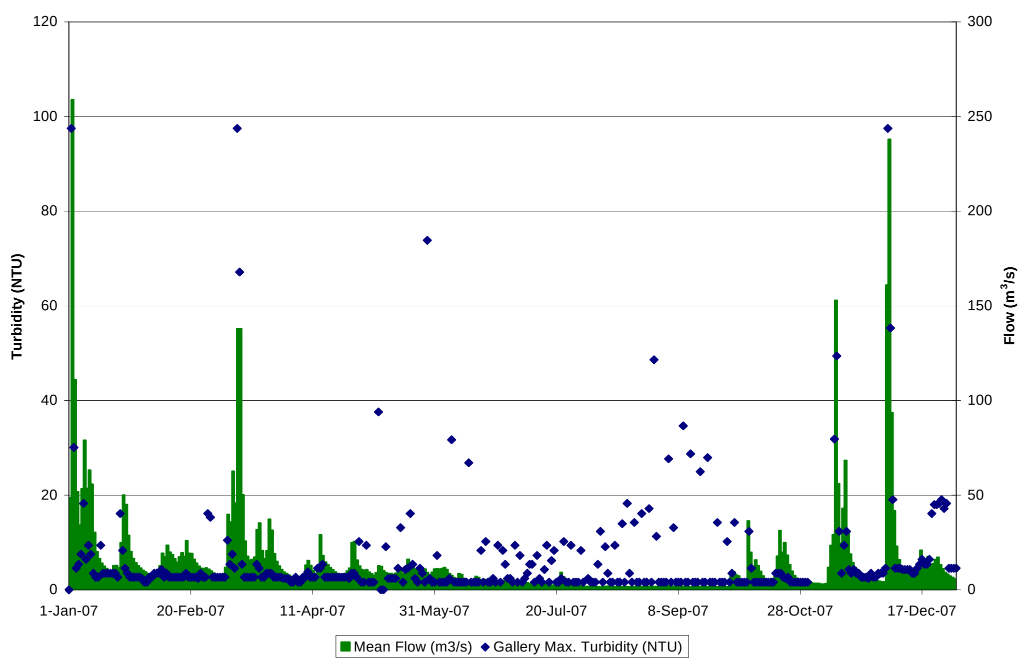


Figure 3-5
Turbidity Versus River Flow, 2007



3.1.4 Turbidity versus Location

The turbidity grab samples as documented in the KRC, Gartner Lee, and EPD reports were grouped by reaches as defined in Figure 1-1. The minimum, average, and maximum turbidity readings for each reach are provided in Table 3-2.

Table 3-2
Turbidity versus Location

Reach	Minimum (NTU)	Average (NTU)	Maximum (NTU)	Count
E-2	0.24	0.78	5.37	42
E-3	0.13	0.46	70	45
E-4	0.13	0.35	72	17
E-5	0.13	0.27	27	19

As grab samples can miss the peak of a turbidity event, the maximum turbidity levels presented in the table do not give an accurate profile of turbidity through the river. However, the average turbidity levels measured in for each reach indicate a gradual increase in turbidity as water flows downstream, the greatest increase occurring between reach E-3 and E-2.

3.1.5 On-going In-situ Turbidity Measurements

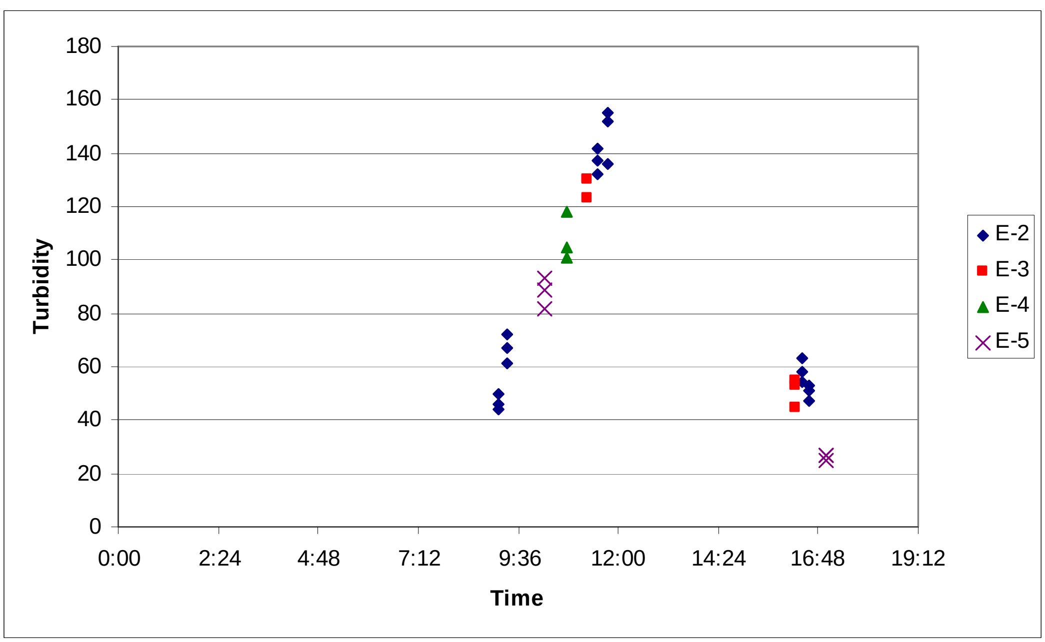
At the request of the consultant team, City of Parksville staff are conducted additional in-situ turbidity monitoring along the various reaches of the river during the late fall of 2009. Several turbidity events occurred in the Englishman River between November 9 and 25, 2009. The City was able to take turbidity measurements, using a portable Hach 2100P turbidimeter, at various locations along the river, to capture the rise and fall of the turbidity spike. The data is summarized in Table 3-3. Turbidity from November 9 was plotted against time for each reach as shown in Figure 3-6.

Table 3-3
Turbidity versus Location - November 9 to 25, 2009

Date	Location	Reach	Sample Time	Measured Turbidity (NTU)		
November 9, 2009	Turner Road	E-2	9:08	44	46	50
	Turner Road	E-2	11:45	136	152	155
	Turner Road	E-2	16:35	47	51	53
	Plummer Road	E-2	11:30	132	137	142
	Plummer Road	E-2	16:25	54	58	63
	Despard Road	E-2	9:20	61	67	72
	Top Bridge Park	E-3	11:15	123	130	130
	Top Bridge Park	E-3	16:15	45	53	55
	Middlegate Road	E-4	10:45	101	105	118
	Englishman River Road	E-5	10:15	82	89	93
	Englishman River Road	E-5	17:00	25	27	27
November 16, 2009	Turner Road	E-2	8:16	232	234	217
	Turner Road	E-2	8:24	213	253	254
	Plummer Road	E-2	13:30	152	139	141
	Plummer Road	E-2	13:40	155	152	151
	Top Bridge Park	E-3	8:04	213	221	219
	Top Bridge Park	E-3	14:00	149	154	161
	Middlegate Road	E-4	9:17	163	158	160
	Middlegate Road	E-4	14:30	103	96	97
	Englishman River Road	E-5	8:51	150	149	143
	Englishman River Road	E-5	15:10	92	103	106
	Morrison Creek	-	14:55	18	13	12
November 19, 2009	Turner Road	E-2	13:35	25	22	21
	Plummer Road	E-2	13:40	22	21	21
	Top Bridge Park	E-3	13:22	23	22	23

Date	Location	Reach	Sample Time	Measured Turbidity (NTU)		
	Middlegate Road	E-4	11:16	32	31	32
	Englishman River Road	E-5	11:51	14	15	14
	Morrison Creek	-	11:40	9	10	8
November 20, 2009	Turner Road	E-2	13:40	55	47	47
	Top Bridge Park	E-3	13:00	40	43	45
November 25, 2009	Turner Road	E-2	13:52	156	163	170
	Turner Road	E-2	14:09	160	170	179
	Despard Road	E-2	15:25	217	222	239
	Despard Road	E-2	15:35	211	219	224
	Top Bridge Park	E-3	13:39	159	161	165
	Top Bridge Park	E-3	15:05	199	207	213
	Englishman River Road	E-5	14:40	166	174	174

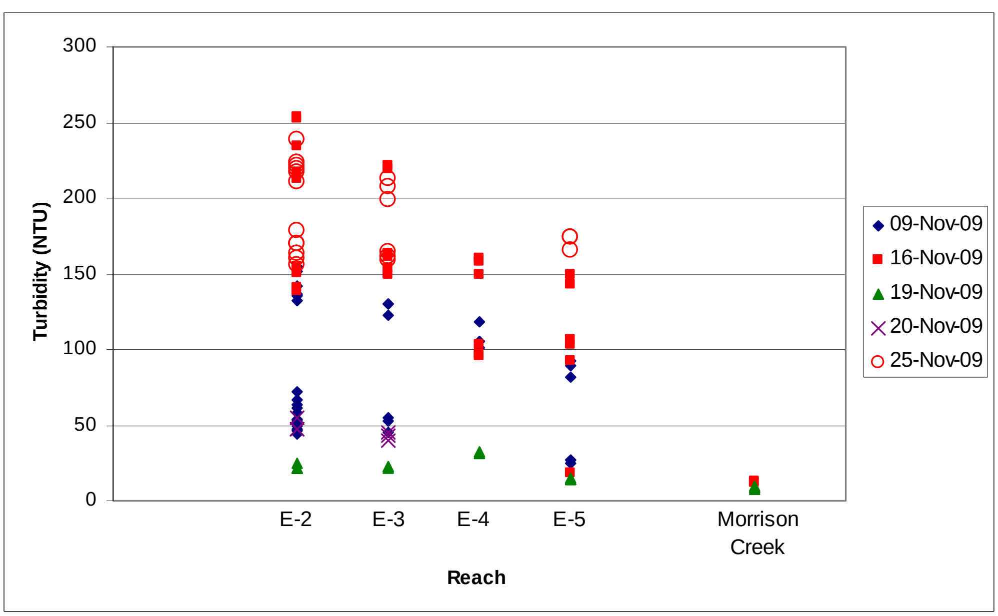
Figure 3-6
Turbidity versus Time – November 9, 2009



In the absence of continuous turbidity measurements, it is difficult to accurately identify the peak of the turbidity event. The data for Reach E-2 shows that the event lasted approximately 12 hours. Overall, the data suggests that there is a slight increase in turbidity when moving downstream, but it is difficult to confirm given the rapid change in turbidity during the event. The lack of a sudden change in turbidity between reaches also suggests that no single reach is the predominant contributor of sediment during a turbidity event.

Additional turbidity events were observed on November 16, 19, 20, and 25 of 2009. Unfortunately none of these events were captured in their entirety, in that the samples do not show both the increase and decrease in turbidity. The data from these events are provided in **Table 3-3**. The five turbidity events from November 9 to November 25 were grouped into reaches and plotted in **Figure 3-7**. The plot shows the highest turbidity occurring in Reach E-2, although this observation may be due to measurements at E-2 being taken at the crest of a turbidity event that was missed at the other locations. The difference in turbidity at each reach is small in comparison to the overall magnitude of the observed turbidity events. The samples taken from Morrison Creek had either a lower or similar turbidity as the other reaches monitored the same day, indicating that Morrison Creek is likely not a significant contributor to turbidity to the Englishman River. In other words, turbidity levels in the Englishman River are not significantly different upstream and downstream of the Morrison Creek confluence.

Figure 3-7
Turbidity versus Reach of River – November 9 – 25, 2009



3.2 Other Parameters

3.2.1 Physical/Chemical Parameters

Table 3-4 summarizes key water quality parameters for the Englishman River as measured by the City near PRK1 and at MOE2. The limits listed in the Guidelines for Canadian Drinking Water Quality (GCDWQ) were included for comparison. The data in **Table 3-4** was compared to measurements in the same locations documented in the Gartner Lee and EPD reports, as summarized in **Table 3-5**. The data from the two tables are consistent with each other.

The PRK1 and MOE2 data indicate that the Englishman River generally conforms to the GCDWQ. Some instances of iron exceeding its aesthetic objective were observed, but are likely attributed to analytical error.

According to the EPD data, Englishman River ultraviolet transmittance (UVT) varies significantly at MOE2 (MOE, 2009). The average UVT observed in the EPD report is consistent with the one UVT measurement taken at PRK1 in 2007. UVT does not impact the safety or aesthetics of drinking water but is an indicator of how effective UV irradiation will be at disinfection. Dissolved organics are a typical cause of low UVT.

3.2.2 Change in Water Quality with Location

The data from the Gartner Lee, KRC, and EPD reports were compiled to approximate changes in physical and chemical water characteristics at different locations along the Englishman River. **Tables 3-6**, **3-7**, **3-8**, and **3-9** provide key measured water characteristics when moving upstream from the Island Highway crossing up to the Morrison Creek confluence.

Tables 3-5 to **3-8** indicate that Englishman River water quality remains consistent along the Englishman River. The exception is UVT, which was observed to be high in upstream portions of the river, until passing the BC Hydro right-of-way in Reach E-3. Downstream of this location, the UVT values decrease and vary over a greater range. As the number of samples taken upstream of the crossing is limited, it is difficult to know whether UVT decreased downstream or whether dips in UVT upstream of the South Englishman River were not captured during sampling. Further monitoring is recommended.

Table 3-4
Englishman River Physical/Chemical Parameters near Intake, Reach E-2

Parameter	MOE2 (2006-2009)				PRK1 (2006-2008)				GCDWQ
	Minimum	Average	Maximum	No. Samples	Minimum	Average	Maximum	No. Samples	
General Parameters									
Alkalinity (mg/L as $CaCO_3$)	7	18	28	51	15	20	23	3	-
Hardness (mg/L as $CaCO_3$)	9	23	44	122	21	28	38	3	-
pH	6.6	7.4	7.9	122	6.6	6.8	6.9	3	6.5-8.5
True Colour (TCU)	<5	7	15	9	<5	<5	8	3	≤15
TDS (mg/L)	-	-	-	0	30	52	78	3	≤500
TOC (mg/L)	-	-	-	0	1.1	2.1	3.0	3	-
DOC (mg/L)	0.5	2.4	9.6	12	-	-	-	0	-
UVT (%)	-	-	-	0	-	72.5	-	1	-
Nitrate (mg/L as N)	0.002	0.03	0.19	122	<0.04	0.06	0.08	3	≤10
Total Metals									
Aluminum (mg/L)	0.001	0.088	0.555	114	0.012	0.020	0.027	3	-
Arsenic (mg/L)	0.00005	0.0002	0.003	118	-	<0.001	-	3	≤0.010
Cadmium (mg/L)	-	<0.002	-	118	-	<0.002	-	3	≤0.005
Chromium (mg/L)	<0.002	<0.002	0.021	117	-	<0.001	0	3	≤0.05
Copper (mg/L)	<0.001	0.001	0.028	118	<0.001	0.004	0.006	3	≤1.0
Iron (mg/L)	<0.045	0.124	0.611	114	-	<0.05	-	3	≤0.3
Lead (mg/L)	<0.001	<0.001	0.002	118	-	<0.001	-	3	≤0.01
Manganese (mg/L)	0.003	0.006	0.021	105	0.001	0.002	0.004	3	≤0.05
Uranium (mg/L)	-	<0.0005	-	118	-	<0.005	-	3	≤0.02

Table 3-5
Englishman River Physical/Chemical Parameters near Intake, Reach E-2
(2003-2005 Data)

Source	Gartner Lee Report				EPD Report: E242010			
	Minimum	Average	Maximum	No. Samples	Minimum	Average	Maximum	No. Samples
General Parameters								
Alkalinity (mg/L as $CaCO_3$)	-	-	-	0	-	-	-	0
Hardness (mg/L as $CaCO_3$)	-	-	-	0	-	-	-	0
pH	7	7.5	7.8	18	6.6	7.3	7.8	75
True Colour (TCU)	-	-	-	0	-	-	-	0
TDS (mg/L)	-	-	-	0	-	-	-	0
TOC (mg/L)	-	-	-	0	3	3.9	4.5	4
DOC (mg/L)	0.6	2.1	3.7	18	0.6	2.4	6.8	61
UVT (%)	-	-	-	0	25.1	79.4	>97.0	44
Nitrate (mg/L as N)	<0.002	0.03	0.2	18	0.001	0.034	0.15	65
Total Metals								
Aluminum (mg/L)	-	-	-	0	0.006	0.09	0.57	43
Arsenic (mg/L)	<0.0001	0.0001	0.0004	20	<0.0001	0.0002	0.0004	39
Cadmium (mg/L)	<0.00001	0.00001	0.0002	20	<0.0001	0.0002	0.0001	39
Chromium (mg/L)	<0.0002	<0.0002	0.007	20	<0.0002	0.0004	0.002	43
Copper (mg/L)	0.0002	0.001	0.004	20	<0.0001	0.001	0.004	43
Iron (mg/L)	-	-	-	0	0.04	0.12	0.21	10
Lead (mg/L)	<0.00001	0.00009	0.0004	20	<0.0001	0.0002	0.004	39
Manganese (mg/L)	-	-	-		0.002	0.006	0.049	43
Uranium (mg/L)	-	-	-		<0.000001	0.000004	0.0001	39

Table 3-6
Englishman River Physical/Chemical Parameters at BC Hydro Right-of-Way Crossing, Each E-3

Source	Gartner Lee Report				KRC Report			
	Minimum	Average	Maximum	No. Samples	Minimum	Average	Maximum	No. Samples
General Parameters								
Alkalinity (mg/L as $CaCO_3$)	10	16	22	3	-	-	-	0
Hardness (mg/L as $CaCO_3$)	15	19	25	3	-	-	-	0
pH	7.2	7.4	7.5	4	6.8	7.4	7.8	25
True Colour (TCU)	-	-	-	0	-	-	-	0
TDS (mg/L)	-	-	-	0	-	-	-	0
TOC (mg/L)	1.2	2.5	5.2	3	-	-	-	0
DOC (mg/L)	-	-	-	0	1	1.7	2.4	3
UVT (%)	-	-	-	0	91.2	-	93.3	2
Nitrate (mg/L as N)	-	<0.1	-	2	0.001	0.02	0.08	23
Total Metals								
Aluminum (mg/L)	<0.1	0.65	1.87	3	0.008	0.08	0.45	19
Arsenic (mg/L)	-	-	-	0	<0.0001	0.0001	0.0003	19
Cadmium (mg/L)	-	-	-	0	<0.0001	0.0001	0.0001	19
Chromium (mg/L)	-	-	-	0	<0.0002	0.0003	0.0012	19
Copper (mg/L)	-	<0.01	-	4	0.0005	0.001	0.002	19
Iron (mg/L)	0.02	0.4	1.55	4	-	-	-	0
Lead (mg/L)	-	<0.1	-	3	<0.0001	0.0001	0.0001	19
Manganese (mg/L)	<0.01	<0.01	0.02	4	0.0013	0.005	0.012	19
Uranium (mg/L)	-	-	-	0	<0.000001	0.000001	0.000001	19

Table 3-7
Englishman River Physical/Chemical Parameters Upstream of South Englishman River Confluence, Reach E-4

Source	Gartner Lee Report				KRC Report			
	Minimum	Average	Maximum	No. Samples	Minimum	Average	Maximum	No. Samples
General Parameters								
Alkalinity (mg/L as $CaCO_3$)	-	-	-	0	12	-	20	2
Hardness (mg/L as $CaCO_3$)	-	-	-	0	15	-	24	2
pH	6.9	7.5	8	15	7.2	7.3	7.3	3
True Colour (TCU)	-	-	-	0	-	-	-	0
TDS (mg/L)	-	-	-	0	-	-	-	0
TOC (mg/L)	-	-	-	0	1.1	-	4.9	2
DOC (mg/L)	1.1	2.4	4.1	7	-	-	-	0
UVT (%)	-	-	-	0	-	-	-	0
Nitrate (mg/L as N)	<0.002	0.03	0.1	14	-	<0.1	-	2
Total Metals								
Aluminum (mg/L)	-	-	-	0	0.089	-	1.16	2
Arsenic (mg/L)	<0.0001	0.0003	0.0005	20	-	-	-	0
Cadmium (mg/L)	<0.00001	<0.00001	0.00002	20	-	-	-	0
Chromium (mg/L)	<0.0002	<0.0002	0.001	20	-	-	-	0
Copper (mg/L)	<0.00005	0.0007	0.001	20	-	<0.003	-	2
Iron (mg/L)	-	-	-	0	0.057	-	0.93	2
Lead (mg/L)	<0.00001	0.00006	0.0005	20	-	<0.01	-	2
Manganese (mg/L)	-	-	-	0	0.002	-	0.012	2
Uranium (mg/L)	-	-	-	0	-	-	-	0

Table 3-8
Englishman River Physical/Chemical Parameters Upstream of Morrison Creek Confluence, Reach E-5

Source	Gartner Lee Report				KRC Report				EPD Report: E248834			
	Min.	Avg.	Max.	No. Samples	Min.	Avg.	Max.	No. Samples	Min.	Avg.	Max.	No. Samples
General Parameters												
Alkalinity (mg/L as $CaCO_3$)	-	-	-	0	16	17	17	3	-	-	-	0
Hardness (mg/L as $CaCO_3$)	-	-	-	0	17	19	23	3	-	-	-	0
pH	7.1	7.4	7.7	16	7.2	7.3	7.5	4	6.8	7.4	7.7	34
True Colour (TCU)	-	-	-	0	-	-	-	0	-	-	-	0
TDS (mg/L)	-	-	-	0	-	-	-	0	-	-	-	0
TOC (mg/L)	-	-	-	0	<1	1.6	4.3	3	-	-	-	0
DOC (mg/L)	<0.05	1.5	2.8	10	-	-	-	0	1	1.7	2.8	11
UVT (%)	-	-	-	0	-	-	-	0	91.2	-	93.3	2
Nitrate (mg/L as N)	<0.002	0.04	0.2	16	-	<0.1	-	3	0.001	0.03	0.19	31
Total Metals												
Aluminum (mg/L)	-	-	-	0	0.05	-	0.5111	2	0.004	0.07	0.52	30
Arsenic (mg/L)	<0.0001	<0.0001	0.0002	20	-	-	-	0	<0.0001	0.0001	0.0003	30
Cadmium (mg/L)	<0.00001	<0.00001	0.00001	20	-	-	-	0	<0.0001	0.0001	0.0001	30
Chromium (mg/L)	<0.0002	0.001	0.0014	20	-	-	-	0	<0.0002	0.0002	0.0007	30
Copper (mg/L)	<0.00005	0.001	0.01	20	<0.003	<0.01	0.004	3	<0.0001	0.0009	0.003	30
Iron (mg/L)	-	-	-	0	<0.02	0.14	0.42	3	-	-	-	0
Lead (mg/L)	<0.00001	0.00006	0.0002	20	<0.01	-	0.012	2	<0.0001	0.0001	0.0002	30
Manganese (mg/L)	-	-	-	0	-	<0.01	-	3	0.0001	0.003	0.03	30
Uranium (mg/L)	-	-	-	0	-	-	-	0	<0.000001	0.000001	0.000001	30

3.2.3 Microbiological

Measured bacteria counts from MOE2 and PRK1 are summarized in **Table 3-9**.

Table 3-9
Bacteriological Parameters

Bacteria	Minimum	Average	Maximum	No. Samples
Total Coliforms (CFU/100 mL)	<1	-	1	2
Faecal Coliforms (CFU/100 mL)	1	37	370	118
E. coli (CFU/100 mL)	<1	36	370	118

Every measurement taken at MOE2 detected *E.coli,* while the two samples taken at PRK1 contained no detectable levels. The EPD report mentions wildlife that feed on fish carcasses near the existing treatment plant intake during salmon runs as a possible source of faecal contamination.

In the Gartner Lee report, five samples from different locations on the Englishman River were analyzed for *Cryptosporidium parvum* and *Giardia lamblia* counts. *Cryptosporidium* was detected in the two samples taken at the BC Hydro right-of-way crossing of the river, which is near the Inland Island Highway crossing. *Giardia* was detected in one of the two samples taken at the confluence of Morrison Creek. Protozoa were below detection in the remaining samples. These results do not indicate an unusual level of the protozoa in the Englishman River. It is generally accepted that these protozoa will occur in surface waters.

Some concern has been voiced by project stakeholders about the risk of the *Didymosphenia geminate* algae returning to the Englishman River. The algae has not been observed in Vancouver Island water bodies since the 1990's, but has been reported to appear quickly in previously pristine waters. The primary impact on water treatment infrastructure is that the algae can clog intakes, but can be dealt with by incorporating self-cleaning screens into the intake.

3.3 Discussion

Based on the reviewed data, the water quality of the Englishman River is good overall, in that it meets the GCDWQ physical and chemical criteria with the exception of turbidity. The majority of time turbidity is low and considered suitable for drinking water, but the turbidity spikes that occur periodically have a significant magnitude. To place these spikes into perspective, spikes observed at the City of Nanaimo's surface water source are typically in the order of 10-50 NTU. Turbidity spikes in the Englishman River regularly reach the 200 NTU level and in some cases have exceeded 1000 NTU. Except for in the summer, turbidity spikes correlate to periods of high flow in the river. The lack of a correlation between the spikes and precipitation implies that intermittent bank sloughing within the river maybe a more significant contributor.

The existing data shows a consistent increase in turbidity when travelling down the river, both under high and typical flow conditions. During a turbidity event, no sharp increase in turbidity was observed between the reaches, implying that no single reach was the primary source of turbidity. This is of note since two unstable banks in reach E-3 and the confluence of Morrison Creek in E-4 were believed to be significant sources of turbidity. Under typical conditions, a slightly greater increase in turbidity was observed in E-3, but turbidity remained below 1 NTU. The relatively low turbidity levels observed at Morrison Creek indicate that the Creek is not a significant sediment contributor to the Englishman River.

It is evident that turbidity decreases when travelling upstream of the Englishman River. However, the November 2009 data shows that, even when significantly upstream from the existing intake, turbidity spikes are still relatively high and particulate removal treatment will be required in order to meet drinking water objectives.

4 Risks to Water Quality

In addition to historical water quality data, potential risks to the Englishman River will impact the recommended location and characteristics of the AWS intake and water treatment plant. Risk matrices were developed in the following sections, identifying factors that could detrimentally impact water quality of the site selection process.

4.1 Long Term Impacts

Table 4-1 lists a number of potential long term developments in the future that could impact the quality of the Englishman River water. The long term impacts would cause a gradual change in water quality and the problems caused by these changes would remain with the plant for months or years.

Table 4-1
Long Term Risks to Water Quality

Description	Potential Impacts	Potential Mitigation Strategies
Change in land use on upstream portions of Englishman River.	Increased sediment loading during construction of new developments. For agricultural developments, increased risk of faecal and nutrient loading to the river. For industrial developments, risk of metals, petrochemical, and industrial chemical contamination of the river. For residential developments not connected to a sanitary sewer, risk of faecal contamination.	• Select intake type and location that minimizes collection of particulates. • Include or provision for future addition of adequate particulate removal and disinfection processes at the treatment plant.
Construction of new dam upstream.	Increased sediment loading, algae growth during initial years of operation.	• Select intake type and location that minimizes collection of particulates. • Include or provision for future addition of adequate particulate removal and disinfection processes at the treatment plant.
Climate change.	Greater concentrations of trace organics and inorganics due to lower base flows. Increased sediment loading during peaks in flow.	• Select intake type and location that minimizes collection of particulates. • Include or provision for future addition of adequate particulate removal and disinfection processes at the treatment plant.
Forestry activity upstream.	Increased sediment loading during periods of rainfall and freshet.	• Select intake type and location that minimizes collection of particulates. • Include or provision for future addition of adequate particulate removal and disinfection processes at the treatment plant.
Presence of seasonal algae blooms.	Clogging of treatment plant intake.	• Incorporate self-cleaning screens at intake.

4.2 Acute Impacts

Table 4-2 lists potential events that could have a short term, but immediate impact on the quality of the Englishman River water.

Table 4-2
Acute Risks to Water Quality

Description	Potential Impact	Potential Mitigation Strategies
Slope instability and land slides.	Increased sediment loading and concentrations of microbiological parameters.	• Select intake type and location that minimizes collection of particulates. • Implement slope stability initiatives upstream of intake. • Design treatment processes to treat high sediment loading spikes.
Automobile accidents near Englishman River crossings.	Petrochemical contamination.	• Locate intake upstream of crossings. • Include sufficient treated water storage capacity to allow plant to be temporarily shut down during emergencies. • Develop alternate groundwater supply to supplement water system during emergencies. • Include advanced treatment processes to be used only during threats of contamination.
Forest fire.	Increased sediment loading.	• Select intake type and location that minimizes collection of particulates. • Design treatment processes to treat high sediment loading spikes.
Intentional contamination of river.	Presence of chemical dangerous for human consumption. Fish kills leading to increased organic concentrations.	• Implement monitoring and increased security measures at intake. • Include sufficient treated water storage and develop alternate groundwater supply to allow treatment plant to be temporarily shut down during emergencies.

5 Summary

The water quality of the Englishman River generally meets the GCDWQ criteria. The main concern is the high spikes in turbidity that occur throughout the year. The available data suggests that turbidity increases as water flows down the river, but is insignificant in comparison to the turbidity spikes encountered in all monitored reaches of the river. No specific reach of the river was identified as a primary sediment contributor, and available data suggests that Morrison Creek is not a significant contributor to turbidity. The occurrence of turbidity spikes generally correlated with high river flows but not heavy rainfall, implying that turbidity increases in the river are primarily caused by gradual erosion of the banks.

An extensive amount of water quality data is available from the reviewed monitoring stations. However, some contradictions and gaps in the data set remain. To allow for a more accurate assessment of water quality and treatment requirements, it is recommended that the following parameters be monitored:

Turbidity: Continuous turbidity monitoring should continue at stations PRK1 and MOE1. In addition, the city should continue the in-situ turbidity monitoring at different reaches of the river during extreme turbidity events. Once an intake site is selected, additional monitoring at the location should be carried out to confirm water treatment design parameters.

UVT: After a site has been selected for the new Arrowsmith intake, it is recommended to collect weekly UVT samples. Currently, it is difficult to confidently assess UVT characteristics along the Englishman River, as UVT measured at PRK1 varied significantly and only a small sample set is available in the other river reaches. UVT has a direct impact on the feasibility of using ultraviolet irradiation as a treatment process and, therefore, should be confirmed.

Didymosphenia Geminate: After a site has been selected for the new intake, additional work should be carried out to confirm that the algae *Didymosphenia Geminate* are not a concern in the Englishman River. Presence of the algae would mean that the intake would require self-cleaning screens, but would not impact treatment requirements.

6 List of References

1. LGL Limited, 2005. A Strategy for Protection and Restoration of the Englishman River Mainstem, Englishman River Watershed Recovery Plan Roundtable / Pacific Salmon Endowment Fund Society, October 2005.

2. Gartner Lee, 2004. Arrowsmith Water Service – Englishman River Water Quality Study, Arrowsmith Water Services, 2004.

3. KRC Consultants, 1993. Regional Water Supply System Englishman River, Draft Predesign Report (Update), Arrowsmith Water Service, 1003.

4. Ministry of Environment, 2009. Water Quality Assessment and Objectives for the Englishman River Community Watershed (Draft), Environmental Protection Division, Distributed for Review 2009.